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Evaluation of the Energy-Related Inventions Program: An Empirical Analysis of 204 Inventions

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OPERATED BY
MARTIN MARIETTA ENERGY SYSTEMS, INC.
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ENERGY DIVISION

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ABSTRACT

This report is an evaluation of the Energy-Related Inventions Program (ERIP). It assess the program's effectiveness and impacts, characterizes participating inventions and inventors, and identifies correlates of successful commercialization in order to suggest possible improvements.

Seventy of the 204 ERIP inventions that were studied were successfully introduced into the market, accounting for more than $200M in sales from 1976 through 1984. During 1984, 921 full-time equivalent employees were supported directly by ERIP inventors or their licensees. (Estimates of indirect economic impacts are also contained in the report.) Data on patterns of fund raising clearly show a need for assistance by programs like ERIP. Commercially successful inventors shared several traits. They had less formal education, fewer patents, more work experience in small firms, more outside funding early in their work, more shared responsibility with others for invention development, more management experience, and greater previous experience with starting new businesses.

Recommendations are made regarding: (1) priorities for allocating ERIP grants; (2) improved efficiency of the NBS/DOE operations; (3) delivery of technical and commercialization assistance to grant recipients; and (4) further evaluation research.

EXECUTIVE SUMMARY

This report is an evaluation of the Energy-Related Inventions Program (ERIP). It assess the program's effectiveness and impacts, characterizes participating inventions and inventors, and identifies predictors of successful commercialization in order to suggest possible program improvements. ERIP was established in 1976 to facilitate the development of non-nuclear, energy-related inventions, particularly by individuals and small businesses. It is operated jointly by the U.S. Department of Energy (DOE) and the U.S. Department of Commerce/National Bureau of Standards (NBS).

Since 1980, ERIP has undergone several evaluations; the latest and most comprehensive is the subject of this report. Past evaluations have centered around in-depth case studies of selected inventors. The current evaluation incorporates, updates, and expands these case studies, in an attempt to provide more definitive empirical conclusions about the entire population of ERIP inventions and inventors.

The chief tool in this evaluation is a telephone questionnaire. Using this questionnaire, information was collected from 204 of the 307 participants recommended to DOE by NBS as of June 1985. Although information was sought from all 307 ERIP participants, some of the inventors could not be found, while others declined to take part in the evaluation. In addition, for participants who have had more than one ERIP invention, information was collected only on their latest project. There is no known bias in the sample of 204.

ERIP STRUCTURE AND SERVICES

DOE and NBS operate the program through an interagency agreement. The goal of the NBS portion of the program is:

this area have included sponsorship and participation in workshops and conferences. Planned future activities include the disbursement of grants for state-level invention initiatives.

CONSEQUENCES OF ERIP

To analyze the effectiveness of ERIP, three definitions were developed. **Commercialized inventions** are characterized by a direct sale of a unit of product or service, the conclusion of a licensing agreement, the conclusion of a joint venture, or the sale or licensing of a spin-off technology. A more rigorous definition is used to identify the more successful of these commercialized inventions. In particular, **successful inventions** are those with $50,000 or more in sales for any single year from 1980 through 1984, or cumulative royalties of $5,000 over the same period of time. Finally, **inventions in the production/marketing stage** are also identified. This stage includes both limited and full production and marketing, but not sales of prototypes. The relationships between these three are displayed in Figure S-1.

The classifications are not meant to infer that noncommercialized, unsuccessful, and pre-production/marketing inventions will not eventually achieve market entry and significant market penetration. On average, less than six years had elapsed between time of application to NBS and the end of the evaluation period (1984).

The following conclusions were drawn from an analysis of data for the period 1976 through 1984.

- Market entry. Of the 204 inventions in the database, 70 were commercialized, 37 were successful in terms of achieving significant sales, and 31 were in production/marketing. Figure S-1 shows how these inventions overlap. It is known from previous case study evaluations that another three ERIP inventions have been commercialized. The number of ERIP inventions that are commercialized or put into production

from ERIP, other than grants. The following benefits were among the most frequently cited:

- Opportunity to prove an invention. Some 34% cited ERIP's role in allowing them to actually bring their ideas to fruition as one of the program's chief benefits.
- Credibility or prestige. The backing of a government program gave much-needed credibility (which sometimes translated into outside commercial funding) to many of the inventors in the program. This form of assistance was noted by 29% of the inventors.
- Encouragement. The personal guidance and encouragement given by ERIP's invention coordinators was cited by 13% of the respondents as the most important nonfinancial benefit of the program.
- Commercialization education. ERIP inventors also emphasized the benefits of ERIP's commercialization education efforts, including the personal contacts with invention coordinators and the Commercialization Planning Workshops. This type of assistance was cited as "most important" by 9% of the inventors.

Overall, the ERIP inventors expressed a high level of satisfaction with the program. More than 40% of them had already recommended the program to others; some 80% said they would be willing to submit another invention to ERIP; and 25% have already done so.

THE INVENTIONS

NBS uses a nine-category classification system for the inventions submitted to ERIP. Using this classification it was determined that technologies involving **Energy Conversion from Natural Sources** and **Energy Conversion from Secondary Sources** have proportionally fewer successes than those involving **Industrial Processes; Fuels and Lubricants; Buildings, Structures and Components;** and **Transportation** technologies. It was not possible to characterize the

projects before application to NBS does not correlate with a more mature stage of innovation development at the time of application, nor does length of time in the program correspond with later stages of development in 1985.

THE INVENTORS

There is great diversity in the personal characteristics of program participants. However, in the course of the evaluation, some commonalities and patterns were found:

- ERIP inventors have a wide array of formal education: 31% have graduate degrees while 29% have no undergraduate degree.
- Almost half of those with college educations majored in engineering.
- On average, the respondents were quite a bit older than the general adult male population. The mean age of ERIP participants is 56; 24% are 65 or older.
- The inventor's current job was usually, but not always, related to the ERIP invention; his previous work experience typically had little connection with it.
- While many ERIP inventors had little or no prior inventing experience, some had a substantial amount--22% of the inventors owned more than 10 patents.
- Many inventors (79%) reported having started at least one new business in the past, and 18% had started more than two.

These and other personal data were used in an attempt to identify any general characteristics that successful inventors tend to share. As before, the definition of "success" is based on thresholds of sales and/or royalties. While no clear, stereotyped figure of a "success" emerged, it was found that many of the successful inventors do share several personal traits, including:

- less formal education than unsuccessful inventors;
- fewer patents;
- more work experience in smaller firms;
- greater amounts of pre-ERIP personal funding;
- greater amounts of pre-ERIP commercial funding;
- more sharing of innovation-development responsibilities;
- more management experience; and
- greater experience with new businesses.

individualistic responsiveness of ERIP would be to establish a fund to pay consultants for special short-term, quick response assistance to inventors.

(6) Provide greater commercialization education covering such topics as effective marketing and the development of business plans.

Recall that the transition from prototype development to production/ marketing was found to be the most difficult. The program needs to help facilitate this process.

(7) Ensure the effective use of the computerized database currently being developed for DOE's ERIP program.

This involves providing DOE with sufficient hardware, software training, and funds to support data input and analysis needs.

(8) Consider using the computer equipment to communicate electronically with ERIP participants.

Several areas for future evaluation are also recommended.

(9) Evaluate the administrative functioning of the DOE and NBS aspects of ERIP.

Given the inventors' concerns about the application processing time, particular attention should be given to the time delays.

(10) Develop more up-to-date estimates of the economic impacts of ERIP.

Sales and employment data on ERIP inventors need to be collected for 1985 and 1986, and information on the most recent ERIP participants should be compiled.

(11) Compare the progress of ERIP inventions with the technical and commercial progress of a control group.

None of the ERIP evaluations to date have been able to definitively estimate the impacts of ERIP because of the absence of a control group.

1. THE ENERGY-RELATED INVENTIONS PROGRAM

1.1 PURPOSE OF THE REPORT

This report is an evaluation of the effectiveness of the Energy-Related Inventions Program (ERIP), a program designed to provide carefully-targeted federal support for non-nuclear energy-related innovation among small businesses and individuals. In order to evaluate the effectiveness of ERIP, the report examines the technical and commercial progress of ERIP-supported inventions, characteristics of the most successful inventions and inventors, types of funding acquired by ERIP inventors over the course of their projects, and stages in the innovation process that appear to be most difficult to transcend. As such, the evaluation is useful well beyond its specific application to ERIP, providing insight into the process of technological innovation as a whole--a topic of considerable importance to national, state, and local economies, and one which is particularly timely given recent evidence of an apparent decline in U.S. productivity growth and international competitiveness.

It is now well known that technological innovation is a major determinant of productivity growth (Nelson, 1981; Schmookler, 1957; Schumpeter, 1934). New technologies generate employment growth and high rates of productivity, and send spin-off effects rippling through the economy. According to one study, technological innovation was responsible for 45% of the nation's economic growth between 1929 and 1969 (Gore, 1981).

Technological innovation occurs as the result of a two-step process--invention (the creation of a novel idea or concept) and the translation of an invention into a commercial product or process. Many experts attribute the nation's slowdown in productivity growth to a diminished rate of inventiveness--the first step. Other experts have claimed that the slowdown in

national energy security, strength, and stability are typically not considered in the setting of corporate R&D agendas.

