# GOALS, STRATEGIES AND POLICIES FOR RURAL ENERGY

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## 1 Rural Energy -- the Abandoned Priority

Rural energy systems have become an abandoned priority. There was an upsurge of interest in them in the 1970s triggered by the appropriate technology movement and the enthusiasm for the application of science and technology to rural areas. Very soon, however, the emphasis shifted to renewable energy. There are suspicions that this shift was in response to industrialised country concerns over the global environment and the ensuing promises of funding. Unfortunately, though rural energy invariably implies renewable energy, the converse is ***not*** true -- renewable energy does not necessarily imply a concern either for rural energy systems or for the people living in rural areas.

The primary focus in the rural energy work of the 1970s was on ***cooking***. Research, development and dissemination were devoted to stoves, particularly fuelwood stoves. With some initial success in improving the efficiency of fuelwood stoves and even more, with making them less smoky, the emphasis turned to large-scale dissemination particularly through government programmes.

Success in this dissemination drive was only partial[1]. Even this partial success led, however, to a reduction of the intensity of the efforts of woodstove research and development workers and the associated disseminators. In this process, there was little concern for the fact that restricting efforts to improved fuelwood stoves implied the acceptance of a “dual-fuel” society, i.e., a society in which the poor cooked with messy solid fuels in relatively inefficient stoves and the rich enjoyed clean gaseous fuels like LPG in efficient stoves. There was also little consciousness of the strong gender bias against women in this shift of priorities. By and large, the cooking challenge was soon forgotten by donors, activists and technologists. In the real world, however, the overwhelming majority of rural households and particularly their women had no option other than continuing with the arduous task of fuelwood gathering and cooking in an unhealthy environment.

The other focus in rural energy work was on rural electrification which was equated with ***village*** electrification. Even one pole near a village qualified it as an electrified village. Further, agricultural consumers dominated the priority list of electricity end-users with their demand for energizing ***irrigation pumpsets***. Home electrification was not taken up as a challenge by the electricity boards and even the political parties. Gandhiji’s dream that electricity would be a boon to every home was abandoned in the land of his birth. Interestingly, the African National Congress in South Africa highlighted “Electricity for all!” as a goal for the power sector.

On the supply side, rural electrification was understood as ***grid electrification*** following centralised generation from mega projects. The whole challenge of decentralised generation from local sources was not included in the agenda. This process was in tune with the general usurping of governance powers by centralised authorities and the underemphasis of local sources observed in other sectors such as minor irrigation and forestry. The crucial importance of rural energy as the necessary foundation for rural self-reliance was ignored.

Fortunately, in many parts of the country, the drive for decentralised planning at the panchayat level is gathering momentum. Energy is on the verge of entering the agenda for this decentralised planning and implementation. It is being realised that decentralisation of political power has to be buttressed with decentralisation of electrical power in particular and of rural energy in general.

Yet another factor is the widespread urbanization in developing countries. The growing politically powerful urban population is generating a growing urban energy demand that is eclipsing rural needs. Rural energy is not getting the importance it deserves. The realization that "half" the population will be urban is blinding recognition of the fact that the other "half" of the population of the world still lives in rural areas. And in the poorest regions of the world, the rural fraction is even greater. In India, for example, the rural percentage of the population is decreasing, but it was still 74.3% in 1991. This translates to an enormous population of 627 millions in villages. So, rural energy needs must not be swept aside by urban energy demands.

Above all, with the growing trend to leave implementation to market forces, the rural poor (constituting a large fraction of the rural population) do not have the purchasing power to articulate their needs through market demand. Attention therefore gets turned to those sections of the population and those areas of the country that can provide a market with purchasing power. Thus, urban concentrations get priority while rural populations requiring special attention get sidelined.

Against this backdrop, the World Bank has "discovered"[2] that there are about 2 billion people[3] in the world who cook with traditional biomass/ fuelwood and about 1.7 billion people are without electricity. Most of these people without access to modern energy carriers live in rural areas. What they need above all is a major improvement in the services that energy provides, particularly the ***energy services*** of efficient, safe and clean cooking and electric lighting. The World Bank emphasis, however, is on improving energy ***supplies***. This supply bias opens the door to a flood of devices and gadgets and to a procession of industrialised country technology vendors. Whilst waxing eloquent about the energy-deprived two billions and talking of providing access to modern energy, the real agenda appears to be the selling of solar photovoltaic systems primarily for domestic lighting. There is an on-going global solar photovoltaic (SPV) sales drive. But the market for such systems is restricted to an upper crust of the rural population (see Section 10). Thus, the challenge of improving energy services to rural areas and the poor looms as large as ever.

## 2 Why Rural Energy deserves Special Attention

There are many reasons why rural energy deserves special attention distinct from energy in general. First and foremost, if rural energy is not treated separately, it is bound to be deprived of appropriate and deserved emphasis because it "would fall between the cracks".

Second, the demography of rural areas differs fundamentally from that of urban towns, cities and metropolises. Rural areas consist of dispersed populations in contrast to the population concentrations of urban conglomerations. Actually, rural settlements are of two main types – (1) the ***compact villages*** of India and China and other countries with similar rural settlements and (2) the ***"homestead" type settlements*** of Kerala state in India, Sri Lanka and many parts of Africa.

This fundamental distinction leads to a third reason for treating rural energy differently. Centralised generation/production of energy followed by its transmission/transport makes eminent sense for the dense populations of urban conglomerations. But, this urban approach may prove prohibitively costly and inefficient for the dispersed populations presenting remote, scattered and low loads leading inevitably to greater transmission and distribution losses. Beyond certain break-even distances from the grids/transport systems associated with centralised generation/production, it may be more cost-effective to implement decentralised village-scale generation/production coupled to mini-grids. And when the settlements consist of scattered homesteads, it may even be better to install household energy systems.

