Note: Figures are not available

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PROCESS MODEL FOR THE COMMERCIALIZATION OF IMPROVED TECHNOLOGIESœ IN RURAL AREAS

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INTRODUCTION

In the industrialized countries, science tends to develop through the interplay between the momentum of its past concerns (the carried-forward balance of unsolved problems) and the continual challenges posed by technology. Unfortunately, neither of these driving forces operates in the same form in developing countries.

Firstly, scientists in the developing countries derive from their counterparts in the West, the emerging areas for research, the trends and fashions and the stream of inspiration, and they turn to these counterparts for the criteria of excellence, and for assessment, evaluation and recognition. Secondly, most of the technologies used in the developing countries are imported from the industrialized countries, and therefore there is very little emphasis on the type of R & D, which throws up basic problems for science.

In countries where the market plays a dominant role, technology is like a commodity catering to the demands of those who can purchase it, and ignoring those who cannot afford it. With this feature, technology tends in the dual societies of developing countries -- with small islands of (primarily urban) affluence amongst vast oceans of (mainly rural) poverty -- to be oriented towards the demands of elites, rather than towards the needs of the large percentage of the population below the poverty line.

It is in this stifling context that the challenge arises of re-vitalizing science and re-orienting technology in developing countries and making them development-oriented. The overwhelming thrust should be towards technologies for the satisfaction of basic needs, starting from the needs of the neediest, and for strengthening an endogenous self-reliance that is based on social participation. In such a development process, rural technologies must get their rightful emphasis because such technologies have a central role to play in rural development.

The tackling of this challenge of generating rural technologies depends to a great extent upon the formulation of a valid model for the indigenous development of rural technologies and their commercialization in developing countries. This task of model 3 building has been addressed recently by building upon several previous efforts in this direction

The special problem of commercialization of rural technologies is the large fraction of the population living below the poverty line. This fraction does not have the purchasing power to articulate its demands through the market, and is ”de facto outside the market economy.

The existence of these poverty-stricken masses without adequate purchasing power, firstly, distinguishes the commercialization process in developing countries from that in the industrialized countries, and secondly, implies that the market alone cannot be relied upon to channel goods and services to them.

The problem of satisfying the needs of the poor has been addressed in various ways:

(1) The "top-down" approach in which centralized agencies are entrusted with the task;

(2) The "bottom-up" approach where individual and voluntary initiative is harnessed for the effort; and

(3) The "franchising" approach

P Ashok Khosla of Development Alternatives, Delhi, has been responsible for articulating this approach in which the benefits of the centralization are combined with the advantages of decentralization. where the advantages of centralized agencies are coupled to the strengths of entrepreneurship.

Each of these approaches has its special problems and an understanding of the limitations of each approach is essential for effective commercialization.

Thus, effective commercialization depends not only upon socioeconomic will but also upon a grasp of the process of commercialization, and the factors that determine its success and speed. And this grasp is in turn facilitated by the formulation and use of a valid model for the commercialization process. This task is the principal concern of this paper.

Models are intended to be simplified representations of reality designed to illuminate the path to successful action and to aid the discovery of further insights into reality. They are refined by a process in which predictions on the basis of these models are compared with empirical evidence.

The commercialization of rural technologies has been emphasized for a decade or more. During this time, not only has the case for rural technologies been established, but the activity of research and development pertaining to these technologies has attracted the attention of centres of excellence. A large number of technologies have been identified for commercialization, and efforts have also been concentrated on spreading many of these technologies. These efforts have been spread over a number of sectors, ranging from rural industry and agriculture through transport and energy to housing and health.

Sufficient material has therefore been accumulated to provide an empirical basis for the development of a model for commercialization of technologies in rural areas. This model should lead to certain broad guidelines will be drawn up for effective commercialization of rural technologies.

TECHNOLOGY-SOCIETY INTERACTIONS IN MIXED MARKET-NON-MARKET ECONOMIES

When an overwhelming majority of consumers (individuals or households) can articulate demands and satisfy them through the market mechanism, a very simple model of technology-society interactions is adequate. Since such conditions certainly do not obtain in developing countries like India, the simple model is relegated to Appendix 1.

In point of fact, Indian society is economically and socially stratified. This stratification is manifested in a number of ways, including through a skewed distribution of expenditure, which is the result of income inequalities. At the poorest end of the spectrum are the approximately 50% of the population (about 400 millions) below the poverty line, particularly the rural poor consisting of the very small farmers, landless labourers, tribals, harijans, etc.

Thus, as a first approximation, the stratification of Indian society can be represented as a dual society - a society of the elite (the richest 10%) and a society of the masses (particularly the poorest 50%), which may not be isolated from the former, but is separated from it by a wide chasm of incomes and consumption patterns.

More significantly, there is a tremendous difference in the attitudes and life-styles of these two societies. The poorest 50% struggle for elementary minimum needs in respect to water, food, shelter, clothing, health, education, transport, etc. In contrast, the elite of India -- and that of most other developing countries -- seek a life-style similar to that in the developed countries -- above all, in the goods and services they try to acquire. This means that there is a strong influence of the developed countries upon the elites of developing countries.

Even more importantly, the elite secures its demands through the market mechanism in contrast to the section of the population below the poverty line, which normally cannot satisfy its needs through the market because it does not have the requisite purchasing power. If, therefore, technology and its benefits are to reach this poorest section, which for all practical purposes is outside the market, then special mechanisms for the generation and commercialization of technologies have to be deployed. The simplistic model shown in Appendix 1 is not sufficient; it has to be extended so that special non-market mechanisms are incorporated to ensure the generation and commercialization of technologies for the benefit of the rural poor.

One attempt to develop an elaborated model is shown in Figure 2.

There are two features of the extended model that distinguish it from the simple model of Appendix 1.

The first feature consists of the ”facilitating mechanisms which must be located in the processes of the generation and commercialization of rural technologies, and be an integral part of them. ”A facilitating mechanism is a group or department or organization or agency that is committed to rural technologies and takes special steps to counter the biases against the generation and commercialization of rural

technologies that operate in developing countries like India. The facilitating mechanism can be either a governmental, semi-governmental, or autonomous organization, or it can even be a non-governmental organization such a voluntary agency, the emphasis being more on its actions than on its status.
With regard to the commercialization of rural technologies, the facilitating mechanism must ensure that the prospective beneficiaries of the commercialization process are not left at the mercy of the market even though they do not have the purchasing power to satisfy their needs through the market. The facilitating mechanism, therefore, has "to think through and see through" all the steps involved in the non-market mode of technology commercialization (Route I of Figure 2).

