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ABSTRACT

A product of the National Science Foundation's Program on Appropriate Technology, this paper discusses and presents an agenda for research on questions relating to technological innovation and the objectives of appropriate technology. The concept of appropriate technology is defined, the contrast between appropriate technology and current industrial technologies is outlined, and the institutional mechanisms in the American economy occupying the middle ground between appropriate technology and the practices of industrial technology are described. Innovation and its role in the appropriate technology context are then considered and the contrasts between appropriate technology innovation and industrial innovation are reviewed. Problems facing appropriate technology innovation are also addressed, and an examination of the various perspectives for understanding appropriate technology innovation (i.e., research and development, social interaction, problem solving, linkage, implementation, and delivery systems) are summarized. The four major categories for research on appropriate technology are then presented and discussed: (1) national appropriate technology issues, (2) federal appropriate technology programs, (3) innovation in appropriate technology businesses, and (4) use of appropriate technology. Three tables and three figures accompany the text. (Author/JL)

Exhibit 3

CONTRASTING APPROPRIATE TECHNOLOGY AND TRADITIONAL INNOVATION PROCESSES

Dimension	AT	Industrial
Motivation	Tech push/social concern	Market pull/profit/war
Key phase of process	Tech feasibility	Commercialization
Performers	Individuals/small businesses	Small business/large corporation
Money sources	Equity	Debt Tax writeoffs
Need for success	Diversity/Interest	Uniformity/predictability
Paradigm	Economies of household/community	Economies of scale
Relation to economy	Insensitive to cycles	Sensitive to business cycle
Time required to innovate	Short gestation	Long gestation
Source for ideas	Individuals	R & D labs
Selection criteria	Informal/trial and error	Formal/bureaucratic procedure
Dissemination/propagation	Each one-teach one Journals (hobbyist)	Professional societies Licensing
Criteria of success	Successful operation at any scale General societal benefit	Widespread adoption and resulting return on investment Profit
Cause for failure	Loss of interest Lack of local support Lack of information Lack of resources Lack of experience	Failure to capture sufficient market share. Macro economic fluctuations
Knowledge base	Craft knowledge Science of the concrete	Scientific Abstract science
Participation	Understood by all Science and technology by all	Complex/highly specialized Elite science and technology
Structure of technology	Self-sufficient small units	Small dependent on big
Relation to worker	Work and leisure flow together	Work/leisure have sharp distinction

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Innovation in Appropriate Technology: Directions for Policy Research

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In recent years the phenomenon denoted by the term "appropriate technology" (A.T.) has become increasingly widespread—in energy, farming, housing, community development, communications, and other areas. In response to this growth, the National Science Foundation sponsored the development of a research agenda on the roles and impacts of A.T. on the society, economy, and technology development. This paper reports one element of this research agenda—questions surrounding innovation and appropriate technology.

I. INTRODUCTION

A key element of the N.S.F. February 1979[1] Program Plan on Appropriate Technology (A.T.) is research on the roles of A.T. and its impacts on society, the economy and technological developments. The N.S.F. plan points out that appropriate technology may have such important implications for economic and social structure in the United States that its long-run advantages and disadvantages should be studied now.

The specific goals of the N.S.F. A.T. program are:

- to strengthen the science base needed to identify and develop promising appropriate technologies which have the potential for generalization beyond the initial application and which fall outside the responsibility or interest of mission agencies.

- to improve the understanding of appropriate technology as a concept in the development of science and technology and to better understand its role and impact on the U.S. society and economy.

This paper describes a research plan on A.T. innovation developed for N.S.F. by J.F. Coates, Inc. The innovation research plan is part of a larger research plan developed by J.F. Coates, Inc. on the socio-economic and technological implications of appropriate technology.* The overall plan has three elements:

- social and economic implications of appropriate technology

- the role of appropriate technology in technological innovation

- manpower and training issues of appropriate technology.

Several broad considerations guided the development of the plan. First, it had to be research. Second, it could not overlap the functions of the more mission-oriented agencies. And third, it must be compatible with the traditional functions and objectives of the National Science Foundation.

Our strategy for determining a useful and sound research agenda depended upon exploring the meanings of appropriate technology, in contrast and as a complement to traditional views of technology in the industrialized American economy. The contrast -- between the objectives of appropriate technology and the current structure, goals, and practices of the industrial systems dominant in the United States -- reveals crucial choices and uncertainties subject to clarification by research. Specifically, examining the contrast between the extreme objectives of appropriate technology as an ideological movement, and the implicit and explicit principles of the dominant industrial, technological system reveals mid-range concepts and issues in need of specific research.

1 National Science Foundation, Appropriate Technology: A Program Plan of the National Science Foundation, prepared for the Committee on Science and Technology, U.S. House of Representatives. (Washington, D.C.: National Science Foundation, February 1979).

* J. F. Coates, Inc. A Research Agenda on the Roles and Impacts of Appropriate Technology on the Society,

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II. APPROPRIATE TECHNOLOGY: CLARIFYING THE CONCEPT

A. Definitions

The House Committee on Science and Technology used as a working definition of the concept of appropriate technology:

- "those technologies which are decentralized, which require low capital investment, which are amenable to management by their users, which are in harmony with the environment, and which are conserving of natural resources."[2]

While useful as a general concept and convenient for discussion, the definition is not an adequate basis for a research program to inform public policy. Both its vagueness and its prescriptive bias mask several of the most crucial issues. An earlier definition by the National Science Foundation, by being more precise, has stronger research implications.

> "Appropriate technology is technology which is best suited to the specific local cultural, economic, social and political conditions at the site of application. The design or adaptation of such technology includes an examination of conditions of the site and consideration of several factors normally not identified through the marketplace. Some of these factors include preferences of users for technology which conserves natural resources, is compatible with local labor skills, and which enhances the social and ecological fabric of the site of application. The markets for appropriate technology are varied and widely diffused, and include the small farmer, the small businessman, and the small manufacturer."[3]

Confusion about the concept of appropriate technology is demonstrated by the range of synonyms and near synonyms such as alternative technology, intermediate technology, self-sufficiency, self-sustaining communities, self-reliance, self-help, the soft path, and voluntary simplicity. Langdon Winner has pointed out that implicit in these kinds of definitions is the suggestion that there is "a realm of customary understanding in which judgment about right and wrong are made as a matter of course."[4] He goes on:

> "It is precisely that sense of subtle customary distinction and evaluation that twentieth century understandings of technology lack. Our adherence to the terms of the technological orthodoxy have brought us to see everything in terms of progress, growth, narrowly conceived efficiencies, and the myth of technical neutrality."