Patent data over the past 15 years also indicate diminished inventiveness. The number of patents issued to U.S. inventors has decreased from 47,076 in 1970 to 46,728 in 1975, 37,327 in 1980, and 38,371 in 1984 (Narin, 1987; Bailey, 1986). Patents are often used as indicators of the "stock of technology," because in order to get a return from R&D investment, companies usually must patent a product or process to protect it from competition.

There is also evidence that the nation has been slow in translating its technological advancements into commercial applications. From the 1950s through the mid-1970s, the federal government was the primary source of R&D funds. Numerous studies point to the smallness, and the lag, in commercial application of federally funded R&D. The rate of licensing of federally-owned patents, for example, is only 2.5% (U. S. General Accounting Office, 1985).

ERIP's focus on small businesses is advantageous because it is this sector that has been particularly successful in producing creative innovations for the marketplace (Rabinow, 1982; Soltanoff, 1978; Baily, 1986; Gellman Research Associates, 1982). Firms with less than 1,000 employees accounted for almost one-half of the major innovations during the 1953-1973 time period (Gore, 1981). They produce 2.5 times as many innovations as large firms, in relation to the number of people employed, and they bring their innovations to the market much faster than large firms (Gellman Research Associates, 1982). Small firms need to develop new products and services in order to carve out niches in those areas of the economy not already controlled by large corporations (Gellman Research Associates, 1982; Rothwell and Zegveld, 1984). Large firms tend to limit their innovations to refinements of existing products

1.3 DESCRIPTION OF ERIP

1.3.1 Goals and Objectives

ERIP was established under the Federal Non-Nuclear Energy Research and Development Act of 1974. It is administered jointly by the U.S. Department of Energy (DOE) and the U.S. Department of Commerce/National Bureau of Standards (NBS).

DOE and NBS operate the program through an interagency agreement. The goal of the NBS portion of the program is:

- To evaluate energy-related ideas and inventions, and to select for further support those inventions that are likely to increase energy efficiency and are technically and economically feasible.

The goal of DOE's efforts is:

- To provide the initial funding for these projects, as well as the guidance necessary to speed inventions toward introduction in the marketplace.

A secondary goal of DOE is to encourage invention activity and inventiveness, in the economy as a whole.

1.3.2 Program Structure and Services

Within DOE, ERIP is a part of the Office of Conservation and Renewable Energy. It is located under the Director of Energy Utilization Research and is staffed by four Invention Coordinators, a program manager, and various support personnel. Although this evaluation deals exclusively with DOE's portion of the program, a brief overview of the NBS functions is important to an overall understanding of the program; that overview appears below and is summarized in Fig. 1.1.

NBS Program Procedures. To enter ERIP, inventors must file an NBS application and an invention disclosure. NBS then performs a "threshold screening" before any evaluation is done, to make sure that:

their potential impact on energy production and conservation, and their practicality. The first stage is based on two sequential evaluations and eliminates 45% of the total number of submitted projects. The sequencing allows the first evaluator to point out specific technical issues that need to be examined by the second evaluator. NBS then reviews the final reports of both evaluators and decides whether or not the project should progress to the second stage. The inventors are given written notice of rejection or passage, with a detailed explanation of why rejected projects did not measure up.

Approximately 5% of all submissions pass into the second stage. There, one evaluator reviews the technical aspects of the proposed invention, working directly with the inventor to resolve any possible misunderstandings. A decision is then made to recommend or not to recommend the project to DOE for possible financial and nonfinancial support. The NBS recommendation includes the technical merits of a project, and an estimate of its marketability and potential energy impact.

At each stage of the evaluation process, rejected inventors are asked to deal with the deficiency cited in the rejection, and to resubmit the project, entering the evaluation process at the same stage at which they were rejected. Some 15 percent of the inventions recommended to DOE are resubmissions of projects previously rejected by NBS.

By the end of calendar year 1986 more than 23,000 inventions had been submitted to NBS since ERIP began; fewer than 400 of these have been recommended to DOE. The rate of acceptance has varied from 2 to 3% since the beginning of the program.

DOE Program Procedures. Once a project has been recommended by NBS, DOE takes it over. The invention is assigned to an Invention Coordinator, who plays a pivotal role in the development process as the point of all interaction

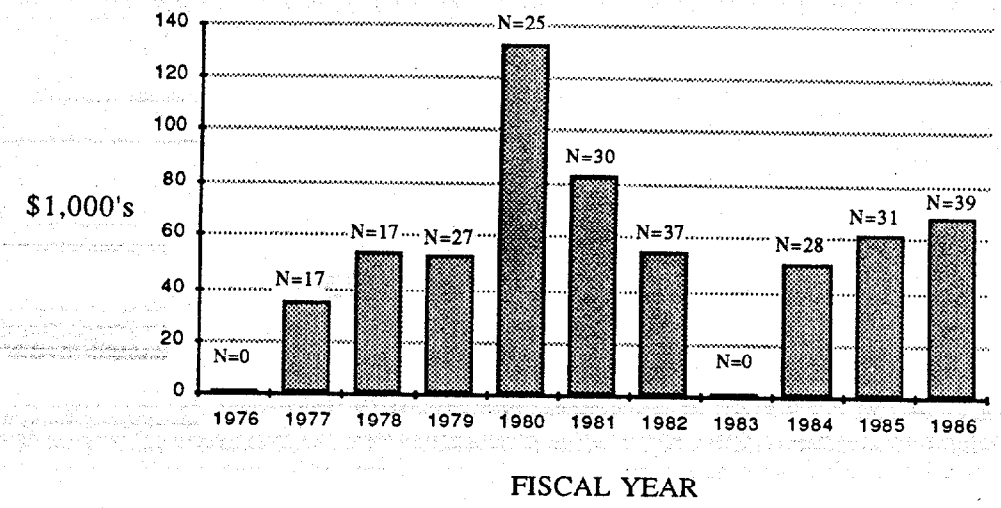

Fig. 1.2 Number of ERIP grants and average grant size: 1976-1986.

Among the types of nonmonetary assistance provided by the program are commercialization advice and contacts. In addition to the informal contacts and directions given by the Invention Coordinators, commercialization education is provided by ERIP through its Commercialization Planning Workshops (CPWs).

Each CPW is an intensive, three-and-a-half day program designed to help the inventor develop a focused strategy for moving his technology into the market. Classes cover patenting, licensing, business planning, financing, marketing, and a variety of other issues related to the commercialization aspects of inventing. The sessions are directed by experts drawn from the business, engineering, legal and academic communities. They usually involve about 12 inventors and 6 or 7 experts, allowing for plenty of one-on-one discussions about specific problems inventors may have. Since 1984, there have been 3 or 4 CPWs per year.

Technical assistance is given to the inventors through the NBS reviewer comments and later contacts with the Invention Coordinators. In addition to the coordinators' own expertise, they are able to provide inventors

groups; past local sponsors have included Small Business Development Centers, inventor organizations, and economic development centers. The workshops last for two days, with several plenary sessions and three workshop periods per day. The topics covered in the workshops include idea protection, marketing, capital acquisition, product liability and business planning. They are conducted by volunteers from business, universities, the law, inventor groups, etc. ERIP staff also conduct workshops on how the ERIP program works.

Other outreach activities are directed toward state initiatives. The state programs are aimed primarily at small business development groups, inventors groups, and economic development groups. In the coming year, ERIP will give approximately six grants, ranging from $25,000 to $50,000 to several states. The purpose of these grants will vary: for example, Illinois will receive an award to support a program linking small businesses in the Chicago area with the inventor community; New Jersey is being given a grant to develop a resource referral information system.

ERIP also participates in the conferences of various associations in the invention field, such as the American Association of Small Research Companies. ERIP buys space at the conferences, and invites the program's inventors to exhibit their technologies.

1.3.3 The ERIP Budget

ERIP is small for a federal program, with an annual budget of about $5 million. Total program appropriations from 1976 through 1984, the period of this evaluation, were $34 million. Approximately one-third of this total ($12 million) was provided to inventors as grants, and a majority of the remainder supported the NBS evaluation process.

2. PAST ERIP EVALUATION EFFORTS AND CURRENT EVALUATION METHODOLOGY

Program evaluation is an effort to assess both how well a program is working and what impact the program has had. In so doing, it spans a continuum from analysis of a program's internal management to examination of how close the program has come to achieving its highest goals. Between these extremes, the evaluator looks at whether a program's actions are reasonable, given its objectives, and the program's attainment of intermediate goals.

In terms of ERIP, evaluation efforts can focus on:

- **ERIP operations** (e.g., how well NBS and DOE are managing ERIP)
- **ERIP services** (e.g., the quality of these services)
- **direct consequences of ERIP** (e.g., the amount of technical and commercial progress of ERIP inventions)
- **societal consequences of ERIP** (e.g., net employment, energy, and environmental effects)

This evaluation and those conducted previously focus primarily on ERIP services and their direct consequences.

