Dr. M. M. Qureshi

TECHNICAL EDUCATION AND APPROPRIATE TECHNOLOGY IN THE ISLAMIC WORLD TODAY

1. Background History of Science and Technology

Technology, in the sense of practical application of invention or discovery, is as old as mankind itself. From the dawn of history, the power of the human group, be it family, tribe or nation, had depended on the strength of its technology, military, industrial, agricultural or organizational. What is new in human history is science-based technology, the conscious application of science or, better, the results of scientific research to the solution of practical problems. Development is a complex social process, which rests in large part upon the internal innovative capabilities of a society; imports of foreign ideas, values and technologies have a major part to play, but few societies in history have developed exclusively on the basis of such imports.

Technology in some rudimentary form is to be found in the earliest known history of man, and each civilization has tended to build on the achievements of the preceding ones. The Babylonians, the Egyptians, the Greeks and the Romans each added a bit more knowledge, but it fell to the Muslims to establish science as organized experimental knowledge.

Improving the effectiveness and efficiency of Industrialization programmes has today become of increasing concern to the planning authorities in the developing countries, as also to their political leaders and opinion-forming agencies. This being the age of scientific and technological growth, the role that science and technology can play in the developing countries has been the subject of investigation and debate at many important forums, particularly in view of the crisis of unequal relations between a few dominant countries and the majority of developing countries. The "Third World" countries have been left behind in technology and industrialization and thus suffered numerous disabilities. There is indeed an increasing urge in the liberal sections of the advanced nations to share the benefits of progress with the people who have been left behind, but concrete realization of even the elementary requirements by the deprived people of the world has been impeded by vested interests, and so the crisis persists. Accordingly, the developing countries are now stuggling to achieve greater control over their resources, obtain equitable terms of trade and acquire a technological capability for self-reliant development.'

Whatever technological help is today being given by the highly industrialized world to the less developed countries is on terms that generally involve not only high economic and social costs, but also perpetual dependence. Severe constraints are imposed on the transfer of the more sophisticated technologies. The so-called "Third World" countries are paying heavily for import of technology without in most cases being provided the detailed know-how. This makes it impossible for them to engage effectively in reproduction or adaptation of the imported technology. For example, the direct cost to Pakistan is over Rs. 1,000 million annually for patents, licences and imported technical services alone, apart from heavy indirect costs on import of machinery and similar hardware. The initiative taken lately by UNCTAD in relation to the liberalisation of the patent and copyright system and the technology transfer terms has met with formidable opposition from the dominant industrial countries. The dependent nations continue to accept all sorts of invidious conditions, because the power of modern technology to transform the nature and orientation of development is such that it must necessarily be secured, no matter how harsh the terms of transfer may be. And this process is repeated year after year, as new sophisticated technologies are put forth by the developed countries.

2. Transfer of Technology for Development: First and Second Laws

Technology transfer involves a composite of four distinct factors, *viz.* equipment, money, manpower and information, and in each of these, the interests of the seller and the buyer of technology are usually at variance with each other. The flow of technology can be considered as the sum of the imported technology and the local technology. The latter is a minimum in the so-called horizontal transfer of technology, consisting essentially of factories set up as "turn-key jobs" with a maximum of "embodied technology". A mixture of this with a large measure of vertical transfer of technology and transfer of technical information and basic technological skills is essential if the existing technical base in a developing country is to be adequately utilized and developed.

The experiences of the last fifty years in various attempts of technology transfer lead to several general conclusions, some of which can almost be put down as laws of Technology Transfer. First and foremost the amount of technology transfer, both qualitatively and quantitatively, depends in a direct way on the capability of the recipient country as well as on the ratio of the capabilities of the donor and recipient country; the quantity may reasonably be considered as proportional to the G.N.P., while quality may be measured by per capita G.N.P., thus[2] leading to the development capability index derived [cf. Fig. 1(a)] by the author, *viz.*

Development Capability Index

$$= \{(\text{G.N.P.})^{0.55} \times (\text{per capita G.N.P.})^{0.45}\} \ldots . (1)$$

Accordingly, the optimum technology transfer expenditure can be taken as proportional to

$$\left[(\text{Develop Cap. Index of recipient}) \times \left(\frac{\text{Dev. Cap. Ind. of donor}}{\text{Dev. Cap. Ind. of receipt}}\right)^m\right]^p \quad (2a)$$

where $p \sim 2$ and the power 'm' should obviously be between the limits of 0 and 1. If now this power 'm' is taken as 1/2 to a first approximation, then

$$\text{Optimum technology transfer} \propto \left\{ \frac{(\text{Cap. Index of receipt.})^{\frac{1}{2}}}{\times (\text{Cap. Index of donor})^{\frac{1}{2}}} \right\}$$

$$= \left[(\text{G.N.P.})_M^{0.45} \times (\text{p. cap. G.N.P.})_M^{0.45}\right]^2 \quad (2b)$$

where (G.N.P.) M-Geometric mean G.N.P. for the two countries, and (p. cap. G.N.P.)M = geometric mean per capita G.N.P. for the two countries.[3] For transfer between nearly comparable countries, the Geometric Mean can be replaced to a good approximation by the arithmetic mean; in such cases there may also be considerable reverse flow of technology. The technology transfer function 2b may well be taken as a tentative statement of the first principle of technology transfer, and the constant of proportionality is found below to be of the order of 1.0 if the left-hand side is taken as the total cost of embodied and unembodied technology transferred, cf. Fig. 1(b). Also, the unembodied component i.e. royalties, know-how technical services, is found to be about one-fifth of the total expenditure on technology transfer.

Accordingly, Fig. 1(b) shows a logarithmic plot of this sum of the expenditure by various countries[4] on know-how royalties and technical services, against their development capability index, the units for ordinates and abcissae being $ millions. The plotted points split up into two lots, through each of which a mean straight line can be drawn, the upper one with a slope for eleven countries of 1.00, and the lower one with a slope of 2.0 the two meeting somewhere near a development index of about $55 (million). The upper one (corresponding to $m=\frac{1}{2}$) is mostly for countries with per capita G.D.P. less than $450, with Pakistan, Mexico and Nigeria as unusually high spenders, and fits the equation 2b, yielding:

Expenditure on unembodied technology transfer = 0.21 × (recipient deve. index × 60 = (technology transfer function) 2(c)

The second important result of experience is that it has been repeatedly found during the last two decades that, in spite of all the transfer of technology, the gap between the developed and most of developing