For Winner, the first task is clarifying the idea of alternative or appropriate technology. We must be "able to articulate general evaluative notions through which the range of available technological means might once again be reasonably judged."[5] The notion of appropriate must, therefore, go beyond hardware fetishism and the attempt to manipulate hardware and derivatively society through simple changes in size, location, or labor intensity. Appropriate technology must reflect some view of the good life which can be translated into principles and criteria of institutional design.

This same conclusion is captured succinctly by R.C. Desai in a report of the United Nations Industrial Development Organization. While addressing the problems of the developing nations, he nevertheless highlights the universal problems of complexity, balance and social goals when he says that appropriate technology is:

> "that technology which contributes most to the economic, social and environmental objectives of development. Hence what constitutes appropriate technology in a given case is determined by development goals, resources and the economic and social context in which it is to be used. No technology is therefore either appropriate or inappropriate in itself. The appropriateness of a technology is a function of its contribution to development strategy."[6]

Writing also from the perspective of the developing nations, but highlighting a lesson equally applicable to the industrial nations, Colin Norman points out four concerns -- employment, equity, energy, and ecology -- which must be taken into account in the choice of technologies.[7] That accounting would define a more or less appropriate technology.

Nicolas Jequier, now of the OECD, in a World Tech report, (September 1975) sees the concept of appropriate technology going beyond the four E's cited by

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the Economy and Technology Development, prepared for National Science Foundation. (Washington, D.C., J. F. Coates, Inc., August 28, 1980) NTIS #PB81-120073.

2 House of Representatives, Report No. 95-993, 95th Congress, Second Session, Page 23.

3 Evans Rogers and Roberta Ross, Final Report and Proceedings: Midwest Regional Appropriate Technology Forum. Indianapolis, Indiana, October 1978. (For National Science Foundation, document number NSF/RA-79006, Indiana Center for Advanced Research, 1978).

4 Langdon Winner, "The Political Philosophy of Alternative Technology," Technology in Society 1 (1979) 82.

5 Ibid.

6 R.C. Desai, "Industrial Development Strategies and Choice of Appropriate Technology in Developing Countries," Conceptual and Policy Framework for Appropriate Industrial Technology, Monographs on Appropriate Industrial Technology No. 1. (New York United Nations, 1979).

7 Colin Norman, "Soft Technologies, Hard Choices," Worldwatch Paper 2 (Washington; D.C.: Worldwatch Institute, June 1978).

Colin Norman, and also going beyond the question of technical soundness. He adds to these central concerns, adaptation of technology to the social and cultural environment.[8]

B. Contrast Between Appropriate and Current Industrial Technologies

Appropriate technology is a protean term embracing all of the above considerations. The concepts subsumed by appropriate technology are contrasted in Exhibit 1 with the present industrial system of the U.S. and other advanced nations. The exhibit contrasts many of the goals of appropriate technology advocates with the general characteristics and functional elements of the contemporary industrial society. It does not mix analysis and advocacy; it only displays and contrasts what is with what some advocates believe should be. It is organized around the key points in appropriate technology advocacy and therefore omits some characteristics of each system.

A small number of communities, self defined as representing appropriate technology, fit the characterization of appropriate technology in Exhibit 1. The list more nearly represents the aspirations and advocacy of those who would promote more simplified, labor intensive, localized economies and lifestyles. On the other hand, the characteristics of the industrial society may be seen as reflecting the characteristics of the current system. Some see the industrial model as the only appropriate technology for the United States. For some, bigger, better, and faster technology, integrated growth, and fuller exploitation of the environment and resources is the continuing desirable trend. For them consumption and growth are oriented toward the now traditional measures of gross national product and gross domestic product. These extreme differences -- between the advocates of the present industrial system and the advocates of appropriate technology -- make it difficult to directly identify research appropriate to understanding and guiding the further development of the American economy and society. Fortunately, the tension between these polar positions precipitates a small number of core issues around which one can frame useful research.

C. Middle Ground Institutions

Before turning to the researchable issues, it is worth noting the many different kinds of institutional mechanisms in the American economy occupying the middle ground between the objectives of appropriate technology and the practices of the major national or multi-national corporations. These mid-range institutions demonstrate the richness and diversity of our society. From a research point of view, they are a potential test bed on which to study appropriate technology innovation. Twelve mid-range institutions include:

- Barter. This increasingly significant factor in the economy usually involves the exchange of labor or services. Less frequently it involves the exchange of goods for services. Barter avoids the problem of the exchange of cash, such as taxable income, while permitting the persons involved to utilize either their highest skills, for example dentistry exchanged for carpentry, or to use discretionary time for an attractive return.

- Hobbyists. A large percentage of the population engages in self-initiated learning, construction, and craft activities. These are often motivated by aesthetics or the desire to pleasantly use leisure time. In other cases, hobbies simulate the work scene, as with the computer programmer who works with his own micro-computer. In other cases the hobby is semi-economic, such as those who do their own auto repairs or market their craft products or art work. Research on hobbies may be a particularly fruitful approach in understanding the motivations, circumstances and conditions of work, which under other circumstances would be considered employment.

- Do It Yourself. In the decade following World War II the do-it-yourself movement swept America. Too few craftsmen, pent up demand, limited but rising personal income, and high aspirations combined to stimulate millions of people to learn semi-skilled and skilled crafts -- from house painting, to woodwork, masonry, plumbing, and gardening. With continuing prosperity, the do-it-yourself movement went into a decline; but it may be in for a great resurgence, under the dual impetus of inflation and the rising cost of energy.

- Free-Lance Salesman. The Avon lady and the traveling salesman are in many regards examples of autonomy, freedom of choice, independence, and many of the other desirable characteristics sought by the appropriate technology movement. Too frequently these characteristics are absent from industry and the marketplace.