For instance, there must be institutional arrangements that mimic and discharge all the functions that are handled by the market -- market survey, demand forecasting, test marketing, marketing (including the provision of capital and credit if necessary), after-sales service, etc.

Some caveats must be added here. Even these facilitating mechanisms to take care of the generation and commercialization of technologies of special relevance to sections below the poverty line, are not sufficient. In addition, political will is required to give these facilitating mechanisms the "go ahead" and to support them in their efforts. This product champion role of the state cannot be taken for granted. The political dimension of the processes of generation and commercialization of rural technologies must be reckoned with in the model. For instance, it may be necessary to consider the broad general objectives of the decision-maker, and whether the decision maker's role is supportive or neutral or an atagonistic with regard to the technology.

Of equal importance is the fact that even if facilitating mechanisms exist, they are unlikely to have matured to a stage of being institutionalized. Hence, they are very much dependent on the qualities of those leading the mechanisms. If the leaders are charismatic, then the facilitating mechanisms work well. In other words, viewing a technology as a product, it is clear that product champions are essential and they have a crucial role to play particularly if government departments have to back the technology. A particular government official can prove an outstanding champion of a technology, but his successor may be a hindrance more than help.

Thus, the abstract circles and rectangles of the model must not obscure the crucial role of individuals in both the generation and commercialization of rural technologies.

The second distinguishing feature of the extended model (Figure 2) concerns the manufacturing technology. There is a tendency in industrialized societies to pursue so-called "economies of scale" so that the norm in market economies is centralized manufacturing. In the case of rural technologies, however, there are many situations in which it may be preferable to go in for on-site manufacture, construction or erection, i.e., decentralized manufacturing. It must not be assumed that the market mode of technology commercialization (Route II of Figure 2) is always associated only with centralized manufacturing and that the non-market mode of technology commercialization (Route I of Figure 2) is always associated only with decentralized manufacturing. Just as the products of decentralized manufacturing (for instance, of handicrafts and products of cottage industries) can be commercialized through the market mechanism, it is also possible that the mass produced items of centralized manufacturing can be commercialized through non-market mechanisms for example through public distribution channels.

The differentiation that has been made here between the market and non-market modes of generation and commercialization of technologies is not the only possibility. It is also possible

P N.C.B. Nath to "finetune" the analysis and consider the processes as being driven by different types of demand signals:

(1) prices,
(2) subsidies and
(3) welfare.

In other words, the generation and commercialization of rural technologies can be categorized on the basis of whether they are

(1) profit/price-driven -- the market mode,
(2) subsidy-driven -- the modified market mode, or
(3) welfare-driven -- the non-market mode.

Thus, there are a variety of options involving centralized or decentralized manufacture and price or subsidy or welfare market/nonmarket distribution. This variety can be described succinctly through the matrix of possibilities:

DISTRIBUTION/ PRICE(P) SUBSIDY(S) WELFARE(W) MANUFACTURE CENTRALIZED(C) CP CS CW DECENTRALIZED(D) DP DS DW

In such situations, effective supporting arrangements have to be made for this decentralized manufacturing -- arrangements for feedback from users to the product/process development group(s), productionizing and standardization for on-site construction or erection, training of manufacturers/constructors/erectors, procedures and manpower for maintenance, etc.

A MODEL OF RURAL TECHNOLOGIES

The extended model of Figure 2 has identified the three distinguishing features of the generation and commercialization of rural technologies:

(1) the facilitating mechanism,

(2) the possibility of decentralized manufacturing, and

(3) the necessity of a modified market mode or a non-market mode of technology commercialization.

These features, however, have not been presented in sufficient detail to highlight what are the critical steps in the process that determine the "success" or "failure" of the generation and commercialization of rural technologies. Hence, a still more elaborate model must be developed (Figure 3) to emphasize the special precautions that must be taken to avoid failures of technology generation and commercialization.

Considering technology generation first, Figure 3 shows that there are two failure modes:

(1)F1, ”the failure to identify needs, is a cognitive failure to understand and act on the basis of the true felt needs of rural society,

(2)F2, ”the failure of the R & D effort, is a failure of the R & D process to come up with a technology that satisfies the needs of rural society.

Figure 3 also shows that there are three possible failure modes in the matter of technology commercialization:

(1) F3, ”the failure to meet priority needs, is a failure to meet the needs of the villagers according to their order of priority,

(2) F4, ”the failure of operation, is a failure to provide the inputs, operate and maintain the technology, and off-take the outputs, all under rural conditions, and

(3) F5, ”the failure to modify behaviour, is a failure of the change-agents to modify the operational behaviour of the technology-users to take advantage of the technology.

The model shows that all the five failure modes must be avoided to ensure success in the commercialization of rural technology in a rural area. If the technology avoids the first four failure modes (i.e., needs are identified, the R&D is successful, priority needs are met and operation is successful.) but the failure F5 occurs, i.e., the users are not trained to benefit from the technology, the whole effort is defeated and the exercise loses significance. On the other hand, a good opportunity is lost if a successful technology that avoids failure modes F1,F2,F4 and F5 by decision makers in the village fails because of F3, i.e., it does not meet their perception of priority even though it can do real good to the rural poor. Above all, the model implicitly emphasizes that iterations of certain segments of the model are ”most essential for the success to be achieved. It is here that the political, administrative and scientific will of the organizations involved becomes important.

The above description of failure modes does not refer explicitly to the question of which persons or organizations must determine then needs. It is obvious, however, from the failure mode F3 that it is far more important that the priority needs of the villagers are addressed according to their order of priority, than who determines the needs and how the needs are identified. But, some mechanisms of identifying needs are likely to be more appropriate than others for instance in avoiding gender biases in the process.

A related issue that is often raised is whether the priority should first be assigned to income-generation technologies and only then to technologies that are directed towards the satisfaction of basic needs, or whether the priority should be the other way around so that basic needs satisfaction is addressed before income generation.

