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THE DEMONSTRATION PROJECT AS A PROCEDURE FOR ACCELERATING THE APPLICATION OF NEW TECHNOLOGY

(CHARPIE TASK FORCE REPORT)

February 1978

U. S. DEPARTMENT OF ENERGY
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(The Charpie Task Force)

Dr. Robert A. Charpie (Chairman)

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Mr. Robert C. Gunness

Mr. Wallace B. Behnke

Mr. George Montgomery

Mr. William Cross, Jr.

Mr. Howard K. Nason

Dr. Edward E. David, Jr.

Dr. Alan Pasternak

Mr. W. Kenneth Davis

Mr. John Quarles, Jr.

The Honorable Elisha Freedman

Dr. Denis M. Robinson

Table I

DEMONSTRATION PROJECT TASK FORCE MEMBERSHIP BY SECTORS

SECTOR

Product Development Companies

- **Dr. Robert Charpie**, President, Cabot Corporation
- **Mr. Robert C. Gunness**, retired Vice-Chairman of the Board, Standard Oil Company (Indiana)
- **Dr. Edward E. David, Jr.** Executive Vice-President, Gould, Inc.
- **Dr. Denis M. Robinson**, Chairman of the Board, High Voltage Engineering Corporation
- **Mr. Howard K. Nason**, President, Monsanto Research Corporation (1)

A & E / Design

- **Mr. W. Kenneth Davis**, Vice-President, Bechtel Power Corporation (2)

Investment Companies

Commercial Banks

- **Mr. William Cross, Jr.**, Executive Vice-President, Morgan Guaranty Trust

Investment Banks

- **Mr. George Montgomery**, Senior Vice President, White, Weld & Co.

[1] Now President, Industrial Research Institute Research Corporation.

Delivery Organizations

Utilities

- **Mr. Wallace B. Behnke**, Executive Vice-President, Commonwealth Edison Company
- **Mr. Robert A. Baker, Sr.**, retired Executive Vice-President, Public Service Electric & Gas Company

Local Government

- **Mr. Eli Freedman**, City Manager, Rochester, New York

Regulators

Federal

- **Mr. John Quarles, Jr.**, Deputy Administrator, Environmental Protection Agency (2)

State

- **Dr. Allan Pasternak**, Commissioner, California State Energy Resources Conservation and Development Commission

Responsible Federal Official

- **Mr. C. B. Smith**, Special Assistant for Research Application, ERDA Headquarters/Plans and Analysis

Secretariat

- **Mr. Thomas Calhoun**, Program Analyst, ERDA Headquarters/Plans and Analysis

[2] Now associated with Morgan, Lewis & Bockius, Attorneys at Law.

III. THE DEMONSTRATION PROJECT

A. General Consideration

Before the demonstration project as a commercialization incentive can be analyzed, it is necessary to review what has to be done, and what constraints the government is under in attempting to accomplish the desired objectives. Section A attempts to lay this foundation. Section B explores the character of demonstration, Section C reviews past federal experience therewith, and Section D discusses the type of results needed.

1. **Necessary Conditions for Commercialization:** [1] The Task Force wishes to emphasize in the strongest possible terms, that while improved technical performance—the primary business of ERDA—is important, it is by no means a sufficient condition for commercialization. A new development must also satisfy economic criteria, which in general terms means that the rate of return on the capital required must be commensurate with the risk as seen by the prospective investor, and in relation to alternative opportunities. Although many factors enter into the determination of the rate of return, in the case of new energy technology one factor stands out among all others, namely, the present and expected cost of the new development in relation to the expected future price of existing energy alternatives, e.g., imported oil or domestic coal and hydrocarbons. Forecasts of required development cost and time are crucial factors in calculating the rate of return on major R&D investments.

Additional non-technical considerations involved in the decision of a given company to proceed with the commercialization of a new technology include: assessment of other investment opportunities, the extent of departure represented by the new technology from the firm's traditional business areas, management's perception of the importance of the development to the long-term survival of their corporate entity, and an appraisal of the likely costs and risks of regulatory requirements which must be satisfied if the investment is to be successful. The Task Force offers more specific guidance in this area in Section III. D.

The point to be made here is that technical performance is *not* a sufficient condition for commercialization.

It is essential that an agency contemplating sponsorship of a prototype commercial demonstration thoroughly explore and evaluate the applicable commercial criteria before deciding that a demonstration project is a cost effective way to assist in achieving early commercial acceptance of a new technology and, if so, exactly what uncertainties should be the focus of the demonstration project design and test program. This subject is discussed further in Section III.D.4, a. and b.

2. **The Role of Government/ERDA in the Energy Market:** The rationale underlying Federal participation in the energy market may be summarized as follows:

- In ideal markets, there is perfect allocation of resources and no need for Government intervention.
- In real markets, there are always imperfections which, in particular cases, may result in the expected returns on socially desirable developments being inadequate to provoke private sector investment. Two examples of such defects in the U.S. energy market are:
  a. *Prices regulated to artificially low levels.* The effect of this distortion is to inhibit the development and sale of improved alternatives—which are economically justifiable at world energy prices, but not economically viable in the controlled market.

[1] For a more complete discussion of this subject see Section V, Appendix A: Jacoby, H. D., Linden, L. H., et al., Government Support for the Commercialization of Energy Technologies, MIT Energy Lab., Policy Study Group, MIT-EL 76-009, November 1976.

Energy conservation investment is widely affected by this market defect.

b. *Nonrecoverability of pioneering costs.* This problem can occur when, as a result of limitations in patent ownership, nonappropriability of solutions to environmental and other regulatory problems, and/or price regulation of the final product, the entrepreneur who incurs first-of-a-kind cost is unable to protect the knowledge gained and recover his pioneering costs against sales. This problem may inhibit firms in the private sector from investing more expansively in basic research related to their business competence and experience. It is a generally accepted rationale for many civil oriented, Federal R&D programs. As applied to ERDA's commercialization programs, it shows up most markedly in problems of private implementation of developments growing out of the nuclear and fossil fuel programs.

3. If a market defect is inhibiting the evolution of a socially desirable development, Government involvement directed to elimination of the market defect may justify public investment to produce desired public benefits.

4. Public benefits derive from two types of objectives recognizable in Federal energy policy:

a. *Social objectives;* i.e., nonmarket related objectives, such as reducing dependence on foreign oil, reducing environmental degradation, and cushioning the social dislocations of the transition to a new national energy supply and distribution system, and

b. *Economic objectives;* i.e., market related objectives such as maximizing the economies to be derived from the free market system, or, in ERDA's case, developing alternatives which will reduce the future cost of energy and energy dependent systems.

How the Government goes about promoting public benefits depends largely on the relative emphasis placed on these two types of objectives at any given time. If a social objective is very compelling (such as winning a war), the Government will be prepared to do many things, (including paying the full cost of starting up a new industry and, if necessary, subsidizing its cost in responding to the public need) that might not be considered desirable—in terms of preserving the free market—in more normal times.

In less immediate circumstances, it is common to defer to long-term economic objectives and to try to accomplish social objectives within the free market system, i.e., by attempting to remove or compensate for offending market defects, but with the ultimate objective of establishing a self-sufficient commercial operation. Often, circumstances lie somewhere between the extremes of total war and total peace, and, as the urgency surrounding the social objective decreases, the objective of operating within the free market system increases.

5. To the extent that social objectives are to be accomplished within the free market system, (as indicated by ERDA's authorization) Government support is permissible only if the inhibiting market defect can be corrected by a temporary government intervention—such as supporting a prototype demonstration project. If the problem cannot be overcome by a short-term intervention, either the social objective has to be foregone, or the free market process has to be modified by regulation or subsidy.

6. ERDA's nonnuclear enabling legislation [2] does not authorize the agency to force an application by regulation or to sustain one by subsidy of an entire industry.[3]

7. A program so limited can produce long-term impact only to the extent that prototype support, in and of itself, can eventually result in subsidy-free commercial operations. The determination of whether ERDA should support the application of any given technical development thus turns on the answers to two questions: Given an option which is technically sound.[4]

a. *Will the venture be pursued by the private sector in a sufficient and timely manner?* If the answer is yes, the Government withdraws and allows the private sector to pro-

[2] P.L. 93–577. Solar, geothermal and electric vehicles have prior or subsequent legislation which authorizes support for a substantial number of initial installations. DOE will not be subject to this limitation.

[3] ERDA can however enter into purchase agreements and other arrangements which amount to subsidy of an individual demonstration plant.

[4] I.e., the *technical* risks have been reduced to the point customarily accepted by the applying industry. If not, the development is not yet ready for application support in the context here used.

1st Plant to answer this Question.

ceed. If no, the second economic criterion must be explored, i.e.,

b. *Will the expected public returns justify the public investment required to bring about application?* If the answer to this question is yes, the basic criteria for Federal intervention will have been met (which does not mean that all such projects will be pursued).

The decision as to what support mechanism should be used will be determined by the reason which has been established for the private sector not responding on its own. The decision process in which a and b, above, are tested and the support mechanism selected is outlined in Figure 11.

8. To the extent that non-market social objectives dominate, e.g. reducing dependence on foreign oil, the agency is less concerned with establishing self-sufficient commercial enterprise and more concerned with creating technical options as a backstop or contingency against another oil interruption, or in the long run, depletion. This is the basis on which the Nation builds and maintains a military establishment. On this same basis, perceived social benefits (in the form of a full learning experience) might well justify the construction and the subsidized maintenance of a prototype industrial capacity.