- Independent Authors and Artists. The independent author or artist -- working alone in creative enterprise, with full commitment to work, with sole responsibility for what is done -- is an extreme example of autonomy. The understanding of the economics, the satisfaction, and the life quality of the author is an opportunity to again shed light on many of the issues.

- Cooperatives. The cooperative is a significant institution for producers as well as consumers. In some cases producers' cooperatives, such as those producing Sunkist oranges, approach the size of the largest national corporations. But farmers' cooperatives exist

8 Nicolas Jequier, Low Cost Technology: An Inquiry Into Outstanding Policy Issues. (Paris: World Tech, Report No. 2, 1975).

Exhibit 1

COMPARISON OF APPROPRIATE TECHNOLOGY AND MODERN INDUSTRIAL TECHNOLOGY

A. Characteristics of the Technology

Industrial	Appropriate
Complex	Simple
Integrated/Networked	Localized
Dependent on Scientific Advances	Dependent on Craft and Common Knowledge
Interchangeable Parts	Fewer Interchangeable Parts, More Uniqueness
Integrated or Compatible With Other Technologies	Self-Contained
Optimized on a Few Goals or to Meet a Specific Need	Meets Multiple Needs and Goals
Mass Production	Individual, Team, and Craft Production
Obscure	Convivial, Readily Understood
Difficult and Expensive to Maintain or Repair	Repairable by Owner or User
Controls are Complex and Require Expert Assistance	Controls are Simple and Straightforward

B. Use/Production Process

Industrial	Appropriate
R&D Dependent	More Skill, Craft Dependent
Large Scale/Mass System Orientation	Local System Focus
Central Management	Decentralized Management
Complex Bureaucratic Management	Simplified Management
High Energy Requirement	Energy Requirement Meets Value of End Use
Controlled by Investors	Controlled by Users
Financial Profit Maximized	Other Goals Optimized--Ecology, Personal Growth, Community Service
Goal: Growth (Material)	Goal: Growth (Personal)
Production Separate From Use	Producers Can Become Users

Industrial	Appropriate
Automation/Capital Intensive	Labor Intensive
High Investment per Worker and Per Unit of Output	Low Capital Investment per Worker and Per Unit of Output
Low Adaptability to Social and Cultural Environment	High Adaptability to Social and Cultural Factors
Generous Use of Material and Energy Resources	Sparse Use of Material and Energy Resources
High and Low Cost Products	Low & Medium Cost Products (and different costing model)
Reduced Importance of Human Factors	Increased Worker Satisfaction
Continued Purchase of New Items	Recycling/Retrofiting of Existing Items
Import Dependent	Local Resources Emphasized
Consumer Inolvement Minimized	Local Consumer Involvement Maximized
Rigid Design to Protect Consumer	Easy Maintenance/Modification
Large-Scale Work Places	Individualized Work Places
Credit or Money Based	Barter, Exchange and Cooperation Important
Ecologically Disruptive, Polluting	Benign or Protective of Human and Natural Environments
Energy and Materials Wasteful	Resource Conserving
Violent	Non-Violent
Dangerous	Safe
Choice Limiting	Pluralistic
Separation of Raw Material, Manufacturer, and Market	Low Production and Consumption, Self-Sufficiency
Promotes Urbanization	Promotes Small Communities, Delocalization

C. Support Systems

Industrial	Appropriate
Highly Trained Personnel	Limited Training Required
Mass Culture/Mass Advertising	Local Culture/Informal Networks
Belief in Progress as Bigger, Faster, "More is good."	Focus on Quality of Experience, "Less is More"
Centralized Regulation of Risks (Health, Financial, Social)	Localized Protection
Uniform National Policies	Policies Appropriate to Local/Regional Circumstances

D. Some Economic Emphases

Industrial	Appropriate
Chronic Underemployment	Full Employment
Periodic Mass Unemployment	Full Employment
Periodic Economic Depression	Full Employment
Inequality	Egalitarian
Externalize Social Costs	Minimize and Internalize Social Costs
Neglect Long Term	Attention to Long Term
Advertising, Brand Names, Marketing, Franchising, and Chains	Unadvertised, Unbranded, Local
Oligopolistic, Monopolistic	Localized, Independent Ownership, Free Market and Barter Economy

E. Social and Values Emphases

Industrial	Appropriate
Material Growth	Material Sufficiency Coupled With Psycho-Spiritual Growth
Man Over Nature	People Within Nature
Competitive Self-Interest	Enlightened Self-Interest
Rugged Individualism	Cooperative Individualism
Rationalism	Rational and Intuitive
Large, Complex Living and Working Environments	Smaller, Less Complex Living and Working Environments
Growth of Material Complexity	Reduction of Material Complexity
Space Age Technology Prized	Older Proven Technology Sought
Identity Defined by Patterns of Consumption	Identity Found Through Inner and Interpersonal Discovery
Centralization of Regulation and Control at Nation/State Level	Greater Local Self-Determination Coupled with Emerging Global Institutions
Specialized Work Roles—Through Division of Labor	More Integrated Work Roles (e.g., Team Assembly, Multiple Roles)
Secular	Balance of Secular and Personal
Mass Produced, Quickly Obsolete, Standardized Products	Hand Crafted, Durable, Unique Products
Cultural Homogeneity, Partial Acceptance of Diversity	Cultural Heterogeneity, Eager Acceptance of Diversity
High Pressure, Rat Race Existence	Laid Back, Relaxed Existence
Alienation and Anomie	Self Worth High, Self Identity Clear, Self Fulfilling

on all kinds of scales for many purposes. Cooperatives also exist among specialized groups to render special services, such as the production and marketing of the work of the handicapped, Native Americans, and artists. Consumers' cooperatives are generally on a smaller scale but can cover anything from groceries and gasoline to eyeglasses. Often the participants are active as consumers or producers, and as managers or selectors of managers in the cooperative enterprise. This situation relates to the concerns of appropriate technology over management. Cooperatives also function among public utilities, as for example in the formation of the Electric Power Research Institute which is a research cooperative. Cooperative agreements for the exchange of electricity to meet peak demands are common among public utilities.

- Professional Offices. The goals of autonomy, independence, and self-fulfillment through work have traditionally been found in American society among professionals such as doctors, dentists, and lawyers. Increasingly other professionals -- architects, designers, consulting engineers, accountants -- have joined the ranks of these autonomous and quasi-autonomous professionals.