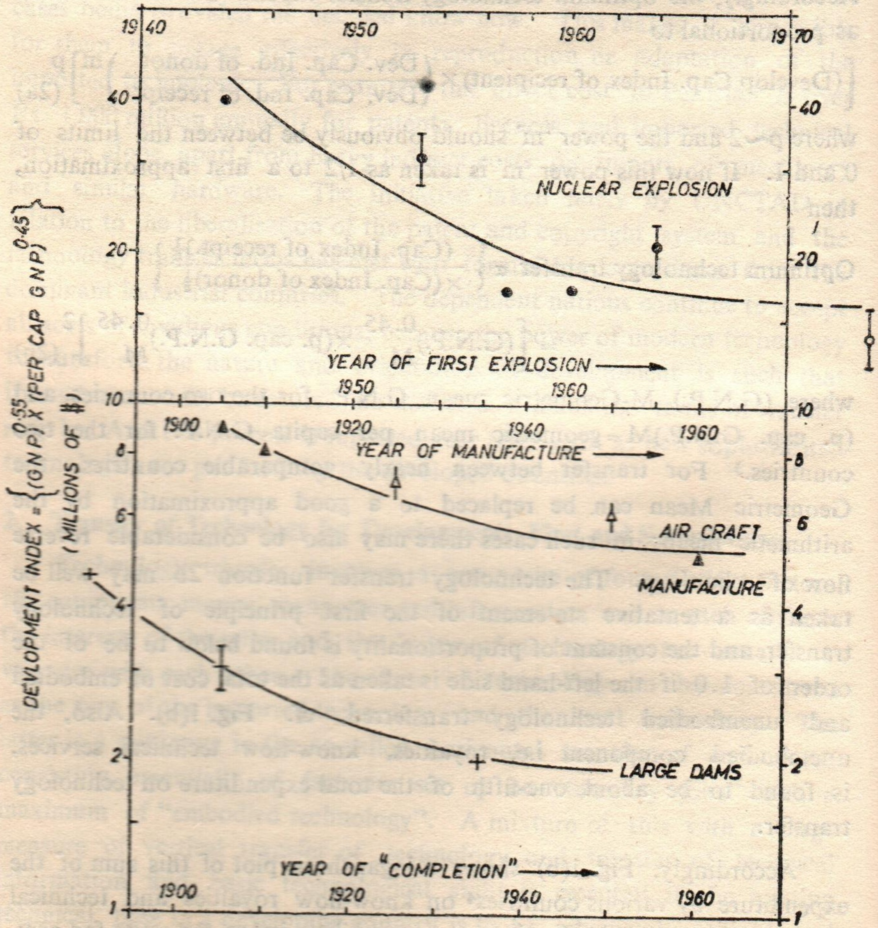


Fig. 1 *(a)*: Semi-log. plots of variation of Development Index with successive repetition of a project by various countries for three categories of project.

countries has consistently been increasing. So, we may generalize this into the second principle[3] of technology transfer to say that technology transfer by itself cannot bring any developing country upto a level with the developed or donor country, i.e. Δ (Technology)$\geqslant 0 \ldots (3)$. This is discussed further in Section 3. In fact, to bring developing countries even upto the level of developed countries, several factors other than simple technology transfer must be considered.

It is also worthy of note that the equation (1) shows that mutual collaboration of 4 countries with the same per capita G.N.P. can in fact increase their effective Development Capability Index by a factor two, through the 2-fold increase in the first factor, *viz.* $(G.N.P.)^{0.55}$.

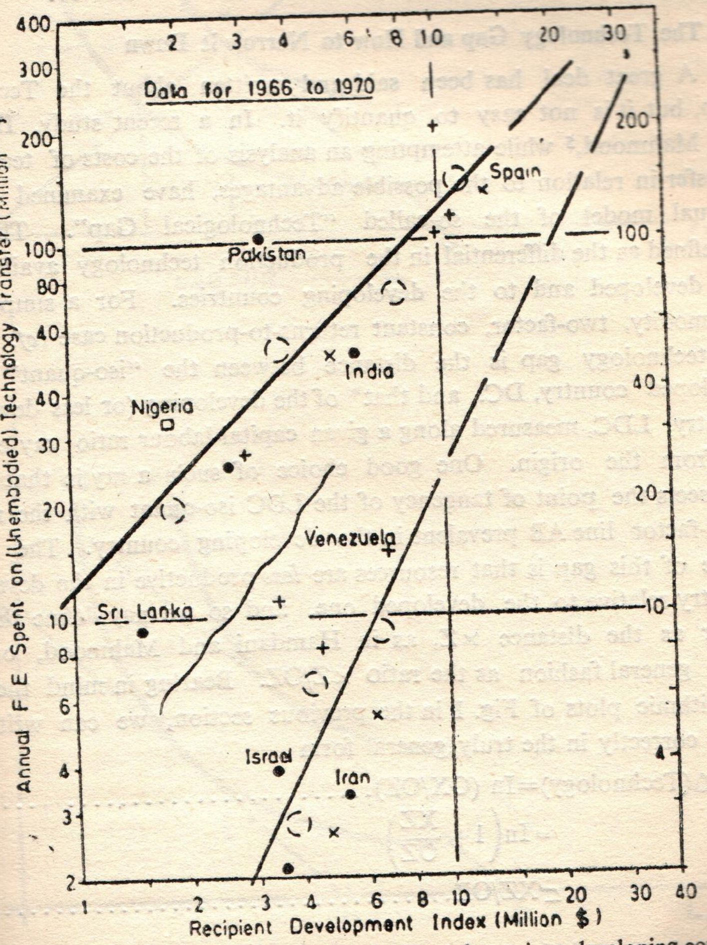


Fig. 1 (*b*): Logarithmic plots of the annual expenditure by various developing countries on the import of unembodied technology versus the Development Index of the recipient country.

"Detailed analysis of the expansion of scientific and technical education in the Soviet Union from 1914 to 1959 and the growth of scientific societies in Japan between 1868 and 1927 shows that the growth factors for these were 2.0 ± 0.2 and 1.75 ± 0.1 per decade, respectively, which compares well with the economic growth rates of $\times$ 1.9 per decade. This led to the formation of a Third Law, *viz.*

$$\frac{\partial}{\partial t}\left[\ln \text{ (Economy)}\right] = \frac{\partial}{\partial t}\left[\ln \text{ (Tech. Education)}\right] \quad \ldots .3(b)$$

namely that the *optimum growth-rate* of the economy is equal to the growth rate of technical education, with the rider that the motivation must stem from a belief in the nation's own ethical values".