## 3 Rural Energy Systems – the Current Situation

Any discussion of rural energy requires an appreciation of current energy consumption patterns at the village level. There have been several studies of the patterns of energy consumption in villages. Among the earliest of the studies was that of six villages in the Ungra region of Tumkur District, Karnataka State, South India, carried out in the late 1970s[4].

The energy-utilising activities consisted[5] of: (1) agricultural operations; (2) domestic activities -- gathering fuelwood, fetching water for domestic use particularly drinking, cooking and grazing of livestock, (3) lighting and (4) industry (pottery, flour mill, etc.)[6].

These activities were achieved with human beings, bullocks, fuelwood, kerosene and electricity as ***direct***[7] sources of energy.

The ranking of **sources** (in order of percentage of annual requirement) was as follows: (1) fuelwood, (2) human energy, (3) kerosene, (4) bullock energy, and (5) electricity. The ranking of **activities** was as follows: (1) domestic activities, (2) industry, (3) agriculture and (4) lighting.

Human energy was distributed between domestic activities (grazing livestock, cooking, gathering fuelwood, fetching water), agriculture, and industry. Bullock energy was used wholly for agriculture including transport. Fuelwood was used for cooking and heating bath water in the domestic sector, and to a small extent in industry. Kerosene was used predominantly for lighting, and to a small extent in industry. Electricity flowed to agriculture, lighting, and industry.

There are several features of the patterns of energy consumption that must be highlighted.

(1) What is conventionally referred to as ***commercial*** energy, i.e., kerosene and electricity in the case of Pura, accounts for a trivial fraction of the inanimate energy used in the village. The overwhelming portion comes from ***fuelwood***.[8] Further, fuelwood must be viewed as a ***non-commercial*** source since only a small amount of the total fuelwood requirement was purchased as a commodity, the remainder being gathered at zero private cost.

(2) ***Animate*** sources, viz., human beings and bullocks, only account for a small percentage of the total energy, but the real significance of this contribution is revealed by the fact that these animate sources represent most of the energy used in agriculture.

(3) Virtually all of the village's energy consumption comes from ***traditional renewable sources*** -- thus, agriculture was largely based on human beings and bullocks, and domestic cooking (which utilises an overwhelming portion of the total inanimate energy) was based entirely on fuelwood.[9]

(4) However, the environmental soundness of this pattern of dependence on renewable resources was achieved at the exorbitant price of ***very low productivity*** especially in agriculture. And large amounts of human energy are spent on ***fuelwood gathering*** (on the average, several hours per day per family and several kilometres of walking to collect a headload of about 10 kg of fuelwood).

(5) ***Fetching water*** for domestic consumption also utilises a great deal of human energy (an average of 1.5 hr and 1.6 km per day per household) to achieve an extremely low per capita water consumption of less than 20 litres per day.

(6) A great deal of the human energy is spent on ***grazing livestock*** that are a crucial source of supplementary household income.

(7) There is a strong gender bias in fuelwood gathering and fetching water – both these activities are primarily the traditional burden of women.

(8) Only a fraction of the houses in typical "electrified" Indian villages have acquired domestic connections for electric lighting, the remaining houses depend on ***kerosene lamps***. Thus, village electrification does not mean home electrification.

It is obvious that the inhabitants of Indian villages, particularly its women and children, suffer burdens that have been largely eliminated in urban settings by the deployment of inanimate energy. For example, gathering fuelwood and fetching water can be eliminated by the supply of cooking fuel and water respectively. The serious gender and health implications of rural energy consumption patterns, have been brought out in several studies[10],[11],[12],[13],[14].

Since the 1970s, there have been innumerable other studies[15],[16],[17] of rural energy consumption patterns. The actual numbers show differences depending upon the country, the region of the country, the agro-climatic zone, the proximity to forests, the availability of crop residues, prevalent cropping pattern, etc., but the broad features of the patterns of energy consumption highlighted above have been generally validated.

Thus, the almost universal features of current rural energy consumption patterns all over the developing world are as follows

- the major contribution of **arduous human labour** (especially the labour of women) for domestic activities and agriculture,
- the dominance of **biomass** (in the form of fuelwood, crop residues and/or animal wastes) as an energy source in traditional devices,
- the overwhelming importance of **cooking** as an end-use,
- the dependence in many places on **unsafe sources of surface water** for domestic requirements,
- the darkness between sundown and sunrise because of the **lack of electricity** and satisfactory illumination.

## 4 Goal for Rural Energy Systems

If the goal ( = objective to be achieved) for all energy systems is sustainable development, then ***the goal for rural energy systems is that they must be instruments of sustainable rural development***. Rural energy systems, therefore, must advance rural economic growth that is economically efficient, need-oriented and equitable, self-reliant and empowering, and environmentally sound.

The stress on equity means that rural energy systems must above all promote poverty alleviation involving improvement of the living conditions of the poor. Betterment of the life of the rural poor requires an improvement of the Physical Quality of Life (PQOL) or the Human Development Index (HDI). This improvement of HDI has three crucial dimensions: **equity** based on a marked increase in the access of poor to energy services, **empowerment** based on strengthening of endogenous self-reliance, and **environmental soundness**.

For an energy system to be in the interests of the rural poor, it must qualify from three points of view. It must increase the access of the rural poor to affordable, reliable, safe and high quality energy. It must strengthen their self-reliance and empower them. It must improve the quality of their environment (starting with their immediate environment in their households).

## 5 Relationship between HDI and Energy

For rural energy systems to play the role of advancing sustainable rural development, the emphasis must be on **energy services** -- and not merely on energy consumption (or supply) as an end in itself. The focus has to be on energy services that improve the Human Development Index (HDI) **directly** (cooking, safe water, lighting, transportation, etc.) as well as **indirectly** via employment and income generation (motors, process heat, etc.).

