Rural Energy Issues in a Developing Society: The Case of Yemen

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For the major industrialised states of the world, the primary effect of the increased price of petroleum in thee last decade has been largely measured in terms of its impact on the automobile, the home, and the price of goods and services, often of luxury items. For the less-developed countries (LDCs), the consequences, as well as the basic issues involved, are often quite different and far more substantial. This paper deals with one aspect of the issue: the effect of increased petroleum prices on the various contemporary strategies for rural development, the concomitant effect on traditional energy resources, and the possibility of employing alternatives.

Regardless of whether development is measured in terms of macro-indicators (such as gross national product or gross domestic product), or micro-indicators (such as basic needs), energy development appears critical to national development. The continuing evidence for the existence of a strong positive relationship between energy prices (particularly for oil) and the rate of growth in the gross domestic product shows what seems only logical: that energy, in some form, is a requisite to the satisfaction of what have come to be termed "basic needs" — i.e., food, health, education, shelter, clothing, and security. Further, energy development plays a vital role, indeed is a critical factor, the economic development of rural areas, regardless of the development strategy to which one is committed.

Rural Development Strategies

Two basic approaches with rather different underlying assumptions, as well as different goals and targets, have characterised rural development strategies and programs. The first of these usually has been termed as the "growth strategy". In simplified form, it rests on three propositions:

1) gains from economic growth in the overall economy would "trickle down" to the poor (whether rural or urban) through market mechanisms;

2) even if there were incomplete or insufficient "trickle down", the mechanisms of government, in one fashion or another concerned with the plight of the poor and in some way prepared to respond to their demands and economic situation, would extend the benefits of growth through a variety of mechanisms, such as progressive taxation; and

3) in the most extreme instances, it could be argued, the fate of this portion of the population was not of immediate concern since there were other and more immediate political and economic issues that deserved priority and were in any event a necessary prerequisite to effective action with respect to the poor.

The overwhelming number of development organisations have rejected one or more of these assumptions/propositions. In response to their perceived shortcomings and deficiencies, a new approach evolved: the "basic needs" approach, placing the emphasis not on general economic growth but, rather, on direct and immediate improvement in "the conditions of life of the rural poor — in particular, their needs for essential goods and services".[1]

This approach targeted several specific goods and services, which although subject to modifications based upon country and region, had a common core. This core included basic health, nutrition, education, water, sanitation, shelter, and security. And, although the target population also varied somewhat from country to country, the "normal" target group was the poorest 40 percent.

It may be argued that with all its problems, and they are indeed numerous, the growth strategy is not without some merit, even though it may be inappropriate for rural or national development in specific instances. Nonetheless, the basic needs approach, while also not without its faults, has been accepted for the most part by the major development organizations and donor programs.

The United Nations, the World Bank, USAID, OECD, and the major nonprofit organisations (such as Resources for the Future, World Watch, and VITA) have all contributed to the evolution of a comprehensive approach to rural development. In part, they have also contributed to the subject of interest here: rural energy development.

The argument of this paper is that rural energy development is a prerequisite to the provision of the accepted list of "basic needs". It seems most unlikely that most of them can be provided effectively without a substantial energy input.

Energy Needs in a Developing Society

Two types of energy needs, based on source mobility characteristics, can be distinguished. The first type requires a source of power (fuel) as well as a conversion process that is highly mobile. In general, this type is used for transport and for some agricultural applications (such as plowing, cultivating, and harvesting). It has been traditionally satisfied by a combination of human and animal resources. The modern equivalent and replacement is, overwhelmingly, the internal combustion engine (ICE).

The second type of energy needs includes all those situations in which a lack of mobility is not a constraint. This type generally includes industry and manufacturing, most household applications, (such as heat and cooking); agricultural applications such as irrigation; as well as any associated activities, (such as food processing). Even in the least developed societies and states, it is this second category that accounts for most of the energy consumed in rural areas. Household consumption alone accounts for about 50 percent of all energy consumed in rural areas.[2]

In addition to mobility and application, however, there are other factors that must be taken into account in any analysis. The most important of these are: 1) transmitability (transportability); 2) applied efficiency (which may of course vary according to end-use); 3) the physical properties

of the fuel; 4) cultural preferences for specific tasks (for example, the Yemeni wood-fuelled clay oven, *tannur,* will assure that demand for fuelwood will continue to remain high); and, 5) the availability of supplies (which implies some knowledge of sources both domestic and foreign). Some combination of these will determine how applicable any energy source is to a particular task or function.