3. The Technology Gap and How to Narrow it Down

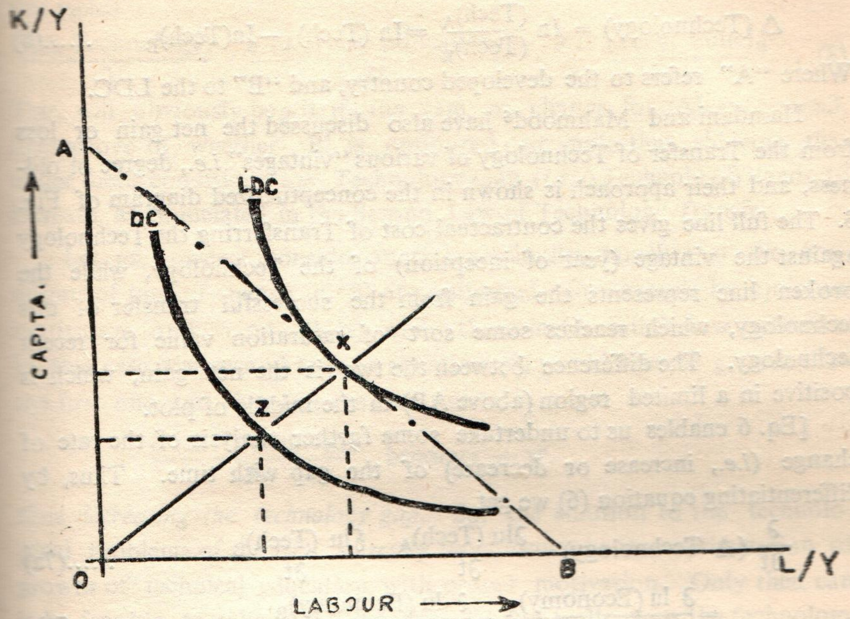
A great deal has been said and written about the Technology Gap, but it is not easy to quantify it. In a recent study, Hamdani and Mahmood,[5] while attempting an analysis of the costs of technology transfer in relation to the possible advantages, have examined a conceptual model of the so-called "Technological Gap". This Gap is defined as the differential in the production technology available to the developed and to the developing countries. For a simple one-commodity, two-factor, constant returns-to-production case (*cf.* Fig. 2), this technology gap is the distance between the "iso-quant" of the developed country, DC., and that* of the developing (or less developed) country, LDC, measured along a given capital-labour ratio ray emanating from the origin. One good choice of such a ray is that which intersects the point of tangency of the LDC iso-quant with the relative price-factor line AB prevalent in the developing country. The significance of this gap is that resources are *less* productive in the developing country relative to the developed one, and so we may define this gap either as the distance $\times$Z, as in Hamdani and Mahmood, or in a more general fashion as the ratio $\times$Z/OZ. Bearing in mind the semi-logarithmic plots of Fig. 1 in the previous section, we can write this more correctly in the truly general form

$$\Delta(\text{Technology}) = \text{In (OX/OZ)} \ldots\ldots (4)$$

$$= \text{In}\left(1 + \frac{XZ}{OZ}\right)$$

$$\simeq XZ/OZ \ldots\ldots (5)$$

*An iso-quant is the locus of points corresponding to a constant level of production for varying proportions of the factors of production, *viz.* labour and capital.



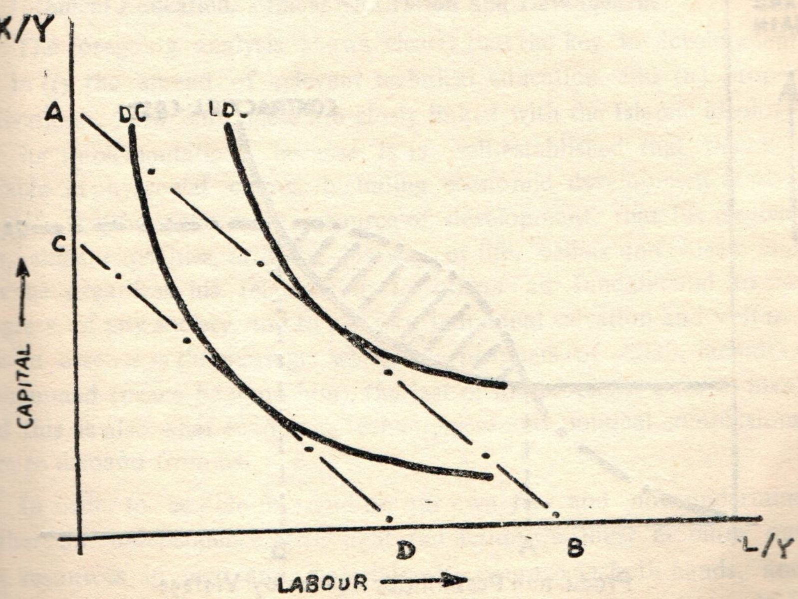


Fig. 2: Conceptual diagrams depicting the technology gap (top) and the gain from bridging this technology gap (bottom).

From the above, we can by inference put down the relation

$$\Delta\,(\text{Technology}) = \text{In}\,\frac{(\text{Tech})_A}{(\text{Tech})_B} = \text{In}\,(\text{Tech})_A - \text{In}(\text{Tech})_B \qquad \ldots\ldots(6)$$

Where "A" refers to the developed country, and "B" to the LDC.

Hamdani and Mahmood[6] have also discussed the net gain or loss from the Transfer of Technology of various "vintages" *i.e.*, degree of oldness, and their approach is shown in the conceptualized diagram of Fig. 3. The full line gives the contractual cost of Transferring the Technology against the vintage (year of inception) of the Technology, while the broken line represents the gain from the successful transfer of this technology, which reaches some sort of saturation value for recent technology. The difference between the two is the net gain, which is positive in a limited region (above AB) in the middle of plot.

[Eq. 6 enables us to undertake some further analysis of the rate of change (*i.e.*, increase or decrease) of the gap with time. Thus, by differentiating equation (6) we get

$$\frac{\partial}{\partial t}\,(\Delta\ \text{Technology}) = \frac{\partial \text{lu}\,(\text{Tech})_A}{\partial t} - \frac{\delta \text{lu}\,(\text{Tech})_B}{\partial t} \qquad \ldots\ldots(7a)$$

$$= \frac{\partial\ \text{lu}\,(\text{Economy})_A}{\partial t} - \frac{\partial\ \text{lu}\,(\text{Economy})_B}{\partial t} \qquad \ldots\ldots7(b)$$

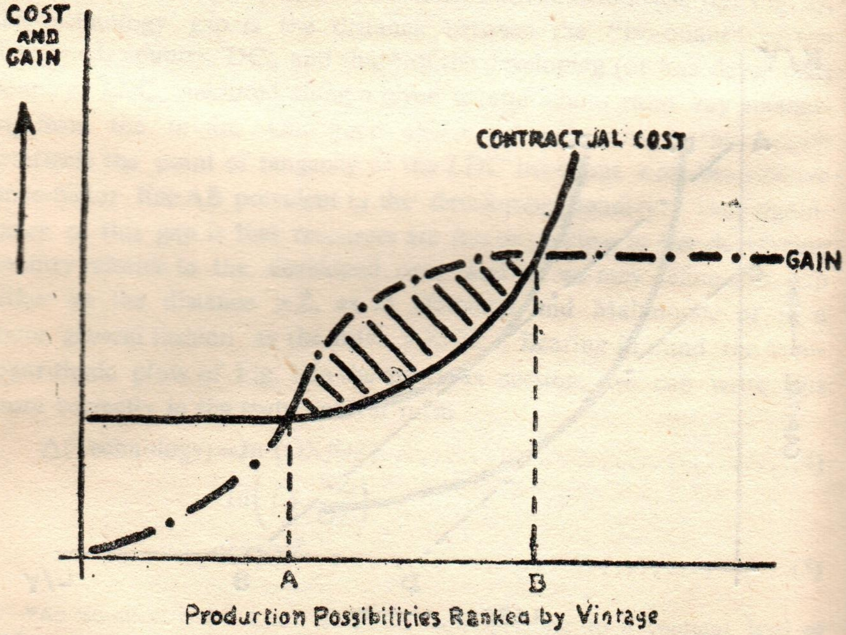


Fig. 3: The gain and contractual cost of technology transfer for different technology vintages.