The impact of energy on the HDI depends on the end-uses of energy and on the tasks that energy performs. The direct impact of energy is associated ***inter alia*** with, and is produced by, cooking, supply of safe water, and lighting. The indirect impact of energy is associated with, and is produced by, electric drives [motors, pumps, compressors] and process heat [processing industries].

The role that energy can play in improving the HDI is not just a matter of hope or conjecture. There is an empirical basis to the relationship between HDI and energy (Figure 1a and 1b). Strictly speaking, the relationship must be between energy **services** and HDI. If, however, end-use efficiency is virtually a constant, energy consumption can be taken as a proxy for energy services and the Figures 1a and 1b display the dependence of HDI on energy.

The relationship between HDI and energy has several important implications. Firstly, the relationship can be considered to consist of ***two regimes*** (Figure 2).

Secondly, in Regime I, the slope $\delta(HDI)/\delta E$ of the HDI vs E curve is high, and in Regime II, the slope $\delta(HDI)/\delta E$ of the HDI vs E curve is small. Hence, in the "elastic region" of Regime I, **large** improvements in HDI can be achieved with **small** inputs of energy (small improvements of energy services). Thus, in this regime, the HDI-energy (benefit-cost) ratio is very high. In contrast, in the "inelastic region" of Regime II, even ***large*** inputs of energy (large improvements of energy services) result only in ***marginal*** improvements in HDI, i.e., in this regime, the HDI-energy (benefit-cost) ratio is very low.

Another important implication is that, in the "elastic" Regime I, enhanced energy services lead ***directly*** to the improvement of HDI, i.e., Energy Services à HDI. But, the impact of energy on HDI can also be indirect. Improvements of energy services can yield increased income that can be used to “purchase” HDI improvements. Thus, in the "inelastic Regime II, enhanced energy services can lead ***indirectly*** to the improvement of HDI via income generation, i.e., Energy Services à Increased Income à HDI increase.

In the "elastic" regime, the coupling between HDI and income (used for defraying the operating costs of energy devices) can be reduced. In fact, HDI can even get decoupled from income so that HDI increases can be achieved without income increases. A shift from kerosene lamps to electric lights is an example of the improvement of energy services at operating costs that are the same, or even less than, the costs of using kerosene lamps.

In the "inelastic" Regime II, HDI is coupled to income. But, income-coupled improvement of HDI depends on important conditions being satisfied. The improvement of HDI via income-generation depends on what the income is used for -- HDI improvement? or liquor? or gambling? or conspicuous consumption? These conditions in turn depend on which gender gets the income – women tend to make expenditures that improve the HDI of their families particularly their children. Women seem to use a much lower discount rate and focus on a longer term than men.

Thus, the implication of the "elastic" and "inelastic" regions is that ***the elastic region guarantees direct improvement of HDI whereas improvement of HDI via income depends on what the income is used for. The direct improvement of HDI is therefore a necessary condition for launching an indirect improvement via income.***

## 6 Approaches to Poverty alleviation

The relationship between energy and HDI also has profound implications for the strategy for alleviating poverty. In the 1970s, the emphasis in poverty alleviation was on direct satisfaction of basic human needs. However, these concerns were swept aside by the wave of liberalization. It was believed that income generation was the magic wand that would make poverty vanish. Macroeconomic growth became the standard approach to poverty alleviation. Even this did not "do the trick", for the benefits of economic growth are absorbed far too slowly by the poor. Attention was therefore turned to human capital investment but even this is a slow process. Poverty alleviation directly, rather than indirectly via income generation and human capital formation, is a much surer method of improving the HDI.

The "elastic" Regime I of the energy-HDI relationship shows that dramatic improvements of the HDI can be achieved with very small investments of energy. In fact, it is possible to get a very rough estimate of the energy cost of an "elastic" improvement of energy services for the poor. Assume that this necessary improvement of energy services consists of (1) safe, clean and efficient cooking with LPG or a LPG-like fuel and (2) home electrification for lighting, TV and fans. The energy required for cooking would be about 2.3 GJ/capita/year or about 73 watts/capita[18]. The electricity for lighting and fans at twice the consumption of the ordinary connections in Karnataka, which is 33 kWh/HH/month, would be about 18 watts/capita. Allowing another 50% (9 watts/capita) for TV, etc., it appears that only about 100 watts/capita is adequate to achieve the dramatic improvement in the quality of life corresponding to safe, clean and efficient cooking with a LPG-like fuel and home electrification for lighting, TV and fans.

## 7 Strategies for Rural Energy

Strategies are the paths to be followed to reach the goal or objective. The strategies for rural energy systems follow from the present features of such systems as spelt out in Section 4 above. The specific strategies that would advance the goal of sustainable rural development are:

- the ***reduction of arduous human labour*** (especially the labour of women) for domestic activities and agriculture,
- the ***modernisation of biomass*** as a modern energy source in efficient devices,
- the ***transformation of cooking*** into a safe, healthy and less unpleasant end-use activity,
- the ***provision of safe water*** for domestic requirements,
- the ***electrification of all homes*** (not merely villages),
- the ***provision of energy for income-generating activities*** in households, farms and village industries.

The strategies listed above pertain to ***what products/outputs*** rural energy systems should achieve. But, there should also be strategies that pertain to ***how*** these ***products*** should be delivered, i.e., the ***process*** that should be followed.

The standard approach to the establishment of new infrastructures (for example, rural energy systems based on new technologies) is for the government to take the initiative. This approach ends up with the emergence of new government ministries/departments/agencies and their bureaucracies.