Obviously, the answer depends upon the relative importance that the villagers, or rather their decision-makers, attach to basic needs satisfaction and income generation.

”DETAILED MODEL FOR TECHNOLOGY GENERATION AND COMMERCIALIZATION

The details of the generation and commercialization of technologies can now be filled into the scheme (Figure 3) for the "success" and "failure" of rural technologies. Figure 4 shows these details with the concerned with technology generation (TG) and Figure 5 with technology commercialization (TD) the interface between these two aspects of rural technologies being the state in which the technologies are ready for commercialization.

The issues involved in the commercialization of technology (TD) are shown in Figure 5 which consists of two branches depending upon whether involvement of the whole community is a necessary condition for the commercialization or whether the commercialization mechanism can proceed via individual families/households, i.e., whether the technologies are public/community or individual technologies.

When the targets for the technology are individual families or households, then the initial issues are whether

(1) the households are motivated towards the technology (FM),

(2) the commercialization process is effectively organized (EO).

Each of these issues can be explored in greater detail. For instance, as seen from Figure 5.1 motivation for the technology (FM) depends upon whether

(1) the household has the capacity to invest on the technology,
(2) the use of the technology and/or its byproduct(s) offers financial benefits to the household,
(3) there is an improvement in some living condition,
(4) the technology is a status symbol in the community,
(5) a subsidy/loan brings the technology within the financial capability of the household, and
(6) the subsidy/loan is a better investment than other opportunities for the government or financial institution.

Figure 5.2 provides details on effective organization for commercialization (EO) and reveals that this effectiveness depends upon whether the commercializing organization has

(1) identified a local organization of technology users and is in a dialogue with it,
(2) identified a pressing need for the technology,
(3) effective coordination for its subsidy/loan, installation, training and education activities.

And when community technologies are involved, the issues that are initially relevant are quite similar, i.e., whether

(1) the community accepts the technology (CA),
(2) the commercialization process is effectively organized (EO).

In this case too, it is possible to go into greater detail. Thus, Figure 5.3 which deals with the acceptance of the technology by the community (CA) is concerned with whether

(1) the use of the technology or its byproduct fulfills the community's pressing need(s),

(2) the technology is cost-effective,

(3) the community or those who matter are agreed regarding the introduction of the technology,

(4) there is a sense of community ownership,

(5) the responsibilities for investment, inputs and operation are shared,

(6) there is agreement on pricing, sharing outputs and bartering labour and capital,

(7) the community ensures equity in benefits, and

(8) there is a positive acceptance of the technology by the community.

Apart from motivation for the technology and effectiveness of the organization, there are three important feasibility issues that follow:

(1) the inputs must ensure that the operation is feasible (FI),

(2) the environment must be compatible with the operation (FE), and

(3) the critical features of the technology must be maintained (FCF).

Further details can be provided for each of these issues. Figure 5.4 shows that the operation of the technology is feasible (FI) if

(1) the inputs are either available locally or importable economically,

(2) seasonal variations, if present, do not cause problems,

(3) deficits of prescribed inputs can be made up by alternative inputs.

Figure 5.5 shows that the compatibility of the environment with the operation (FE) depends upon whether

(1) any special en conditions are necessary for the operation of the technology,

(2) seasonal changes result in the surroundings going beyond the range required by the technology,

(3) design changes can compensate for these deviations of the environment.

Finally, Figure 5.6 shows that the critical design features of the technology can be maintained (FCF) if there are operational devices/adjustments that can offset the sensitivity of these features to variations of the input(s) and the environment.

Notwithstanding all the care that may be taken as described above, the timing of the components of the technology package must be just right. For instance, it is necessary to avoid premature marketing in the market mode.

BARRIERS TO COMMERCIALIZATION

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Introduction

The commercialization of rural technologies involves a number of actors operating at various levels. In particular, the following actors are involved technology users, equipment manufacturers and providers, generators of technology, financial institutions, local, state and national governments, and funding/aid agencies of international and multilateral organizations and of the industrialized countries. Thus, action is required at the lowest level of the technology user (individual, household or community) through the highest level of global agencies. Barriers to the commercialization process can arise at all these levels.

An attempt will be made in this section to attempt a typology of the possible barriers, to explore the origin of these barriers and suggest ways of overcoming these barriers. Once such a scheme is formulated, it can be expanded and improved. In that sense, this section is intended to initiate the typology of barriers to commercialization.

Technology Users

The Ignorant: The commercialization of a technology in a rural area requires the concurrence of the ultimate user of the technology (individual, household or community). In turn, this concurrence depends upon the potential user knowing about the technology, being aware of its advantages and understanding the costs and benefits of the options. A large number of technology users, however, are quite ignorant of the advantages of the technology and unaware of its cost effectiveness.

The obvious way of overcoming this barrier of ignorance is to provide information in various ways. Whereas door-to-door canvassing, leaflets through the mail, newspapers and magazines are very effective in urban areas with literate target audiences, in rural areas, radio and television are preferable. Demonstrations also can play a key role. And, of course, the training of technology users is a powerful way of educating them with regard to the advantages of the technology.

Thus, the supply of relevant information to, and the education of, the technology user is the means of overcoming the barrier posed by the ignorant.

The Poor and/or first cost sensitive: Even if a potential user is fully knowledgeable about the net benefits accruing from the technology, it does not necessarily follow that this user will make the necessary investment on the associated device or equipment. The higher initial cost of the new technology intended to replace the older version is a barrier. The technology user naturally asks: do benefits of the new technology justify the increased investment?

The answer to this question depends upon whether the technology user is prepared to invest capital resources now in order to reap the regular benefits of lower energy bills in the future. In other words, is the technology user prepared to postpone current consumption for the sake of future benefits? The index of this preparedness is the user discount rate (UDR), which is approximately equal to the annual return or benefit expected for a long period (say 10 years) on an initial outlay of $100. For example, if the UDR is 60%, it means that the technology user will be prepared to make an initial investment of $100 only if an annual benefit of at least $60 can be obtained for the next 10 years.

When empirically determined UDRs are compared with bank interest rates, it is found that the UDRs of individuals and households tend to be very much higher than commercial interest rates of around 10%. Obviously, the UDR is a reflection of the availability of capital with the technology user the more disposable cash the user has, the greater the preparedness to invest this cash now to earn future benefits.