Now, using third law (of technology transfer) as stated in eq. 3 (b), this yields

$$\frac{\partial(\Delta \text{ Technology})}{\partial t} = \frac{\partial \text{ lu (Tech. Education)}_A}{\partial t} - \frac{\partial \text{ lu (Tech. Educ)}_B}{\partial t} \quad ..(8)$$

This will obviously be >0 if the rate of change for 'A' is optimal, irrespective of whether 'B' is optimized or not, thus showing that under these conditions the Technology Gap (*i.e.* ΔTechnology) tends to increase, as enunciated in the Second Law of Technology Transfer.

Let us, however, consider another possibility, namely that the conditions of rate of change in 'B' are optimized (for example by optimum motivation and sound ethics) while those in 'A' fall below optimum. In this case, the second term in equation (8) would become greater than the first one, and therefore the nett rate

$$\frac{\partial(\Delta \text{ Technology})}{\partial t} \text{ becomes — ve,}$$

thus *decreasing the technology gap.* So, the solution to the technological problems of the LDC's really boils down to the optimization of growth of technical education with proper motivation. Only then can it be feasible to take a "Leap forward" and really close the technology gap, possibly in collaboration with other developing countries.

4. Technical Education, Ethical Motivation and Development

The foregoing analysis shows clearly that the key to development lies in (*i*) the spread of relevant technical education and (*ii*) proper motivation. Now both these are closly linked with the Islamic ideology and its implementation, because it is well-established that the key variable in any social change including economic development is man himself, that he is the main resource of development, that his motivation, skills, capacities, attitude, his way of life, beliefs and ideas, and how he organizes his relationship to others are fundamental to the progress of any society, and to his own individual salvation and welfare. This in essence is the message which the prophets of Allah, including Mohammad (peace be upon him), the last of the prophets, gave to man. And this is also what economic, technological and political complusions seem to demand from us.

In order to be able to stand on our own feet and not undermine further our independence of thought and action we must mobilize our own resources in men and materials with courage in both hands, and remember that God never helps those who do not help themselves. It is also not without reason that Allah has made man his vice-regent on earth, and endowed him with the capacity and thirst for knowledge. The fact that major education and training programmes require a 6 years period for their introduction and another 6 years for their viable and productive continuation has led some authors (for example Zahlan[7]) to maintain that 12 years is the basic period for bringing above a major socio-economic change. This is substantiated by the existence of 12-year period for such change in the case of many countries in the world today.

There are several short-comings in the present system of S and T teaching and training in the developing countries, of which at least two need special attention :

(*i*) Poor quality. One of the most pernicious traits of poor quality is self-perpetuation; bad teachers and research supervisors breed bad successors. Mismanaged scientific institutions repel the creative and dynamic workers, while they accumulate the mediocre and the timid. Thus the system of mediocrity perpetuates itself, giving the appearance of substantial scientific manpower but wastefully consumes the funds set aside for science and technology.

(*ii*) Lack of development of human resources in the country at the rural levels, where 90% of the manpower in the developing countries lives. The education and training of rural people should generally receive much greater attention than has been the case in the past. The training for rural people should be aimed at increasing both their organizing capability for community action with regard to the resources for developmant, as well as enabling them to participate in various productive activities. This would require motivation for the generation of entrepreneurship as well as a strengthening of vocational training programmes.

Only if we attend to these immediate deficiencies can we begin to stand to our own feet and build up our own technologies.

Some practical measures that may be suggested for appropriate manpower development are as follows:

(*i*) In addition to the existing polytechnics, establish such polytechnics that do not put stringent pre-condition of academic entrance qualifications, and where courses are short and open-ended with choice for the trainee to take up training in a particular skill. This is practically demanded for the villages and backward areas;

(*ii*) A system of apprenticeship in the big industrial units should be enforced. This can ensure the availability of technicians according to the specialised needs of the industry;

(*iii*) Mobile training units should be introduced. These units should send advance parties to different areas and localities to identify and assess the local training needs and then move into localities that have a potential for training. These units should be equipped with a variety of workshop facilities and the trainers should be able to impart all kinds of requisite training;

(*iv*) Techno-information centres should be established at Divisional/District level. These centres should provide technical information to the people on request, or at least indicate the source from where the information could be obtained directly. These centres should also have a technology audit system to catalogue the local technological capacities;

(*v*) To improve the capabilities of 'mistries', special courses on designing, use of tools, and precision work should be arranged.

5. What is Meant by Appropriate Technology ?

It is now a common observation that many of the developing nations, in their drive for modernization and development, utilize technologies that have been borrowed or slightly adapted from the developed nations. Furthermore, the result of having placed reliance upon the developed nations as a technological source has often been the installation of expensive, ill-adapted, and socio-economically damaging technologies (damaging in the respect that surplus labour and indigenous resources are not optimally utilized). These and similar problems have resulted in much reviewed attention to the constraints affecting technological development in developing countries. Most national policy-makers and development experts today agree that indiscriminate technology-transfer is not source of self-sustained growth for developing countries. What is required is to find a way to graft technologies that will effectively nurture the innate capacity of the people to invent and adapt. This of course requires (*i*) an emphasis on indigenous technologies, (*ii*) a very careful selection of what to import, if at all, and (*iii*) the development of new concepts and organizational methods that will fully suit the local conditions. Broadly speaking, if (*i*) is paramount we get the Ghandian philosophy of (low-cost) indigenous technologies, while if (*ii*) is the main consideration, we get the so-called Intermediate technologies, whereas if (*iii*) is our main target or objective, then we have the Appropriate Technology Concept.

Although the phrase Appropriate Technology has acquired a current popularity in development literature, the underlying concept is *not* new. Man has always tried to combine skill and science for devising methods to solve his problems and increase his productivity. When he adapts the resource readily available to him to create techniques and tools that are consonant with his particular circumstances, then he is applying Appropriate Technology. Thus, either a simple hand-hoe or a sophisticated tractor may be appropriate, depending on the condition to which they are applied. Since Appropriate Technology is of particular importance to developing countries, it *generally* involves low-cost, labour-intensive, and small-scale processes and equipment. It utilizes local energy sources, and is characterized by simplicity, facility of maintenance, and minimal operating costs. Usually, it is applied to alleviate the unemployment and hardships of the rural poor, who have been largely bypassed in many development assistance efforts. It should also be mentioned, however, that Appropriate Technology concepts are increasingly being applied in so-called developed countries in their economically depressed regions, and for the benefit of their native people.

Appropriate Technology is only gradually gaining recognition as an effective means of development and as an important component of overall development strategies. Although many individuals and groups throughout the world are using Appropriate Technology principles in their development efforts, there is little communication in this field, particularly among governmental and non-governmental agencies in developing regions. There is an increasing need for collection, collation, and dissemination of data and information about Appropriate Technology on a widespread basis. A communicating network is necessary to inform groups interested in development programmes about some of the alternatives available to them, and to assist those who wish to explore Appropriate Technology methods and integrate them into their development schemes. From another perspective, Appropriate Technology concepts should be popularized as an element in an on-going process of development education.