The Task Force feels that ERDA is dealing both with technical developments which are potentially market viable (and can be accelerated through demonstration, on the basis of the rationale contained in steps 1-5 above), and, technologies which will not be market viable in the foreseeable future, but which should be pursued as a contingency on the basis of the rationale stated above. It is important, however, for ERDA to establish clear criteria as to the applicability of each of these legitimate cases, otherwise it could find itself expending public funds unnecessarily, and possibly in counterproductive competition with the private sector. Guidelines for making such determinations are discussed in Section IV.

B. Characteristics of Demonstration

1. **Demonstrations—Experimental versus Exemplary:** The term "demonstration" is loosely used and, if misunderstandings are to be avoided, must be carefully defined. In general, the term means making evident through tangible actions. In practice, ambiguity can arise in terms of who is demonstrating what to whom.

In one sense, a demonstration is a tangible display staged by an advocate for the purpose of demonstrating the utility of a technology to potentital users, investors, regulators and others, not all of whom are fully knowledgeable in the field, but whose support is essential to the adoption process. It is, in this sense, an example intended primarily to persuade. It becomes an *exemplary* demonstration. As such it is intended to be the last step before commercial exploitation.

At the other extreme, the term may be used to describe a test undertaken by an investigator primarily to demonstrate (to himself) whether a development, which may have been proven under laboratory conditions, is workable at adequate scale in the operational environment. To him, a failure which leads to an improved design is a positive result. To the extent that its outcome is known to be uncertain, and its primary purpose is to resolve or confirm a result, such a demonstration is in reality an *experiment*. It is part of the development process and is not normally expected to be the last step before commercial exploitation.

To minimize ambiguity, ERDA refers to exemplary demonstrations as *commercial demonstrations* and to experimental demonstrations as *technical demonstrations*. The relative position, in the development cycle, of these respective types of demonstrations is shown in Figure 2.

Figure 3 indicates the most significant operational differences between *experimental* (technical) and *exemplary* (commercial) demonstrations.

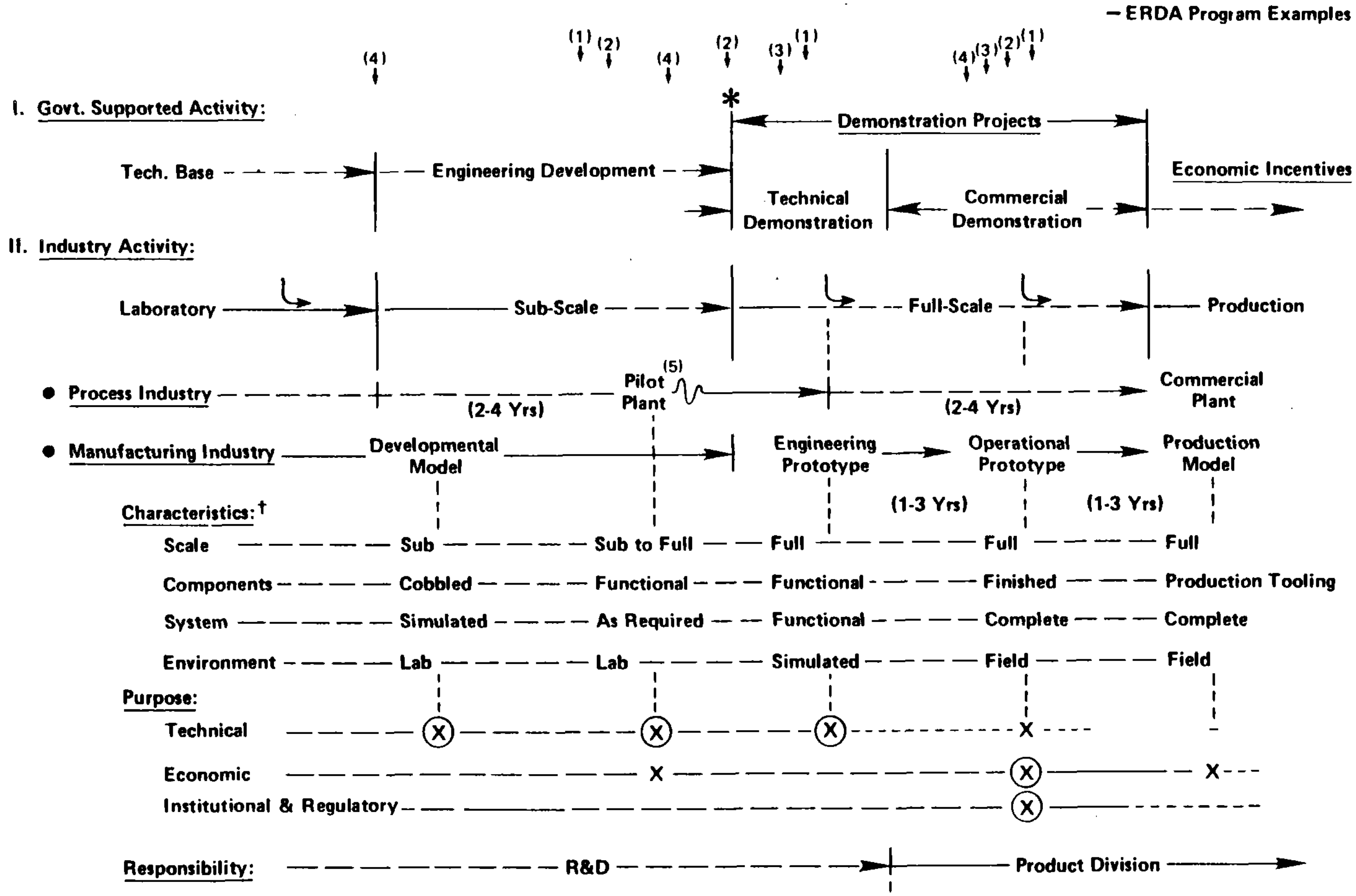
First, we prefer experiments which have low visibility. While success is hoped for, disappointment must be anticipated. . . . Examples, on the other hand, should be publicized.

Second, to accomplish their purpose, experiments must be well-controlled and carefully evaluated. Examples, on the other hand, focus primarily on demonstrating the *development in* the most "realistic" manner possible. The final evaluation is made by the potential users.

Third, the scale and environment of experiments will replicate the actual operating conditions only to the extent necessary to resolve the uncertainty in question. As example, by contrast, to be most effective, should be carried out in an operational environment and on a scale large enough to convince with respect to every possible uncertainty.

Finally, management should take a different

Proposed Government Nomenclature



(1) Nuclear/FFTF, CRBR & PLBR.
(2) Fossil/Solvent Refined Coal – 6 Ton Per Day, 60, 500.
(3) Conservation/Fuel Cell, Electric Car.
(4) Solar/Solar Thermal Test Facility, 10 mw, 100 mw.
(5) Pilot Plants Supported by Govt. R&D Programs are Typically Small Scale and an Additional Step Corresponding to "Technical Demonstration" Is Usually Required to Obtain Scale Up Information.

*Decision as to Desirability and Best Form of Commercialization Support.
† See Fig. 1 for Clarifying notes.

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Figure 2

Figure 3 *
DEMONSTRATIONS: TECHNICAL VS COMMERCIAL

	Technical Demonstration (EXPERIMENT) Tests Feasibility	**Commercial Demonstration** (EXAMPLE) Shows Utility
AUDIENCE	• Sponsors	• Customers
PROJECT DESIGN OBJECTIVES	• Low Visibility • Quantitative Control & Evaluation • Simulated Pertinent Environment • Smallest Scale to Get Information	• High Visibility • Sufficient Control for Credibility • Full Operational Environment • Fullest Scale to Approximate Reality
MANAGEMENT POSTURE	Healthy Skepticism	Optimistic Assurance

* Based on work supported by the Office of Transist Management and Demonstrations, Urban Mass Transportation Administration, Department of Transportation.

attitude toward an experimental demonstration as compared with an exemplary demonstration. The experimental demonstration calls for a skeptical attitude, while the exemplary demonstration is best treated with optimistic assurance. In an experiment, the experimentor should take control. In an example, the audience ideally should be involved as much as possible.

Whether a demonstration should be classified as an experiment or an example depends for the most part on the readiness of its technology for commercialization. In private industry, the tendency is to confine experiments to the laboratory environment.

In the public sector, the opposite tends to be true. As described later, five major government-sponsored demonstrations disappointed expectations largely because they were forced to "go public" before the technology was ready. Those disappointments might have been avoided had the demonstrations been designed and managed as experiments, not examples.

The Task Force is concerned that many of ERDA's so-called demonstrations are in reality large scale experiments, but that the public or the Congress may be expecting them to be followed immediately by commercial application. The case of the nuclear ship Savannah is often cited as an example of an agency losing face through such a misunderstanding.