With the growing experience and awareness of the defects of government efforts, the liberalisation trend has entered the picture. The market is claimed to be the best solution to the problem of establishing and running economic activities such as the infrastructure. Hence, the slogan: “Leave it to the market!” The market, however, may be an excellent mechanism for allocating labour, materials and resources, but it does not have a very successful record at looking after equity, the environment, the long-term, and research, development and dissemination of new technologies. That is, the market is an inadequate instrument in situations warranting a low discount rate.

There is, however, a third option of encouraging individual initiative subject to local community control. It has been shown that it is possible to realise "Blessing of the Commons" situations[19] (the converse of the well-known "Tragedy of the Commons") an example of which is the Pura Community Biogas Plant in Tumkur District, Karnataka State. There, the price that an individual/ household pays for not preserving the commons far outweighed whatever benefits there might have been in ignoring the collective interest. In other words, ***there is a confluence of self-interest and collective interest*** so that the interest of the commons is automatically advanced when individuals pursue their private interests. Thus, ***individual initiative plus local community control is a third option*** that can be more effective that either the government or the market acting alone.

This third option suggests three process strategies for rural energy

- ***individual initiative*** if necessary through the market
- ***village community (decentralised)*** monitoring and control,
- facilitation and enabling support from the ***government***.

## 8 Preferences in the Choice of Energy Sources and End-use Devices

Attention must be focussed, not only on the supply aspects, but also on the demand aspects of the energy system. Rural energy systems must therefore be considered to consist of **whole "fuel" cycles --** from energy sources through energy carriers via transmission/transport to distribution to end-users for utilisation in end-use devices to provide energy services. Thus, there must be an emphasis on energy **sources** and efficient **end-use devices**.

The primary sources of energy are fuels and electricity -- fuels for cooking (stoves) and for process heat (boilers/ furnaces/kilns), and electricity for lighting (lamps) and for electric drives (motors, pumps, and compressors).

The thrust must be on energy sources and devices that are renewable, biomass-based, universally accessible, affordable, reliable, high quality and safe.

Special attention must devoted to sources that are locally available, small-scale, decentralised and renewable, and systems that are amenable to local control and enhance it.

The choice of energy sources (fuels and/or electricity) must be guided by preferences for sources that

- facilitate access by the entire rural population particularly the rural poor -- through micro-utilities and community-scale systems for compact settlements (high housing density) and through home/household systems for isolated homesteads (settlements with low housing density);
- are compatible with high-efficiency end-use devices;
- are decentralised/locally available to strengthen self-reliance and to empower people/communities;
- are renewable to promote environmental soundness.

Access to (and penetration by) home systems is determined by the affordability of the energy source -- costly sources restrict access to the affluent few, and cheap sources facilitate "universal" penetration. Household systems commandeer capital, energy resources and entrepreneurship, and may even pre-empt the establishment and operation of micro-utilities (which increase access by the rural poor). ?? PV SHS vs Pura

The following questions are important in the choice of end-use devices. Do they directly improve the HDI? and/or do they generate income that (used constructively) improves HDI? Are they accessible to the rural poor? Do the devices have a low enough first cost and operating cost? or do they have the same/lower operating cost as traditional devices after innovative financing (to convert unacceptable initial costs into affordable operating costs)? Do they benefit women? Are they environmentally sound?

## 9 Elitist Sources and End-use Devices

If rural energy systems have to be instruments of sustainable rural development, the distribution of the benefits of a rural energy technology have to be scrutinised. Equity impact assessment (EqIA) statements are important. This obligation to anticipate and examine the distributional or equity implications of a technology falls on those who implement technologies for sustainable development. But those who pursue technologies, particularly renewable energy technologies (RETS) as ends-in-themselves to advance global environmental objectives, may ignore distributional or equity implications.

Consider the current drive to disseminate photovoltaic solar home systems (PV SHS) in rural India. India’s population according to the 1991 census was 846 millions. The rural population was 74.34% or 623 millions which at 5.5 persons per household corresponds to 114 million households. 69% of these households were un-electrified, i.e., 78.6 million households were without electricity. The initial cost of a PV SHS is about Rs.16,000 which, assuming a 12% discount rate and a 5-year life, corresponds to a household expenditure of Rs.4,439 per year or Rs.370 per month. On average, a household spends about 7.5% of its expenditure on energy. If this could be doubled, it means that 15% of its monthly expenditure is the upper limit to what a household can spend on energy. The monthly expenditure on a PV SHS of Rs.370 per month translates at 15% to a household income of Rs.2,466 per month. The income distribution pattern in India is such that less than 10% of the households have this income required to afford PV SHS. Further, not all households that can afford PV SHS are prepared to adopt them. Assuming that 50% of those households that can afford PV SHS are prepared to switch to PV SHS, it appears that less than 5% of the richest rural households constitute the market for such systems. Even if the PV SHS technology is aggressively promoted by reducing the interest rate to 10% and spreading the repayments over 25 years, the penetration is only increased to 25% of the richest households.

?? Grameen and RAPS

It follows that PV SHSs are beyond the means of the rural poor and are therefore **inaccessible** to them. They are elitist energy sources/devices because they can only be afforded by the rural rich constituting between say 10 to 20% of the population.

The window of technological opportunity is upper-bounded (after the most favourable financing scheme) by the maximum possible household expenditure on energy (say 15%). The operating costs of traditional devices (e.g., kerosene lamps) are therefore an important benchmark because they invariably define the maximum possible expenditure on energy. But, (after a favourable financing scheme), the operating costs of proposed (improved) devices (e.g., electric lights) can be even lower than the operating costs of traditional devices (kerosene lamps). Thus, technology can widen window of technological opportunity.