- The Moviemaker. The moviemaker and the producer of live theatre are among the most fully autonomous and independent users of, and workers with, technology. These technologically-based artistic enterprises embody many of the objectives and aspirations of appropriate technology and may provide a test bed for research.

- Small Business. Small businesses as commercial enterprises can vary from Mom and Pop grocery stores to companies employing 500 workers and doing tens of millions of dollars of business. Relatively little is understood about the similarities and differences of small and large businesses with regard to worker participation, autonomy, self-fulfillment, adaptability, externalization of costs or the scores of other characteristics compared in Exhibit 1.

- Franchise Operations and Licensees. An institutional compromise between the need of large nation-wide integrated corporations to grow, and the desire of individuals for autonomous business ventures has evolved in the franchise business. Little is known about how felicitously they strike a balance between the conflicting elements in Exhibit 1.

- Family-Held Big Business. Far short of the national and multi-national stock company, yet a great distance away from the small business are a substantial number of individual and family-held large corporations. They have not been systematically studied with regard to the characteristics in Exhibit 1. More significantly, little is known about the evolution of their operations and the effects of any transition from proprietorship or limited partnership to general stock company.

- The Conglomerate. Widely recognized, or purported to be the most pathological form of business enterprise in the United States, is the conglomerate which fundamentally exists for growth's sake. Yet little is known about the comparative activities of the conglomerate versus the large, single purpose corporation versus the others in this spectrum.

These institutions, shown in rough order of increasing size in Exhibit 2, highlight the functioning alternatives between the major industrial corporations and the goals of an appropriate technology society. We know relatively little about most of these socioeconomic institutions either in an absolute or in a comparative sense with regard to the fundamental issues to which appropriate technology is a proposed resolution.

D. General Goals for A.T. Innovation

Basic differences between the industrial system and the goals of appropriate technology notwithstanding, there are properties which advocates of either extreme are likely to see as desirable for any technological system. These include:

- Resilience to economic, social, and other shocks;
- Invulerability to planned subversion, or to unplanned collapse;
- Flexibility to permit ordered societal evolution in contrast to wrenching or precipitous revolutionary change;
- Maintenance of options rather than the premature or definitive foreclosure of technological and other alternatives.

Research, development, diffusion, and implementation of appropriate technologies should relate to these general desirable characteristics of any technological system.

III. INNOVATION AND APPROPRIATE TECHNOLOGY

A. Innovation in the A.T. Context

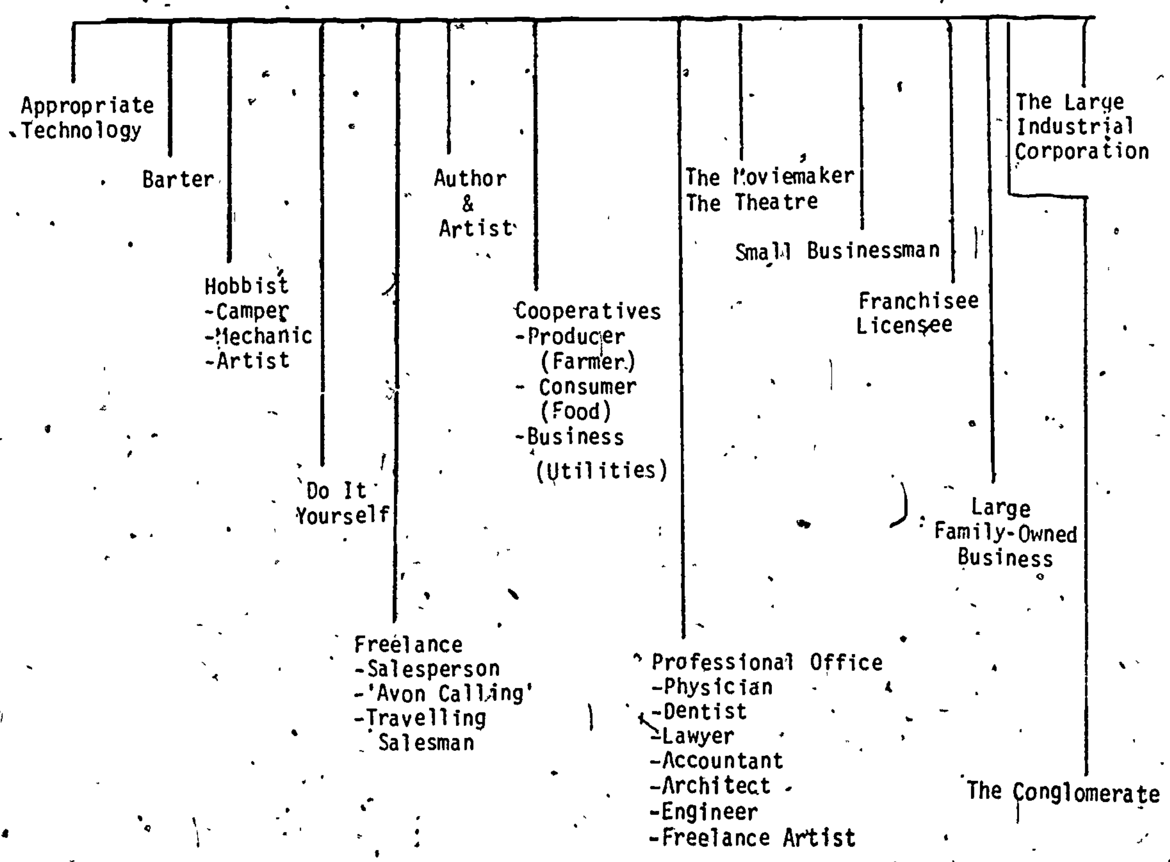
Appropriate technology (A.T.) innovation may seem to be a contradiction in terms. To many, A.T. means simple, already existing tools; innovation implies the new "bigger and better" world view of industrial, technological development. This false dichotomy reflects a narrow definition of appropriate technology innovation. Appropriate technologies include new and current technologies, and significant refinements on technologies now in use. Examples of new appropriate technologies include:

- the "solar tubes" (clear plastic tubes filled with algae for raising fish) developed by the New Alchemy Institute;
- "automatic louvers" (insulating shutters which use freon evaporation to close) invented by Steve Baer;

Exhibit 2

THE MIDDLE GROUND

SOCIO-ECONOMIC ALTERNATIVES TO THE INSTITUTIONAL EXTREMES



- the "aquacell" (waste treatment plant which uses solar energy and aquatic life to purify water) being built now by the town at Hercules, California.

