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SYSTEMATIC APPROACHES TO APPROPRIATE TECHNOLOGY

Background Paper

SYSTEMATIC APPROACHES TO APPROPRIATE TECHNOLOGY

Ross W. Hammond

What is being called appropriate technology these days is an activity which has been going on since man first invented the wheel. It has been conducted in the villages of the world, in the urban centers, in the backyards of entrepreneurs, and in laboratories and machine shops of industries and research institutes, wherever the analytical capabilities and ingenuity of human beings could be applied to problem solving.

For the purpose of this paper, appropriate technology is defined as "that level of technology best suited to solving an identified problem or satisfying a perceived need, taking into consideration the social, cultural and economic environment where the technology is to be used."

What appropriate technology lacked during all these centuries was (1) a name, (2) a systematic approach, and (3) a missionary advocate. The most commonly accepted name these days is appropriate technology, although one frequently hears intermediate technology, adaptive technology, light capital technology, and a variety of similar names. They all appear to be virtually synonymous, although the purist will argue the subtle differences between the terms.

With the acceptance of the name "appropriate technology," a body of literature has emerged and some organizations exist which attempt to place AT activities in a systematic framework of research and development.

The missionary advocate who emerged as a champion of appropriate technology was, of course, E. F. Schumacher, an English economist who wrote a widely read book, Small Is Beautiful. In the book Schumacher wrote about the need to "humanize" man's activity by reducing the scale of man's enterprises and to consider that many small-scale activities may have more merit than a few giant enterprises, especially in the context of social and cultural values. Because the book is philosophical in tone, it tends to lend a certain "mystique" to appropriate technology.

In utilizing appropriate technology to deal with real-world problems, however, the essence of the approach is simplicity and practicality, and this provides ample opportunity to exercise innovative talents in a systematic manner.

The characteristics of appropriate technology are well known and have been documented in a number of publications. While some differences appear among writers, most agree on the following characteristics:

1. Appropriate technologies are generally low-cost and labor-intensive in manufacture and usage. Hence, such technologies are particularly important in the developing countries, where capital is limited and labor is abundant.

2. Technology is seldom directly transferable without adaptation to suit different social, cultural, economic, and other conditions.

3. To the maximum extent possible, appropriate technology utilizes locally available materials, resources, and manpower. This is especially important in the developing countries because foreign exchange for imports is generally in short supply and imports are frequently more expensive.

4. Appropriate technology should encourage and stimulate indigenous initiative and innovation. It is not sufficient to buy and transfer technology without incorporating features which will build local capability to adapt and manufacture the technology.

5. Logistical support systems, such as maintenance services and spare parts availability, are essential to the successful utilization of appropriate technology.

Perhaps the characteristics can best be illustrated by a series of slides which show varied examples of appropriate technology from around the world.

SLIDE PRESENTATION

A Systematic Approach to AT Design and Utilization

In the course of working in the appropriate technology field over a period of years, a simple seven-step methodology has been evolved at Georgia Tech.

Steps in Appropriate Technology Research

1. Problem and Need Identification. The selection of appropriate technology must be preceded by recognition of a problem or need. In Georgia, for example, the burning of peanut shells in open incinerators was adding to air pollution. This was a recognized problem and the need was to find some way to utilize these shells in a non-polluting manner.

2. Available Alternative Technologies and Resources. Some determination of the technologies which are known and, hence, available must be made in the light of the available materials and resources.

There are many ways to build a factory chimney and a number of different materials which can be utilized. The Koreans in Yeungdongpo Industrial Estates in Seoul, Republic of Korea, chose to utilize a locally available material, stacked empty oil drums, for this purpose. Thus, it is a cost-effective appropriate technology for that environment.

3. Analysis. Analysis of the various alternative technologies which may be available to solve a recognized problem is essential. The analysis for a developing country must consider educational, social, cultural, economic, infrastructure and political aspects to the maximum extent possible.

Lower labor costs in developing countries greatly influence the choice of technologies, skewing the selection to more labor-intensive alternatives.

National plans, with their varying emphases, have a bearing on the selection of appropriate technologies. The level of education and skills of the available manpower resources obviously impacts on technology selection.

These and many other factors must be considered in the analysis phase.

4. Design, Including Adaptation. Technology from the developed world usually requires modification, adaptation or redesign when utilized in the developing countries. This is especially true in the small industry sector.

The IRRI[1/] rice machinery, designed for wetland farming, must be modified for upland rice farming. The $5,000 tensile strength tester must be scaled down, sacrificing accuracy or other characteristics to provide a low-cost unit. The tire retreading casing was modified by material substitution.

Design, redesign, modification, or adaptation of technology becomes an extremely important phase of the selection and utilization of appropriate technology.