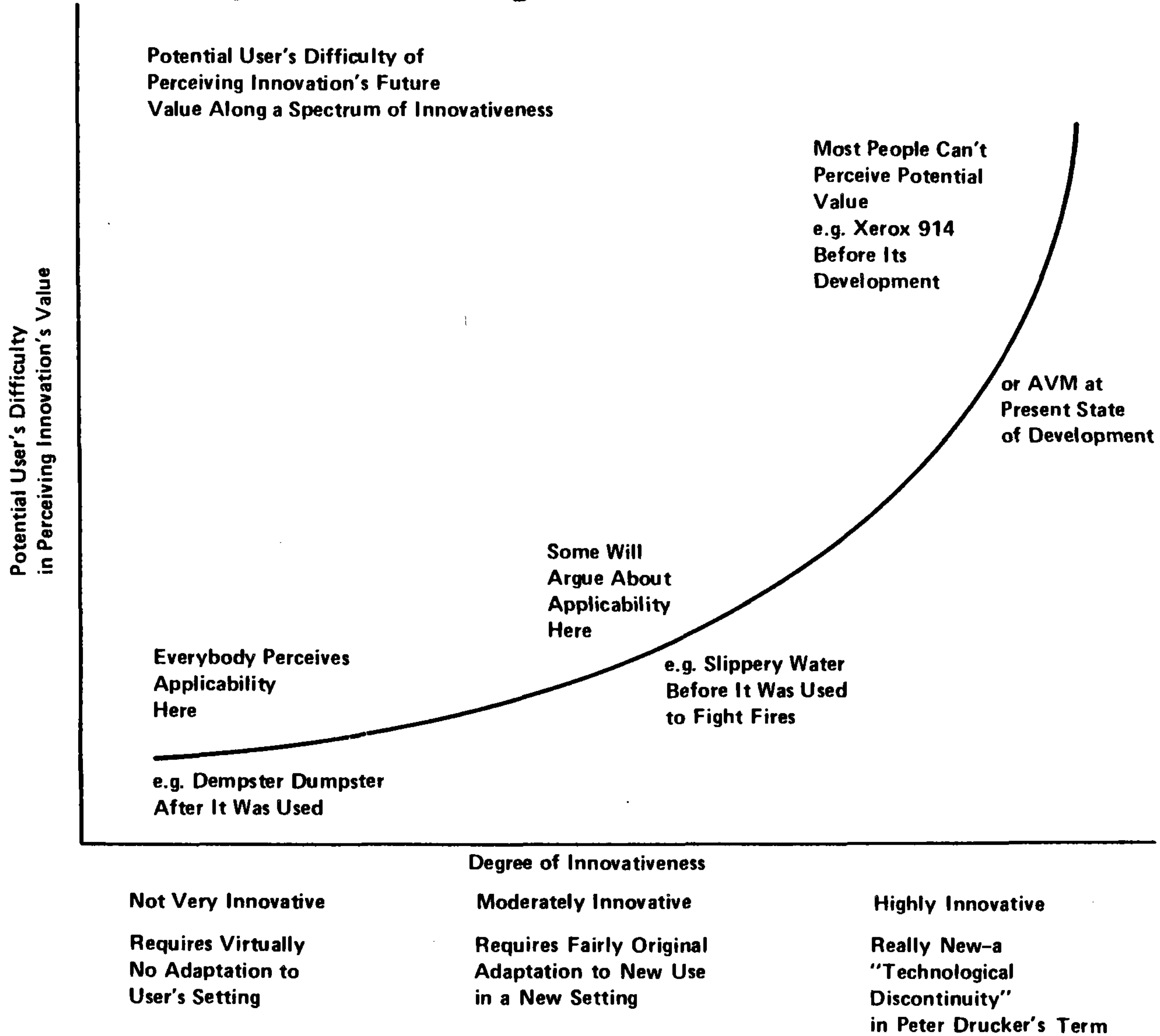
2. **Demonstrations Convince:** To the extent that a demonstration is exemplary in character, its primary purpose is to convince decision makers to move ahead with commercial implementation. Experimental demonstrations are a high risk means of achieving this objective. While it is always hoped that the results of an experimental demonstration will reveal the technology as promising, thereby convincing decision-makers to invest, negative results may discourage investors.

Exemplary demonstrations are less perilous in this regard. When the performance of a project is almost certain to be successful, a demonstration can safely be used to help convince its audience that the technology is worthwhile. The persuasive character of any demonstration project is mostly a function of how closely its workings approximate reality. If a given demonstration seems too far removed from reality, another demonstration may be needed to make the case. In any event a successful exemplary demonstration must clearly show the prospect of an adequate return on investment and a low enough risk to attract private capital in competition with other investment alernatives.

The questions, therefore, to be asked about any demonstration project are (1) *Who* is the project intended to convince? (2) *What* are they supposed to do once convinced? (3) *What* will it take to convince them?

Fig 4

Difficulty of Assessing Innovation's Latent Value



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In short, the overall goal of all demonstration projects is to stimulate the acceptance and diffusion of technological innovations by inducing industry to adopt and commercialize the demonstrated technology. *Experimental* (Technical) demonstrations contribute to this end by generating new technical information that will (1) reassure sponsors that the technology merits further development and (2) assure potential users that the technology is sound. *Exemplary* (commercial) demonstrations are often needed to convince the full spectrum of decision makers (many of whom must be shown) of the overall comparative advantages of the technology. The following section will address the inherent complexities of that function.

3. **Demonstrations Aid Perception:** The difficulty of gaining user acceptance of a new technology turns on the users' perception of its advantages and disadvantages compared with available alternatives. The difficulty of accomplishing this is influenced by its degree of innovativeness; the more radical the technology the more difficult it is for potential users to become convinced of its value and, hence, the greater is the risk they assign to it. Figure 4 implies that the higher a technology is on the scale of innovativeness, the less immediately perceivable is its value. At the uppermost level of the spectrum it may be very difficult to convince users of the potential value of an innovation unless it is actually demonstrated. This is what Chester Carlson, the inventor of xerography, discovered as he took his invention from company to company seeking support.

At the low end of the spectrum are technologies which, while not new to the world, are unfamiliar to the potential new user. An example is the Dempster Dumpster trash-collection system now employed throughout the country. Late adopters hardly need a demonstration of it because they know its comparative advantage from the experience of others.

In the middle of the spectrum are technologies representing adaptations of old items to new purposes or environments. A good example is slippery water, which is formed by adding a polymer to water. While the benefits of this product to fire fighting are easily outlined, it took a demonstration to convince firemen that such water can actually be thrown farther than the ordinary variety.

The top end of the spectrum is the area of technological discontinuity where inventions are genuinely new. As was previously discussed, the Xerox 914 was such a discontinuity. Its cost-effectiveness, now so easily seen, was far from obvious at that stage; indeed, the 914 was then widely appraised as unpromising. Exhaustive market surveys by two separate consultants each concluded that the 914 would fail to be adopted because of its size, cost and a host of other problems. Both consultants, of course, missed the two key factors which made the 914 a success: first, its relative speed in producing dry copies was great enough to make it a qualitatively different innovation, which would not merely replace existing methods but would also generate its own markets. The comparative advantage of its speed could not be appreciated until it was tried. Second, the 914 was successfully marketed on a lease/hire basis rather than sold outright. This facilitated its demonstration to users, who were then able to perceive its advantages. Clearly, the very innovativeness of the 914 made demonstration indispensable to its diffusion.

4. **Demonstrations Generate Demand Pull:** Most technological innovations are confronted by financial, institutional, and psychological barriers to their use. These problems are surmounted only for technologies perceived to be cost-competitive with other alternatives; unfortunately, both costs and benefits are highly uncertain as long as an innovation remains an abstraction, or thought of as a laboratory toy. Seeing an innovation work reduces that uncertainty dramatically—for all of the varying professions involved, many of whom are not in a position to evaluate technical analysis and simulation experiments.

Often the demonstration of an innovation is a "technology push" which generates the "demand pull" that is essential for the adoption of that innovation by other users. In the private sector most innovations occur in response to demand. That is, they are developed to meet "felt" needs or to solve identifiable problems. A recent study of several hundred commercially successful innovations showed that three-quarters of them were direct responses to a clearly stated need or market demand. One-quarter, however, started with a technology push.[1]

[1] Sumner Myers, IPA and Donald Marquis, MIT, *Successful Industrial Innovation: A Study of Factors Underlying Innovation in Selected Firms,* National Science Foundation Report NSF 69–17, GPO, Washington, D.C., 1969.

There are, of course, many ways of identifying potential demand, the primary one being a careful analysis of user needs. Market research, however, is for the most part restricted to improvements in existing technologies and products. As Peter Drucker in *The Age of Discontinuity* points out, the market is unlikely to call for the kinds of radical innovations he terms "discontinuities," e.g. computers, television and xerography. Or, as physicist Athelstan Spilhouse once said, "people don't know what they want until they see what they can have."

The physical demonstration of a new technology shows people what they *can* have and in so doing may set up a *demand pull* for the innovation. A *New York Times* article made this point, describing an exciting trade exhibit where retail merchants were shown the latest automation technology for billing and inventory control. One merchant, when asked what he thought of the exhibit, replied, "All of a sudden you discover there are problems that you did not know you had." [2] Innovations such as Automated Vehicle Monitoring (AVM), then, may define hitherto unexpressed needs and problems. As Joseph Rossman phrased it, "A problem is best defined in terms of a possible solution." [3]

Demonstration projects, it must be remembered, pose only tentative answers to problems and should not themselves be mistaken for final solutions:

> It is taken for granted that the statement of the problem will be incorrect and this means that the problem must be reviewed at regular intervals and restated in the light of any information or partial solution. If this problem is not restated as new information is obtained, either the wrong answer will be arrived at, or a number of false starts will be required to arrive at the proper answer.[4]

5. **Demonstrations Generate Political Pressure:** Government-sponsored demonstrations are uniquely different from private industry demonstrations in that they are subject to varying amounts of political pressure. While such pressure can be helpful, it is often counterproductive. Political pressure was the basic cause of failure in five major government demonstrations the Task Force studied. In the public sector, especially, there is an unfortunate tendency to overpromise and underdeliver. The audience for important technologies includes not only private industry but public interest groups and the federal agencies. These groups all have interests at stake and their influence in the funding or cutting of a given project cannot be discounted. A further characteristic of government-sponsored demonstrations derives from the short tenures of most high government officials, which promotes a tendency to urge projects towards completion within unrealistic time-frames; or alternatively, such projects are delayed while succeeding administrations restudy the justification for them.