2.1 A BRIEF HISTORY OF ERIP EVALUATION EFFORTS

2.1.1 Past ERIP Evaluations

The initial evaluation of ERIP began in 1980, with 30 case studies of program-supported inventors. These studies focused on the history of the inventions' development, the grantees' experience with ERIP, the amount of progress made after ERIP financial aid was given, and the technical aspects of the invention. An analysis of the studies can be found in Rorke, Bronfman, and Soderstrom (1983), while the case studies themselves are contained in Bronfman, Rorke, and Soderstrom (1982).

funded cases, five cases were chosen which were recommended by NBS, but were not funded by ERIP. This was done for comparison purposes. Details on each of these 30 new cases studies can be found in a report by Kierulff, et al., 1984.

Based on a DOE/ORNL review of the 245 inventions that NBS recommended to DOE as of October 1983, an additional evaluation was conducted in FY 1984. The purpose of this evaluation was to update and expand the estimates of project outcomes in terms of: (1) job creation, (2) sales of the technology, (3) follow-on investment, and (4) energy impact. In order to update this information for FY 1984, "outcomes" data were collected by mail questionnaires and telephone interviews for 105 of the of 245 inventions. The results of the impact assessment and case studies are contained in the 1984 Evaluation Annual Report (Soderstrom and Rorke, 1984). The same updated "outcomes" data for FY 1984 are also used in the 1985/86 evaluation, the subject of this report.

2.1.2 Past Program Analysis

The program analysis area has focused on developing information on issues and other programs relevant to the operation of the ERIP. In FY 1983, panels of experts were assembled to provide information on each of three topics:

- new product development;
- financing inventions; and
- licensing inventions.

The intent was to consider possible modifications to the services provided by the program, given a state-of-the-art review of each topic. A second major effort was an examination of alternative approaches for providing services by similar foreign and domestic invention support programs. While the overall consensus was that ERIP serves inventors appropriately, it was agreed that

2.2 CURRENT EVALUATION DESIGN

As was true of previous ERIP evaluations, the research design employed here relies primarily upon data collected from program participants. Thus, information from at least three major sources is lacking. First, no comparison or control group is surveyed to estimate how the ERIP inventors would have performed in the absence of ERIP services. Rather, the literature at large has been relied upon for insight into the invention and innovation processes. This leads to imperfect comparisons--as when our findings are compared with those of much earlier studies, or when ERIP technologies are compared with technologies that do not have an energy focus. In such instances, the limitations of the comparisons are noted.

Second, information is not collected from licensees, joint venturers, suppliers, distributors, and others who may be actively involved in commercializing ERIP inventions. As a result, estimates concerning impacts of the ERIP inventions are limited to those experienced by or known to the ERIP participants. Indirect program impacts are therefore not fully articulated.

Finally, details of the administrative functioning of the ERIP program are not collected. For instance, no time management analysis was conducted to determine how the Invention Coordinators spend their time. Similarly, no data are available on variations in grant processing periods across Invention Coordinators. As a result, it is difficult to draw conclusions about the efficiency with which ERIP services are delivered.

Despite these limitations, this evaluation is the most comprehensive empirical assessment of the ERIP program conducted to date. In particular, it analyzes data drawn from more ERIP inventions than had previously been

In all but 31 cases the respondent was the program participant. Program participants are typically the ERIP technology's inventor, although in some cases they are the entrepreneurs/licensees. The 31 respondents who are not ERIP participants were the result of referrals from participants or their colleagues. Five of these referrals were licensees, and eleven were entrepreneurs such as the inventor's current employer or the owner of a new venture set up to commercialize the invention. In seven cases an employee of the program participant completed the survey. Several of the remaining eight respondents were relatives or colleagues of deceased program participants.

2.2.3 The Sample

This evaluation sought information on the 307 ERIP applicants recommended to ERIP as of June 1985. Of this population of 307, information specified in the telephone questionnaire is available for only 204 cases. Data are missing for several reasons. Some people declined to be interviewed; others simply could not be found. In cases where a single inventor had multiple inventions, concerns about imposing on the respondent led to a decision to collect data on only the most recent invention. Finally, there were some case studies which could not be transcribed into the interview format. A breakdown of cases and the reasons for noninclusion in the database, appears in Table 2.1.

Like those who were interviewed, some of the ERIP inventors who were not interviewed were unsuccessful, while others probably had sales. Invention Coordinators indicated that some of the nonresponding inventors have been unsuccessful in terms of commercializing their ERIP technologies, and interviewers found that some of the nonrespondents were unenthusiatic about ERIP. In contrast, other participants who are not in the database stated

These three definitions represent alternative and distinct measures of achievement for ERIP inventions. Inventions which are being produced and marketed are not necessarily successful since they may not have achieved the threshold level of sales or concluded a licensing agreement necessary to be labelled "successful." Until they have sold their first unit, they are also not considered "commercialized." Conversely, neither commercialized nor successful inventions are necessarily in the production/marketing stage since inventions can achieve substantial sales and licensing while still in prototype development or even earlier stages.

3. SALES OF ERIP INVENTIONS AND THEIR SPIN-OFF TECHNOLOGIES

This section provides an in-depth description and analysis of the sales of ERIP inventions and their spin-off technologies through 1984. The data are examined from three viewpoints. First, the inventions are characterized according to their status as commercialized, successful, or in production/marketing, as defined in Section 2.2.4. Next, the commercialization modes (direct sales, licensing agreements, joint ventures, etc.) used by ERIP inventors are analyzed. Finally, an estimation is made of cumulative invention sales--a vital factor in assessing the overall impact of the program.

3.1 INVENTIONS THAT ARE COMMERCIALIZED, SUCCESSFUL, OR IN PRODUCTION/MARKETING

More than one-third (N=70) of the 204 inventions studied here were commercialized by 1985; that is, they had direct sales, a licensing agreement, a joint venture, or a spin-off technology with sales or licensing. It is also known from previous case study evaluations that another three inventions have been commercialized. Although telephone survey data do not exist for these three, sales data are available, enabling their inclusion in this section of the evaluation. Eighteen percent (N=37) of the 204 inventions are successful (that is, they have achieved a minimum level of sales), as are the same additional three inventions for which survey data are unavailable. Fifteen percent (N=31) of the 204 inventions are in production/marketing, as are the additional three.

Figure 3.1 illustrates how the three categories of inventions overlap. While successful inventions are a proper subset of commercialized inventions, they do not include all of the inventions in production/marketing. Only 23 of the 31 inventions in production/marketing have been commercialized, of

ERIP inventions have been terminated as commercialization projects and that others have been shelved or temporarily placed on hold. As of the 1985 survey, however, these were few in number.

On the other hand, the numbers of ERIP inventions that are commercialized, successful, or in production/marketing are quite impressive when compared with the success rates of technological innovations as a whole. One study estimated that it takes some 58 ideas to yield one successful new product (Booz-Allen and Hamilton, 1963). Myers and Sweezy (1976) estimate that only about 10 or 12% of ideas submitted to corporations for screening will enter the development pipeline.

A recent preliminary evaluation of the Small Business Innovation Research (SBIR) program also suggests that lower rates of commercialization are typical (U. S. General Accounting Office, 1986). Information was collected from 19 firms receiving awards in 1983 or 1984 to develop 48 different technologies. As of the end of 1985, only one of the firms had developed or sold products using technologies developed with SBIR funding. Most of the others were trying to attract private-sector funding. An unknown number of firms had also used licensing agreements or had given options for ownership as a means of securing private-sector financing for commercialization.

Several dissimilarities between the evaluations of SBIR- and ERIP-supported technologies make direct comparisons difficult. The SBIR evaluation was based on the state of supported technologies only one to three years after their SBIR grants had been awarded. ERIP grants were issued as early as 1977--eight years before the collection of data for this evaluation. On the other hand, the average SBIR award studied by the General Accounting Office was $91,525, which is nearly twice as great as the typical ERIP grant.

agreement with one or more licensees. However, the data collected on sales from licensing is less complete, thereby limiting comparisons.

Of the 204 inventions included in the database, at least one unit of product or service from 30 of these had been manufactured and marketed by the inventor and/or his company between 1980 and 1984. Gross sales by year, 1980-1984, were collected for 25 of these, cumulative gross sales for the same period were collected for four of these, and the gross sales for the remaining invention was reported as "confidential" by the inventor.

3.2.2 Sales Through Licensing Agreements

The data collected on invention sales through licensing agreements are primarily a cross sectional view of 1984. In the questionnaire used to generate the data, no information regarding the origin or duration of the technology's licensing was requested. While gross sales by year are available for some of the agreements, data on inventor royalties are unavailable by year.

As of 1984, one or more licensing agreements had been concluded for 38 of the 73 commercialized ERIP inventions. Thus, licensing would appear to be the preferred (or perhaps the most accessible) mode of commercialization for ERIP inventors. The types of data collected on licensing agreements are given in Table 3.1. Although 25 of the 38 licensing agreements have resulted in sales of the invention, sales data are available for only 11 of these.

The responses of nine inventors who reported their royalties as a percentage of invention sales are provided in Fig. 3.3. Based on these figures, the average royalty is between 5 and 6%. This information becomes important in Section 3.2.3, where sales data are estimated in instances when only royalty data are available. It also provides some support for the criteria used in this evaluation to define successful inventions (i.e., $5,000 in cumulative royalties or $50,000 in sales in any one year from 1980 through 1984). Cumulative

identify those which were known to and divulged by the 1985 survey participants.