5. Prototype Development. When modification and adaptation take place, the question must then be asked, "Will it work?" To answer this question, it usually is necessary to build a prototype and to analyze its operating characteristics and performance.

The Tech counterpart in Korea, Soong Jun University, has built several different prototypes of a "cheegay" (or backpack) on wheels to determine the most appropriate application.

6. Testing, Evaluation, Modification. The prototype must be subjected to testing and evaluation. Modifications and adaptations, however small they may be, can significantly alter the capabilities and performances of the technology.

Hence, prototypes with built-in modifications or adaptations require field testing and evaluation under real or simulated use conditions.

1/ The International Rice Research Institute

Frequently, such field testing reveals operating problems which may occasion additional modification or adaptation.

7. Replication (Manufacture). When analysis indicates that the prototype has been debugged and appears commercially feasible, the final step may include the encouragement of manufacture of the prototype in sufficient volume to supply the market needs.

This may involve the creation of a new venture for the specific purpose of manufacturing the appropriate technology, but more usually, it would involve interesting existing manufacturers in adding the prototype as a new product. The manufacturers, in turn, may adapt and modify the equipment in accordance with the specific needs of their customers.

An example of this process can be seen in the Philippines. A number of existing Philippine manufacturers used and sometimes adapted IRRI rice machinery designs to build more than 16,000 units last year, mostly for the domestic market.

It is, of course, desirable to develop and utilize appropriate technology which may have widespread applicability. This is not always an attainable goal in the industrial sector, where problem solving through appropriate technology is frequently location-specific, and process- or product-specific. In such cases, widespread applications may not be possible.

This procedure is not exactly innovative, but merely a systematic approach to the selection and adaptation of technology. Let me illustrate the process with two case histories drawn from the Georgia Tech experience.

Case History #1: Manually Operated Water Pump

One of the developing country needs which has been recognized for a number of years is for a low-cost, low-maintenance, manually operated water pump. Most developing countries do not have piped water systems except in urban areas, and the majority of the population must rely on surface water (rivers and streams) or groundwater from open wells. Both of these sources of water frequently are contaminated, causing intestinal problems of various kinds and contributing to shortened life spans for developing country populations. Moreover, where wells do not presently exist, those who procure water for household purposes (usually women) sometimes have to walk miles to and from the nearest surface water source with containers of water. This time-consuming activity can be eased by the drilling of wells and installation of pumps.

To give some measure of the need, let me cite statistics from a few countries. The Ministry of Health in Costa Rica estimates the present needs of that small country to be 47,000 additional pumps. Pakistan is planning a program to install 110,000 pumps. Bangladesh is in the process of installing 400,000 pumps. In Africa, many countries have need for large numbers of pumps.

U.S. AID contracted with Battelle Memorial Institute about 12 years ago to design a low-cost, low-maintenance pump (both shallow- and deep-well) -- one which could hold up under usage by 1,000 people a day. This is a much greater usage than the farmyard pump that many of us in the U.S. recall from our earlier years. Battelle studied the situation and came up with a design which seemed to be suited to such usage. In a limited field test in Nigeria, Bangladesh, and elsewhere, it became obvious that design changes were needed and a more extensive field test needed.

Utilizing the latest design drawings of the AID pump, Georgia Tech undertook a field test program to see if the pump could be successfully manufactured in developing countries, to install the AID pumps and available competitive pumps at rural well locations, and to compare the relative economics and performance of the AID pump and the competitive pumps. Costa Rica and Nicaragua were chosen as the locations for this field test.

The first step was to identify foundries and machine shops in both countries which appeared to be capable of pump manufacture. This was done successfully, and short production runs of 20 pumps were produced in both Nicaragua and Costa Rica.

In general, the quality was good, although later a few problems developed in the pumps which had to be dealt with. A couple of the handles broke because of imperfect castings and had to be replaced. The cap of the deep-well pump had to be redesigned to suit the foundry capabilities. The leather cups were cut oversize by a manufacturer and had to be more accurately made to prevent rapid and excessive wear.

Thirty locally available competing pumps were purchased. These included pumps from Japan, Brazil, Canada, and the United States.

Working with the Ministries of Health in both countries, 60 rural wells were identified to be used in the field test. These were open wells for the most part, in use for some time by the nearby residents. When the wells were inspected and the water tested, every well, without exception, was found to contain contaminated water. All wells had to be treated with chlorine to purify the water.

With the assistance of Ministry and ICAITI personnel (the Tech counterpart organization in Central America), the local people were encouraged to build concrete aprons around the wells and the concrete superstructure to hold the pumps. The apron, which extends 8-10 feet from the well proper, is designed to prevent spillage water from running directly back into the well and recontaminating the water. Periodically the well water is analyzed for contamination.