One would expect, therefore, that as the income of the technology user increases, the UDR used for investment decisions will decrease, and conversely, the poorer a user is, the less the likelihood of the user being prepared to sacrifice scarce capital on new devices and equipment, however great the advantages accruing from the new technology.

In fact, a recent study

U B. Sudhakar Reddy, "The Energy Sector of the Metropolis of Bangalore, Thesis submitted in July 1990 for the degree of Doctor of Philosophy of the Indian Institute of Science. carried out in Bangalore shows that as the technology user's income decreases, the UDR ”rises exponentially (Figure 1). Further, surveys of technology users indicate that the UDR for household technology users with an average income of $16.60/month is in the range of about 60%. With this information, consider a specific efficiency improvement measure such as the replacement of a 60W incandescent bulb with a 15W compact fluorescent lamp. The internal rate of return (IRR) for this replacement is that value of the interest rate at which the present value of all the energy savings due to the efficiency improvement are exactly equal to the extra initial cost incurred on the measure. It is found that the IRR for the replacement is only about 16.5% whereas technology users in that income bracket will not make capital investments unless the return is about 60%. Clearly, such technology users will not make the investment on compact fluorescent lamps even if they consume only one quarter of the energy.

If this first cost sensitivity of the technology user is to be overcome, the IRR must be increased so that it exceeds the UDR. The way of making rural technologies (for example, replacing IBs with CFLs) affordable even to the poor and/or first cost sensitive is to convert the initial down payment into a payments stream that coincides in time with the benefits stream. It is even better if the payments stream is financed out of the benefits stream. This situation can be achieved by a loan being advanced for the new device or equipment (e.g., replacement of an IB with a CFL) and the principal being recovered with interest, or by an agency leasing the efficient device or equipment to the technology user who then pays the regular leasing charges. Thus, innovative financing is the method of overcoming the barrier posed by the poor and/or first cost sensitive.

The Indifferent: The third type of barrier involves technology users who are indifferent to the benefits even though they are fully knowledgeable about the net benefits and in a position to afford the first costs associated with the device or equipment. This attitude is due to the fact that the costs associated with the technology are too insignificant a fraction of their total expenditures to motivate them to implement the improved technology even though the benefits from this technology, for example, lower resource use, may be extremely important to society at large.

In such situations, intervention by the government is imperative. Apart from realistic pricing (discussed under Section 8.3), the government can also promote the improvements by means of regulations regarding those devices and equipment (boilers, furnaces, pumps, lights, etc.) that are primarily responsible for inefficient resource use. The regulations could, for instance, be implemented through manufacturers by means of standards regarding the resource efficiencies of equipment manufactured by them. It is also necessary to generate pressure from technology users and market demand for efficient equipment. This can be done by making it obligatory for manufacturers to label all these appliances so that their performance is evident to all by prospective purchasers of the appliances and becomes a factor in the decision-making of technology users.

In this context, the experience of the state of Karnataka in South India with power cuts for electricity showed that the introduction of shortages had the unintended result of bringing about energy savings. The implication is that a type of rationing of energy can induce conservation measures. Of course, the restrictions have to be of a small enough magnitude that the main productive activity of the technology user is still possible in spite of the shortage. In the case of electricity, for instance, most technology users can easily tackle 10-15% power cuts with simple house-keeping measures (turning off unnecessary lights and fans, improving mechanical couplings, avoiding wastage, etc.). This restriction-induced efficiency improvement is an important instrument even though it is relatively unknown and little discussed in the industrialized market economies.

Thus, the barrier arising from the indifference of technology users can be surmounted by government intervention based on supplementary mechanisms such as regulations, standards, labels, restrictions in supply, etc.

The Helpless: Finally, there is the class of technology users who are knowledgeable, who can afford the improved technology and who are motivated, but are nevertheless completely helpless in the face of all the problems that must be tackled in identifying, procuring, installing, operating and maintaining the associated devices and equipment.

The origin of all these problems is that it is easy for a technology user to purchase the conventional equipment. Welltested economic systems exist for making such transactions, and both producers and technology users understand the values of the devices involved.

This is not the case for investments in improvements. Compared to the mature industries associated with the conventional equipment, the infant industry for the improved technology industry is in the initial stages of development and is quite often limping with government support, subsidies, etc. This invariably means that there is a great deal of paper work to secure the requisite credit, negotiate with the suppliers/erectors of the improved devices or equipment, and get them installed. Unfortunately, it looks as if the technology user must have a great deal of know how to identify, procure, install, and maintain improvemed devices and equipment.

Such a situation will prevail until the technology user can obtain total packages of hardware plus software (the latter being all the instructions and knowledge to run the hardware). In turn, this means that an efficiency improvement industry must be established and developed to provide these packages.

Thus, to overcome this barrier of the helpless technology user, it is necessary that an industry devoted to the improved technology industry must be grown so that it can provide technology users with the knowhow in the form of total hardware plus software packages.

Equipment Manufacturers

The Efficiency Blind: In poor countries, it is generally the case that the sales of equipment are insensitive to the efficiency with which the equipment uses resources. In fact, these sales depend far more on the capital cost because poor customers are very sensitive to this parameter, and since invariably cheaper equipment often means lower efficiency of resource use, the sales may actually decrease with improvements. Such an environment encourages efficiency blind producers of enduse devices and equipment. Part of the problem is that the manufacturer and seller of enduse devices and equipment is not obliged either by market pressure or by law to reveal the performance of the devices and equipment. Thus, an Indian technology user cannot know which of a number of electric water heaters has the lowest energy consumption.

The barrier to commercialization of improved technologies arising from efficiency blind manufacturers can be overcome by government intervention enforcing the labeling of enduse devices and equipment so that the prospective buyer can take the performance into account even before the purchase of the equipment. The technology user will be further motivated to ascertain the performance of equipment if the financing of this equipment (e.g., the interest rate) is tied to the performance.

Resource Producers and Distributors

The Supplyobsessed: The producers and distributors of resources (water, electricity, petroleum products, etc.) are so obsessed with the ”supply of their resources that they devote little attention to the ”utilization of these carriers. In particular, they do not bother with the efficiency with which their resources are used.
This supplyobsession of the producers and distributors of resources has become a barrier to the marketing of improved technologies.