Curiously, political pressures can be generated by technologies that are demonstrably *not* cost-effective. It is only necessary that they function reliably and look cost-effective to some observers. Prefabricated, panelized housing is an example. Its demonstration, particularly in Europe, created much of the pressure for Operation Breakthrough, despite the fact that the early cost data indicated little likelihood of success. Similarly, now that the Morgantown PRT (Personal Rapid Transit) is operating reliably, it is generating pressure for other such systems, even though they do not appear to be cost-effective. The reason, of course, is that neither well-intentioned citizens nor congressmen analyze cost data as precisely as do potential investors. And even these are sometimes misled by political pressures, as can be seen in the bad experiences of private investors with Operation Breakthrough.

6. **Demonstrations Change Institutional Barriers:** Demonstration can force the political process to remove institutional barriers standing in the way of a particular innovation. In order for this to happen, however, the demonstration must show people something that they want very much to have. For example, General Motors demonstrated the concept of a grade-separated urban freeway system through its Diorama at the 1939

[2] Dial-a-Ride is an example of a solution that articulated a "new" problem. In 1967, Dial-a-Ride seemed to promise low-cost, door-to-door transportation, and thereby drew attention to the inadequacy of public transportation for the elderly and handicapped who need door-to-door transportation. Ironically, it may turn out that Dial-a-Ride is not the solution after all because it is too expensive. But once the problem has been identified it will suggest approaches from many different angles, as the current proliferation of means to transport the elderly attests.

[3] Joseph Rossman, *Industrial Creativity: The Psychology of the Inventor.*

[4] George Landis, *Ideas, Inertia, and Achievement*, p. 46.

Table II
SUMMARY OF FEDERAL DEMONSTRATION PROJECTS REFERRED TO IN TEXT

NAME OF DEMONSTRATION	SPONSORING AGENCY AND YEAR	PROJECT DESCRIPTION
Saline Water Conversion Plant Freeport, Texas	Office of Saline Water, Department of the Interior, 1958	Demonstration of the long vertical tube evaporator (VTE) process for water desalination.
Operation Breakthrough (Industrialized Housing Techniques)	Department of Housing and Urban Development, 1969 and continuing	To demonstrate the use of mass-produced housing technology. Three phases: (1) housing design and selection; (2) prototype construction and testing; (3) mass production. To set up performance standards and evaluation procedures for industrialized housing.
Dial-A-Ride Transportation System Haddonfield, New Jersey	Urban Mass Transportation Administration, USDOT, 1971. Ceased operations in 1975.	Small buses provided door-to-door transportation service by individual telephone request. Project demonstrated both a manual and computer-based vehicle routing and control.
Personal Rapid Transit System, West Virginia University, Morgantown, West Virginia (Morgantown PRT)	Urban Mass Transportation Administration; USDOT, 1970. Began carrying students in 1975 and continues to operate.	Public transport system using remotely controlled small cars on an automated guideway. Person can obtain a car upon demand at one of 3 stations. Currently composed of 3.3 miles of track connecting 3 stations and vehicles with capacity of 20.
Fish Protein Concentrate Plant Aberdeen, Washington	Bureau of Commercial Fisheries, Department of the Interior (now National Marine Fisheries Service in Department of Commerce), 1971. Plant closed June, 1972.	Plant to demonstrate the production of fish protein from hake to provide a concentrated food for human consumption.
Mechanized Refuse Collection (Godzilla) City of Scottsdale, Arizona	EPA, 1969. Continues to operate.	New method for collecting family refuse. Hydraulic arms were added to the collection trucks to pick up, dump and return trash cans without requiring anyone to leave the truck.
Yankee Nuclear Power Reactor New England	Atomic Energy Commission, 1956. Continues to operate.	Construction and operation of a pressurized light water reactor. One of the first civilian nuclear power reactors built under AEC's Power Demonstration Reactor Program.
Connecticut Yankee Power Reactor	AEC, 1963. Continues to operate.	Nuclear reactor built to demonstrate the economies of large scale reactors (400 megawatts)
Refuse Firing Demonstration (Solid-Waste-to-Fuel-Conversion Plant) St. Louis, Missouri	EPA, 1970	Process to demonstrate the recovery of energy, metals, and other materials from municipal refuse.
Hydraulic Knee Prosthetic Devices	Veterans Administration, 1959–68	Fluid controlled knee mechanisms for above-knee amputees were developed by private firms and clinically tested. Still used today.
Computer Assisted Electrocardiogram Analysis (ECG)	DHEW, 1969–72. Continues to be used.	To demonstrate the use of computers for preliminary analyses of electrocardiograms.
Shipbuilding Research, Development and Demonstration Program	Maritime Administration, 1970 and continuing.	Shipbuilding firms are aided in the development of new technological devices or production methods. Demonstrations are then held in commercial shipyards.
Teleprocessing of Medicaid Claims, Alabama	HEW, 1971–74	To demonstrate the billing of physicians' services via Telephone lines to a central computer.

Information obtained from Baer, Johnson & Merrow, *Analysis of Federally Funded Demonstration Projects*: Final Report, U.S. Department of Commerce, 1976.

World's Fair. From it, people saw what they could have, wanted it and pressured the government to provide it. And so, some institutions were destroyed or changed in order to get the highway system we now have.

Demonstrations can also change institutional barriers within industry. The demonstration must show that the cost-savings to the potential adopters are great enough to be worth the price of institutional change. For example, the diesel locomotive (which was demonstrated successfully by General Motors) was adopted by all American railroads within two decades despite a host of institutional barriers: rigid labor practices, large investments in steam equipment, and the relatively weak financial condition of many railroads.

C. Past Federal Experience

1. **Classification:** As noted in Section I.A.I, the Federal government already has a track record in the sponsorship of technical demonstration projects. The specific cases referred to in the following discussion are summarized in Table II.

While there are no hard data on the success or failure of these demonstrations, it is the general impression that they are mixed. Charles Hitch sums up that impression. "Most government R&D in the past has been either basic research or health research for use by physicians, or R&D for government use as in defense or space. It has done little research for private commercialization. And most of that is not very effective." [5] Even so, much can be learned from that experience that might increase ERDA's success in using demonstrations to induce the commercialization of its R&D products.

In order to get a systematic picture of that experience, the RAND Corporation, under a contract from the Experimental Technology Incentive Program of the U.S. Department of Commerce, undertook a study of federally sponsored demonstration projects. The goal of the study was "to formulate guidelines for use by Federal agencies to improve the processes of planning, implementation, monitoring, evaluation, and dissemination of results for future demonstration projects." [6] A digest of this study prepared by RAND for the Task Force is included in Appendix B herewith.

RAND's final report lists six attributes which tend to be associated with successful demonstrations. They are as follows:

1. *A technology well in hand.* Projects showing significant diffusion success were those in which the principal technical problems had been worked out beforehand.

2. *Cost and risk sharing with nonfederal participants.* Each of the seven cases showing significant diffusion success involved nonfederal cost sharing, while the projects funded entirely by the federal government resulted in little or no diffusion.

3. *Project initiative from nonfederal sources.* Demonstration projects originating from private firms or local public agencies enjoyed greater diffusion success than did those directly pushed by the federal government.

4. *The existence of a strong industrial system for commericialization.* Diffusion proceeded more rapidly when there were obvious manufacturers and purchasers of the new technology, and when markets for similar products existed.

5. *Inclusion of all elements needed for commercialization.* Demonstrations showing significant diffusion success included potential manufacturers, potential purchasers, regulators, and other target audiences in project planning and operations.

6. *Absence of tight time constraints.* Demonstrations facing externally imposed time constraints fared less well than others.

While seven of the twenty-four projects studied by RAND resulted in significant diffusion of the technology demonstrated, at least five were at the failure end of the spectrum. Failure may be too harsh a term to describe the outcomes of these demonstrations because they did generate some useful knowledge. At the same time, their outcomes were so disappointing that they deserve special attention for the lessons they teach.

In considering the RAND results the Task Force found it desirable to recast the RAND data into an operational framework that differentiates among the kinds of technical innovation being dealt with. The most widely used method of classifying product innovations is by the product diversification matrix developed by Booz Allen & Hamilton. The coordinates of this matrix are three degrees of technical novelty versus three degrees

[5] "Energy," Charles Hitch's remarks to the White House Advisory Group on Technology/Economics, March 12, 1976.

[6] RAND, *Analysis of Fedeally Funded Demonstration Projects: Executive Summary,* prepared for the Experimental Technology Incentives Program, U.S. Department of Commerce, April 1976.

of market development, defining nine cells, the most extreme of which is a new technology for which a new market must be developed. The Task Force noted, however, that virtually all of the demonstrations involving government participation have been new technology, and that the *nature* of the new technology was, along with the extent of market development, the most significant variables for such demonstrations. Hence, the *classification* used herein. This structure may be helpful to ERDA in anticipating the magnitude of the problems associated with a given future demonstration.

On the surface, the RAND data show that government backed demonstration projects have met with a good deal of success. Of the thirteen innovations considered here, seven were not only application successes but diffusion successes as well—over fifty percent. On closer inspection, however, it appears that the government can take credit for no more than three successful diffusions: Refuse Firing,* Hydraulic Knee, and ECG. It seems probable that none of these would have been developed, applied and diffused without government funding. From these cases we may learn what the government did that was right. Three other diffusion successes—Connecticut Yankee, Marad Welding and Godzilla—might have occurred with or without government participation. For these the question is: how can the government identify innovations that will probably succeed on their own?

For the five failures—PRT, Dial-a-Ride, Fish Protein, Desalination and Breakthrough—the question is: what guidelines might have helped the government avoid disaster?