Rural energy needs are usually satisfied by a combination of traditional and modern technologies. One of the most traditional of all, fuelwood, accounts for by far the largest share of traditional energy supplied to and for households. This dependence has led at least one authority to declare the existence of a "second energy crisis" — that is, the depletion of LDC forest resources to the extent that *no* resources of this type may be available within the next forty years.[3] The substantial number of more immediate side-effects of forest depletion (such as increased erosion of top soil and flooding) have been adequately covered elsewhere.

In the event of severe depletion of fuelwood supplies, the rural population generally switches to crop residues and/or various kinds of dung (the use of which also has substantial impact on soil fertility and crop yields due to the soil nutrients that have been diverted).

Where the supply of traditional fuels is limited, or where the financial resources are avaialble to permit the use of commercial (i.e., modern technology) fuels, kerosene is the first choice, for lighting as well as cooking. Kerosene is easily transported, is high in energy content, and usually is widely available. Even though it is relatively expensive, it is competitive with other sources if it is burned efficiently. On the other hand, it produces substantial amounts of fumes and soot and may present a serious fire hazard if not carefully used. Because of its advantages, kerosene is often subsidized by governments, but the rapid increases in petroleum prices in the 1970s caused some severe economic strains in some of the countries that have done so.

Several sources of energy can be substituted for fuelwood and kerosene, each of which has some advantages and disadvantages — both for governments as well as the ultimate consumer. The following are the best known of these alternatives:

1) *Charcoal* is easier to transport, contains more energy per unit of weight (or volume), gives off fewer toxic gases, and generally is more efficient in home uses. On the other hand, its source is usually the self-same forests that are the source of fuelwood, its manufacturing processes are often inefficient, and the emission of environmentally damaging side-effects tends to be concentrated in the production areas (usually near cities which already have air pollution problems).

2) *Microbiological conversion* of plant and animal wastes is well-tested and currently in use in the People's Republic of China and India.

3) *Wind energy* is primarily a source of mechanical energy (for pumping), though the technology for its use in the generation of electricity is also well-established. Furthermore, both the necessary materials and operating skills are not difficult to transfer to new surroundings.

4) *Fuel crops* is a technology that encompasses a wide range of activities, from village wood lots, to alcohol production from specific plants (as in Brazil), to large-scale electric power generation using plantation grown trees with short maturities.

5) *Solar energy* has two forms: 1) "low tech" variation, such as passive solar installations for water and space heating, and 2) a "high-tech" variation, such as installations that use solar cells for on-site electricity generation.

6) *Geo-thermal* energy. Despite its experimental and "high-tech" characteristics, some survey of geo-thermal resources would appear to be needed in view of the many hot springs and sub-surface conditions recently highlighted by the earthquake.

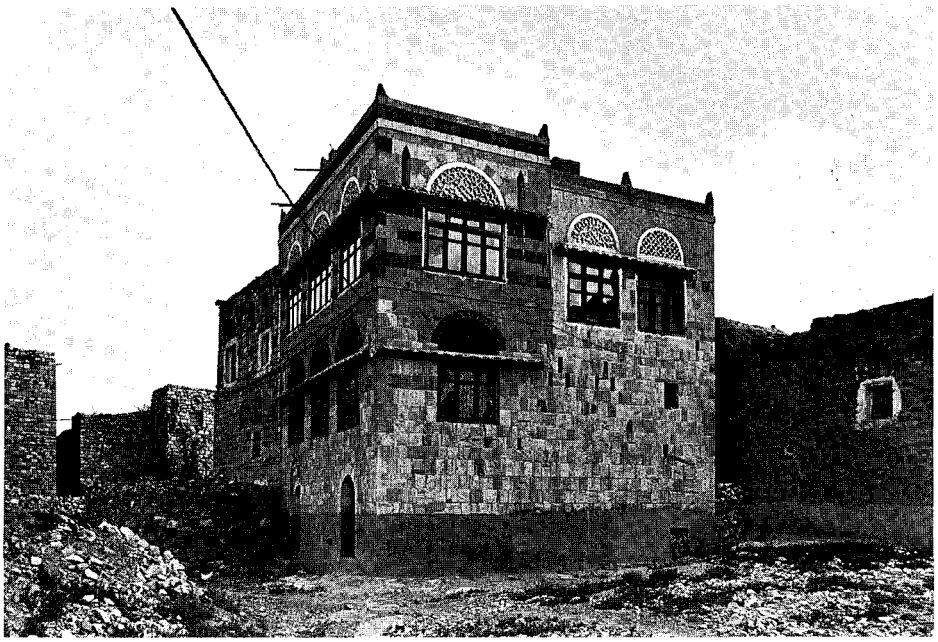
7) *Small-scale hydro-electric generation* requires a substantial investment in dams and diversion projects to retain adequate water supplies but has the immense virtue of not "using up" the water resources that are used for generating purposes. It is commonly the most desired of all.