The problem is aggravated by the fact that the marketing of improved technologies of respurce use is inherently more complicated than the marketing of resource supplies and conventional end-use technologies. One must be concerned not just with producing new improved devices, but with the full spectrum of relatively novel marketing problems:

(1) diagnosis of the individual technology user's needs for obtaining energy services in the most cost-effective manner and thereby identification of the technical changes that are necessary;

(2) technology user education as to the necessity of making these changes -- a task made difficult because the expected saving is often ambiguous;
(3) the financing of any new devices or contractor work that may be required -- a problem that arises because improved technologies are usually associated with increased first costs;
(4) after-sales servicing;
(5) monitoring of performance in the field to ascertain actual improvements, with

feedback that can be used to modify commercialization strategies.

To promote effectively improved technologies, efforts should address all these aspects of the marketing, i.e., the efforts should be concerned not just with the production of the hardware involved but with all the necessary supporting "software" as well. The producers and distributors of resources (irrigation departments, the electricity boards, oil companies and gas utilities) are good candidates for marketing the services required for such an effort. Already a number of the more progressive utilities in the industrialized countries have initiated programs that include:

(1) providing advice on investments in improved technologies,

(2) offering to arrange for contractors to carry out such work;

(3) financing such investments with low or zero interest loans; and

(4) providing rebates to technology users for the purchase of improved appliances and/or to appliance dealers for promoting their sales.

Accustomed to handling large quantities of capital, the producers and distributors of resources are well-positioned to direct these resources to investments on improved technologies. Also, they have an administrative structure for channelling the capital to essentially all households and businesses. Moreover, the billing systems of the suppliers of resources offers the opportunity for customers to invest on improved devices with loans from the suppliers and to pay back these loans through their resource bills.

If the charter of the producers and distributors of resources is restricted to the supply of carriers, they cannot undertake the comprehensive marketing of improved technologies. What is required, therefore, is a conversion of resource supply agencies into resource service companies, that is, companies that market resource services (heating, cooling, lighting, etc.) in much the same way they today market resources. Resource suppliers must diversify in this direction of resource services. Then, they would come to play a role originally envisioned for them by Thomas Edison when he invented the incandescent bulb he proposed that utilities sell illumination, thereby giving them a financial interest to provide this illumination in the most cost-effective way.

In the case of those autonomous producers and distributors of resources that are publicly regulated, the regulators can play an important role in creating effective energy efficiency programmes.

Instead of simply requiring the resource distributor to establish resource conservation programmes, regulators should consider modifying the reward structure to give the resource company a financial stake in exploiting opportunities for cost-effective improvements in resource use. One promising approach would be for the government to allow the utility to treat resource conservation program costs as operating expenses and grant financial rewards for resource savings actually realized or financial penalties for failure to meet established goals.

In some instances, the producers and distributors of resources may be unwilling to create and implement resource conservation programmes.

For example, a board may have sufficient supply capacity that it sees no need to help its customers use the resource more efficiently. In such circumstances, government could stimulate the creation of independent new companies that would market improved technologies, e.g., by making loans or grant assistance available to customers.

Thus, the barrier of supply obsessed producers of resources can be surmounted through a change in the charter of the producers from suppliers of resources to vendors of resource services and/or a growth in independent resourceservice companies.

The Centralization biased: As if the obsession with supplies is not a sufficient barrier to improved technologies, the producers of resources concentrate exclusively on centralized supplies. This bias towards centralization prevents any attention being paid to decentralized sources. A barrier is therefore generated as a result of which there is a virtually total neglect of improved technologies in decentralized generation as well of the efficiency with which such sources are utilized are completely neglected. In the context of this bias, any attempts at least cost planning degenerate into least cost centralized supply planning.

The way of surmounting this barrier is to increase the scope of supplies so that they include decentralized sources and then to adopt least cost planning so that the noncentralized sources find a place if their costs are lower.

The Supply monopolists: Not only do the producers and distributors of resources focus exclusively on the supply of resources produced in a centralized manner, but quite often there are laws to prevent the production of resources by any other producer. The producers and distributors of resources have become supply monopolists and this has become a barrier to improved technologies with respect to the production of resources.

This barrier of the supply monopolist has to be overcome by enacting incentives that will encourage and reward independent producers to produce resources.

Financial Institutions

The Supply biased: Just as the producers and distributors of resources are obsessed with the supply aspect of the resource system, the financial institutions that provide the capital are also supply biased. The origin of this barrier is the conventional #pp# approach to resources followed by financial institutions. According to this approach, the purpose of the resource system is to increase resource consumption, which means that the emphasis has to be on increasing the supply of resources. Improved technologies become a separate issue that is automatically ignored because it does not lead to increases in supply and consumption.

This barrier has to be tackled firstly at the conceptual level by propagating the paradigm that it is the level of resource services, rather than the magnitude of resource consumption, that is the true indicator of development. But a given resource service, say lumens of lighting, can be obtained either by increasing supplies of resources or by using more efficient devices. For us to know which is the best way of obtaining that service, the various options must be compared with each other. Hence, sound financial management requires that tenders must be called, not merely for augmenting supplies, but for providing the resource services that are necessary. In addition, improved technologies must be included in the least cost planning process.

Thus, the best way of dismantling the barrier posed by the supply biased is to shift the emphasis from resource consumption and supplies to resource services, to include improved technologies in the list of options for providing services and to pursue least cost planning process.

The Unfair: If there is concern for ”least-cost resource planning, then it must be ensured that the competition between supply increases (of centralized and decentralized sources) and conservation measures is fair. In the first place, resource savings should be treated symmetrically with resource production. This might mean, for instance, that the expenses associated with resource efficiency are considered as the cost of service and used for a "cost plus" method of charging customers as in the case of supply technologies. Then, all three contenders -- centralized sources, decentralized sources and conservation measures -- must be compared on the same terms of credit (including interest rates), benefits, incentives, subsidies, etc.