A.T. innovation can also refer to the introduction of existing tools in new settings.

Innovation is an umbrella term including invention, adoption, and diffusion of technology. Invention is generally thought of as something which happens once or which may occur independently several times. Innovation is the adoption of something new. Every time a person or institution tries or adopts something new it is innovating. Innovation in this sense is a repeatable process. Diffusion covers the processes by which social, political, or physical invention is adopted.

The distinct subfamilies and submovements under the rubric of A.T., such as community technology, soft path or renewable energy technology, and alternative technology may exhibit quite different innovation processes. For example, innovation in community technology tends to be localized and participatory; soft path or renewable energy innovation involves national or regional institutions (e.g., federal agencies, utilities).

To clarify the meaning of A.T. innovation, it is useful to classify these innovations in terms of the types of settings involved:

1. National or Macro-Societal Level Programs. National level efforts include application of A.T. ideas and devices in national planning and policies for restructuring business, industry, the economy (e.g., Lovin's soft path), and government operations (e.g., heating of building, procurement of products). More important are policies, laws, and regulation made or formulated at the national level which affect activities at all other levels.

2. A.T.-Based Businesses. A.T.-based businesses are existing or new businesses producing appropriate technologies (windmill factories), or applying A.T. work patterns in existing business operations, e.g. solar heating of factories, more job rotation, team work, or participation by workers. This category may include small and relatively large businesses.

3. Local/Community Self-Sufficiency. Local A.T. innovations occur at the rural and urban community level. These also include applications of A.T. devices or programs in or by state and local governmental agencies. Examples include community energy or agriculture programs.

4. Individual Self-Sufficiency. This includes development and adoption aimed at the individual or household self-sufficiency; an example would be solar collectors for individual residential dwellings or self-sustaining farms, or exchange and barter arrangements with other groups and individuals.

Within each of these settings, A.T. innovation is the process of developing or introducting technology appropriate to the goals at that level. A.T. development is the creation of techniques or technologies which meet A.T. criteria. A.T. introduction is the implementation of one or more technologies or techniques which meet A.T. criteria within a specific site, community, organization, or setting.

A.T. development and introduction usually involve awareness by the parties involved that the technology(s) being developed or implemented meet A.T. criteria. These criteria may vary from group to group and case to case. For example, neighborhood technology developers may stress different criteria than soft path advocates or commune dwellers, but there will be some commonality across settings. If NASA develops a new solar collector that a self-help community group later installs, should that be characterized as an A.T. innovation? If a grass roots appropriate technologist invents a new windmill which a big city utility adopts, should that also be counted as an A.T. innovation? The answer is yes in both cases since innovation includes development and introduction.

From our preliminary analysis of the concept of A.T. innovation, it is clear further research is needed to clarify its meaning. How does one recognize an appropriate technological innovation? When is something not an A.T. innovation? To what extent is the concept context specific?

B. Contrast Between A.T. and Industrial Innovation

There are significant conceptual differences between A.T. and mainstream technology and innovation. Exhibit 3 contrasts some of these differences in approach and world view. Specifically, A.T. innovation differs from mainstream technological innovation in the following six major respects:

- Value considerations and ideology are explicit in A.T. innovation and differ from those governing mainsteam innovation, such as profits and efficiency.
- Objectives in A.T. innovation tend to be more multidimensional and include social and environmental externalities.
- A.T. innovation views a particular technology as part of a fuller social ensemble of factors and consequences.
- A.T. development and introduction tend to advocate and to be more decentralized than mainstream technological innovation.
- There tends to be more participation by potential clients in A.T. development and introduction.
- A.T. development and introduction is often carried out by different kinds of institutions (e.g., grass roots A.T. developers, regional A.T. networks, self-help community groups) than is mainstream technological innovation (universities, R & D firms, government laboratories, and high tech corporations).

Appropriate technology delivery systems and the associated innovation processes are not completely separate from industrial technological innovation. To date, A.T. innovation has been somewhat isolated; an important topic for research is the compatibility of A.T. and industrial systems innovation.

Exhibit 3

CONTRASTING APPROPRIATE TECHNOLOGY AND TRADITIONAL INNOVATION PROCESSES

Dimension	AT	Industrial
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Relation to economy	Insensitive to cycles	Sensitive to business cycle
Time required to innovate	Short gestation	Long gestation
Source for ideas	Individuals	R & D labs
Selection criteria	Informal/trial and error	Formal/bureaucratic procedure
Dissemination/propagation	Each one-teach one Journals (hobbyist)	Professional societies Licensing
Criteria of success	Successful operation at any scale General societal benefit	Widespread adoption and resulting return on investment Profit
Cause for failure	Loss of interest Lack of local support Lack of information Lack of resources Lack of experience	Failure to capture sufficient market share Macro economic fluctuations
Knowledge base	Craft knowledge Science of the concrete	Scientific Abstract science
Participation	Understood by all Science and technology by all	Complex/highly specialized Elite science and technology
Structure of technology	Self-sufficient small units	Small dependent on big
Relation to worker	Work and leisure flow together	Work/leisure have sharp distinction

C. Problems Facing Appropriate Technology Innovation

Appropriate technologies are advocated as having many social benefits, such as benign environmental impacts, work enrichment, job creation, community building, and resource conservation -- goals not normally taken into account by a large firm's investment decisions. Hence, from a macro-societal view there is likely to be under-investment in A.T. research and development if left entirely to the private sector.

There are also significant attitudinal problems facing A.T. development and introduction. Many producers and consumers still subscribe to the idea that "bigger is better"; others associate A.T. exclusively with hippies or the counterculture.