8) *Rural electrification* can be undertaken in two distinct and perhaps complementary approaches: through grid extension, that is, large-scale conversion facilities and the construction of the network of lines to distribute the electricity to the ultimate consumer; and through decentralised generation, usually by ICEs (additional inputs can, of course, be provided by one or more of the alternatives given above).

Electricity, being a "high-quality" energy, is extraordinarily flexible and adaptable to a wide range of applications. These include lighting, cooking, power for both industry and agriculture, power for such highly desired modern devices as radios, televisions, miscellaneous household appliances and labour-saving devices, as well as power tools that may be essential to the development of any localised industry. Furthermore, it has a very long list of additional advantages: no fumes at point of use (though there may be considerable pollution at the point of generation), little risk of fire, generally moderate prices, generally lower capital costs for the machinery employing it, lower maintenance costs, higher reliability, and longer lifespan.

For all of these reasons, there is a clear and overwhelming preference for the widespread development of electrical generating facilities — both in the developing and developed areas of the world. It is, of course, of some relevance that a good deal of the social and economic characteristics of the developed world are attributed to the widespread availability of electricity. In the United States this same connexion was made by President Franklin D. Roosevelt in his programmes to provide electricity to the rural areas as a means of assuring their social and economic development.

Electricity is not without its problems; these may vary, however, depending upon



The electrification of Kawkaban.

Photo: C. Little/Aga Khan Awards.

whether or not one is concerned with grids or local generation. For example, autogenerators are considerably less efficient than large-scale steam power plants. Further, autogeneration applications are usually lacking in any back-up system, which makes reliability for high tech as well as average users a problem. On the other hand, grid systems, which can pick up the slack created by local shortfalls or problems, rely on long lines that suffer a greater likelihood of failures resulting from line breakages (whether these are the result of accidents or deliberate acts is a separate but relevant issue in many political environments). Further, such installations also require massive expenditures for construction and materials, particularly in mountain environments.

At least some of these problems are evident in Yemen. For example, although all governments since the revolution have committed themselves in one fashion or another to the development of electricity resources, only the major cities are currently supplied by centralised generating facilities. In many (if not most) of Yemen's smaller villages, small diesel-fuelled generators have been installed by local entrepreneurs who charge a fixed fee for their electricity (usually available from sunset to about midnight). The average cost for such locally produced electricity is around 70 cents (YR 15) per kilowatt hour — a rate that is roughly ten times what OECD consumers pay.

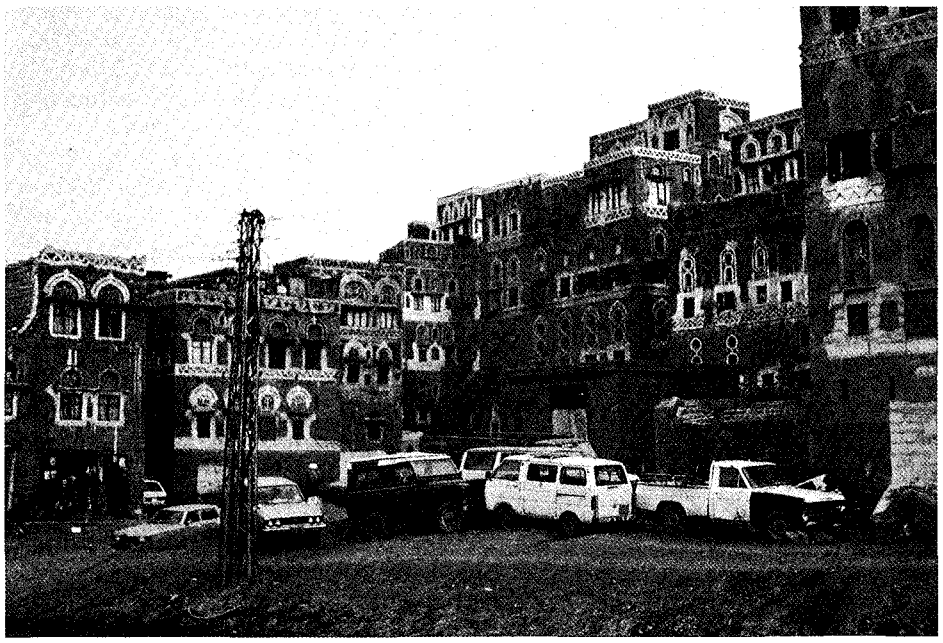
Energy Availability in Yemen

Modern Yemen is not well-endowed with *any* energyy resources: it has no presently known, commercially feasible deposits of oil, coal, or uranium. To make matters worse, it has no extended forest areas; indeed, it does not even have large regions of abundant natural vegetation that could be used as a continuing source of fuelwood.