At present, the competition is certainly not fair. In particular, financial institutions tend to be quite unfair in their comparisons of supply increases and improved technologies -- the advantages are heavily weighted in favor of centralized sources and against conservation measures with decentralized sources in between. The origin of this unfair discrimination can be traced to the fact that the financial practices regarding resource have grown in association with the development of the centralized supplies, and over the course of time, a number of hidden subsidies and other supports for such supplies have evolved.

This barrier of the unfair financial institution must be overcome by a stress on fair competition through the elimination of subsidies to resource supplies, correct pricing (see Section 8.3), same terms of credits, benefits, incentives, etc.

Government

The Uninterested Government: Most governments in developing countries believe that resource conservation is a rich country's game because the term has been understood to mean making do with less resource services, for example, less light in homes. This recommendation for less services is unacceptable because the level of services is already low Indian villages are "areas of darkness". Developing countries, therefore, have shown a tendency to be disinterested in improved technologies. In fact, the enormous disparities in the level of resource services enjoyed by the industrialized and developing countries have led to a widespread popular pressure for stepping up the level of resource services. This pressure has thus far been understood by decision makers as an imperative need for escalating the magnitude of resource consumption (more kilowatt hours for lighting).

The real problem lies in the understanding of conservation. If conservation is understood, not as making do with less resource services through reduced resource consumption, but as increasing resource services with less resource consumption (more light with less kilowatt hours), then resource efficiency becomes the core of any development strategy.

What is required is a balanced approach in which there is a holistic integration or mix of three types of resource technologies enduse improved technologies, centralized generation and generation from decentralized sources. The components of such a mix need not be identified in an ”ad hoc manner; a rational procedure can be used. One such procedure utilizes leastcost supply curves (Figure 3). Since it is invariably cheaper to save a kilowatt than to generate a kilowatt and to avoid transmission/transportation and distribution costs by generating at or very near the point of consumption, it turns out that many conservation and decentralized generation technologies get included in the leastcost mix.

Technology mixes arrived at in this way make possible major increases in the level of resource services with far less increase in the supplies of centralized resource than would have been required with conventional resource systems which are based exclusively on centralized sources. In contrast, the leastcost mixes include significant contributions from conservation and decentralized sources.

There is also an economic implication: since improved technologies can increase GDP without a corresponding increase of resource, technology mixes that include conservation reduce the coupling between GDP and resource. As a result, the annual investment required for the resource sector goes down and becomes more manageable in a capitalscarcity situation.

Thus, the barrier of the uninterested government has to be overcome by showing the economic advantages of making resource efficiency the core of the developing strategy and of pursuing least cost resource planning.

The Powerless Resource Efficiency Agency: Even if governments are interested in resource efficiency, they tend to create for it an separate cell, centre or department or even ministry. Unfortunately, such a separate cell, centre or department or ministry just cannot wield enough power to enforce resource efficiency related decisions on other departments and ministries. It ends up with the efficiency improvement agency of the government confining itself by and large to publicity and information. The barrier in this case is that of the powerless resource efficiency agency.

Since resource enters every economic activity, it therefore cuts across all economic ministries. If resource efficiency is to become the core of the development strategy, the agency responsible for efficiency improvement must have sufficient clout. This will happen only if the agency responsible for efficiency improvement is (1) outside and above the resource system and resource ministry and (2) under the highest political and/or financial authority. One of the suggestions in this context is that the resource efficiency agency must be under the Prime Minister or the Finance Minister. Then it will be powerful enough to see that the decisions regarding efficiency improvement are implemented by all departments and ministries.

Thus, ”the barrier of the powerless resource efficiency agency can be surmounted by locating the agency outside and above the resource system and under the highest political authority, viz., the President/Prime Minister or the Finance Minister.

The Costblind Price Fixer: Resource prices in developing countries are generally no reflection at all of the real costs of generating resource and the true costs to society -- they include large elements of subsidy. In such situations, the frugal are not rewarded and the profligate are not punished. Technology users do not `feel the pinch' of resource prices and do not receive the proper signals regarding the value of resource resources. Also, the resource consumption of these technology users tends to be largely unaffected by small increases in the price of resource. Since resource prices in these countries are administered prices fixed by government, the cost blindness of these governments has become a barrier to the dissemination of improved technologies.

Prices should be determined, not by the average costs of cheap supplies established in the past, but what it will cost to generate resource in the future. What matters is not the sunk cost of the previous unit of resource but how much it will cost to generate the next unit for the next technology user in the future. That is, prices should reflect the long-run cost of producing the next unit of resource in new generating stations -- what the economists call long-run marginal cost pricing -- because that is what the resource companies will have to pay to set up facilities to deliver this next unit.

Attempts have to be made to move in the direction of long-run marginal cost pricing, but the political barriers in the way of increasing electricity prices must not be under-estimated. An important guideline in this context is that technology users are more concerned about their expenditure on resource than about resource prices. This means that ”improved technologies must be implemented simultaneously with price increases so that the decrease in expenditure brought about by the efficiency improvement compensates (fully or partially) for the increase in expenditure due to the price increase.

Thus, the barrier of the cost blind price fixing government can be surmounted by a move towards long-run marginal cost pricing and by ensuring that price increases are implemented along with improved technologies.

The Fragmented Decision makers: Since the conventional approach emphasizes resource consumption, its attention turns to supply increases, which are then differentiated into, centralized and decentralized sources. Conservation becomes a separate issue. As a result, centralized and decentralized supply increases and resource efficiency measures become separate decisions handled by separate offices or departments or ministries with separate budgets. In such a context, empires and satrapies develop. And, in the ensuing conflict over funds, centralized supplies (with the strongest lobbies) get the biggest budgets, decentralized sources, much less, and resource efficiency has to be content with the leftovers.

But, any resource service, say, lighting, can be obtained either by increasing centralized or decentralized supplies or by using more efficient devices and equipment. To know which is the most cost effective way of obtaining that service, they must be compared with each other. Hence, sound management requires that tenders must be called, not for augmenting supplies, but for providing the resource service at the least financial cost.

Hence, the barrier of fragmented decision making can be surmounted by ensuring that improved technologies are made part of the same investment decision as the considering resource supply and made in the same office by the same decision maker and by including improved technologies in the least cost planning process.