To quote from the excellent exposition of the origins and meaning of Appropriate Technology by Nicolas Jequier:[8]

"When speaking of low-cost technology, one is focussing primarily on the economic dimension of innovation. The concept of Intermediate Technology on the other hand belongs more specifically to the field of engineering. As for Appropriate Technology, which tends today to be somewhat more popular than low-cost or intermediate technology, it represents what one might call the *social and cultural dimension* of innovation, cf. Fig. 4. The idea here is that the value of a new

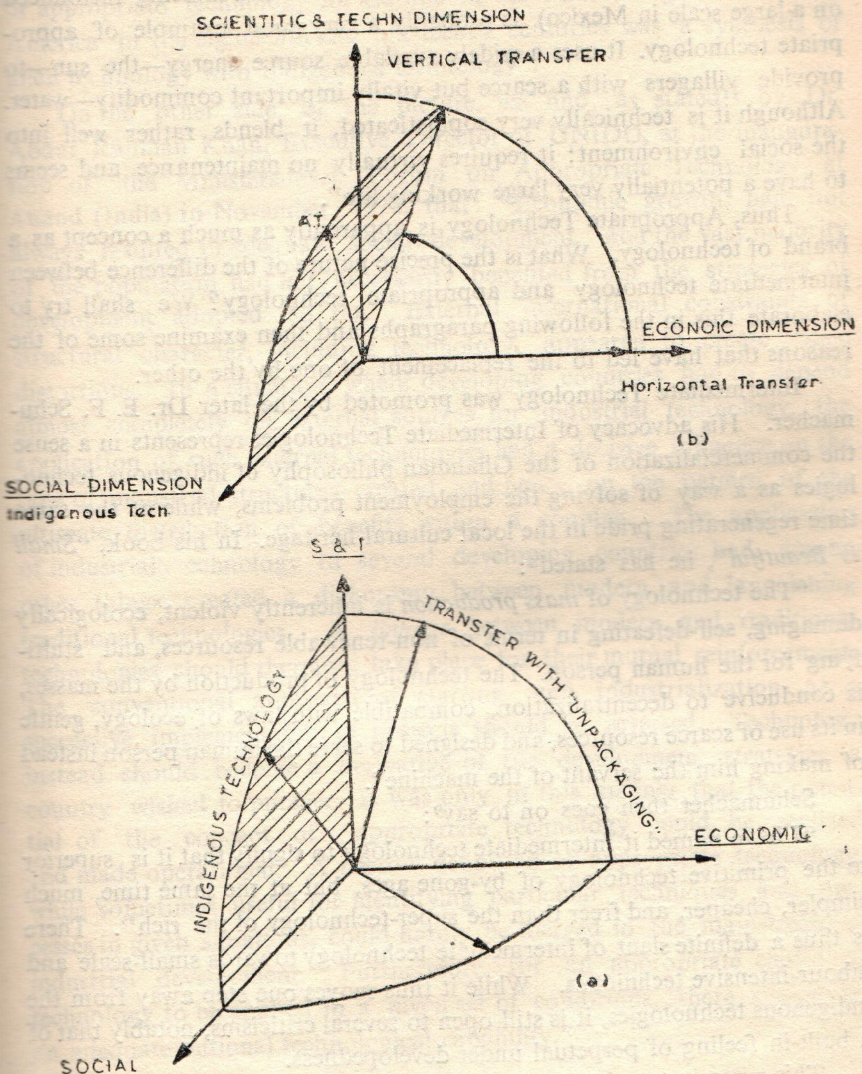


Fig. 4: Conceptual Diagrams showing :

(*a*) The three dimensions of technology development/transfer, namely Economic, Scientific/Technological, and Social.

(*b*) The two stages concept of technology transfer : First from horizontal to vert ical, and second its matching with indigenous technology and ocial factors to yield "Appropriate Technologies".

technology lies not only in its economic viability and its technical soundness, but in its adaptation to the local social and cultural environment". According to him, "the solar pump developed by a French firm in collaboration with the University of Dakar (and which is being introduced on a large scale in Mexico) is probably a very good example of appropriate technology. It uses a widely available source energy—the sun—to provide villagers with a scarce but vitally important commodity—water. Although it is technically very sophisticated, it blends rather well into the social environment: it requires virtually no maintenance and seems to have a potentially very large working life".

Thus, Appropriate Technology is apparently as much a concept as a brand of technology. What is the precise nature of the difference between intermediate technology and appropriate technology? We shall try to elaborate this in the following paragraphs and then examine some of the reasons that have led to the replacement of one by the other.

Intermediate Technology was promoted by the later Dr. E. F. Schumacher. His advocacy of Intermediate Technologies represents in a sense the commercialization of the Ghandian philosophy of indigenous technologies as a way of solving the employment problems, while at the same time regenerating pride in the local cultural heritage. In his book, "*Small is Beautiful*", he has stated[8]:

"The technology of *mass production* is inherently violent, ecologically damaging, self-defeating in terms of non-renewable resources, and stultifying for the human person. The technology of production by the masses, is conducive to decentralization, compatible with laws of ecology, gentle in its use of scarce resources, and designed to serve the human person instead of making him the servant of the machine".

Schumacher then goes on to say[9]:

"I have named it intermediate technology to signify that it is superior to the primitive technology of by-gone ages, but at the same time, much simpler, cheaper, and freer than the super-technology of the rich". There is thus a definite slant of intermediate technology towards small-scale and labour-intensive techniques. While it thus moves one step away from the indigenous technologies, it is still open to several criticisms, notably that of a built-in feeling of perpetual under-developedness.

This excessive emphasis on small-scale technology as being the most suitable for third-world countries has been criticized by several experts, notably Thomas deGregori, who feels[10] that this "can generate an intellectual apartheid and create technological Bantustans". Again, "small-scale labour-intensive technology does not always carry with it all the virtues that its proponents ascribe to it. Labour-intensive technologies are *not* always capital saving. For example, it has been demonstrated that the spinning wheel is the most capital-intensive way of spinning, because it is the most inefficient". He further says that the most suitable or appropriate technology for Europe in the Middle Ages, for North America in the eighteenth and nineteenth centuries was a synthesis of alien technology with indigenous technology".

On the other side of the picture, we find, as stated[11] by Dr. Abdur Rahman Khan, Executive Director of UNIDO, at the inauguration of the Ministers-level Forum on Appropriate Technology at Anand (India) in November 1978, that: "Economic growth had not always resulted in adequate social development, and the vast majority of the population had *not* necessarily benefited from the strategies of development adopted so far. External international constraints of structural character, including technology, appeared to create basic distortions. In a situation where developing countries had to depend almost completely on external sources for industrial technology, the application of such external technologies had a decisive influence on the type of industrial structures created and hence on the pattern of the ultimate distribution of benefits within a country. The application of industrial technology in several developing countries had, among other things, created a dichotomy between modern and languishing traditional technologies. A *linkage* between modern and traditional technologies should therefore take place for their mutual reinforcement. The conventional approach of starting with industrialization as a successive implementation of projects should be reversed. Technology instead should become a derivative of the development strategies a country wished to pursue. It was only in this manner that the potential of the concept of appropriate technology could be realized and made operational. A narrow definition of appropriate technology, while sometimes useful for identifying particular techniques and processes in given situations, could hardly be merged in the mainstream of industrial development. Furthermore, for an appropriate choice of technology to be applied in a given set of conditions, there should be an adequate national technological capability."