3.3 TOTAL SALES OF THE ERIP INVENTIONS

3.3.1 Total Sales of 43 Commercialized Inventions

Gross sales data were collected for 43 of the 73 commercialized inventions, totaling $122M for the period 1980 through 1984 (Table 3.2). From these data, yearly and cumulative totals have been derived for the three modes of commercialization described above.

First, comparing across the sources of sales shown in Table 3.2, a number of observations can be made. The average gross sales per invention is higher for those sold through licensing agreements than for those that were manufactured and marketed directly by the inventor. For the 11 licensed inventions (where gross sales by year are known), $75M in sales were generated. Only $44M in sales resulted from the 29 inventions sold directly. The greater sales resulting from licensing can perhaps be attributed to the fact that licensees tend to be established enterprises; they have already gone through the startup phase that those in direct sales have to experience. Over time one might expect the difference between sales through licensing versus direct sales to diminish as the new ventures mature.

Second, comparing across years in Table 3.2, sales are found to grow between 1980 and 1982 and then level off between 1983 and 1984. This stability is to some extent an artifact of the rule used to assign sales to specific years when inventors indicated only total gross sales. In such instances, total sales were distributed equally between the first year of sales and 1984. Gross sales of $33.6M for four inventions were treated in this way.

sales over grant expenditures. The gap between sales and grants is even more dramatic on the cumulative figure. To complete the two figures, annual sales of $32M are assumed for 1985 and 1986. These are likely to be conservative estimates, based on the growth in sales from 1980 through 1984. The extrapolation of sales from 43 to 73 inventions is explained below.

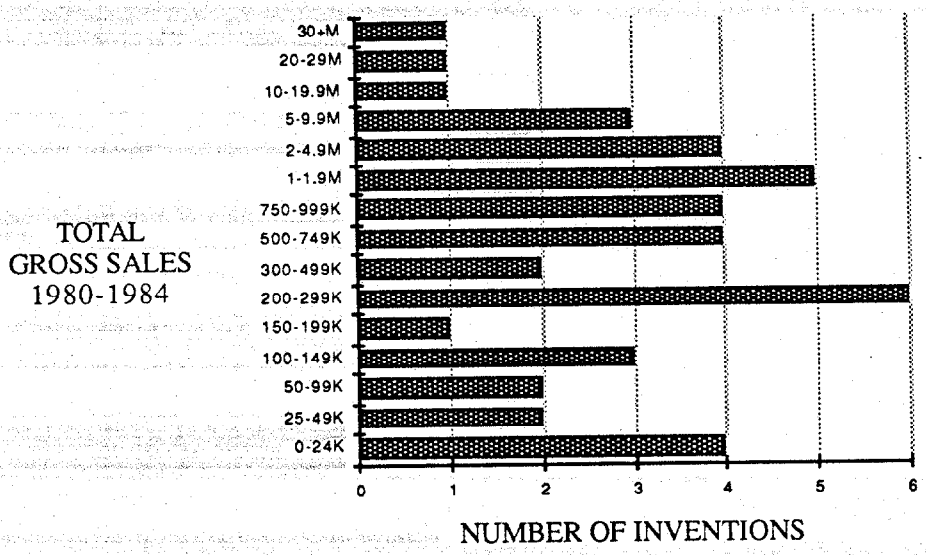

Fig. 3.4 Distribution of cumulative gross sales for ERIP inventions.

3.3.2 Extrapolating from 43 to 73 Commercialized Inventions

The data reported in Table 3.2 represent a conservative estimate of gross sales of ERIP inventions. One major reason for this is that the data describe only 43 of the 73 commercialized inventions. Yearly gross sales were not collected from 14 of the known licensing agreements with sales. If these 14 remaining inventions were as successful as the 11 for which yearly sales data were available, cumulative sales from licensing agreements would be approximately $169M. Applying the same rationale to the missing data on direct and spin-off gross sales, cumulative sales for these two commercialization modes would be

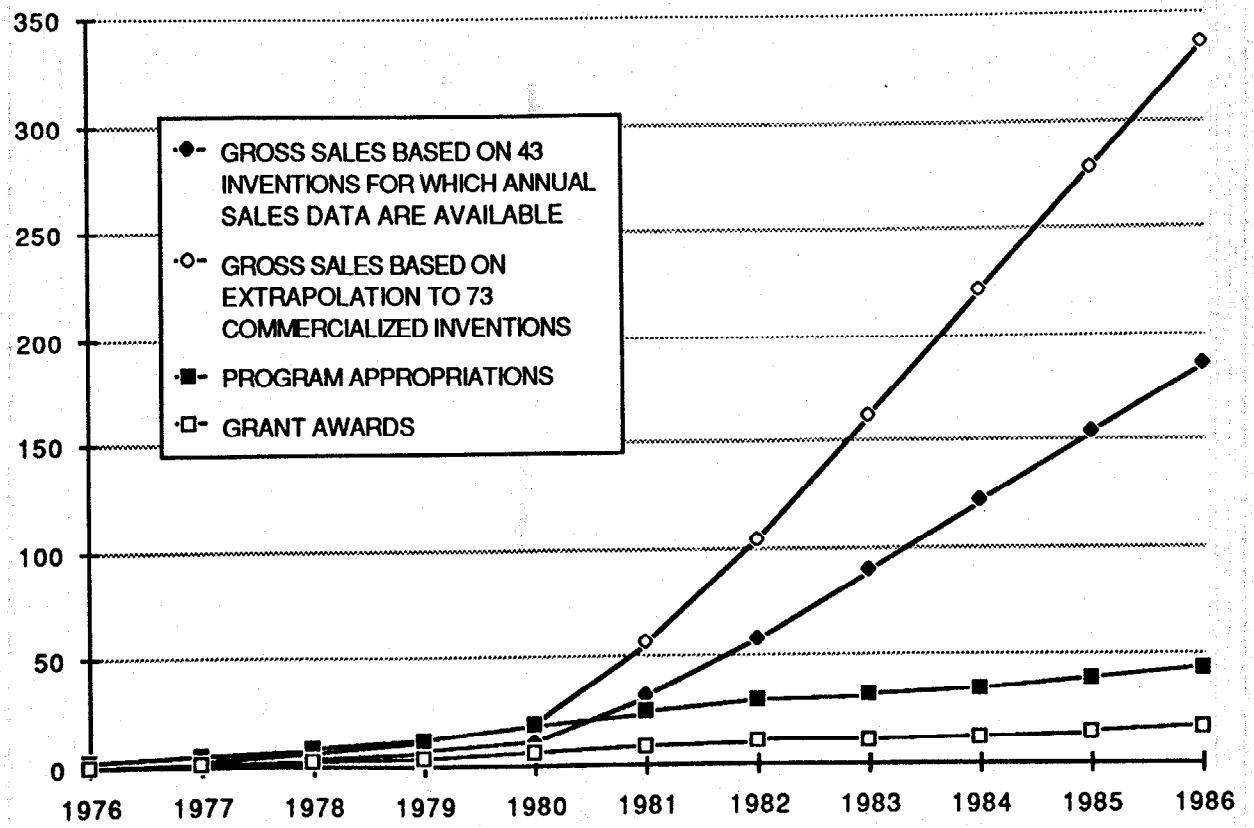

Fig. 3.6 Cumulative invention sales, program appropriations and grant awards. (Sales data for 1976-1979 and 1985-1986 are extrapolated.)

As a summary indicator of the effectiveness of ERIP, the $221M in cumulative gross sales can be compared with program costs. Approximately $12.1M in grants were awarded through 1984. Thus, the ERIP program has generated an 18:1 return in terms of the value of sales to grants. Using total program appropriations from 1976 through 1984 ($34.0M) as the denominator, this ratio is reduced to 7:1.

4. JOBS, FUND RAISING, ENERGY BENEFITS, AND PARTICIPANT SATISFACTION

4.1 INTRODUCTION

This section estimates some of the economic and nonmonetary consequences of ERIP, other than sales of ERIP inventions--the subject of Section 3. The economic impacts discussed here include: job generation, fund raising, and energy savings and production (Sections 4.2 through 4.4). Other economic effects (e.g., on wages, product prices, and production costs) are not analyzed, nor is the impact of specific ERIP technologies upon their subject fields. The nonmonetary consequences of ERIP (technical assistance, credibility, etc.) are assessed and compared with participants' expectations in Section 4.5. The section concludes with a discussion of participants' assessments of ERIP.

4.2 JOB GENERATION

Interviewees were asked for the number of full- and part-time employees working for them on tasks related to their ERIP inventions. The responses to these questions indicate that the inventors (and their firms) had a total of 619 employees, 371 full-time and 248 part-time, directly working on their ERIP inventions at the time of this evaluation. Assuming that part-time workers are employed half-time, this equates to 495 full-time equivalents (FTEs).

The 495 FTEs do not include the full- or part-time employment of ERIP inventors. Slightly more than one half of the inventors held jobs at the time of this evaluation that involved specific issues related to their ERIP invention (see Table 6.5).

Further, the employment reported here relates only to the companies of people who were interviewed in this evaluation. Employment by licensees and

comparison suggests that jobs are generated in a more even fashion across the inventions than are sales.