CONCLUDING REMARKS

The model that has been developed involves a hierarchical approach in which the analysis can be carried out at various levels 1, 2, etc. As the level number increases, the analysis goes deeper and deeper, and each level is associated with characteristic failure modes. The aim of the analysis is to achieve ”understanding rather than evaluation because the former is enlightening and encouraging in contrast to the latter which is threatening. The objective of the understanding is two-fold:

(1) designing technology generation and commercialization before a project is undertaken, and

(2) improving technology generation and commercialization post facto by analysing the degree of success that has been achieved.

In order to design technology generation and commercialization prior to undertaking a project, one approach can be to start with Level 1 and incorporate the features necessary to prevent the failure modes at that level, then to repeat this process of introducing failure-preventing features at Levels 2, 3, etc., until all the detailed features are built in. In an analogous way, technology generation and commercialization can be improved by starting with Level 1 and checking whether the features necessary to prevent the failure modes at that level have been incorporated, then to repeat this process of checking whether failure-preventing features have been incorporated at Levels 2, 3, etc., until all the missing features are identified and built in during the improvement.

The above analysis is helpful in developing a checklist that can be used when a new technology is under consideration for generation and commercialization. The checklist can serve as a tool for highlighting pitfalls in the process of which the planner has to be wary. This will help in systematically increasing the probability of success of the generation and commercialization process. An example of such a checklist is given in Appendix 2.

Further, the process of generation and commercialization are modeled in detail much in the same way as mechanical systems are depicted mainly to highlight the failure modes of the system. Such modeling exercises are essential for the Indian rural technology scene, because it reveals many cases of failure causing much concern to the R & D policy makers and to the scientists involved in the generation of these rural technologies.

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APPENDIX 1: TECHNOLOGY-SOCIETY INTERACTIONS IN MARKET ECONOMIES (1,2)

The starting point of the present analysis is the view that both technology as well as the productive apparatus of society (its industry, agriculture and services) respond to social wants, which are in turn modified and transformed through a causal chain, or rather causal spiral. A deeper understanding of technology-society interactions is facilitated by a very simple model shown in Figure 1.

Every society has wants, and these wants can be satisfied through goods and services produced by industry, agriculture and technologies developed by the institutions responsible for the generation of technology, viz., the educational and scientific and technological institutions. All social wants, however, do not necessarily receive a positive response. There is a process of ”filtering these wants, so that only some of them are transmitted as demands upon technological capability, and the rest are bypassed either because the productive apparatus does not deploy available technologies or because technology-generating institutions do not develop the required technologies. In other words, there are ”ignored wants that are not included in the product-mix of the economy despite the availability of technologies. Or, the educational, scientific and technological institutions avoid these ignored wants in their research and development programmes even though the satisfaction of these wants requires the generation of new technologies.

In untempered market economies, the operation of the filter is dominated by the forces of the market-place. Only wants which can be backed up by purchasing power become articulated as demands upon the research and development institutions, and the remaining wants are bypassed, however much they may correspond to the basic minimum needs of underprivileged people. Thus, like all commodities in these economies, technology too is a commodity, catering to the demands of those who can purchase it, and ignoring those who cannot afford it.

The process by which a society arrives at a particular product-mix is outside the scope of this study -- it is a matter of conventional political economy. In contrast, the filtering process, which results in, a particular set of social wants being responded to with science and technology is important for the analysis here.

This filtering process is operated by decision-makers at four levels:

(1) the national level through the apportioning of national research and development budgets,

(2) the agency or corporation level where each agency or corporation gives a specific orientation to its mission or charter,

(3) the institutional level through the special emphasis given to various programmes, and the individual level through the motivations, predilections and capabilities of scientists and engineers.

All these decision-makers are either conscious agents of social and economic forces, or are unconsciously influenced by those very forces.

The generation of technology can in the first instance be considered in terms of the so-called "innovation chain" which is the linear sequence of steps by which an idea or concept is converted into a product or process. This sequence of steps varies with the circumstances, but can often by schematically represented thus:

Idea Generation ----> Research ----> Development & Design ---->

Engineering for Manufacturing ----> Manufacturing ---->

Product/Process --> Commercialization.

The step of Development and Design may include pilot-plant trials and that of Engineering for Manufacturing may include scale-up, production/product/process engineering and plant fabrication. It is essential to note that socioeconomic constraints and environmental considerations enter the process in an incipient form even at the stage of formulation of the research objective that evokes the idea, and then loom over the chain at several stages. These constraints are in the form of preferences or guidelines or paradigms, for example, "Seek economies of scale!"; "Facilitate centralized, mass production!"; "Save labour!"; "Automate as much as possible!"; "Treat polluting effluents or emissions as externalities!"; "Only worry about the unit cost of the product from the point of view of the entreprise, and let social costs, e.g., damage to community health or increased load on the transport system or exhaustion of non-renewable natural resources, be society's problem!"; etc.

Thus, every technology that emerges from the innovation chain already has congealed into it the socioeconomic objectives and environmental considerations that actors in the innovation chain introduced into the process of generating that technology. Further, at a previous stage in the spiral, the very decision to respond to a particular social want by generating the necessary technology is the result of a deliberate filtering process wielded by decision-makers.

The technology that emerges from the innovation chain will become an input, along with land, labour and capital, to establish an industry or agriculture or service ”if and only if the aforesaid socio-economic and environmental constraints are satisfied. Thus, it is not only the technical efficiency of the technology, but also its consistency with the socioeconomic values of the society, that determine whether a technology will be deployed and utilized.

Social wants are not static. The products and services that are produced create new social wants, and in this process the manipulation of wants through advertising, for example, plays a major role, and thus the spiral:

Social wants ----> Products/services ----> New Social wants

----> .....

Since social wants, which are the driving force of technological development, are themselves transformed by technology (and its embodiment in industry, agriculture and the services), it is clear that technology shapes society.

The model also reveals that every pattern of technology is shaped by society. Technology therefore is a product of its times and context, and bears the stamp of its origins and nurture. It is in this sense that technology can be considered to resemble genetic material that carries the code of the society which conceived and nurtured it and, ”given a favourable milieu, tries to replicate that society.