The goal of demonstration projects is to diffuse technological innovation by convincing potential users to adopt the innovation demonstrated, or some variant thereof. Potential users are more likely to adopt an innovation if they can see it applied successfully in a context that is similar to their own. By the same token, they are less likely to adopt it if they cannot see it, and still less likely to do so if the innovation is shown to be a failure. Indeed, all seven *diffusion* successes were preceded by *application* successes (ECG, Godzilla, Yankee, Connecticut Yankee, Refuse Firing, Hydraulic Knee, and Marad Welding). While application success is not sufficient for diffusion success (Medicaid), it is necessary; application failure signals diffusion failure. That, at least, was true in the case of all five application failures (Dial-a-Ride, Breakthrough, Desalination, Fish Protein, and Morgantown PRT.)

The demonstrations studied by RAND were intended to diffuse technological innovations which differed in the degree of risk the *adopter* of the innovation faced in his marketplace. This is important because, as noted below, market-related barriers are the greatest single source of risk. Different classes of innovation expose their adopters to differing degrees of market risk:

- *Process Only:* The adopters of resource-saving innovations which require no change in end-product will face *little* if any market risk.
- *Process-Product:* Adopters of resource savings innovations requiring end-product modifications will face *some* market risk.
- *Process/Scale Economies:* Adopters of innovations saving resources through economies of mass producing the end product will face *more* market risk.
- *Qualitatively new product or services:* Adopters of such innovations for sale will face the greatest risk in their markets.

The following discussion covers the demonstration projects studied by RAND as charted in Figure 5. For each innovation class (as listed above), demonstrations that were application *successes* will be discussed first (and in this category, diffusion successes will be discussed before diffusion failures), and *failures* last. (See Figure 5)

2. **Process-Only Innovations:** These are resource-saving innovations requiring no change in the end-product: hence their adopters face little market risk. The adoption of such innovations saves labor, capital or material in the production of goods or services which remain essentially unchanged in the eyes of the end user. An example is the diesel locomotive which cut railroad costs without affecting the quality of service appreciably, as far as shippers were concerned. Because the end-product or service is unchanged, process innovations avoid consumer acceptance barriers. If other factors are equal, then, process-only inno-

* Although generally regarded as a success (is being adopted in other parts of the country) the initial St. Louis project has been abandoned because of social and political factors—the importance of which are discussed in Section III.D.1.

Figure 5

RAND CASES LISTED ACCORDING TO INNOVATION CLASS

Innovation Classes	**Successful Application** — **Diffusion**	**Successful Application** — **No Diffusion**	**Failures, Both Application & Diffusion**
PROCESS ONLY Adopter faces *no* market risk because his end-product is unchanged.	• Refuse Firing • Yankee • Connecticut Yankee • Marad Welding		• Desalination
PROCESS AND PRODUCT Adopter faces *some* market risk because his end-product must be modified.	• Godzilla	• Medicaid	
PROCESS AND SCALE ECONOMIES Adopter faces *more* market risk because his lower cost of end-product depends on demand.			• Breakthrough • Dial-a-Ride
NEW PRODUCT OR SERVICE *High* market risk because product success depends on consumer acceptance.	• Hydraulic Knee • ECG		• Morgantown PRT • Fish Protein Concentrate

vations tend to be relatively risk-free. Innovations considered by RAND which fall in this category are Refuse Firing, Yankee, Connecticut Yankee, Marad Welding and Desalination (Freeport). All were diffusion successes except Desalination, which failed to achieve application.

ERDA's enhanced recovery and much of its industrial conservation program fall in this area.

a. *Successes*

The process-only successes are attributable to the fact that the selected technology resulted in large enough dollar savings to make the project a good investment. Process-only innovations are inherently less risky than other kinds because the adopting institution has more control over the various factors that need to be dealt with in introducing the innovation. Risk is primarily of a technological nature and therefore likely to be fairly small. An IPA study of innovation failures[7] showed that technology is typically a relatively low risk factor, accounting for only 11.5 percent of all failures, as compared to the marketplace, which accounts for more than twice as many failures, 27.5 percent.[8]

Refuse Firing. The Refuse Firing Project is a good example of a project "most likely to succeed"—but only with government help. For the first application, technical risks were fairly low: the technology was reasonably well in hand, requiring primarily the integration of off-the-shelf components. As a process-only innovation, the project involved no market risk, although there were other external uncertainties of a very serious nature. Why, then, did the Union Electric Company need government help to induce it to go ahead?

We can infer from the data that given such risks as there were, the return on investment (ROI) for refuse firing probably looked too small in comparison with alternative, less risky capital investment opportunities. Beyond saving fuel, the utility had no incentive to apply the system. The firing system was not generally patentable (although elements of it were patented); and there was no unique profit potential for the utility to exploit if it successfully introduced the firing project on its own. Furthermore, the acceptability of the process by environmental regulators was uncertain. Government cost-sharing offered the company an incentive to do something that would benefit the utility if it succeeded. It further helped to reduce the risk of environmental acceptability. In effect, the government incentive changed the investment priorities of Union Electric.

In this instance the government judiciously used its money to align a private company's priorities with its own. Government participation in this project can be justified by the external bene-

[7] Myers, S. and E. E. Sweezy. *Why Innovations Falter and Fail; A Study of 200 Cases* Denver, Colorado, Denver Research Institute, University of Denver, Report R 75–04, January 1976.

[8] Myers and Sweezy, *op cit.*

fits of getting many utilities, including Union Electric, to burn refuse. Refuse disposal is, of course, a major problem in cities throughout the country. The government therefore tried to start the diffusion process by getting one utility to demonstrate to others the comparative advantages of burning refuse along with coal. The only question to be raised here is whether, given scarce public capital, this type of relatively low-risk innovation can be stimulated in some other way at less expense to the federal government.

Willingness to cost share by private industry is an indicator of probable success but raises questions. If the probability of success is high and the cost-savings are likely to benefit the first adopter, why should the government cost-share with him at all? The answer may be that a government contribution might still be necessary under these circumstances to spur the first user to adjust his investment priorities. This was probably the case with Union Electric. Despite the relative certainty of some benefits to the first user, the project may not be high enough on his priority list to be implemented without government participation.

Connecticut Yankee. In retrospect, it appears that the Connecticut Yankee project would probably have been undertaken without government help because the cost-saving opportunity, compared to other alternatives, outweighed the risks to the utility.

Marad Welding. The Marad Welding Project was a process-only innovation that theoretically should have been taken up by industry using its own capital. As a practical matter, the industry did not do so. Why not? Because the shipbuilding industry has a history of low productivity and anti-innovativeness. In this case, the purpose of the demonstration was to break down the cultural pattern of non-innovativeness and low productivity. The industry had to be shown the benefits of process-only innovations in order to induce it to undertake such improvements on its own. Apparently, the discipline of the free enterprise system was not working and subsidy was therefore necessary.

Process-only innovations are usually low risk and pay for themselves in a short time. That fact alone, however, is not always sufficient inducement for private sector investment. There may be higher-ranked projects on a company's priority list. If the government wants a project undertaken in the public interest, it must occasionally be prepared to change a company's internal investment priorities by offering a financial incentive. In any case, when ERDA negotiates for demonstration projects benefiting the first user, it should try to determine where the innovation ranks among the user's priorities and then fund it accordingly.

b. Failures

All of the demonstration failures are summarized in Figure 6.

Desalination (Freeport). This was the only failure among the process-only innovations, and it is traceable to political factors. As a process-only innovation, desalination stood a good chance of succeeding, since it avoided problems of market acceptance. While the proximate cause of failure was technological, those difficulties were apparently produced by political pressures which forced the attempted application of the technology before it was completely developed.

3. **Process and Product Innovations.** These resource-saving innovations require end-product modifications and face some market risk because of the difficulty of fully anticipating consumer demand. For example, the substitution of plastic for ceramics in the manufacture of electrical fixtures reduced production costs, but changed the quality of the end-product enough to create some market resistance. Successful diffusion of such an innovation depends on the acceptance of such changes, which in turn depends on the comparative cost of the good or service relative to other, similar goods or services. Thus, process/product innovations tend to be riskier than process-only innovations although not as risky as scale and economy innovations. Godzilla and Medicaid, both of which required acceptance by their users, fall into this process and product category. Godzilla was something of a diffusion success; Medicaid was an application success but failed to diffuse.

Many of ERDA's consumer product programs fall into this category.

a. *Successes*

Godzilla. The Godzilla Demonstration Project, which may be classified as a partial diffusion success, was exposed to more external risk than the process-only innovations discussed above. Its successful application depended on public acceptance of a qualitatively new service. In this

Figure 6
FIVE DISAPPOINTING DEMONSTRATIONS BY CATEGORY OF INNOVATION AND CAUSES OF FAILURE

INNOVATION CATEGORY	DEMONSTRATION	CAUSES OF "FAILURE," PROXIMATE AND BASIC
PROCESS ONLY Adopter faces *no* market risk because his end-product is unchanged	DESALINATION (FREEPORT)	Immediate: TECHNOLOGY—Manifested by unreliable production Basic: *POLITICAL*—Pressure hurried application of technology before it was ready.
PROCESS-PRODUCT Adopter faces *some* market risk because his end-product must be modified		(NO MAJOR FAILURE IN THIS CATEGORY)
PROCESS AND SCALE ECONOMIES Adopter faces *more* market risk because his lower cost of end-product depends on demand	BREAKTHROUGH	Immediate: TECHNOLOGY—Manifested by failure of breakthrough technologies to reduce significantly the cost of housing Basic: *POLITICAL*—Ideology introduced too many goals. Also obscured fact that cost-reduction targets were too small.
	DIAL-A-RIDE	Immediate: TECHNOLOGY—Manifested by failure to reduce cost of door-to-door service below taxi fares. Basic: *POLITICAL*—Failed to evolve Dial-a-Ride from taxis because (1) feared to include taxis under agency's purview and (2) disliked researcher who recommended it.
NEW PRODUCT OR SERVICE *High* market risk because product success depends on consumer acceptance	MORGANTOWN PRT	Immediate: TECHNOLOGY—Manifest by failure of PRT to work reliably and large cost overruns. Basic: *POLITICAL*—Pressured to (1) develop complex system "in public," (2) hurry "completion" of system by election time.
	FISH PROTEIN	Immediate: TECHNOLOGY—Manifested by unreliable and too costly production. MARKET—Resoundingly rejected. Basic: *POLITICAL*—Pressures hurried technology into demonstration before it was ready. Apparently same pressures foreclosed a sensible market-test strategy.