To better understand the nature and origin of these data, the employment figures for the 73 commercialized inventions identified in this section were extracted from the total sample. Table 4.1 displays the percentage distribution of full-time and part-time jobs for both the commercialized and noncommercialized inventions.

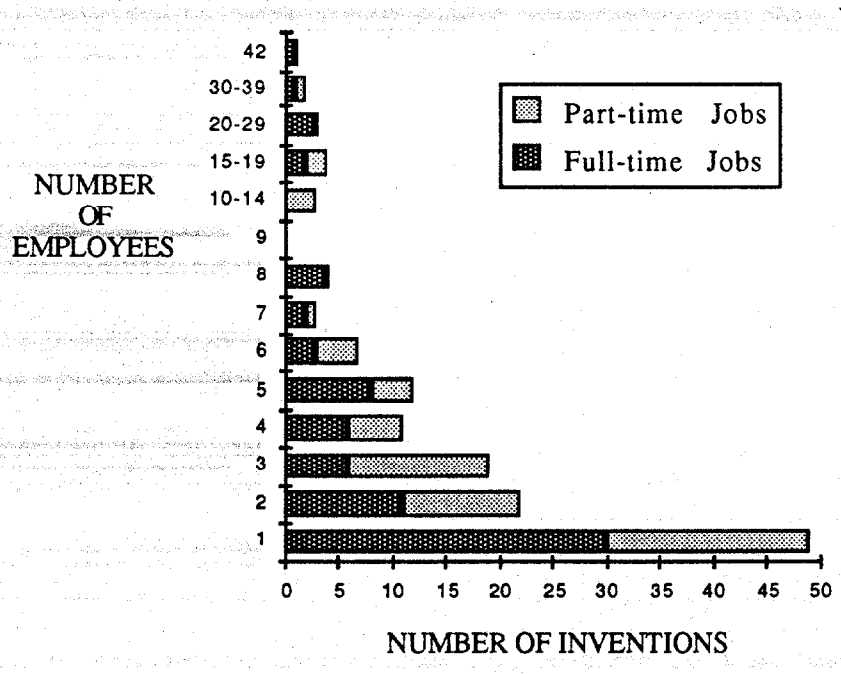

Fig. 4.1 Full and part-time job generation for ERIP inventions. (Jobs refer to the employment created by ERIP inventors and do not represent the program's net employment impacts. Also, jobs held by the ERIP inventors and many of their licensees are not included.)

Table 4.1 shows that the 131 noncommercialized inventions have been almost as important as the 73 commercialized inventions in generating jobs. This accounts for the dispersed distribution of jobs across inventions, noted earlier. It is also true, however, that the noncommercialized inventions have

point of use. In 1984 dollars, the same threshold is approximately $250,000 (U.S. Department of Commerce, 1985). Only 26% of the ERIP inventors believed it would cost less than this amount to bring their inventions to market.

Many inventors anticipate obtaining substantial funding for invention development, with the dominant anticipated source being venture capitalists (Tables 4.2 and 4.3). The average ERIP inventor expects to raise slightly more than $1M from all possible funding sources. However, this average is highly inflated by the expectations of four inventors to raise a total of $44M from stock offerings. If this $44M is removed from consideration, the average expected funds reduces to $599K per inventor.

Data on actual money raised are sobering. The average funding obtained by each inventor before application to NBS is $198K, and since entering the program, the average raised is $183K per inventor. If we assume that each inventor received an ERIP grant of $50K, the total funding of each inventor, as of their 1985 interview is $431K. Thus, the ERIP grant represents, on average, 12% of the inventor's funds, and a much greater percentage for most ERIP inventors since the funding data are highly skewed by a minority of the inventors who have been highly successful.

The funding sources which dominate in the pre- vs post-ERIP periods differ substantially. The average amount of "personal funds" (i.e., self-funding and friends and relatives) goes steadily and markedly down from pre-ERIP ($121K), to post-ERIP ($32K), to "expected availability" ($6K). So, too, does the number of people who used (or expect to use) personal funds decline over time (Table 4.3). The most prevalent source of pre-ERIP funding is the inventor himself, with 81% of the respondents reporting an average of $140K of such funding prior to their application to ERIP. Only 45% of the inventors reported

Table 4.3 Actual and expected sources of funding for invention development: mean values for inventors reporting nonzero funding (in $000 s)[a]

Funding source	Average pre-ERIP funding	Number reporting	Average post-ERIP funding	Number reporting	Average expected funds	Number expecting funds
Self funding	140	141	61	78	42	13
Friends or relatives	59	24	101	8	50	2
Inventor's company	119	9	96	5	113	2
Sales, royalties, or joint ventures	31	2	153	5	361	7
Venture capitalists	316	20	1,000	17	1,100	47
Stock offerings	400	1	1,600	2	11,000	4
Lending institutions	74	7	37	6	41	4
Small Business Administration	150	1	333	3	258	3
Other federal programs	126	6	139	12	413	10
State or local government	5	2	33	4	228	5[b]
Others	427	11	183	13	426[c]	14
Totals[d]	34,622		32,411		111,271	

[a]Mean values are based on the number of people who reported nonzero funding.

[b]This figure omits one very large outlier of $35M.

[c]This includes ten inventors who reported expecting a total of $500K more in ERIP funds.

[d]Total amount of funding, summed across all the inventors shown above.

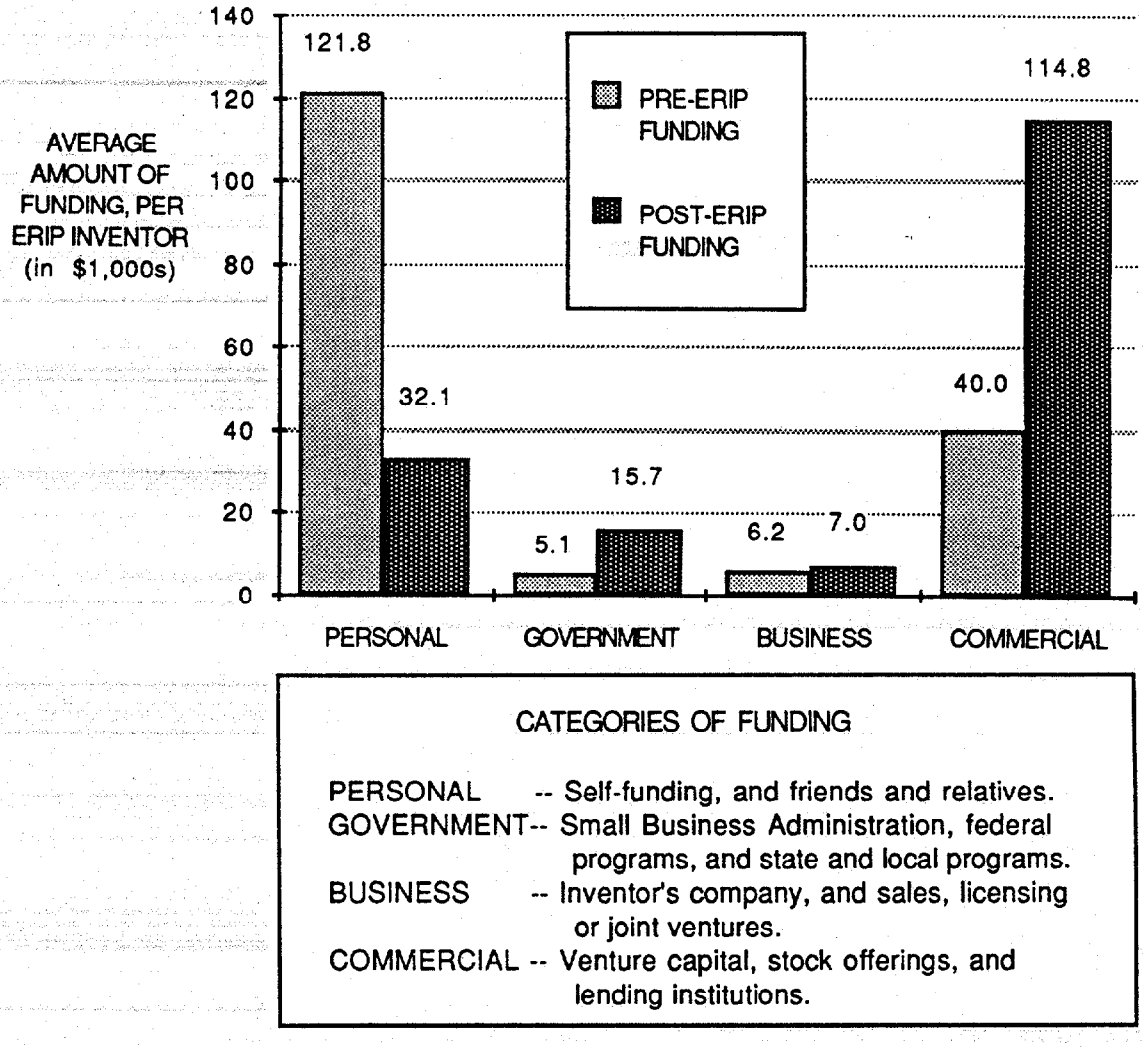

Fig. 4.2 Major categories of funding during the pre- and post-ERIP periods.

during early stages of innovation development, and the importance of commercial funding in later years.