The major deforestation took place centuries ago, However, the pace of such deforestation has undergone rapid acceleration in the past decade due to increasing population pressures as well as greater population mobility. Yemen is currently estimated to have about 1.6 million hectares under sparse woodland and shrub (which the World Bank has estimated at about 8 percent of the total area). In fact, this vegetation is so sparse that it is of little importance beyond the local level, and it is precisely this fact that leads to a rate of deforestation beyond the ability of the rangeland/scrub areas to replenish under current demand rates.

As in other less developed countries, especially those where there have been notable increases in income, the demand for energy increases. In Yemen this has been most notable in the demand for electricity, and the various governments since 1970 have committed at least some resources to expanding the availability of electricity to the major towns and their surrounding rural areas. In the First Five-Year Plan (1976-1981), some 7.85 percent of the plan was devoted to electrification, and it was expected that private investments of roughly one-seventh of the government's expenditures would contribute further to the spread of electricity into smaller towns and villages.

In the meantime, what happened to the traditional sources? The demand for these fuels (wood and kerosene) rose dramatically, which is probably illustrated most effectively by the fact that fuelwood more than quadrupled in price in a span of less than two years. Clearly, the demand for energy — both in the urban and rural areas — was increasing at a considerable pace, and the variety of other development projects supported by both the government and local organisations (education, water, and health facilities) further promoted the demand for electricity and even *required* that additional energy resources be made available.



Sana'a, Yemen Arab Republic. New modes of transportation and electrification, while bringing many benefits, have not always been comfortably integrated with the traditional urban townscape.

Photo: S. Özkan.

A scene from rural Yemen. Woman carrying straws on her head.

Photo: W.L. Porter.

Yemeni Government Energy Policies and Alternatives

In brief, it must be said that the Yemeni government has no coherent national energy policy, either for the urban or the rural areas. But this is not to say that the government is not aware of the issues and problems, nor that it has not developed specific plans to cope with the issues raised here.

In one sense, it may be argued that it would be premature for a country with the variety of issues and problems that beset contemporary Yemen to even consider the drafting of a coherent national energy policy. Indeed, many other states with far more resources and far more complex infrastructural investments have yet to produce a coherent national energy policy — not the least of these, the United States. The problem, as social scientists are fond of point out, is that the lack of any agreed-upon and stated policy does *not* mean that there is no policy; the myriad decisions that are made on an ad hoc basis to cope with immediate problems still constitute policy, and the decisions so reached still have significant short-term and long-term effects.

In some respects, of course, Yemen is not unique. A number of other countries have some of the same problems in developing rural (as well as urban) energy resources. There are three questions that al these countries need to address:

- Will rural electrification become the government's policy for developing rural access to energy resources, if only by default (in the sense that no systematic investigation or analysis of alternatives is ever undertaken)?
- If rural electrification is consciously selected as the desired alternative, will the government take an active role in developing a national grid, or will the decision of where and how much be left to individual entrepreneurs or the assistance policies of donor organizations and states?
- Are there any real alternatives?

If one considers the experience of the developed states during the last hundred years, it would certainly appear that there is no real alternative to rural electrification. Flexibility and convenience, which have come to be expected as rights in the Western states, and are easily learnt "demands" in the less developed countries, do not appear to be attainable by any other form of energy.

If that is the case, the question becomes an entirely different one: What will be the means by which electricity will be provided/generated? It would seem that some viable alternatives can be offered. The following general analysis is based upon a review of the situation in Yemen.

1) Certain areas of the country, most notably those in the south, appear to be amenable to the construction of "mini-hydro" systems. Although it is certainly true that we have very poor or nonexistent data on stream flows and water run-off rates,[4] the existence of previous dams in many areas, rainfall statistics, geologically appropriate conditions and the experience of others with analogous conditions would seem to indicate that this alternative warrants further investigation. Of considerable interest here is that mini-hydro tends to be a benign energy source (both in that it does not pollute, and that it allows the

water to be utilised for other purposes after its generating role is completed), and that it is exceedingly durable and does not usually require extensive maintenance. Interestingly, at one point it was proposed that some 300 small dams be constructed for the exploitation of wasted rainwater; further, about 100 dams were to have been built during the First Five-Year Plan at a cost of about YR 150 million. But there does not seem to have been any effort made to determine whether mini-hydro might have been tied into these water control projects, thereby doubling their value to the population. Even more interestingly, this project to build 100 small dams was one of the suggested projects that was utterly ignored by foreign donors.