After some 12 months of monitoring, it appears that the AID pump is performing very well, requires little maintenance, and is cost effective compared with the competitive pumps. Additional orders for the pump and spare parts are being received by the manufacturers. Pump manufacturing programs are being considered by a number of other countries as a result of the perceived needs for such appropriate technologies.

Most of the steps in the seven-step methodology were followed in this program, including adaptation of the basic design, testing, evaluation, modification, and manufacturing.

Case History #2. Pyrolysis of Agricultural and Wood Wastes

About seven years ago, Georgia Tech began research on pyrolysis of agricultural and wood wastes into alternative sources of energy -- charcoal, oil, and gas. This research was originally occasioned by the need to stop the air pollution caused by burning of peanut shells in open incinerators and to find some alternative way to utilize this agricultural waste.

A process was developed, and several prototypes were built on campus. The advent of the energy crisis and the resultant drive to find alternative sources of energy accelerated research in biomass conversion. It was found that the prototype units could be used with all sorts of agricultural wastes (cotton gin waste, coffee bean hulls, etc.). The char, oil, and off-gas produced could be used as fuels, substituting for oil and gas in various ways.

This highly automated process was licensed to a company, Tech-Air, which was subsequently acquired by American Can Company. A commercial unit with a capacity of 50 tons a day of raw material was built at a sawmill in Cordele, Georgia. This plant which utilizes the sawdust from the mill, has been operating successfully for a number of years, providing substantial quantities of charcoal and pyrolytic oil, and an off-gas which is burned to dry out additional sawdust for insertion in the system.

In a global sense, most developing countries are feeling the impact of the increase in oil prices greatly and have little foreign exchange to meet these costs. There is a great interest in alternative sources of energy.

In 1975, AID contracted with Tech to look at the feasibility of designing a simple, labor-intensive pyrolysis system for use in Ghana. The study indicated the availability of sufficient raw materials and markets for the energy products.

With the need for alternative energy sources well established, a lower level of pyrolysis technology than the push-button, highly automated system licensed to American Can was required.

A new pyrolysis system was designed, keeping in mind the elements of labor intensity, economy, simplicity, and feasibility of manufacture in a developing country. This analytical and design phase was part of a follow-on demonstration project in Ghana which entailed the construction and testing of a unit there.

While some components (blowers, motors, etc.) had to be purchased in the U.S., the fabrication and construction of the unit was done in Ghana, supervised by Georgia Tech engineers who worked closely with the University of Science and Technology, a Tech counterpart institution.

The construction phase was not without its difficulties, even though all concerned realized that the unit was experimental in nature. Ghana's economy is plagued by a rampant inflation, amounting to 12½% a month. or 150% per year. This invalidated all earlier estimates of cost and operational economies, and made additional project funding necessary. In addition, Ghana at present is beset with shortages of all kinds, especially materials and equipment. A special trip to a steel mill and considerable governmental pressure were required to get an early release of steel needed for the unit. Cement for the concrete pad was not available and had to be purchased in a nearby country and trucked in. And there always is the problem that in the absence of the field engineer, the fabrication and assembly work slows down noticeably.

The first of four similar units was built, tested, evaluated, and modified to obtain the optimum design. Significant technical innovations were introduced to make this scaled-down unit perform acceptably. Then the other units were built, incorporating field modifications made in the first unit. These units are presently being installed in a plant built expressly for the pyrolysis process.

This procedure may be followed by a program of manufacture of units for village use to produce alternative fuel products which can reduce the demand for petroleum products and wood.

Some idea of the potential for conversion of wastes by pyrolysis can be seen from the actual volumes of various kinds of waste produced. Table A shows the annual waste volumes for three countries (Ghana, Indonesia, and the Philippines) in which such analyses have been undertaken. The tonnages of agricultural and wood wastes are large. Obviously, not all of these wastes could be used in pyrolysis since a proportion of the wastes presently are used for other purposes. However, approximately 40%-60% of the listed wastes are available in most countries for conversion to alternative sources of energy. Many countries have unused agricultural and wood wastes of comparable magnitude.

In this case history the entire seven-step methodology is being followed from the identification of the problem, through consideration of alternative technologies, design of technology, building of a prototype, testing, evaluation, and modification and replication of the design.

Table A

AGRICULTURAL AND WOOD WASTES

Waste Materials	Metric Tons (Annual)		
	Ghana 1/	Indonesia 2/	Philippines 3/
Rice Hulls	--	--	1,355,775
Rice hulls & straw	465,930	5,700,000	--
Rice straw	--	--	15,089,775
Coconut shells & husks	617,760	2,400,000	6,872,750
Bagasse	N.A.	3,100,000	16,679,195
Sawdust	22,950	1,100,000	N.A.
Logging wastes	362,700	1,400,000	N.A.
Oil palm wastes	20,520	1,500,000	N.A.
Rubber wastes	N.A.	1,900,000	N.A.