Jequier has identified four institutional problems facing A.T.:

- the relative weakness of A.T. development institutions (the lack of institutions equivalent to industrial R & D laboratories);
- the absence of an equivalent of the industrial firm, with its institutionalized commitment to growth, its ability to take risks, and its mastery of large-scale production processes;
- the absence of an effective A.T. marketing and distribution system;
- the weakness of the financial infrastructure with regard to A.T., e.g., a firm has to be, or promise to become, large to get adequate risk capital in the United States.[9]

Added to this list should be the lack of adequate educational and media institutions to educate people for careers in A.T.-related activities and to inform the public and private firms about the potential of A.T. (see the original report for a discussion of issues). Current institutions, regulations, and laws also present problems for the development and introduction of appropriate technology. For example, government R & D procurement procedures tend to favor big firms over small firms; HUD regulations on tax rebates for solar favor active systems over simpler passive systems; health and building codes restrict or prohibit certain appropriate technologies (e.g., composting toilets); minimum wage requirements may hamper some self-help A.T. projects. Tax policy can also block to such a major social and personal changes.

D. Bases for Understanding the A.T. Innovation

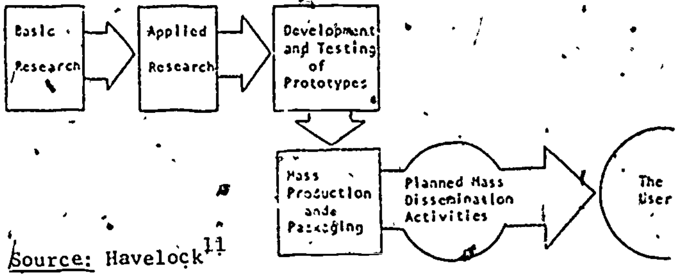
The literature on innovation is framed around the study of technology introduced into the growth, scale-economy oriented industrial sector. Within this corpus the most useful knowledge for A.T. innovation polity deals with the social innovation at the community level. The following are six perspectives from the literature on innovation which are useful starting points for analyzing A.T. innovation:

1. Research, Development, and Diffusion
2. Social Interaction Perspective
3. Problem Solver Perspective
4. Linkage Perspective
5. Implementation Perspective
6. A.T. Delivery System Perspective

There is relatively little on the development aspects of the A.T. innovation process. This will require additional research.

1. Research, Development, and Diffusion Perspective. The research, development and diffusion perspective, while more characteristic of mainstream technological innovation, may be relevant to cases where appropriate technologies are developed in one setting or locality, and then transferred or applied in another. This model assumes a staged sequence in which an innovation is:[10]

- discovered or invented in the laboratory;
- tested and demonstrated in the field;
- communicated to potential users;
- tested by the user;
- finally adopted or rejected by the users on the basis of their testing.



Source: Havelock[11]

2. Social Interaction Perspective. The social interaction perspective is useful for studying influences on the decisions of individual adopters of A.T.[12] This perspective stresses the importance of communication within the social network in the innovation process. Interpreting the innovation process from the user's viewpoint, it discusses the following stages in the process:

- awareness of innovation by potential adopter;
- interest in the innovation;
- evaluation and decision to test by adopter;

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[9] Nicholas Jequier, Appropriate Technology - Problems and Promises. Development Center of the Organization for Economic Cooperation and Development. (Paris: 1976).

[10] Robert Yin, Karen Heald, and Mary Vogel, Tinkering With the System. (Lexington, MA: Lexington Books, 1972).

[11] Ronald G. Havelock, Planning for Innovation Through Dissemination and Utilization of Knowledge. (Ann Arbor, Michigan: Institute for Social Research, University of Michigan, January 1971).

[12] Everett Rogers, with F. Shoemaker, Communication of Innovations. (New York: Free Press, 1971).

- a trial test of innovation;
- final adoption or rejection of innovation.

3. Problem Solver Perspective. The problem solver perspective is similar to social interaction perspective. It is useful in studying the process by which community groups and other organizations attempt to match appropriate technologies to their problems, needs, and resources. This perspective stresses the following points:

- the user's needs and problems are the place to begin in studying innovations;
- innovation begins with a diagnostic stage in which user's needs and problems are defined;
- the role of the outsider is primary to serve as a catalyst, collaborator, or consultant in the user-driven process;
- self initiation by the user creates the best climate for lasting change.

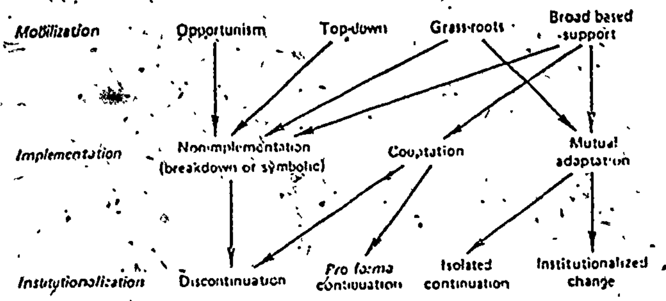
4. Linkage Perspective. The linkage perspective is a hybrid of the previous three approaches. Developed by Havelock,[13] it can be used to explore how potential A.T. users can be linked with mainstream sources of technical expertise such as universities. In this perspective, the user makes contact with the outside resource system while going through the problem-solving cycle. The resource system personnel then go through a similar problem-solving cycle so they can feed back useful information on possible solutions.

5. Implementation Perspective. Of all the perspectives, the implementation perspective is potentially the most useful for A.T. innovation. Its key point is: how something is implemented is as important as what is implemented. The implementation perspective is especially useful in studying and assessing federal, state, and local programs aimed at stimulating A.T. innovation in organizations or communities. Developed by McLaughlin and Berman,[14] the perspective cites three distinct stages of implementation:

- initiation or mobilization where a decision is made to adopt an innovation;
- implementation where the innovation is put in place;
- institutionalization where the use of the innovation is continued and fits into the standard operation procedure of the organization.

The impetus for innovation can come either from the top of the organization, from the grass roots, or from mutual adaption between the two. Situations in which the initiation and implementation stages are characterized by mutual adaptation may be most likely to lead to successful innovations.