6. The Present Scope and Some Characteristics of Appropriate Technologies

At the Ministerial-level meeting representing thirty-five countries, the concept of appropriate technology was viewed as being the *technology mix* contributing most to economic, social and environmental objectives, in relation to resource endowments and conditions of application in each country. Appropriate technology was stressed as being a *dynamic and flexible concept*, which must be responsive to varying conditions and changing situations in different countries. It was considered that, with widely divergent conditions in developing countries, no single pattern of technology or technologies could be considered as being appropriate, and that a broad spectrum of technologies should be examined and applied. An important overall objective of appropriate technological choice would be the achievement of greater technological self-reliance and increased domestic technological capability, together with fulfilment of other developmental goals.

The appropriate Technology Concept thus represents a state of mind that combines an increasing domestic technological capability in most developing countries, a major development objective is to provide adequate employment opportunities and fulfilment of basic socio-economic needs of the poorer communities, mostly resident in rural areas. At the same time, some developing countries are faced with considerable shortage of manpower resources, in some other cases, greater emphasis was essental in areas of urban concentration. The appropriate pattern of technological choice and application would thus need to be determined in the context of socio-economic objectives and a given set of circumstances. The selection and application of appropriate technology would, therefore, imply the use of both large-scale technologies and low-cost small-scale technologies dependent on objectives in a given set of circumstances.

While modern and capital-intensive technologies were essential in some sectors, and in certain country-specific situations, such technologies should be related to the particular factor conditions and circumstances of each country. This would require that foreign technology when acquired should not only be obtained on suitable terms and conditions but should also be rapidly observed and adapted to domestic conditions. Transfer of technology from developed to developing countries should be carried out on the basis of equality and justice, without detriment to the national sovereignty of developing countries.

The term Appropriate Technology implies that there is a range of technologies available from which a choice may be made to suit a particular application. This does not mean that an ideal solution to a problem should be sought. Rather, it is necessary to define a problem in terms of *constraints* and *resources* which actually exist. Then a solution must be selected to improve the situation relative to the needs and priorities of the people affected, without, imposing additional constraints.

Appropriate Technology need not, and, indeed, should not be applied only to rural areas in developing countries; its basic principles are universal. However, in the face of widespread deficiencies of basic needs of such large portions of the population, coupled with the urgent necessity of increased self-sufficiency in food production of most developing countries, the rural developing areas require special attention.

In rural agricultural areas of developing countries appropriate technology applications are likely to have some common characteristic. They will usually be:

Labour intensive;
Simple;
Small-scale;
Low cost.

Since labour is plentiful and relatively cheap in the developing countries, and capital is scarce, Appropriate Technology for those countries, particularly in the rural sectors, is low in capital inputs and high in labour content. The high unemployment and under-employment rates of most of these areas underlies the aim of increasing employment rather than simply using methods that increase production but eliminate jobs. The Technology should be simple enough to be used by people who have limited deduction and skills—it should not require much specialized training. Small scale technology is necessary if it is to be used by a village, a group, or perhaps a single family. It must be affordable and operable at a community level. The need for the technology to be low-cost implies that it should not depend too much on the importation of expensive materials or components (which is also a drain on scarce foreign exchange). Nor should it require high-cost energy sources.

7. Some Examples of Current Appropriate Technologies in Muslim Countries

(a) *The Case for Indigenous Building Technology*

Indigenous planning and building methods have been neglected in most Third World countries. The RCD member countries have some highly developed indigenous technologies, evident in their villages and traditional city quarters. The architecture of these indigenous settlements have evolved over thousands of years and reflect their countries' accumulated expertise on how to build cheaply and appropriately to the local social, cultural, economic and environmental conditions. Furthermore, the majority of people live in these settlements. Thus the approach to developing this appropriate technology is through first understanding and improving the indigenous technologies being used in these settlements.

The irony is that we are importing methods that are being seriously questioned in the countries of origin themselves. For example, high-rise becomes a major feature in many Third World countries at a time when the West is beginning to realise the damaging social effects of high-rise living, the high energy requirements and the cost to keep them even minimally comfortable. Meanwhile, the indigenous courtyard house with its many energy-saving devices, providing a climatically comfortable and quiet atmosphere (increasingly important in our noisy and polluted cities) is in fact being ignored. The potentials for achieving very high densities using the courtyard house from as illustrated in our cities' older quarters is also ignored (high densities being the one most often quoted in defence of high-rise).

Our old city centres, such as those of Isfahan, Istanbul and Lahore, are examples that have much to teach us and should be studied from a number of aspects. In aesthetic terms: the sence of scale and proportion, vistas, and the juxtaposition of open and closed spaces; in climatically functional terms: the shaded streets, orientation according to the sun's angle, and the beneficial air-movement generated by the street layout; in terms of traffic control: the use of rational hierarchy ranging from major vehicular thoroughfares to residential pedestrian access and the just mentioned ability to achieve high densities with low-rise. Again it is ironical that while many Third World planners seem oblivious to such practical lessons offered by their indigenous methods, Western planners are implementing similar principles in their work.

A common situation in Third World countries is one of burgeoning, increasingly unmanageable major cities drawing labour from our rural areas, undercutting our agricultural food base and creating imbalances between a few large cities and the rural areas. National Development Plans should place more emphasis on the development of the rural areas, their villages and service towns, leading as far as possible to self-reliant regional groupings. For effecting this, locally based teams working within regional development projects should act on the following closely inter-related levels:

1. Research Experimentation and Development work on local building resources—materials, technologies and skills.
2. Training of local builders to develop a cadre capable of implementing most building projects independent of extra-regional professionals and contractors.

3. Stimulation of local building materials industries, such as quality-controlled mud-brick yards, and brick and lime industries, to make regions largely self-sufficient in materials.
4. Construction of essential buildings such as schools, clinics, houses and village baths in a way that demonstrates the use of indigenous technologies, and training local builders during the construction.
5. Plan for the growth of the major settlements of the regions, demonstrating how settlements can grow in continuity with its indigenous settlement pattern, as well as develop on traditional planning methods.

The one fundamental principle underlying these proposals is that the local people, such as the local builders, are often both the best sources of information and the most effective implementors. The extra-regional cadres can best act as temporary catalysts.

Mud-Brick Vault and Dome Technology. Here mud-brick vault and dome technology is being presented as an indigenous technology with particular potential in low-cost housing for developing and sharing between various developing countries.

The mud-brick vault and dome system evolved centuries ago in countries like Iran. Their invention came about largly out of necessity in hot-dry semi-arid regions, where roof spanning materials such as timber and reeds became more and more scarce as populations grew. Although mud-brick building reached an extremely sophisticated level, in public and domestic architecture alike, it has in more recent times been neglected in favour of building methods from the West which are automatically assumed superior. Interest in mud-brick developed again in the late 40's and 50's and can be seen in the work of Hassan Fathy in his Gourna village in Upper Egypt, and in research on alternative cements carried out by building stations, particularly in India.