The replication of society referred to above is neither automatic nor inevitable; it is successful only when a host of environmental factors are favourable - hence, the argument is not tantamount to technological determinism. Further, it has been emphasized that technology itself is socially conditioned - hence technology is not viewed as an autonomous factor and a motive force outside society. Of course, all this is obvious to archeologists who must proceed from the material products of technology, i.e., tools, artifacts, etc., to reconstruct the vanished society and its culture, and to social anthropologists who cannot but consider the interactions between technology, industry/agriculture and society.

APPENDIX 2: CHECK LIST COMMERCIALIZATION OF RURAL TECHNOLOGIES

Notation: FMTG -Facilitating Mechanism for Technology Generation
FMTC -Facilitating Mechanism for Technology Commercialization

A. Rural Technology Generation

(1) Is there a FMTG for rural technology?

(2) Is the FMTG channeling rural needs to an institution of education, science and technology?

(3) Is the FMTG initiating and sustaining special innovation chains for rural technology?

(4) Is the FMTG involved in arranging field trials and/or test marketing?

(5) Is the FMTG obtaining feedback from technology commercialization in the market- & non-market modes?

B. Rural Technology Commercialization

(6) Is there a FMTC for the rural technology being commercialized?

(7) Is this FMTC surveying market/users and forecasting demand/requirements?

(8) Is the FMTC arranging (or involved in) field trials and/or test marketing?

(9) Is the FMTC involved in/making decision i.e., centralized or decentralized manufacture?

(10) Is the FMTC organizing production/manufacture?

(11) Is FMTC involved in/making the decision re: market or non-market mode of commercialization?

(12) If the market mode is adopted, then is the FMTC involved in marketing?

(13) If the non-market mode is adopted, then is the FMTC facilitating distribution, provision of credit/finance, delivery, user-training. after-delivery service, user feedback, etc?

(14) Is the FMTG linked to the FMTC? warrant a study of the experiences in order to improve upon the process in the future. Hence, the next step -- described in subsequent papers -- must involve a collection and systematization of empirical material on a selected sample of rural technologies in the form of case studies.

These case studies will be cast into a form that will enable the testing and refinement of the models for the generation and commercialization of rural technologies.

The main points regarding the technology generation (TG) shown in

Figure 4 are the following:

(1) the identification of the users' needs vector,

(2) the specification of the designer's objectives vector,

(3) the research, development and design followed by the laboratory evaluation of the design,

(4) the field trials in a specific locale,

(5) the reckoning with geographical variations, and

(6) the feedback from the field trials to the alteration of the objectives vector and the design process.

In fact, it is possible to go into much more detail with respect to the above steps. For instance, the process of research, development and design, and laboratory evaluation (TG1) can be expanded (Figure 4.1) to take into account the details regarding the

design parameters, the assumptions about inputs, and the status of the inputs, the critical design features, the performance vector, and the operational requirements. Based upon all these factors, an attempt can be made to optimize the design. Many technologies are locale-specific, and therefore, there is a need for a design that lends itself to locale-specific adaptation.

The step involving the influence of field trials (TG 2) can also be elaborated with much greater detail (Figure 4.2). If the objective vector is not changed, then the crucial question is whether the critical design features can be maintained under repetitive use. If these features can be maintained, then the technology is ready for commercialization if (a) the operational requirements are met and (b) the input assumptions are valid. If the operational requirements are not met, then a remedial technical education pack for the user may be sufficient for the .pa H technology to become ready for commercialization. And even if the assumptions regarding the inputs are not valid, the performance may not significantly affected -- in this case too, the technology can be considered ready for commercialization. If, however, the performance is significantly affected and/or the critical design features cannot be maintained under repetitive use, then design changes become imperative. If the required design changes are feasible, and if these changes either do not add to cost or the cost additions are acceptable, then the design changes can be proceeded with and followed by a fresh round of laboratory evaluation and field trials. If the design changes are not feasible, then a simple operational adjustment/device to help the user followed by a communication regarding these changes may make the technology ready for commercialization. But, there may be situations in which the added cost associated with the design changes is unacceptable or in which it is not possible to make a simple operational adjustment/device to help the user -- in either of these cases, the technology generation effort must be deemed a failure and an alternate design cycle attempted.

APPENDIX : (Contd.)

B. ”Generation of Rural Technologies

1. Is there interaction between the end-users needs and the design objectives? Are the needs taken into account in formulation of the design objectives?

2. Is the outcome of R,D & D evaluated in field trials?

3. Do the field trials reckon with local specificity, i.e., with geographical variations of inputs, operating conditions and objectives?

4. Can the field trials

(i) alter the objectives vector & therefore lead to a design review?

(ii) change the design?

(iii) lead to an alternate design cycle?

5. Are assumptions of design regarding inputs adequate?

6. Are the critical features of the design clearly specified for proper functioning of the Technology?

7. Are the requirements of operating the technology elaborately detailed after laboratory performance trials?

8. Are realistic input variations clearly reflected in laboratory trials?

9. Do the field trials clearly vindicate the technology from the point of view of:

(i) Maintenance of critical design features in rural conditions?

(ii) Simple adjustments or devices to help taking care of design feature maintenance/variations in operating conditions?

(iii) Technical package for communicating to the user?

APPENDIX : (Contd.)

C. ”Commercialization of Rural Technologies

1. Are the individuals sufficiently motivated for the technology (in the case of technology for individual use)

2. If the individuals are not motivated then what is the reason?

(i) investment incapability?

(ii) lack of financial benefits?

(iii) no improvement of some living condition?

3. Has an influential local group been identified & rapport with it developed while commercializing technology?

4. Is there a pressing need of the individuals for the technology offered?

5. Have training, coordination of installation, getting subsidy/loan and linking with administrative machinery been achieved?

6. Is the use of technology being monitored?

7. Are the pressing needs of the rural community partly/fully fulfilled by the use of technology?

8. Is there general agreement in the community for the use of technology?

9. Does the influential group ensure equity to the members of the community in sharing benefits?

10. Is there a strong sense of community ownership of the technology?

11. Are inputs for the use of technology available adequately round the year?

12. If it is not, does maintenance or operational problems arise?

13. Are there special conditions needed for operating the technology? Can they be maintained at the locality?

14. Any adjustments needed in design for this purpose?

15. Are there any critical features affected by input fluctuations? Is there any adjustment provided for off- setting it?

16. Has the criticality of features been communicated to the user adequately?