Implementation Perspective



6. A.T. Delivery Systems Perspective. The above perspectives are most relevant to specific A.T. innovations or to innovations within specific organizations. There is a need for more general conceptual frameworks for studying how the institutions involved in A.T. innovation interact with each other and with industrial institutions. The literature on research and development, technology transfer, and technology delivery systems provide some useful insights in this regard. A technology delivery system is institutions involved in creating, developing, implementing, and controlling technology in a certain area. The figure below depicts a general model of a technology delivery system developed by Wenk. It includes four main elements:[15]

- inputs (manpower, capital, prior knowledge);
- institutional structures;
- system processes (social processes through which institutions interact);
- outputs (products, social impacts).

An A.T. delivery system is institutions involved in creating, developing, implementing, and controling one or more types of A.T. The delivery system does not have to have a specific structure (e.g., a centralized system). A.T. delivery systems may be expected to be quite different from traditional industrial technology delivery systems; they would be expected to be more decentralized and more participatory having closer ties between development and introduction. Some embryonic elements of A.T. delivery systems include:

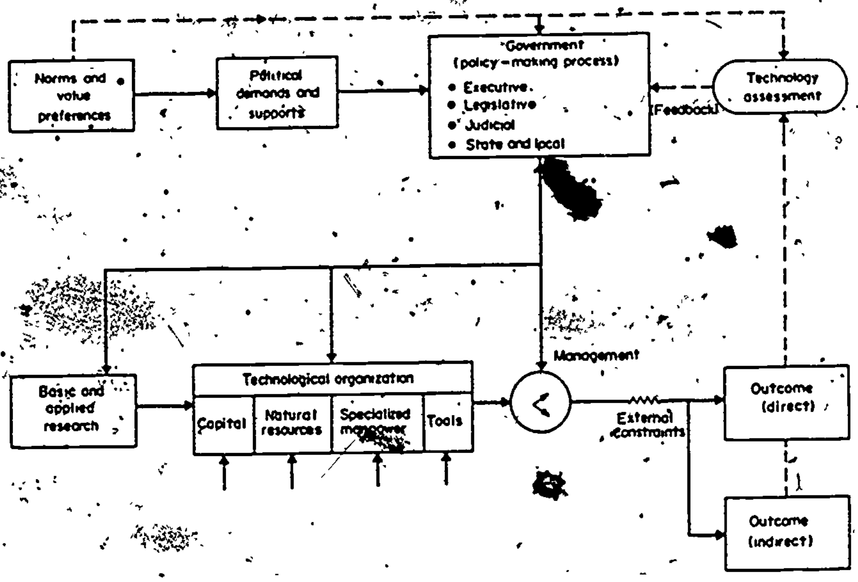
- A.T. inventors and development groups -- such as Zomeworks (New Mexico), New Alchemy Institute (Massachusetts), and Ecotope (Washington):

[13] Havelock, op. cit.

[14] Milbrey McLaughlin and Paul Berman, Federal Programs Supporting Educational Change, Vol. 8: Implementing and Sustaining Innovation. (Santa Monica, California: Rand R-1589/8-HEW, May 1978).

[15] Edward Wenk, Jr., Margins for Survival: Overcoming Political Limits in Steering Technology. (Oxford: Pergamon Press, 1979) 51. See also, for an earlier treatment, "Technological Delivery Systems" (Unpublished, University of Washington, Seattle, March 1973).

THE TECHNOLOGICAL DELIVERY SYSTEM



- Regional A.T. networks -- like AERO in Montana, MEAN in the Midwest, NEAT-NET in New England;
- A.T.-related newsletters and journals -- like RAIN, NEW ROOTS, SOLAR AGE, COEVOLUTION QUARTERLY, and MOTHER EARTH NEWS;
- Federal A.T. programs -- like CSA's National Center for Appropriate Technology, and Seattle's Neighborhood Technology Coalition;
- Local A.T. projects -- like San Bernardino's Westside Community Development Corporation's solar programs and the Franklin County energy study;
- Local consulting and facilitating organizations -- like the N.Y. Energy Task Force and Chicago's Center for Neighborhood Technology;
- Staffers of mainstream technological organizations and programs -- congressional staffers, agencies, private corporation; universities interested in and/or sympathetic to A.T.;
- A.T. educational institutions -- like Goddard College (Vermont) and Farallones Institute (California).

IV. RESEARCH AREAS IN A.T. INNOVATION

What Are the Most Fruitful Areas of Research?

Innovation related to appropriate technology is not the same process as traditional industrial innovation. Several models have been developed in connection with the study of the social aspects of innovation which provide perspectives for investigating the A.T. innovation process. While these models refer primarily to the introduction, in contrast to the development phase of the innovation process, they are a starting point for research. The most fruitful approach to understanding the A.T. innovation process is to divide the problem along the lines of the four-fold taxonomy of settings (see above). In investigating each of these areas, the emphasis will be on applying these models and developing new models where (a) a model does not currently exist, and (b) where existing models prove inadequate. The following presents some possible areas of research under each of these settings.

A. National Level Issues in Appropriate Technology Innovation

There is a need to study national aspects of appropriate technology -- that is, how A.T.-related institutions interact among themselves and with mainstream institutions in creating, developing and implementing A.T.. Because of potential social benefits and institutional barriers to A.T., there appears to be a rationale for federal involvement in A.T. innovation, but what the appropriate role of federal agencies is needs to be clarified. New federal A.T. programs and their interaction need to be assessed. The potential of A.T. and A.T. ideas in existing federal programs and operations needs to be explored. Finally there is a need for better understanding of integrated and mixed system innovation. Specific research topics could include:

1. Research on National Aspects of Appropriate Technology, for example:

- case studies of A.T. innovation in various sectors to identify key factors related to success and failure;
- studies of the A.T. movement/institutions/networks and existing A.T. delivery systems; identification of barriers, gaps and

institutional weaknesses;

- development of ideas and recommendations for facilitating the evolution of appropriate A.T. delivery systems; the appropriate federal role.

2. Assessment of New Federal Appropriate Technology Programs, for example:

- Case studies of 20 or 30 federal-funded A.T. projects which span A.T. development and implementation in various sectors including comparative analysis, problems and lessons;

- Preliminary assessments of new federal A.T. programs' impact on A.T. innovation; comparative analysis and analysis of interaction among programs; programs should include: NCAT, DOE's Small Grants A.T. Program, NSF's Pilot Program, HUD's Solar Demonstration Program, ACTION's A.T. activities, EPA's A.T.-related programs, etc.;

- Analysis of new programs' impact on barriers to A.T. innovation; identification of gaps in federal response, recommendations for refinement of A.T. programs or new ones.