1/ All data in green tons (50% moisture). If converted by pyrolysis, the energy value of the energy products would equal all Ghanain energy requirements.

2/ All data in green tons (50% moisture). If all available wastes were converted by pyrolysis, resultant products could supply 15% of Indonesia's total energy needs.

3/ The energy equivalent of listed Philippine wastes is 71,000,000 barrels of oil annually.

Source: From three separate and independent studies. Ghana and Indonesia analyses by Georgia Tech. Philippines data by the Philippine Ministry of Energy.

Engineering Implications

The role the engineer can play in the previously described process is apparent. The engineer can function in each of the seven steps mentioned earlier. Particularly important, however, are steps that involve engineering analysis, design, adaptation, testing, evaluation, modification, and manufacture.

Most U.S.-trained engineers are accustomed to automating processes to reduce the labor component. This generally increases the capital cost component.

Suppose, then, the engineer is forced to consider economies where the cost of labor is a fraction of the U.S. costs and where capital is scarce and foreign exchange for imported equipment and machinery is in short supply. The challenge in such circumstances (found in most developing countries) is to build smaller technologies, more labor-intensive technologies, and, above all, less-costly technologies, which permit the utilization of locally available resources and materials. The scaling-down of technologies is a demanding technical activity, for the scaled-down version must be as efficient as the larger, more sophisticated technologies in order not to lose the economies of scale associated with larger units.

Recent U.S. Developments in the Appropriate Technology Field

Not every U.S. engineering institution should be involved in foreign assistance programs such as appropriate technology. This was one of the conclusions of a National Academy of Sciences panel which prepared a report on "The Role of U.S. Engineering Schools in Development Assistance." In foreign assistance, the funding sources are relatively few and the funds insufficient to finance every conceivable program. Moreover, many institutions do not perceive development assistance as part of their missions. In other institutions, the motivation to work in this field and the institutional commitment may not exist.

Notwithstanding the above, a large number of educational institutions and other organizations have evinced an interest in the appropriate technology field. Two of the indications of this are the proliferation of conferences, seminars, and workshops on aspects of AT and the constantly and rapidly increasing body of literature, periodicals, newsletters, etc.

U.S. AID has funded appropriate technology projects over the years in many developing countries. These programs were not called appropriate technology, until the increasing popularity and more universal acceptance of the term occurred.

As a result of the interest in appropriate technology, a number of U.S. initiatives have developed.

The U.S. Congress, in amending the Foreign Aid Bill in 1975, inserted a new section on intermediate technology (Section 107). This states very succinctly: "Of the funds made available to carry out this chapter for the fiscal years 1976, 1977 and 1978, a total of $20,000,000 may be used for activities in the field of intermediate technology through grants in support of an expanded and coordinated private effort to promote the development and dissemination of technologies appropriate for developing nations." Congressman Clarence Long of Maryland and some of his colleagues in the House and Senate were responsible for this new congressional initiative.

U.S. AID then set about establishing the mechanism to carry out this legislation. After many public hearings and evolution of concepts and approaches, a separate corporate entity was established -- Appropriate Technology International -- and a board of directors elected. An executive director and small staff have been employed, and ATI is getting organized to carry out the congressional mandate. The first million dollars have been provided by ATI for organizational purposes.

In parallel to this effort, a National Center for Appropriate Technology (NCAT) was established in Butte, Montana. This center is national in scope and aims at problem solving in the domestic areas of rising costs of energy, increasing shortages of nonrenewable energy resources, and the need for individuals and communities to become self-reliant and self-sufficient.

These embryonic efforts have yet to achieve their full potential, and it is hoped that both ATI and NCAT will ultimately fund meaningful appropriate technology efforts both internationally and domestically.

These activities have resulted in a greatly increased interest in appropriate technology in the U.S. and elsewhere. AID is mounting appropriate technology projects of some magnitude in a number of countries. International lending and development organizations such as ADB and the World Bank are emphasizing this field of human endeavor as well. Practitioners in AT are multiplying, AT meetings are numerous, and a considerable body of literature is developing.

Congressman Long and others in Congress are still concerned with appropriate or intermediate technology, although calling it in recent months "light capital technology." There is some indication that the U.S. may propose one or more initiatives in this area at the UNCSTD Conference in 1979. I anticipate that other nations may call for AT activity as well.

There is no question that appropriate technology as a development concept has arrived. One must realize, however, that it is but one facet of a very complex developmental strategy needed to cope with the problems of the developing countries. There is no simple, easy answer to development problems -- appropriate technology approaches can help, but they are not a panacea for the world's ills.

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