When looking at the climatic performance of buildings made of mud-brick and those made of concrete, the advantages of the former are obvious. Mud-bricks' high resistance to heat flow and the thickness of a mud-brick building's walls ensure that interiors of houses are insulated from extremes of heat and cold. Similar structures of concrete tend to heat up excessively due to solar radiation and will require expensive mechanical air conditioning to achieve comfortable condition within.

Hassan Fathy[14], the famous Egyptian architect, and the Development Workshop have drawn attention to the particular suitability of the mud-brick vault and dome construction to the environment of the

Middle East and Iran. The Development Workshop have summarised their view as follows:

> "Sundried brick is probably the most widely available and commonly used building material in the Third World....Mud-brick's basic economy is undeniable. It is an ideal material in hot regions, being an excellent heat insulator. Its plastic qualities make construction of sophisticated forms relatively simple. No where is this more apparent than in the Vault and Dome technology. In regions such as Iran and Egypt where timber and other organic materials are scarce, this technology has been developed to a high degree and is capable of spanning all kinds of spaces. Not only could Vault and Dome continue to be applicable in such regions, but it could also be applicable in other regions that are now facing timber shortages"[15].

Equally they have shown that layout of the indigenous household, village and town is appropriate to climatic conditions—in particular the use of the courtyard surrounding a pool of water in the design of the house and the narrow walkways and passages set upon a north-south axis provide considerable protection from the severe heat.

The resistance to heat transfer across the roof of the modern house is less than a quarter of that of the traditional structure. This implies that, given the same temperature differential across the roof, more than four times more heat will escape through a given area of the roof of the modern building than will escape through the same area of the traditional roof. This is in spite of the fact that average roof thicknesses were identical in both cases. The calculated differences result from two factors. First, the thermal conductivity of the clay-straw mixture of the traditional roof. And secondly, no insulation layer, other than the inherent insulating value of the masonry material itself, has been incorporated into the modern roof structure. An insulation layer of 4 cm of small twigs has been included in the traditional roof.

There are nevertheless certain limitations to be borne in mind. Firstly, in certain cases there are distinct limits to the extent to which the vernacular architecture is appropriate to the prevailing climatic conditions. Certain vernacular architecture of Hadadan being a case in point.

Secondly, the modern community or house provides—or is seen to provide—facilities and amenities which were often not provided by the indigenous house and community. Many of the facilities which are expected of modern housing are based upon modern patterns of energy consumption.

Thirdly, in addition to the amenities provided by the modern house, the desirability of the latter is also a twofold product of fashion and the availability of the necessary building materials.

As one answer to these, the A. T. D. O. in Pakistan are experimenting with pre-fabricated components for low-cost designs of small houses.

(b) *Indigenous Products as Pesticides*

Most chemicals used for agricultural pest control have been selected on the basis of optimum effectiveness and maximum persistence. Relatively little thought has been given to their safety or selectivity with regard to higher animals or humans and to the ultimate quality of the environment. Therefore, it is not surprising to discover that DDT and many other pesticides are affecting the chromosomes, and cell divison of the non-target organisms. The severe criticism and public awareness about the use of pesticides proves that safety should be included in screening programmes.

We need to know much more than is known today concerning pesticides. I share the concern for the hazards of the modern pesticides but not the hysteria of those who demand an absolute prohibition against the use of our leading pesticides, before an acceptable substitute is available. However, this necessity should not be a license for irresponsible application of pesticides.

The human population, specially those of the ancient world and among these, natives living in less disturbed communities carry a rich source of information for rediscoveries. I intentionally use the term of rediscovery, because I mean the search for finding the facts already discovered by natives. In an isolated tribe of Fars Province, the vaccination against smallpox was practised by old women of the tribe, showing that this information has been probably inherited before the beginning of the history of vaccination started by Edward Jener in 1976. Or at least has been invented independently. It is now clear that natives have directly helped the discovery of Pyrethrins, Resperpine, Rotenone, Aspirin, Quinine, Emetine, Ephedrine, Nicotine, and many other chemicals.

It took man over 500,000 years to accumulate a valuable collection of information, for improvement of his life; whereas, by application of scientific methods, it will take comparatively a very short time to evaluate his previous information.

Presently, the discovery of pesticides is random. It takes about 10 years with a cost of several million dollars to discover few pesticides out of some 10,000 candidate chemicals. Whereas, appropriate selection of historic drugs will reduce the cost, the time, and will increase the chance for success. In addition, the history also provides landmarks for selection of safe products. The preliminary selection may be made through the old medicinal books, direct communication with natives and search on the meanings of the names. Names such as Typhoid Flower, Wormwood, Wormseed, Wormgrass, Fly killer, and Louse Grass are few examples of the latter.

Several examples of our investigations revealed that indigenous drugs may be screened as candidate pesticides. These are only a few the only nematicides and insecticides that safely can be taken into our digestive system. Therefore, further studies on these products and similar drugs may throw light on the solution of the pesticide pollution resulted from modern technology.

(*c*) *Appropriate Technologies in Pakistan*

In Pakistan, the concept of small-scale technologies and appropriate technologies has been sponsored both by the Appropriate Technology Organization (ATDO) and by the Pakistan Council of Scientific and Industrial Research (PCSIR). The A. T. D. O. has several projects in operation, of which the more significant ones are listed below:

(*i*) Cottage match industry.
(*ii*) Fertilizer and gas from gobar.
(*iii*) "Nay-Fishar" screw-type sugar-cane juice extraction machine.
(*iv*) Dehydration of fruits and vegetables.
(*v*) Utilization of mazri fibre.
(*vi*) Construction of low-cost housing.
(*vii*) Wind mill (for lifting water for irrigation).
(*viii*) Pancharkhi hydel water-wheel generators for rural use.
(*ix*) Pelton wheel for rural areas.
(*x*) Simple turbine on Bankis principle for mini and micro-hydel units.
(*xi*) Under-soil "pitcher" irrigation.

Some of the above processes/industries, notably cottage match industry, gobar-gas plants, improved sugarcane crusher, low-cost housing, windmills and the electrical power units for rural areas have already passed the acceptability trials, and it remains to proliferate these. A brief socio-economic analysis of two of these is given below:

(*a*) *Hand Made Match Unit-Cost of Production*

Per unit-cost based on 50 gross match boxes per day capacity:

		Minimum	Maximum
		Rs.	Rs.
1. Fixed Cost		5,500.00	5,500.00
(exclusive of peeling and cutting machines)	Splints	170.00	180.00
2. Running cost (50 gr. per day) without duty.	Chemicals	140.00	150.00
	Boxes	280.00	280.00
	Misc.	200.00	222.05
		790.00	832.05
3. Assuming that the equipment will last for 10 years and spreading the fixed cost over 10 years the annual cost is:		895.40	895.40
4. Fixed cost per day		2.45	2.45
Total Production cost without duty		792.45	834.50
5. Duty		100.00	100.00
6. Total production cost with duty		892.55	934.50
7. Per unit cost with duty		17.80	18.69
		Per gross	Year gross
		0.123	0.129
		(per match box)	

The manpower required for producing 50 gross match-boxes per day is 15 part-time workers or 8 full-time workers, thus giving a capital cost of Rs. 700 per work place.