In sum, the data show a strong need for programs like ERIP. Personal funds are available in meaningful amounts only during the initial years of innovation development. Less than one-third of the inventors are able to receive substantial commercial funds, and those who do obtain such support must wait several years for it. Thus, public support at the pre-venture capital stage helps to fill a significant void.

sources or environmental/safety issues. Attempts were made to measure the energy savings of the ERIP inventions, but no reliable numbers were generated.

4.5 EXPECTATIONS AND PERCEIVED BENEFITS OF ERIP

A substantial percentage of ERIP participants (35%) enter the program with the assumption that they will receive more than monetary help (Table 4.5). Straightforward advice about substantive issues (testing, technical assistance, business assistance) accounts for 48% of those who expected to receive non-monetary assistance. All other expectations refer to expanding the inventor's contacts and credibility. Although ERIP is a grant-giving program, many of its participants anticipate help with their marketing and networking efforts.

Table 4.5 Expectations about ERIP

Expectation	Number of participants[a]	Percent of participant
Development funding	116	65
Credibility/endorsement	13	7
Evaluation/testing of invention	12	7
Contacts in other federal agencies	10	6
Commercialization education	9	5
Technical assistance	9	5
Reference to another source of funding	6	3
Industry contacts	3	2
Totals	178	100

[a]Data are missing for 26 inventors.

The extent to which these nonmonetary expectations were fulfilled is suggested in Table 4.6. An open-ended question asked respondents to articulate the most important thing they got from ERIP, other than money. Of the 112

4.6 SATISFACTION WITH ERIP

ERIP grantees are generally satisfied with the program. Have they recommended that others submit inventions to ERIP? Would they submit other inventions to ERIP? Have they submitted another invention to ERIP? A summary of responses to these questions appears in Table 4.7.

Taken together, these figures represent quite a positive view of the program. Without any outside pressure to recommend ERIP to others, 40% of the respondents did so. Eighty percent stated a willingness to submit another

Table 4.7 Indicators of satisfaction with ERIP[a]

Question	Yes		No		N
	Number	Percent	Number	Percent	
Have you recommended others to ERIP?	82	(46)	95	(54)	177
Would you submit another invention to ERIP?	155	(80)	38	(20)	193
Have you submitted another invention to ERIP?	40	(25)	123	(75)	163

[a]Sample sizes vary with the quantity of missing data for each question.

invention, and 25% have actually done so. Thus, grantees' past actions and intentions for the future both indicate a sense that ERIP is a useful and important element in their invention efforts.

In response to a variety of open-ended questions, many ERIP inventors indicated a frustration with the length of time elapsing between submission to NBS and receipt of their grants. Figure 4.3 documents the timing and duration of the NBS and DOE review periods, for 31 ERIP inventors. These inventors are those examined both in Soderstrom and Rorke's 1984 evaluation of 50 inven-

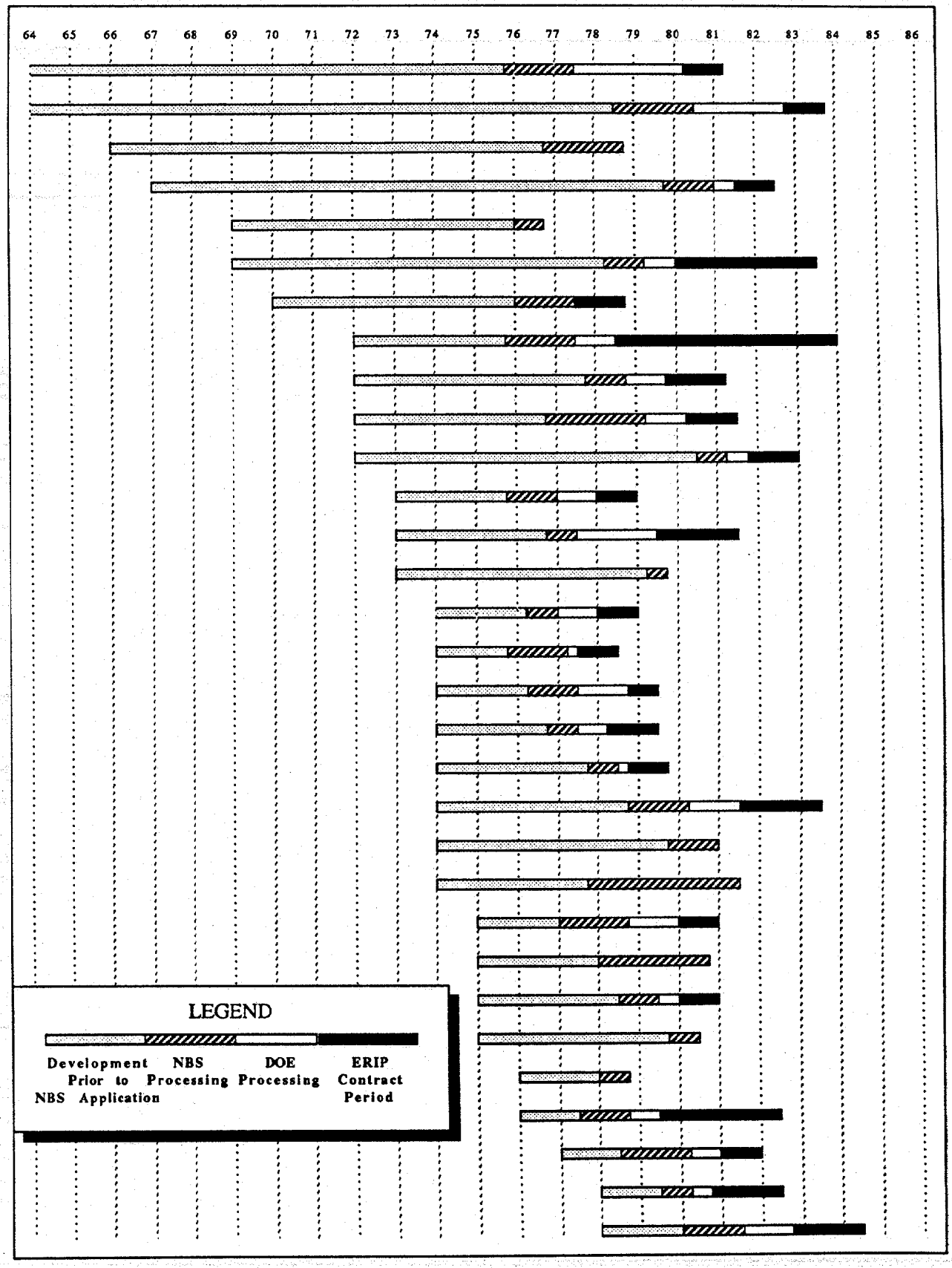

Fig. 4.3 Timing and duration of NBS and DOE review periods.

5. TYPES OF ERIP INVENTIONS AND THEIR LEVELS OF SUCCESS

This section describes the ERIP inventions and analyzes their success using several invention/innovation classifications. The first part of the section analyzes ERIP inventions based on a technical classification. Attention then turns to an analysis of the distinction between product and process inventions. The final section analyzes ERIP inventions using a typology of innovation stages. In general, this section seeks to develop realistic beliefs as to what could be expected from different ERIP inventions, to identify types of inventions which might be given special attention in the selection process, and to determine when assistance to an inventor might be most useful.

With the exception of categories 8 (Consumer Products and Practices) and 9 (Miscellaneous), the NBS technical classification system reflects distinct industrial sectors of the economy. It is well documented that barriers to innovation differ among sectors; some sectors are more receptive to change than others (Nelson and Winter, 1977). As examples, American agriculture has registered tremendous gains in productivity due to numerous innovations in farming technology, while the construction industry has been particularly slow in adopting innovations (Roessner, 1984; Brown, et al., 1985).

5.1 A TECHNICAL CLASSIFICATION OF ERIP INVENTIONS

NBS devised a nine-category technical classification system for the inventions submitted to ERIP. Table 5.1 presents a detailed breakdown of this classification along with the distribution of 343 ERIP inventions recommended to DOE by the end of FY 1985. Nearly one-third of the inventions have been developed to improve industrial processes. Other well-represented categories are Buildings, Structures, and Components and Fuels and Lubricants Acquisition, Production and Distribution.

Table 5.1 Technical categories for energy-related inventions recommended to DOE by the National Bureau of Standards[a] (continued)

Description	Invention class number	Number	Percent of total
Buildings, structures and components	**6.0**	**64**	**18.7**
Design, construction and construction practices	6.1	5	
Heating, cooling and ventilating	6.2	7	
Instruments and controls	6.201	5	
Boilers and furnaces	6.230	6	
Flue heat recovery	6.231	2	
Air and oxygen inductors and injectors	6.232	1	
Oil burners	6.234	2	
Combustion controls and equipment	6.236	1	
Coal-oil-water mixtures	6.237	1	
Electric heat	6.24	1	
Heat pumps	6.25	2	
Air conditioning	6.26	7	
Ventilating systems	6.27	1	
Hot water supply	6.3	5	
Insulation and Insulating practices	6.4	11	
Electrical wiring and fixtures	6.5	6	
Plumbing and fixtures	6.6	1	
Industrial processes	**7.0**	**112**	**32.7**
Civil engineering	7.1	3	
Agricultural equipment and farm equipment	7.2	14	
Mechanical contrivances	7.4	5	
No further classification	--	90	
Consumer products and practices	**8.0**	**10**	**3.0**
Consumer education and behavior	8.1	2	
Appliances	8.2	7	
Lamps and light bulbs	8.4	1	
Miscellaneous	**9.0**	**11**	**3.1**

[a]Numbers represent the numbers of inventions recommended by NBS through October, 1985.
Source: Adapted from National Bureau of Standards, 1985.