case, householders had to change from individual to shared garbage containers. As a money-saver, the Godzilla system represented a good enough investment for Scottsdale, Arizona to make on its own. Given the drive of its city manager, it might have done so. The federal contribution unquestionably made it easier for Scottsdale to proceed. Not only did federal funding provide necessary money, it may also have indirectly helped to persuade Scottsdale's residents to accept the changes entailed by the new system. Opposition might have crystallized around this issue if the citizens had been required to put up the money themselves. As it was, Scottsdale obtained a discount on a product development which was to its benefit. Thus, the significance of government funding can be psychological as well as economic.

b. *Failures*

Medicaid Claims. Medicaid Claims is a process and product innovation which required a modification in end service that may have acted as a barrier to its diffusion success. Reportedly, Medicaid Claims was an application success which saved money, at least for the participating doctors. The amount saved, however, was apparently not enough to overcome the objections of third party payers (Blue Cross and Blue Shield). What was the reason offered by Blue Cross for rejecting a system that the doctors thought was so good? Was the system so obviously incompatible with Blue Cross procedures that it could be rejected despite large savings to everyone else concerned? Or did it require Blue Cross to spend more money on their end to handle claims processed in this new way? Or, as was probably the case, was Blue Cross simply waiting to adopt a better system yet to be developed? These questions remain unanswered at this time.

4. **Process and Scale Economy Innovations:** These innovations save resources by mass-producing the end-product. The large front-end costs of such innovations must be spread over many units produced, which implies large demands for the end-product. That demand may or may not materialize, which makes process and scale economy innovations risky. The end-product itself may have to be qualitatively different. For example, early Fords were all painted black because only that color dried quickly enough to keep up with the assembly line. The point is that mass production and mass demand are interdependent. Examples of innovations in this category are Operation Breakthrough and Dial-a-Ride, both of which failed.

ERDA's solar energy and electric car programs also fall in this category.

a. *Successes*—none

b. *Failures*

Operation Breakthrough. Industrialized housing is a process innovation that was supposed to cut the cost of housing construction through mass production and economies of scale. As it turned out, the production costs for Breakthrough housing were not appreciably lower than those for housing of similar quality, while the quality fell considerably short of what had been projected. Thus, Breakthrough was an application failure because the technology did not meet a prime objective of process innovations, i.e., to lower the cost of production.

Lowering the cost of housing production was the key objective on which all others depended. The highly charged political atmosphere of the times completely obscured it. Technological issues were confused with ideological ones such as community development and institutional change. These goals proved to be incompatible when HUD tried to achieve them simultaneously. Had HUD been able to demonstrate that mass-produced industrialized housing reduced costs by, say, thirty percent, it *might* have been able to get all the institutional changes needed to lower those costs still further.

Unfortunately, Breakthrough failed to lower the cost of housing enough to overcome the institutional barriers that might have made these and other cost reductions possible. To rant against institutional barriers is often to miss the point for future policy.

Institutional barriers remain frozen for marginal savings. Why should anyone give up traditional practices for small benefits to someone else? In the absence of clearly perceived large savings, effective political pressures could not be brought to bear on the relevant institutions.

The Breakthrough Demonstration was a predictable failure because the technology aimed at reducing costs that were too small in relation to the total cost of housing. The Breakthrough concept began to emerge at the Woods Hole Conference on Science and the City. The cost data unveiled at that conference, however, clearly indicated that the concept was likely to fall short of achieving the hoped-for dramatic savings. The first warning came from an FHA presentation which showed that the cost of housing could most effectively be lowered by reducing interest rates and land costs, not through changing the technology of housing.

The technology and cost issue was addressed frontally by Richard O'Neill, editor of *House and Home* magazine. At a National Science Foundation conference (and later in an editorial published in *House and Home*), O'Neill pointed out that the major target of Breakthrough's technological improvement program was the shell of the house. Even if the shell's cost were cut to zero, this would lower the cost of housing by only ten or twelve percent. O'Neill's statement was considered reactionary, and his article had no effect on government policy. Yet later events demonstrated that the cost-reduction opportunity was too small to warrant an attack by a large and complicated research and development process.

The general lesson to be learned here is that process innovations which depend on scale economies should be approached with great caution unless the data show opportunities for large economic benefits to the decision makers involved. The operational lesson of Breakthrough is that once an ideological juggernaut gets rolling, it is difficult to stop it using quantitative data—however rational. Some kind of dispassionate analysis of the potential for economically competitive targets and the likelihood of their achievement was necessary. Unfortunately, the people most qualified to make the analysis were in the housing business in one way or another. Those who were not in the housing business were apparently so committed to "innovation" that they seemed to forget what they were innovating for.

Dial-a-Ride. The Haddonfield Dial-a-Ride project was apparently doomed from the outset because various political forces had distorted its implementation strategy. In order to understand the proximate cause of failure, one has to understand the objectives of the program. Dial-a-Ride was supposed to provide door-to-door service at less cost than a taxi by group-riding people going to and from the same place. Dial-a-Ride response time and cost depended on its scale of operation. This, in turn, depended on demand, which was contingent on price and service quality.

Most observers believe that Haddonfield Dial-a-Ride failed largely because it tried to build a system from scratch rather than evolve it from an existing taxi service. The major reason for the taxi strategy is cost—which determines fares, which, along with response time, determine demand.

Most of Dial-a-Ride's cost is labor. Taxi labor gets less than half of bus driver wages. For example, in Davenport, Iowa, the most successful Dial-a-Ride system to date is based on the taxicab and has been operating at the lowest vehicle cost per hour (between $3.60 and $4.90). In marked contrast, Dial-a-Ride elsewhere has been costing as much as $15.00 per hour. Calculations show that if Davenport carried as few as five passengers per hour, the average fare to break even would have to be only $1.00; at the other sites, the break-even fare would have to average as high as $3.00. Both these fares can be reduced by subsidy, of course, but it is one thing to cut a $1.00 fare to 50 cents, and quite another to cut a $3.00 fare to the same level.

The taxi strategy was suggested to Urban Mass Transit Administration (UMTA) in a major study and several memoranda. It was not accepted. Two possible reasons for this rejection are:

1. In its early years, UMTA was unsure about its role with regard to the taxi industry. Taxis were not mass transportation, but they were part of the public transportation system. While a reading of the UMTA charter could easily be interpreted to include taxis, UMTA's administrators elected not to do so. Today the taxi industry is considered part of UMTA's responsibility.
2. The researcher who recommended the taxi strategy was not a member of the regular UMTA staff. When he was off the premises, there was no strong voice to champion the taxi strategy.

5. Qualitatively New Product or Service

These innovations face the greatest market risk. With or without government support, a completely new product is the riskiest kind of undertaking because it depends most heavily on consumer acceptance. The more innovative the product, the less predictable its acceptance in the market. Market research can do much to minimize these risks, but as Peter Drucker points out in *Age of Discontinuity*, market research techniques do not offer much guidance about innovations that are qualitatively new. This is not an argument against market research as such, but it is a caution against relying too heavily on it under such circumstances.

Innovations in this category studied by Rand include the Hydraulic Knee, ECG, Personal Rapid Transit (PRT) and Fish Protein. The first two are application and diffusion successes; the other two failed on both counts.

a. *Successes*

Hydraulic Knee, ECG. Both Hydraulic Knee and ECG represent diffusion successes despite the market risks inherent in instituting such innovations. They were both good ideas, and once demonstrated their value was easily perceived by potential users. Neither innovation saved its users money, but both enhanced the performance of a service or product enough to be worth the extra cost. Selecting such a product for development requires a touch of business genius. Even so, its ultimate success seems to depend more on its being modest enough to be implemented quickly—outside the spheres of high political pressures.

b. *Failures*

PRT. Morgantown PRT represents a qualitatively new product and service that apparently failed for political reasons. The immediate cause of the failure was technological: the system was expensive and did not function reliably. As a new service, it might or might not have gained market acceptance. At the time, there was thought to be no way to determine this other than by developing a system somewhere (not necessarily in Morgantown) and deploying it in a real-world situation (definitely not Morgantown.)

The potential for technological failure at Morgantown was probably enhanced by two related, politically motivated decisions: (1) the decision to develop it *in situ* at Morgantown instead of at a test track; and (2) the decision to undertake to finish the development of a complex technology within three and a half years, in time for the next presidential election.

The siting decision was at the time seen as something of an opportunity. The university campus appeared to offer a reasonably controlled environment which avoided the complexities of the market but allowed the system to be tested by genuine passengers. It was furthermore reasoned that developing the system at a test track would involve extra cost later, when it was transplanted to a real-world site. These extra costs could be avoided by both developing and deploying the system at Morgantown, which was seen as something of a technological halfway house.

Unfortunately, the timing decision was made for UMTA by the political sector. Having decided to go ahead in public by deploying the system at Morgantown, the target date was set by implication. The project had to be up and running within three and a half years, the next election time. At the outset, the new UMTA administrators were not conscious of the political pressures that would be brought to bear before election time.

Morgantown PRT started as an application failure but more recently has become something of an application success. Users are reported to be enthusiastic about it. How much the Morgantown PRT will ultimately contribute to the diffusion of PRT is hard to say.