(*b*) *Micro Hydel Plant at Lillowni*

1. Capacity of re-conditioned generator		12.5 KVA
		Rs.
2. Fixed investment		
(*a*) Generator and turbine	ATDO	5,500.00
(*b*) Transportation, TA/DA etc.	ATDO	3,000.00
(*c*) Penstock, channel excavation construction etc.		5,000.00
(*d*) Pulleys, distribution, wires, poles, switch-boards etc.		2,000.00
	Total	15,500.00

	Rs.
3. Annual equivalent cost ($i = 13\%$ life $= 10$ yrs.)	2,850.00
4. Running cost (annual)	
(*a*) Belt (replaced in two years; total length 50 ft.) @ Rs. 15/- per ft.	375.00
(*b*) Oiling/greasing	180.00
(*c*) Labour (one man hour per day) @ Rs. 15/- per day.	440.00
(*d*) Miscellaneous repairs etc.	100.00
Total	1,095.00
5. Annual cost 2,850.00 + 1,095.00	3,945.00
6. Output at 50% efficiency (200 bulbs of 25 to 40 watts for four hrs.)	24,000 wh
7. Yearly watt hour	$24{,}000 \times 365 = 8{,}760{,}000$ wh
8. Cost per Kwh $\frac{3{,}945}{8{,}760}$ = Rs. 0.45	8,760 wh

The rate of electricity supplied by the WAPDA in cities is Rs. 0.22 to 0.30 per Kwh.

Due to inaccessibility of areas, where micro hydel stations are installed the linkage with main network of electricity supply will be an extremely costly affair and accordingly the cost per Kwh will increase many folds. Therefore the supply of electricity to these areas at the rate of Rs. 0.45 per Kwh is justified.

The supply of electricity will enable the local folk to utilize their maximum time for productive work.

PCSIR in its effort to ensure commercial utilization of research results has made some valuable contributions in the development of appropriate levels of technology.

About 200 processes[6] developed and leased out by PCSIR are in commercial production. Their annual turnover has been estimated to be around Rupees 30 million in local currency and around 20 millions in foreign currency.

These processes may be categorised as follows:

Category I	Processes Resulting from Mission-Oriented Background Research—48 Processes.
Category II	Import Substitution/Products developed on request—76 Processes.
Category III	Small Scale Processes and Indigenous Technologies—74 Processes.

Some Examples of PCSIR Processes are:—

1. A foot operated spinning machine for wool

A foot operated spinning machine for spinning indigenous wool, developed by PCSIR has been found particularly suitable for adoption of the village-scale industrial level units. The machine costs about $ 35.00. The thread produced is of uniform quality depending upon the skill of the operator.

2. Pile carpet machine

In order to overcome this handicap a pile carpet machine has been fabricated which can produce pile carpets of all sorts at a cost which is 1/5th that of machine made carpet. No skill is required to use the machine. A carpet of 4′ × 6′ size can be produced in three days.

3. Silica gel plant

Silica gel is used for a variety of purposes. The plant available for its production for developed countries is very large and a day's production exceeds the yearly requirements of a developing country. A simple plant of 125 lbs. per day capacity was designed and fabricated locally and production of silica gel according to the standard specifications was undertaken. 10 tons of silica gel were produced and sold before leasing out the process as well as the plant to a local industrialist.

4. Fire fighting foam compound

This is an example of intermediate technology process developed from local raw materials to produce a product comparable to the one produced by sophisticated technology. The production started with pots and pans and produced chemicals worth several million rupees. The plant is in production for the last 12 years.

5. Production of paddy husk cement

The utilization of agro-industrial by-products is essential for national economy. About one million tons of paddy husk remain unutilised every year. The PCSIR Cement Group has successfully produced cement from the paddy husk ash. The method of production is very simple and unskilled villagers can be trained for making cement for the local requirement. The villagers can easily pool their own resources and set up a sizeable plant for the production of this cement. The cost of this cement is about 40% of the factory made portland cement.

9. The Future Course of Appropriate Technology

From the foregoing presentation, it will be seen that appropriate technologies offer many advantages in the future balanced growth of the economies of the developing countries. Many of the basic ideas underlying the appropriate technology concept have a great deal in common with the fundamental concepts of simple living, self-reliance and faith in ones' tradition that are more or less central to the religious and cultural background of the Muslims. As such, the Muslim countries should find a natural sympathy for the appropriate technology approach to development, as against the highly capital-intensive, energy-intensive, environment-degrading, sophisticated high technologies that are often put forth by the developed countries of the world. And mutual collaboration will bring sophistication within easy reach as indicated on p. 61.

Of course, it should be remembered that technology is not contrary to human values. To quote from Melvin Krausberg:

"I do not believe that technology is contrary to human values, because technology is a very human activity. Indeed, according to the anthropologists, what helped change us, really, from almost—man to man was technology: man made tools, but tools, also made man. We now realize that we could not have become homo-sapiens —at the same time. So technology, far from being anti-human, is a very, very human activity, and indeed, according to our anthropologists and biologists and psychologists, it is one of the earliest of man's cultural characteristics. It helped man become man". "Let me point out that technology is not only a basic form of human activity, but it (also) involves human creativity, human imagination, human ingenuity. You know, we find that in antiquity, the craftsperson and the artists, were exactly the same person. Indeed the word 'technology' is very modern. Until half a century ago, much of what we call engineering today was referred to as 'the technical arts' or 'the mechanical arts' or simply 'the arts'—as distinguished from what later came to be called 'the fine arts'. Now, technology has contributed to the arts in many different ways. For one thing, it was first a medium for the arts. The artist uses what technology provides him; clay for pots and so forth. Nowadays, of course, there has been great expansion of what the artist can use for materials, because of the advances of technology".

He further comments: "Nowadays, there are certain dull, routine, stupefying tasks which the machine continues to take over. The old assembly line is no longer what it used to be. The workers, for one thing, move around from one job to another. Many of the hard tasks have taken over by machines, and so the worker gets new satisfactions. Then, lots of things which we used to call 'white-collar' tasks—office clerical tasks, and these are boring and routine and stultifying to the human mind—these are being taken over by computers".

Thus technology when properly applied can give man more opportunities for development as a human being. One may venture to guess that, as the developing Muslim countries become more and more conscious of scientific soundness of their cultural heritage, so will they develop technological self-reliance as a more or less natural consequence. This, coupled with a properly integrated strategy of technical education and cultural motivation, can provide the intellectual and technical environment necessary for major scientific and technological progress of these nations. Of course the application of science and technology does not automatically benefit all groups in a nation equally, and disparities in standards of living can be accentuated by unbalanced technological development. The basic concept of Appropriate Technology ensure that the application of S & T will benefit all sections of the people in a fair and equitable manner.

"خيرالناس من ينفع الناس"

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