Studies show that several factors determine an industry's innovativeness. Industry structure is certainly crucial; decentralized industries (those

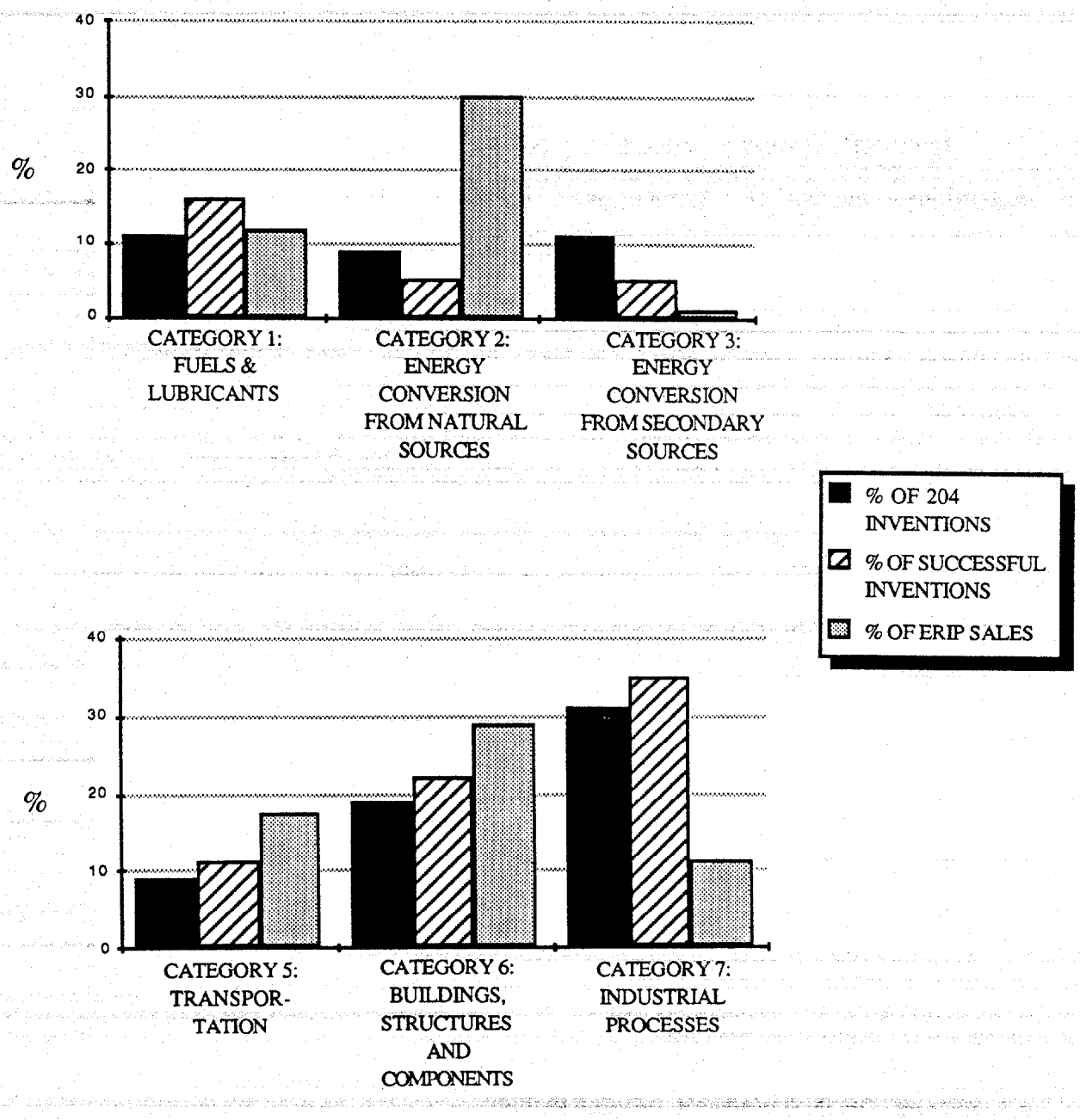

Fig. 5.1 Industry differences in the success of ERIP inventions. (Categories 4--Energy Generation, Storage and Acquisition, 8--Consumer Products and Practices, and 9--Miscellaneous had fewer than 10 inventions and were therefore excluded.)

Table 5.2 Success of product- versus process-oriented inventions

	All Inventions		Unsuccessful Inventions		Commercialized Inventions	
	Number	%	Number	%	Number	%
Product-oriented	78	39	50	36	18	49
Process-oriented	35	17	23	17	7	19
Both	89	44	64	47	12	32
Missing cases	2	--	0	--	30	--

comparing inventions, a means of determining which were progressing and which were not.

A nine-category scheme is used by NBS to classify stages of the innovation process (Fig. 5.2), but it was felt that those categories were too specialized for the purposes of this evaluation. It might be too difficult for ERIP inventors to always understand the finely-drawn distinctions between the NBS categories, and to apply them to their own work. So, in the absence of any other agreed-upon set of categories, it was decided to let the inventors themselves identify the definable stages of the invention process.

To do this, inventors were asked the open-ended question: "Please briefly describe what stage your work was in when you applied to the NBS and what you have done since." Four clear stages emerged from the responses to this question:

1. concept development,
2. feasibility testing,
3. prototype development, and
4. production/marketing.

The following analysis of ERIP inventors' progress is based on these four categories. The relationship of this ORNL typology to the NBS classification is shown in Fig. 5.2.

Table 5.3 Distribution of ERIP inventions across innovation stages

Stage	Inventions at time of NBS application		Inventions at time of interview		Inventions with no stage progression	
	Number	%[a]	Number	%[a]	Number	%[b]
1. Concept development	59	35	21	12	21	36
2. Feasibility testing	36	21	33	19	12	33
3. Prototype development	62	36	85	50	47	75
4. Production/ marketing	13	8	31	18	--	--
Totals	170	100	170	99	80	--

[a]Percentages in these columns are based on the sample population of 170. (Information is missing for 34 inventions.)

[b]Percentages in this column are based on the number of participants in a particular stage upon NBS application (i.e., row percentages).

way to go to achieve full commercial success. Three types of progress were mentioned by inventors who were in production/marketing at the time of application.

- Probably most frequent were product qualifications--technical, design, and installation improvements that allowed the invention to be more cost effective in the use for which it was originally intended. The addition of new components, changes in the materials used, and other such refinements are examples.
- Other advancements at this stage enabled the invention to be applied to a broader range of markets and use situations. This sometimes required substantial redesign.
- Both of these types of progress are related to a third transition occurring in stage 4--from limited to full production. Refinements, redesign, and other types of invention improvements allowed this. One inventor also mentioned that ERIP funds enabled the production of enough units to more fully test market the invention.

descriptions give a sense of significant progress within the prototype development stage.

The movement of those inventions which progressed to a more advanced stage since application to NBS is shown in Fig. 5.3. The transition between prototype development and production/marketing is clearly the hardest for inventors to make. A large proportion of those inventions beginning in stages 1 or 2 progressed to stage 3, but few progressed to stage 4. Inventions that entered in stage 3 tended to be more successful, with 24% of them reaching stage 4. This finding concurs with expert opinions on the subject. The bottleneck occurring at the prototype stage has been attributed to insufficient seed capital to test and demonstrate claims about technologies (Shapero, 1981).

Commercialization education addressing the business aspects of licensing, joint venturing, new venturing, and financing in general would therefore appear to be highly appropriate, given these findings. These subjects are in fact the current focus of ERIP's Commercialization Planning Workshops. It may also be advantageous for ERIP to provide training in the areas of marketing and the development of business plans, in order to overcome barriers inhibiting progress from prototype to production.

In the more technical realm, inventors also found difficulty in moving their projects from concept development to feasibility testing. Approximately one-third of the inventions which were in stage 1 when they applied to NBS for assistance were in the same stage at the time of this evaluation. It appears, then, that a large number of ERIP inventors have special problems with feasibility testing; this too may be an important area for specialized ERIP assistance.

5.3.3 Levels of Success by Stage of Innovation at Application to NBS

Table 5.4 shows the stages at which successful and unsuccessful projects entered the ERIP program. It clearly documents the greater commercial success of inventions which were in production/marketing at the time of application to NBS. Two-thirds of the 12 inventions which were in production/marketing at the time of application were successful in terms of having annual sales of $50K for at least one year from 1980 through 1984, or cumulative royalties of $5K. Of the 56 which entered in the prototype stage, only 10 (i.e., 18%) were successes. For the 93 inventions which entered in earlier stages, only 13 (i.e., 14%) were successful at the time of this evaluation. Thus, other than the high probability of ultimate success of applicants in production/marketing, there is only a weak relationship between stage of innovation at application and subsequent commercial success.