Fish Protein Concentrate. The fundamental cause of the failure of this project is thought to be political. The immediate causes were technology and marketing.

Here the government tried to develop a new product, which is always a risky business because of the unpredictability of consumer acceptance. And yet one cannot say from the evidence that it failed for reasons which market research might have predicted. A market survey *might* have quashed the project before it began. It was, after all, fairly well known that people in less developed countries would often starve rather than change their eating habits from, say, rice to wheat.

It was not unreasonable to think at the time that if people would only try FPC they would like it so much that they would demand more, and yet it is not clear whether the government ever test-marketed the product to potential users. While the samples might have had to be produced "by hand" at high unit cost per sample, this would have been a prudent pre-investment strategy. It seems that this was not done. Rather, the "samples" were produced in the demonstration plant and as RAND notes, ". . . when the demonstration began a large number of technical issues remained unresolved." In other words, it seems that the demonstration plant had trouble producing a good sample of the material. In addition, FDA's initial refusal to approve the output of the plant for internal U.S. consumption made the product even less palatable to potential consumers here and abroad.

It is clear that the technology for producing FPC was not "well in hand," and that this contributed a good deal to its failure. Even if the technology had been developed, it is possible and even likely that the project would have failed for lack of market acceptance. But this is only speculation. The area to be further explored is why the technology failed. Here again it seems that the technological program was distorted by the strong political forces brought to bear. ERDA needs to know more about these forces so that it may develop guidelines for dealing with them.

D. Primary Audiences

There are five primary audiences for federally-sponsored demonstrations. Two of these represent the agency's political audiences: *public interest groups and regulatory bodies*—Federal, State and local—who play an indirect but often crucial role in technology acceptance. *ERDA*, plus the remaining three are the direct participants in the commercialization process: the intended *tech-*

nology end-users, the *technology suppliers*, and the supporting *financial community*. ERDA itself is at the interface between the political and commercial interests that must interact, and must therefore be prepared to mediate the force of those impacts.

1. **Public Interest Groups.** The regulatory climate, which is normally unfavorable to innovation, is strongly affected by groups who lobby at both the national and state level to make sure that the *current* interests of their constituents are protected. At the very least, they will formally insist on equity, i.e., that (1) the costs—broadly defined to include esthetic and environmental, as well as economic—will not exceed the benefits directly accruing to same, and (2) that the incidence of those costs will fall proportionately on those who will benefit from the expenditure.

It would seem easy enough to structure demonstration projects that conform to the principles of equity. Experience indicates, however, that in fact this rarely happens. Such difficulties seem to be compounded when projects are designed primarily by engineers who are sensitive to costs but tend to ignore equities. For example, highway engineers used to insist on building "cost-effective" highways by ramming them through parks and low-income communities. They did so well at this for years that they precipitated a revolt against the whole highway program.

These issues are brought to a head by the decision to locate a demonstration project within a given community where environmental, socio-economic and institutional conditions will all be affected.

An agency planning such a demonstration should (1) establish a sensitive early warning system to pick up signals of controversy well in advance and (2) take steps to address incipient problems before they become the subjects of delaying agitation and litigation.

2. **Regulatory Agencies.**

The importance of early identification of the regulatory audience cannot be overemphasized. This audience, which can have a major impact on both the demonstration and the ultimate acceptance of the new technology, can be very large and includes regulators at the federal, state, regional and local levels.

The federal regulatory audience includes agencies such as the Environmental Protection Agency (EPA) and the Occupational Safety and Health Administration (OSHA) which are concerned with determining the environmental and health impact of both the demonstration plant and the proposed commercial facilities.

To a lesser extent, ERDA demonstration projects will be reviewed by other regulatory agencies, such as the Department of Commerce and the Federal Power Commission. For example, the Federal Power Commission, currently one of the agencies involved in the formulation of energy policies, will certainly review ERDA's demonstration projects with respect to wholesale electric rates, electric systems coordination and reliability, resource allocation, energy conservation, and with respect to their many other functions and responsibilities.

At the state and local level regulatory interest will emphasize environmental, socio-economic and institutional concerns. A demonstration will take place within a regulatory framework consisting of state agencies, regional and local boards, and planning commissions. If the new energy supply system is designed to operate within a regulated industry, e.g., natural gas and/or electric utilities, economic viability may receive scrutiny which can be as detailed as that for environmental impact.

Relative to both federal and state regulation, it is important that demonstration projects generate sufficient data to permit an accurate assessment of the environmental impacts associated with full scale commercial development. Intervenors are likely to charge that "this technology has never been clearly demonstrated and therefore the project in question should not be undertaken." This, of course, creates a classic chicken and egg situation. The best solution is to have available the results of a well designed and executed demonstration project upon which an environmental assessment can be made. Sometimes the demonstration project itself will operate within a complicated regulatory framework (the Clinch River Breeder Reactor is an extreme example of this). In order to facilitate the development of acceptable new technologies, ERDA should invite representatives of state regulatory agencies to participate on advisory panels concerned with the overall technical program including the demonstration project.

The table shown in Appendix G contains, as an example, a sample list of federal, state, and local approvals which must be obtained prior to commencement of construction of a power station in California.

ERDA should strive to achieve acceptance of a streamlined regulatory approach for demonstration projects which, after all, do not represent a long-term commitment of resources. The regulatory framework for a commercialization project is often adjudicatory, adversary and complicated. Demonstration projects should be designed and billed as a means of generating the data which regulators will need to assess future commercialization projects.

Local agencies are sensitive to the desires of local public interest groups which often wield considerable political clout. This can place the federal agency (ERDA) in the role of an "outside interloper" who will be at political disadvantage when the adversary stage is reached. This makes it all the more important to address problems at the demonstration level.

Local governments are involved as an audience in the following ways:

1. As regulators of building construction, the effectiveness of which can contribute to energy conservation.
2. As the focal points of local economic development efforts concerned with maintaining adequate energy production and supplies at competitive costs to attract and maintain industry and jobs.
3. As energy producers and distributors in those jurisdictions which provide such public utility services.
4. As large consumers of energy which manage various municipal services, from street lighting to hospitals to transportation systems.
5. As overseers of social service aid which includes footing the energy bills of persons on assistance.

The size of a jurisdiction, its location and its legal responsibilities all play a part in its concern for the energy question. It is clear that local governments need to have answers that will enable them to more effectively regulate construction, educate citizens seeking advice on conservation, and plan changes in capital programs in response to shifting energy use patterns.

All energy projects have benefits and costs and ERDA should strive for public understanding of the fact that you cannot please all of the people all of the time and that a balanced approach is necessary.

Demonstration projects which are carefully designed to include regulatory concerns can help achieve public awareness of the need for this balance.

The matrix shown in Figure 7 suggests the regulatory sensitivity points to which a demonstration project must be alert.

3. **ERDA.** As was noted earlier, ERDA itself is a most important audience for the demonstrations it sponsors. This is particularly the case with *experimental* demonstrations, whose outcomes are highly uncertain. Those outcomes must permit ERDA to make critical program judgements about continuing, discontinuing or redirecting programs. They must also indicate to ERDA when additional incentives beyond those inherent in the technology itself must be offered to industry as further inducements.

4. **End-Users and Suppliers.** The two direct commercial targets of ERDA-sponsored demonstrations are technology end-users and their suppliers.

Between these, the choice of focus of the demonstration will depend on (1) whether potential suppliers or potential end-users of the technology are likely to be more receptive to the technology or (2) conversely, which of the two might offer the greatest resistance to the new technology. The end-user may be highly receptive to the technology, but their suppliers—the components of the Technology Delivery System [9]—may not be willing to tool up for it, carry it in their line, or whatever.

Each technology has a unique market and must be treated individually. Certain broad principles obtain, however. On the basis of market appraisal, ERDA can decide whether it is better to focus the demonstration on the end-user in an attempt to *pull* the new technology into, and through, the Technology Delivery System; or it may choose to *push* the technology through the system by demonstrating to the potential suppliers that the development has attractive profit

[9] Arthur Ezra, "Incentives and Solar Energy," *Science*, Volume 187. number 4178, February 28, 1975.

Figure 7

IMPACT-AUDIENCE MATRIX
EQUITY ANALYSIS

Target Audience		**Public Sector**		**Private Sector**	
		Local Gov't	**State Gov't**	**Institutions**	**Persons**
Impacts	Economic				
	Social				
	Environmental				
	Institutional				

making potential. The point is to focus the demonstration purposively on its key audiences lest its message become too diffuse.

Transferring technology, whether it be to the user or producer, is a government version of industrial marketing and is just as risky. In the producers goods industries, most technological innovations fail primarily for market reasons, with management error a close second. (See Figure 8.) Technology itself is surprisingly low risk and causes few failures. ERDA's pattern is likely to be similar: given its strong technical competence, it should anticipate few out-and-out technological failures. Rather, the agency can expect most of its dissapointments to stem from management and marketing errors. If anything, ERDA failures due to these factors are likely to be more frequent than those experienced by private industry; government agencies are inherently more difficult to manage, and "selling" technology is an unaccustomed and, generally, uncongenial role for them.

a. *Criteria*. Much can be done to strengthen ERDA's commercialization role and improve its chances of successfully transferring and diffusing the technologies it supports. In general, the agency must enhance its understanding of what motivates industry to adopt technologies, and what criteria industry uses in making such decisions. While reams have been written on new product selection, its principles may be succinctly described as follows. The objective of product selection is:

. . . to pick the best ideas for investing available new product time and money. There are more high-risk than low-risk products; and there are more low payout than high payout opportunities . . . However, management's purpose is to beat the probabilities by finding those rare ideas that are both low risk and high payout.[10]

This is the key to maximum yield on available manpower and resources.