Elitist sources and end-use devices (a) bypass the rural poor, (b) do not alleviate poverty, (c) make a negligible contribution to energy system and (d) hardly mitigate negative environmental impacts. However, elitist sources and end-use devices can offer a small high-profit market for profit-making enterprises.

The skewed distribution of the benefits of some technologies leads to some important questions such as the following. Do elitist sources/devices pre-empt the possibility of dissemination of affordable sources/devices for rural poor? Do they hijack capital that would otherwise be used for poverty alleviation? Do they divert resources that would otherwise be used for the rural poor, for example, do household-size biogas plants use up the dung that could be used by more cost-effective community-scale plant, or do PV SHS (at about Rs.?? per household) prevent the dissemination of community biogas-based electrification of homes (at Rs.?? per household)? Is there a level playing field for elitist sources/devices and devices for the rural poor? Are donors and multi-lateral institutions biased towards elitist sources/ devices?

## 10 Technological Options

The identification of technological options for sources/devices depends very much on the time horizon. Unfortunately, two extreme trends can be observed. Grassroots rural development workers are preoccupied with the immediate problems of the people with whom they work directly. As a result, they tend to choose technological options that are straightaway available off-the-shelf. They use a very high discount rate for their technological decisions being totally preoccupied with the present. In contrast, technical experts are excited by technological possibilities. They talk of futuristic solutions as if they are already valid. They use a very low discount rate for their technological decisions being totally preoccupied with the distant future. Thus, the grassroots rural development workers are moved by real human beings and restrict themselves to “Band-Aid” or Quick-Fix remedies forgetting about ultimate sustainable solutions. In contrast, technologists are sometimes enamoured with technological innovations even though these will take quite considerable time to become realities. They are little concerned with the fact that, while waiting for “the Pie in the Sky”, people are condemned to remain in their present misery.

Obviously, an either-or approach must be avoided. Starting from the present technology (the initial condition), there is a necessity of three types of technologies for each energy-utilising task. A near-term technology should lead to immediate improvement compared to the present situation. A medium-term technology to achieve a dramatic advance should be available in five to ten years. And a long-term technology should prevail after say 20 to 30 years and provide an ideal sustainable solution. Ideally, the technologies for the near, medium- and long-terms should be forward compatible so that the technology at any one stage should be upgradable to the better version. And in planning efforts, it is wise to have a balanced portfolio with a combination of near-, medium- and long-term technologies. This will ensure that political decision-makers will support long-term technologies because of guarantees of near-term improvements before the next election.

The present emphasis with regard to electricity as a convenient energy carrier is on grid electricity. However, due to the problems of supplying grid electricity to small and scattered loads, the attraction of decentralised generation of electricity is increasing. Where appropriate, decentralised generation from biomass and from the intermittent sources of wind and/or small hydel, solar photovoltaics and solar-thermal devices have roles to play. New possibilities are arising because of the development of micro-turbines. Biomass-based generation of fuels to run fuel cells is an attractive long-term option particular because there are possibilities of generating surplus base-load power that can be exported from rural areas to urban metropolises.

At present, the predominant fuel in rural areas is biomass, particularly fuelwood and agricultural crop residues. Improving the efficiency of the stoves in which these biomass sources are combusted is an immediate challenge, but a switch to stoves and furnaces fuelled with natural gas and LPG is an obvious next step. But, modern LPG-like fuels derived from biomass[20], so-called biofuels, are the medium- and long-term answer.

In the case of cooking, the perspective should be to go from the present inefficient, unhealthy stoves using arduously gathered fuelwood through improved woodstoves to gaseous-fuelled stoves to clean, efficient and convenient stoves operating on electricity or on gaseous biomass-based biofuels.

The provision of safe water is a crucial task that yields an enormous payoff in terms of improved health. But, it invariably requires inputs of energy to go from surface water (often contaminated) to "safe" ground water lifted from tubewells to filtered or treated water to safe piped water.

With roughly 70% of rural households being without electricity connections and therefore being forced to depend on lamps burning plant oils or kerosene, the way forward is electric incandescent bulbs that are replaced as rapidly as possible with fluorescent tubelights and compact fluorescent lamps.

Radical improvements in the quality of life often depend on replacing human and animal power with motive power based on electric motors and engines driven by the combustion of fuels. Today, fossil fuels are conventional sources for engines but prime movers running on biomass-derived fuels and hydrogen are the future. In parallel, motors with much greater efficiency should be implemented.

The plight of women is very much connected to their being forced to put in enormous amounts of arduous physical labour performing various household chores. A key objective of rural energy must therefore involve the displacement of this manual labour with appliances. The advance can then be from simple electrical appliances to efficient appliances and super-efficient appliances.

Rural industries such as pottery and metalworking are currently based on process heat derived from fuelwood and/or other biomass sources such as sugarcane bagasse. Future developments have to be based on electric furnaces, cogenerated heat, and solar thermal and induction furnaces. The long-term future will perhaps belong to furnaces based biomass-derived fuels.

Rural transport particularly within villages and from house to farm and vice versa is today based overwhelmingly on animal-drawn vehicles and human-powered bicycles. Mechanisation, however, is making inroads with vehicles fuelled with petroleum products gasoline/motor spirit and diesel. Natural-gas-fuelled vehicles are bound to play a part. Over the medium-term, however, vehicles can be run on biomass-derived fuels such as producer gas and/or methanol and/or ethanol and over the long-term, fuel-cell-driven vehicles are the option.

The technological sources and devices for the near-, medium- and long-term are summarised in the Table 1.