2) Those areas of Yemen with the lowest rainfall are, of course, those with the highest solar flux. While it remains the case that the current cost for solar electricity is considerably higher than that for fossil-fuel generated electricity, a number of factors warrant further investigation in the Yemeni context. First, the cost of fossil-fuel generated electricity must take into account the tremendous equipment and installation costs, which will be amortised for the near future by a very small market. Second, although the current price for fossil fuels appears relatively stable and may undergo a decline in the short term, it is inevitable that it will continue to increase in the future. Third, if the country does not discover indigenous supplies of fossil fuels that re both appropriate to the facilities constructed, and commercially extractable, it will have to depend upon imports to fuel the generators. As many of the OECD states have discovered, this situation is fraught with danger, and usually is not politically popular. Although many of its neighbours on the peninsula are very well endowed with the oil necessary for massive grid systems, it is interesting that these same states are moving into the forefront of developing solar alternatives.[5] Fourth, there is considerable evidence that the cost of solar electricity will experience another sharp decline in the next few years, possibly as great as that which occurred between 1975 and 1980.

3) Village wooddlot development and afforestation schemes do not appear to have been seriously considered in the Yemeni context — one of the reasons for the drastic increase in the price of fuelwood for the rural poor. As a result, there is continued erosion and additional environmental damage that will be difficult to correct. And, of course, those people who shift to kerosene contribute further to the government's imported fuel requirements. It would seem that a program of afforestation and village woodlot development is both appropriate and feasible in the Yemeni context — both in terms of traditional preferences as well as in terms of the agricultural skills available. Neither would seem to require massive assistance programs from donors, thereby making a significant contribution to Yemeni energy independence.

4) Last, but not least, it also appears that wind-power could be a real possibility in many areas of Yemen. While additional research would need to be done, the data already available shows a remarkable consistency of windspeed in certain areas. The technology is not complex and is remarkably reliable, especially insofar as it is used for mechanical purposes. Even its development as a source of electricity would not be that difficult, since much of the hardware could be manufactured locally. The necessity of importing inverters, and similar "high-tech" components from the western states for the short-term would probably still cost less than the kinds of equipment and transportation cost associated with the alternatives.

Conclusions and Recommendations

For Yemen, which must perforce recognise that its role and influence in the making of regional and global energy policies will remain extremely limited, certain conclusions seem inescapable.

If Yemen opts for rural electrification in the Western mode as a means of promoting social and economic development, it opts to enter the modern world through the "back door". Moreover, countries like Yemen will be forced to spend literally billions of dollars to create a system of generation and distribution that is likely to be an insupportable burden on the remainder of the economy and, even more important, stands a good chance of being outmoded by the time it is installed and capable of being utilised efficiently by precisely that portion of the population it seeks to assist. Yemen and its cohorts — no matter the region of the world — ought to consider undertaking their own research programmes to:

- assess the effectiveness of traditional technologies and energy sources; and
- investigate the methods of coping with local energy supply problems through the development of indigenous alternatives that have developed in such disparate areas as New England in the United States, Wales in Great Britain, Indonesia, and the People's Republic of China.

The massive importation of machinery and technology associated with the construction of national grids will induce a dependence upon the supplier states where no such dependence existed before. As many of the projects developed in the People's Republic of China and India have shown, it is possible to develop less-expensive sources and techniques that use indigenous materials and talents to bridge the "energy-gap" that currently exists.

Perhaps the time has come for some country among the LDCs to take the lead in developing a consortium organization to provide countries that desire to promote rural energy development with an effective means to gather, exchange, and collate the available information on these matters. (Perhaps the upcoming First Arab International Energy Conference will help contribute to something of this sort.) But this should not be its only purpose; it should, as a regular part of its operations, undertake to fund both research and specific projects that assist its members in coping with the kinds of issues and problems already dis-

cussed here. There are probably few ways in which countries facing specific problems (such as developing access to rural energy supples in difficult terrain) could more effectively guarantee their economic and political independence, as well as make certain that the technology is appropriate to their own needs and circumstances, than to effectively undertake and promote their own research.

Reference Notes

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