3. Opportunities for Federal Innovation in Appropriate Technology, for example:

- Development of an agency by agency inventory of opportunities for utilizing A.T.s or A.T. ideas in agency operations and programs; the inventory should also be indexed by the A.T. categories developed above;

- Identify barriers to the introduction of A.T.s into federal agency operation and the development of strategies and recommended policies for alleviating barriers.

4. Integrated and Mixed System Innovation, such as:

- Case studies of mixed industrial and A.T. innovation in various sectors (government, industry, non-profit);

- Identification of opportunities for integrated and mixed system innovation and development of strategies and policy options for encouraging integrated and mixed system innovation.

B. Innovation in Appropriate Technology Based Businesses

Need

To date most support for A.T. innovation has come from individuals or the federal government. There is a need to stimulate interest and investment in A.T. by the private sector. Related to this, there is a need to identify and alleviate barriers to A.T. innovation by and in small businesses. On a larger scale, research is needed on the potential of small and intermediate scale production technologies in the private sector and of adoption of A.T.s into the operations of intermediate and large firms. Also the potential role of labor in facilitating or discouraging A.T. innovation needs to be explored. Specific research could focus on:

1. Innovation by Small Appropriate Technology Based Businesses, such as:

- Case studies of innovation by small A.T.-related businesses; comparative analysis and identification of institutional barriers and lessons; inventory of promising opportunities for A.T.-related businesses;

- Development of strategies and policy options for supporting innovation by small A.T.-related businesses, especially options for increasing private sector financing; federal policy options for supporting small A.T.-related businesses.

2. Introduction of Appropriate Technology in the Private Sector, for example:

- Research into the potential of small and intermediate scale production technologies in America's private sector; case studies of existing applications; analysis of trends in production scale; barriers to small and intermediate scale productions; public and private policy options for overcoming barriers;

- Study of adoption of non-production A.T.s by the private sector; case studies of adoption; identification of barriers; development of public and private policy options.

3. Labor and Appropriate Technology Innovation, such as:

- A project to explore issues related to labor and A.T. innovation. Studies would start by assessing the role labor now plays in this and other countries (e.g., Lucas Aircraft in England) in the A.T. and mixed system innovation process. Studies would then assess potential impacts of A.T. and mixed innovation on the nature of work and the work force, and options for promoting increased labor participation in A.T. innovation in the private sector.

C. Local Innovation in Appropriate Technology

Much of the experience with A.T. has been on the local community level. There is a need to summarize the lessons of these local experiences. Which ones succeeded? Why? Which ones failed? Why? The purpose is to develop an understanding of the types of innovation processes most likely to succeed at the local level. On the basis of this understanding, Congress, federal agencies, state governments, and other institutions involved in local A.T. innovation will be better able to set policies for local A.T. development. Specific research could focus on:

1. Local Appropriate Technology Innovation Process, such as:

- Projects to study local innovation in urban rural areas. Each will do case studies of local innovation and community development; develop preliminary models of factors influencing process; identify barriers and institutional problems; and develop policy options for alleviating barriers.

2. Role of Local Government and Institutions, such as:

- Studies of the role of state and local governments in promoting local A.T. innovation for local development; identification of local barriers that state and local governments could alleviate; development of policy options for local governments; clarification of the role of federal agencies vis-a-vis local governments in promoting community technology;

- Study of the potential role of local mainstream institutions — especially universities and community colleges, private firms and high technology companies and financial institutions in facilitating the use of A.T. innovation for local development; identification of policy options for local institutions, and for federal, state, and local government;

- Development of an inventory of opportunities for introducing A.T. innovation into state and local government operations and programs; identification of barriers and policy options for overcoming them; exploration of appropriate NSF and federal role in promoting A.T. innovation in the state and local governments.

3. Appropriate Technology Innovation Outside of Energy, Food & Housing, such as:

- Develop an inventory of promising A.T.'s not already the responsibility of other major mission agencies for local and community development. It could also identify potential barriers to such innovation and develop strategies, and policy options for overcoming them. Areas to be explored include communication, transportation, health care, recreation, and cottage industries.

D. Individual Adoption and Use of Appropriate Technology

There is a need to be able to predict trends in the rate of adoption of A.T.s by consumers and households, and to better understand the processes and factors that are involved in A.T. adoption by individuals. Also there is a need to identify new institutional mechanisms needed to facilitate A.T. adoption by individuals. Most A.T. innovation to date has been in the energy, food, and housing areas. There is a need to identify innovative A.T.s for the individual in other areas such as communications, transportation, recreation, health care, and home economics.

1. Individual Adoption of Appropriate Technology, for example:

- Survey of individual attitudes and values related to technology, A.T. ideas, and A.T. products; identify trends in attitudes and values;

- Study of factors influencing individual adoption of various A.T.s; apply relevant literature and theory; develop models of A.T. adoption by individuals; explore barriers;

- Clarify barriers to individual A.T. adoption; identify needed new institutions or modification of existing institutions especially in public information and education; consumer protection and financing areas; develop policy options for alleviating barriers to adoption and create needed institutional structures.

2. Appropriate Technologies for the Individual Outside of Energy/Food/Housing, such as:

- A project to explore opportunities for individual scale A.T. innovations outside the traditional areas of energy, food, and housing; develop an inventory of such opportunities; identify barriers and policy options for alleviating barriers.

V. SUMMARY

Appropriate technology has become an important part of American life — at the individual, community, business, and even national level. To understand and serve the growing numbers of people interested in A.T. additional knowledge is needed on how A.T. complements and conflicts with the predominant industrial system. In the area of innovation, there are some clear areas of overlap as well as some distinct differences between the A.T. and industrial approaches. Traditional innovation policies are not likely to adequately serve the A.T. community. However, some aspects of traditional innovation experience — especially those related to the social aspects of innovation may be particularly applicable to the A.T. innovation processes. Above we suggest a number of areas in need of research which if better understood might improve our understanding of innovation in appropriate technology.

VI. ACKNOWLEDGMENTS

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