Table 1: Sources and Devices for the Near-, Medium- and Long-term[2]

| SOURCE | PRESENT | NEAR TERM | MEDIUM TERM | LONG TERM |
|---|---|---|---|---|
| Electricity | Grid or<br>No electricity | Biomass-based generation via IC Engines/ Micro-turbines | Biomass-based generation PV/Wind/ Small Hydel/ Solar Thermal | Fuel Cells for baseload power |
| Fuels | Wood/Charcoal/Animal Wastes/Crop Residues | NG/LPG/<br>Producer Gas/Biogas | Biofuels/ Synthetic DME/LPG | Biofuels |
| TASK | PRESENT | NEAR TERM | MEDIUM TERM | LONG TERM |
| Cooking | Woodstoves | Improved Woodstoves/ Producer Gas/Biogas | LPG/Biogas/Producer Gas/NG/DiMethyl Ether (DME) Stoves | Gaseous biofuelled Stoves/<br>Catalytic Burners/ Electric Stoves |
| Safe Water | Surface/ Tubewell Water | Filtered/UV radiated/ Treated Water | Safe piped/ Centralised/ Decentralised | Ultra Safe piped/ treated water |

2 This table benefited from finishing touches from Robert Williams (Princeton University)

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|---|---|---|---|---|
| | | | Treated water | |
| Lighting | Oil/Kerosene Lamps | Electric Lights | Fluorescent/ Compact Fluorescent Lamps | Fluorescent/ Compact Fluorescent Lamps |
| Motive Power | Human/Animal powered devices | IC Engines/ Electric motors | Biofuelled prime movers/ Fuel cells/ Micro-turbines/ Improved motors | Biofuelled prime movers Improved motors |
| Appliances | -- | Electric Appliances | Efficient appliances | Super-efficient appliances |
| Process Heat | Wood/Biomass | Electric Furnaces/ Producer Gas/ Cogeneration/NG-fueled/ Solar Thermal | Induction Furnaces Biomass-fuelled Solar Thermal | Biofuels/ Solar |
| Transport | Animal-drawn vehicles/human-powered bicycles | Petroleum/ NG-fuelled Vehicles | Biomass-fuelled vehicles | Fuel-cell driven vehicles |

## 11 Developmental Implications of Rural Technologies

Real costs are of course the fundamental criterion for identifying technologies. But it also necessary to consider other sustainable development implications of the near- and long-term technological options. In particular, their efficiency, accessibility, employment generation potential, their relationship to urban areas and environmental sustainability have to be considered. A broad characterisation of the near- and long-term technological options from these points of view is given in Table 2.

Table 2: Developmental Implications of Near- and Long-term Options

| PRESENT | NEAR TERM | LONG TERM |
|---|---|---|
| Inefficient/low productivity | More Efficient | Most Efficient |
| Traditional is no longer optimal but "modern" is not accessible to the poor because it is too | More accessible because more cost-effective than modern | Most accessible |

| | | |
|---|---|---|
| expensive | | |
| Extremely backward | Employment generation | Empowers rural areas and strengthens their self-reliance |
| Dependence on urban areas | | Trade balance shifts to rural areas |
| Environmentally unsound | Environmentally sounder | Environmentally sustainable |

## 12 Barriers to Implementation

However well crafted the rural energy strategies, they will not succeed unless the barriers that they face are identified and specific policies designed to overcome them. There is a market sub-set of barriers to new, rural energy options. These include subsidies (open and hidden) to conventional rural energy options, limited access to information, and first-cost sensitivity (where household decisions are based on initial, rather than life-cycle, costs). But there is also the barrier of indifference to energy costs particularly when these costs are not in terms of money but in terms of the labour of women leading to limited attention to alternative energy options.

Another sub-set of barriers consists of non-market barriers including the supply-biased paradigm, vested interests (in the private and public sector) and institutional obstacles. The vested interests benefit from business-as-usual approaches and practices and, therefore, resist change. The institutional obstacles include the monopoly position of government ministries/departments and utilities. But there is also a lack of appropriate fora and rules for interaction between relevant organisations involved in the promotion of rural energy.

## 13 Policies for the Implementation of Rural Energy Strategies

Policies are specific courses of action to implement strategies. To implement the rural energy strategies listed in Section 7, it is necessary to have policies that implement the strategies whilst overcoming the barriers. The more obvious of these policies are indicated below.

- For each rural energy system, for example, producer gas-based electricity generation, it is vital to have an entire ***hardware plus "software"[21] implementation package***. Such packages must consist of the technology, economics, financing, management, training, institutions, etc. necessary for the dissemination of that system. Unfortunately, far too often, crucial elements (for example, institutional requirements) are missing in the dissemination programmes leading to failures. Hence, policies to encourage the preparation of implementation packages are imperative.

- However inadequate government implementation may be, **government involvement** in rural energy systems is essential to provide an enabling environment. However, **parallel operations by government must not compete** with rural energy systems. Policies for ensuring synergistic government involvement are vital.

- It is important to have **transparent, accountable and democratic institutional arrangements at the rural level** to monitor and run rural energy systems. **Clear transparent records and accounts and regular functioning of such institutions** are crucial. Consequently, policies for encouraging and supporting such rural institutions are important.

- Policies that enable and ensure **people's participation** (in particular for the supply of resources and payment for services) as households and/or as a community are imperative. These policies should include a key role for **women** as users, operators and entrepreneurs in rural energy systems.

- The establishment and operation of rural energy systems should lead to **local capacity building** in the matter of hardware (technology) and "software" (particularly management). Policies must be put in place to promote the building up of this capacity at the rural level. Special attention must be given to operation and maintenance know-how if not construction and design know-how.

- Policies are necessary for **immediate-term, medium-term and long-term time-horizons for technology development and dissemination. W**hat is urgently required is immediate improvement of energy services to better the quality of life of the rural poor. These technology policies must focus on **energy services for direct HDI improvement** (cooking, safe water, lighting through home electrification, space conditioning for comfort, etc.) as a necessary (but not sufficient) condition. It also necessary to have policies for **energy services for indirect HDI improvement via income generation** (stationary and mobile motive power, process heating, etc.) ensuring that the resulting income does indeed go to HDI improvement.