A study by the Conference Board of the practices of two hundred and three manufacturing and service firms with active programs of product and service development found that more than

Figure 8

WHY INDUSTRIAL INNOVATIONS FALTER OR FAIL

NUMBER OF INNOVATIONS	%	OBSTACLE
55	27.5	Market difficulties
47	23.5	Management error
31	15.5	Capital availability
24	12.0	Regulation
23	11.5	Technology failure
11	5.5	Anti-trust/Patent
9	4.5	Miscellaneous
200	100.0	

Source: Myers and Sweezy, op cit.

[10] Booz-Allen & Hamilton, *Management of New Products*, 1968, p. 10.

three-quarters of them cited return on investment (RO!) as a principal measure by which new product concepts are judged.[11] While the methods used for computing ROI vary, the criterion remains the cutting edge for decision-making. The Task Force's chairman has emphasized it even more strongly:

> The test of an innovation is return on innovation investment. That is the boundary condition that finally determines the one in two hundred or one in a hundred of the opportunities which will succeed.[12]

In selecting new technologies, companies look for those that will yield the largest rate of return commensurate with the risks involved. If other factors are equal, potential adopters will rank each technology according to its ROI, thereby generating a priority list of investment opportunities. Projects will be funded from that list down to a cutoff point determined by the company's policies and resources (see Figure 9). If ERDA is to induce a particular company to adopt a particular technology, that technology must compete with the company's other opportunities for a position above the firm's cutoff point. Since ERDA cannot, in the nature of things, be privy to the priorities lists of potential adopters, it must either (1) pick technologies that have very large and obvious comparative advantages or (2) be prepared to negotiate on an *ad hoc* basis additional incentives which would raise the priorities of its technologies high enough to close the gap (see Figure 9). That would at least be ERDA's rational response to industry's drive to maximize profits.

b. *Preference for Control.* Many other factors, of course, determine a company's investment priorities, not all of which can be discussed here. One factor is, however, of special concern to ERDA because it relates to uncertainty, particularly to uncertainties about government actions and ERDA involvement in a company's affairs. March and Simon point out that an innovating firm deals first with those problems over which it has full control. It deals secondly with those problems over which it has partial control. And it deals last with those problems which require a change in the variables.[13] In short, industry prefers to work with projects over which *it* has control. That means that industry will rank ERDA technologies lower to the degree that ERDA insists on taking control of the demonstrations it sponsors.

c. *Satisficing.* In actual practice, companies do not rigidly follow principles that would maximize both their control and profits. Instead of a long search for "best" alternative technologies, they will often settle for one that is readily at hand, provided that it falls above the economic threshold suggested in Figure 9. (This practice is referred to as "satisficing" by Herbert Simon in his book *Administrative Behavior.*) Thus support, in one form or another, of the initial application, i.e., demonstration, can be an essential contribution to achieving application.

5. **The Investment Community.** The ultimate disciplinarians of the market are the private investors. They have no emotional attachment to any particular development, or organizational loyalty to be furthered or preserved. They respond directly to classical market allocation forces. Demonstrations directed primarily to this audience must focus strongly on the economics of the process.

While a private equity investor in a project will view it somewhat differently than will a private lender, both the investor and the lender must make a judgment of the relationships between expected return on invested capital and the risks involved. For the equity investor, an analysis of the discounted cash flow relative to the total dollars invested or the stream of net profits relative to the equity invested provides a basic yardstick. The lender of course is more concerned with the likelihood of getting the principal repaid with interest over the life of the loan. For the lender the return is limited to the interest earned and therefore the possibility of loss must be minimal. The equity investor, on the other hand, may be willing to accept a material possibility of loss if the return is believed to be large enough in the event the project should succeed. In either case the fundamental concern is the probable reward relative to the degree of risk being taken.

There are of course many factors which are

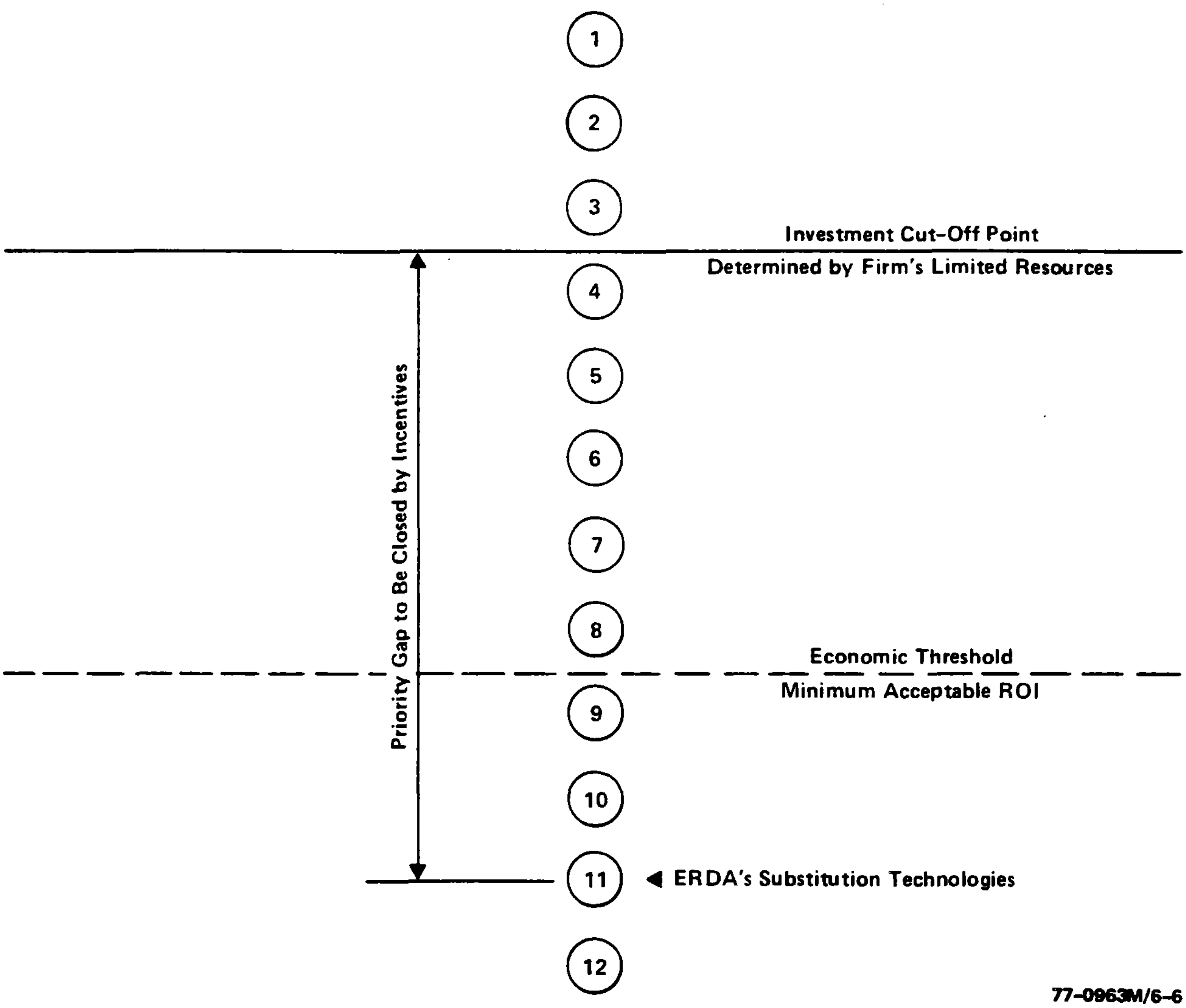
[11] The Conference Board, *Evaluating New Product Proposals*, #604, 1973, p. 19.

[12] Robert Charpie, "The Business End of Technology Transfer," Proceedings of a Conference on Technology and Innovation, NSF 67–5 1966, p. 47.

[13] James G. March and Herbert A. Simon, *Organization*, Wiley, New York, 1968.

Figure 9

Closing the Priority Gap for *"Uneconomic"* Technologies



taken into consideration in determining the projected return from the project. They vary from project to project and, while it is difficult to generalize, some of the most important factors in appraising the return on a venture are these:

1. What is its profit potential and what is the likely timing of the profits? The private equity investor will take into consideration not only the size of anticipated profits but their timing. An investor will time adjust the returns using a discount factor which reflects his assessment of the risk of the cash flow materializing.

2. The second key element is the market potential. Is the market large enough and is there a high enough probability that the project managers can achieve enough market penetration to generate a satisfactory profit?

3. Investors will look at competitive factors. What resources do competitors have to

bring to bear to the market? How proprietary is the technology being applied? How easy or difficult is it for competitors to take a market share away?

4. It is also critical to make a judgment of management's ability to carry out the business plan. Do the managers have the skills, the experience, the incentives and the required capabilities to achieve the plan?

An analysis of the risks in a project is to some extent the corollary of an analysis of the rewards. A long lead time before profits materialize, a small market, easy competitor entry or missing skills in the management team are all elements of risk. In addition, some important risk elements to consider include:

1. The degree of technological challenge involved in making the project successful.
2. The possibility of intervention which could either abort the project or stretch out the flow of profits. Intervention problems might result from Federal, state or local government policies, a change in tax treatment, the likelihood of legislation interfering with success or delays resulting from the influence of outside agencies such as conservationist groups or the press.
3. Another factor to consider in an analysis of risk is the ability of the sponsoring entity to put more resources into the project should problems arise. What are the "fallback" alternatives? Should problems occur, what recourse do the investors or the lenders have? Is the product necessary enough to the customer for the buyer to come to the aid of the supplier should troubles occur?

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