- Policies must promote **community-based supply of energy sources** when the cost of sources for N households (i.e., cost of generation) plus the cost of the distribution network is less (i.e., more cost-effective) than the cost of N household-level sources. But there should also be policies to encourage **"centralised" multi-community supply of sources** if the generation plus distribution is more cost-effective than community-level sources.

- Unlike conventional energy sources/end-use technologies, most new rural energy technologies are in the process of maturing. In particular, their costs are declining because of technological advances and organizational learning. Hence, it is important to have policies that promote **technological advances** and **organisational learning**. If subsidies are used as a policy instrument, they must be time-bound and they must be justified on the basis that they are definitely promoting technological advances and organisational learning. Above all, subsidies must not be a permanent crutch inhibiting the advancement of the technology.

- A fundamentally important issue concerns the choice of technology. In a command-and-control set-up, technologies are chosen in a top-down manner by government. In effect, this means that the choice is made by bureaucrats. Unfortunately, such choices are often notoriously defective. One has only to recall the breeder reactor programmes of the USA, France and Japan, or the Super Sonic Transport (SST) plane. The other option is to allow the market to make the choice through a process of competition. Though the market option is attractive, the problem is that it is effective only when there is a level playing field for the various contending technologies. This means that there should deliberate policies to ensure that there is a **level playing field for centralised supply and decentralised village-level supply and for supply expansion and end-use efficiency improvement.** The problem is that yet-to-mature emerging rural energy technologies must not be compared on the basis of their current costs with mature conventional technologies. The place of emerging technologies must be determined on the basis of their future costs resulting from technological advances and organisational learning.

- Notwithstanding the importance of the cost criterion for the choice of technology, there are other sustainable development criteria that are crucial. In particular, a technology has to be accepted by society for it to be socially sustainable. This means that there has to be social participation in the choice of technology. Special policies are required to ensure that the process of ***technology choice has to be transparent and democratic***. In this process, whatever criteria can be quantified must be quantified. And criteria that cannot be quantified today should, as an interim measure, be represented with traffic-lights colours – green for "acceptable", red for "not acceptable" and amber for "uncertain" – while setting in motion a discovery of the method of quantification[22].

## 14 Institutional Challenges

The policies indicated above require new energy enterprise(s) to be established if existing institutions such as local-level bodies cannot discharge the new responsibilities. Additionally, financial institutions/banks/donors have to take on new tasks. The following institutional challenges for financial institutions/banks/donors and for energy enterprise(s) deserve attention:

**Table 3: Institutional Challenges for financial institutions banks/donors and for energy enterprise(s) ?? Government**

| FINANCIAL INSTITUTIONS/BANKS/DONORS | ENERGY ENTERPRISE(S) |
|---|---|
| Loans for purchase of energy efficient devices (stoves, lamps, drives, boilers/ furnaces/kilns, etc) to improve HDI directly | Marketing of energy efficient devices |

| | |
|---|---|
| and indirectly via income generation | |
| Leasing/Financing of energy-efficient devices so that unacceptably high first-costs become acceptable operating costs | Joint ventures to set up decentralised/renewable energy systems compatible with high-efficiency devices accessible to the rural poor |
| | Establishment and development of micro-utilities (particularly those run by women) |
| | Commercialisation of decentralised/renewable energy sources and of energy efficient devices |

## 15 Rural Energy, Biomass Energy and Renewable Energy

In articulating the strategies and in implementing the associated policies, it is important to preventing rural energy from getting mixed up with biomass energy and renewable energy. The distinctions are elaborated in the following.

The inter-relationships between rural energy, biomass energy, renewable energy and sustainable development are brought out in Figure 3. The set of renewable energy technologies (RETs) at the bottom of the figure consists of both decentralised and centralised RETs. It is the decentralised RETS that are appropriate for rural areas. These decentralised rural RETs are of two types: biomass-based and those that are not biomass-based. Together, they are the basis of sustainable rural energy, i.e., the energy for sustainable rural development. On the other hand, the centralised RETS that are appropriate for urban areas, the urban RETs, are also of two types: biomass-based and those that are not biomass-based. Together, they are the basis of sustainable urban energy, i.e., the energy for sustainable urban development. It is important to ensure a synergy between sustainable rural energy and sustainable urban energy and between sustainable rural development and sustainable urban development.

This delineation of the distinctions and scope of rural energy, biomass energy, renewable energy and sustainable development is particularly important because all the categories do not enjoy the same political standing. Sustainable development is given lip service at international conferences but, within the country, there are no political and economic instruments for its implementation. Worse still, following some industrialised country interpretations, sustainable development is equated with environmentally sound development, ignoring its equity and empowerment (self-reliance) dimensions.

There are no specialised agencies responsible for biomass energy and rural energy. Only renewable energy has been given political approval in India through the formation of a Ministry of Non-conventional Energy Sources. But, it is easy to see that an emphasis on renewable energy can be restricted to technologies that cater to urban energy demands and/or centralised biomass energy particularly when the efforts are guided by market forces. The rural poor are too weak economically to articulate their needs as market demand.

## 16 General Implications of Rural Energy Strategies and Policies

If rural energy strategies and policies are oriented towards the goal of sustainable rural development in the manner outlined above, they will have implications for other pressing social problems. Above all, they will result in a betterment of the quality of life and the HDI. They will advance poverty alleviation in a direct way. In addition, they will dramatically improve the position of women. The life of children will also be improved. The rural environment and the health of rural inhabitants will take a turn for the better. In the long run, there will be a positive impact on population growth. Thus, a focus on rural energy will have a synergistic effect on an array of major social problems.

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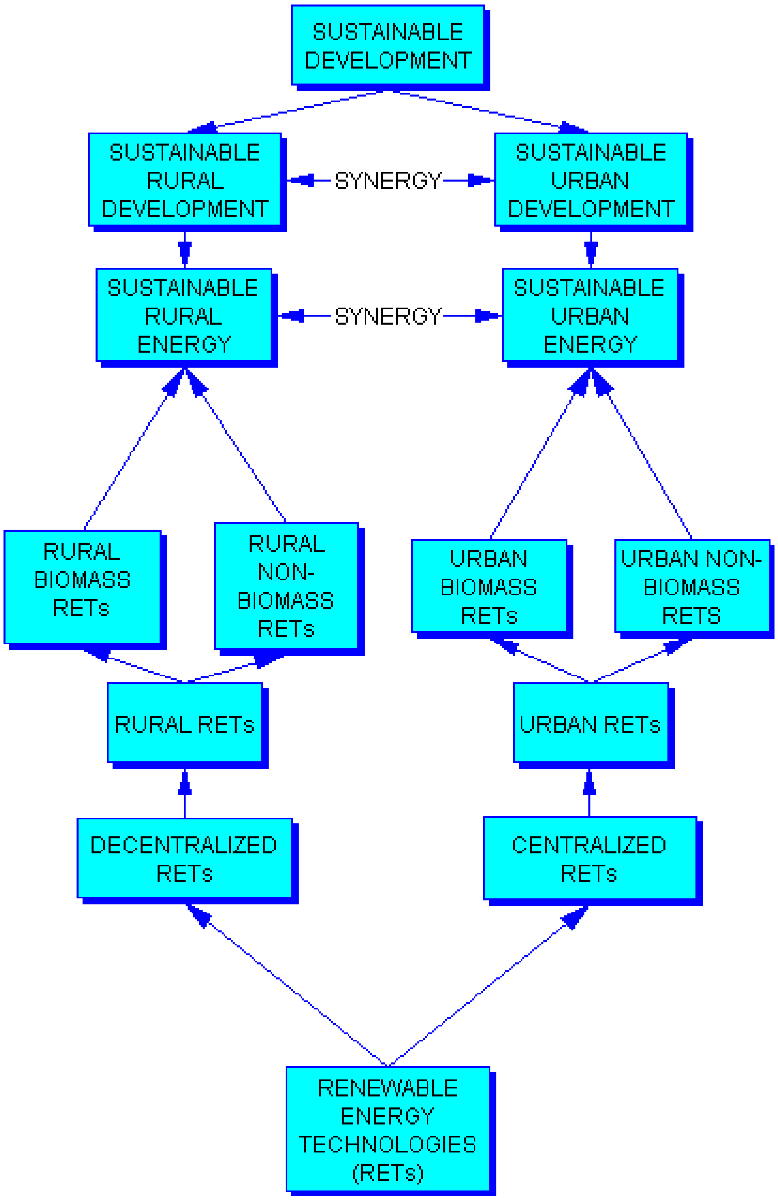


**Figure 3: Rural Energy, Biomass Energy and Renewable Energy Technologies**

## References and End-notes


1. According to Parikh, Smith and Vijay Laxmi (*Economic and Political Weekly,* **Volume XXXIV**, No.9, February 27-March 5, 1999, pp. 539-544), improved cookstoves penetrated only 15% of India's homes between early 1980s and 1992.
2. "Rural Energy and Development: Improving Energy Supplies for Two Billion People", The World Bank, (1996)
3. The rural population in developing countries was 2.52 billion (63% of their total population of 4 billion). If 80% of this rural population did not have access to modern energy carriers for cooking, then about 2 billion people in the world depended on biomass/fuelwood for cooking. And if 67% of the rural population had no access to electricity, it meant that 1.7 billion people were without electricity.
4. ASTRA, *Rural Energy Consumption Patterns -- A Field Study*, **Biomass**, Vol. 2, No. 4, September 1982, 255-280.
5. The past tense is used because the numbers refer to the period when the survey was done.
6. Transport has been included in agriculture because the only vehicles in Pura are bullock carts and these are used almost solely for agriculture-related activities such as carrying manure from backyard compost pits to the farms and produce from farms to households.
7. Direct energy is distinguished from *indirect* energy which refers to the embodied energy used in the manufacture of materials and equipment.
8. Pura uses about 217 tonnes of firewood per year, i.e., about 0.6 tonnes/day for the village, or 0.6 tonnes/year/ capita.
9. Unlike some rural areas of India, dung cakes are not used as cooking fuel in the Pura region. In situations where agro-wastes (e.g., coconut husk) are not abundant, it appears that, if firewood is available within some convenient range (determined by the capacity of head-load transportation), dung-cakes are never burnt as fuel; instead dung is used as manure.
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    *Rural Energy Systems in the Asia-Pacific: A Survey of their Status, Planning and Management*, Ramani, K.V., Islam, M.N. and Reddy, A.K.N., Asia and Pacific Development Centre, Pesiaran Duta, P.O. Box 12224, 50770 Kuala Lumpur, Malaysia, 1995.
17. Veena, D.R.. *Rural Energy: Consumption, Problems and Prospects*, Asish Publishing House, 8/81 Punjabi Bagh, New Delhi – 110 026, 1988
18. Watts/capita is an abbreviation for Watt years/(capita year).
19. ESD
20. Bob's fuel
21. "Software" = the instructions, procedures, knowledge, etc., necessary to utilize the hardware.
22. Reddy, A.K.N., "Technology, Development and the Environment", United Nations Environment Programme, Nairobi, 19??.