Table 5.4 Successful and unsuccessful inventions: stage of development upon application to NBS

Stage upon application	Number of unsuccessful inventions	Percent of unsuccessful inventions	Number of successful inventions	Percent of successful inventions
1. Concept development	51	39	8	26
2. Feasibility testing	29	22	5	16
3. Prototype development	46	35	10	32
4. Production/ marketing	4	3	8	26
Totals	130	99	31[a]	100

[a]There are six successful inventors with missing data on stage of development.

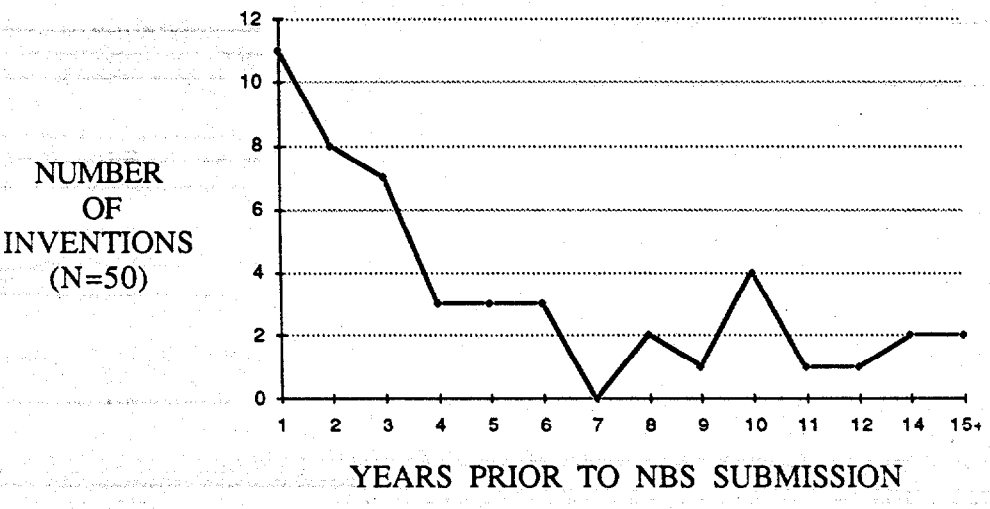

Fig. 5.4 Number of years working on invention prior to submission to the NBS.

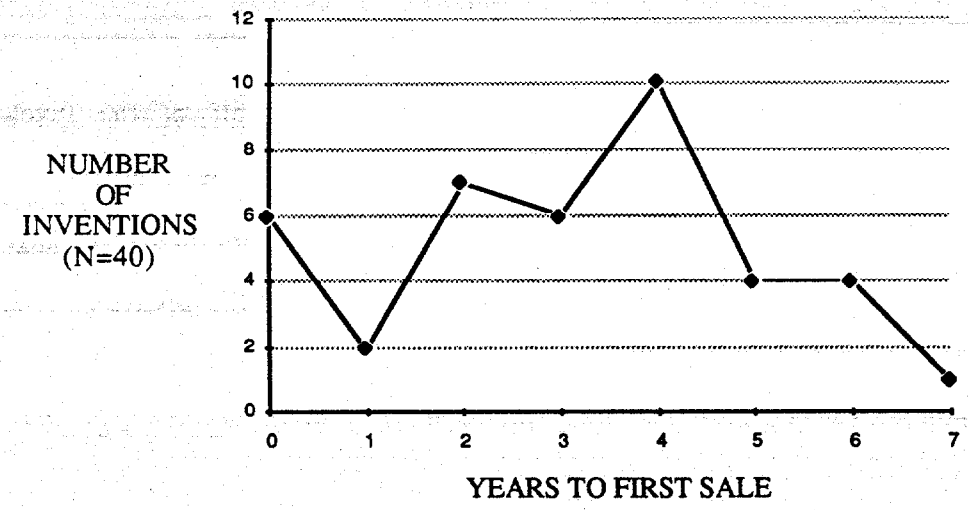

Fig. 5.5 Number of years to commercialization after submission to the NBS.

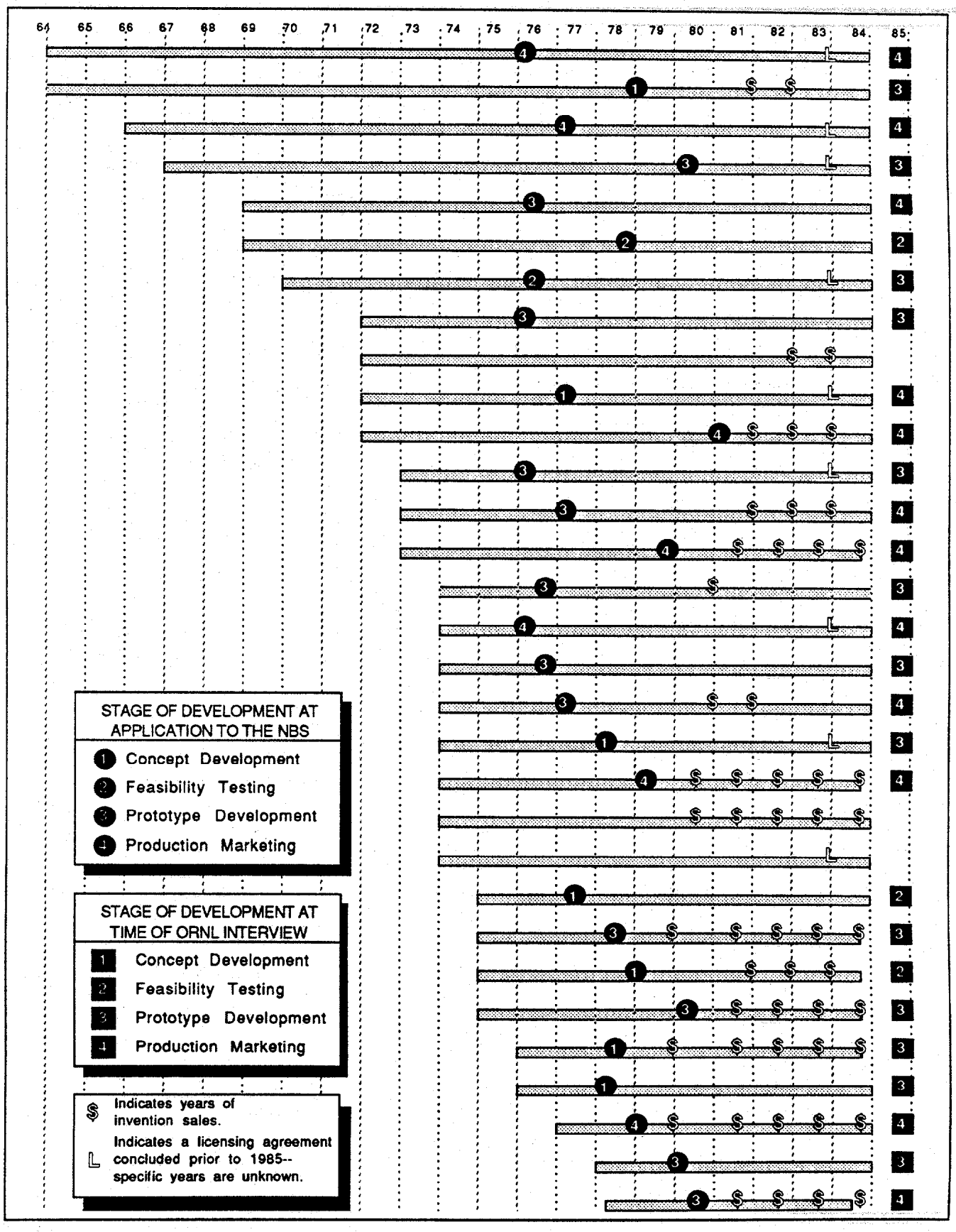

Fig. 5.6 Innovation stages and time to market.

At the time they were interviewed in 1985, the vast majority of ERIP inventors held patents on their technologies (Table 5.6). Almost half (40%) of the ERIP inventions were patented at the time the inventor applied to NBS. Another 35% were patented since application to ERIP, and patent applications were pending for another 13% of the inventions. While it is unclear how instrumental the program has been in achieving this high rate of patenting, several inventors noted in discussions during the telephone survey that the program was helpful with their patent applications.

Table 5.6 Patent status of the ERIP inventions

	Number	Percent
Patented at time of application to NBS	79	41
Patented since application to NBS	68	35
Patent application pending	24	12
No patent application	22	11
Patent withdrawn	1	1
Patent denied	0	0
Totals[a]	194	100

[a]There are 10 missing cases.

An analysis of the 22 inventors who had not applied for a patent at the time of the 1985 survey reveals that they are different in several ways from the 145 inventors with patented ERIP technologies. First, only 55% of the 22 hold patents on other technologies, while this is true for 78% of the 145 inventors. Thus, it may be that a lack of experience with patenting has caused some of the 22 inventors to fail to obtain intellectual property to their inventions. Second, more than half (53%) of the 22 inventors are still in the conceptual design or feasibility testing stage, while this is true for only 30% of

6. TYPES OF INVENTORS AND THEIR LEVELS OF SUCCESS

This chapter analyzes the personal characteristics of ERIP inventors. The first section describes the ERIP inventors as a whole--their formal education, work history, patent activity, business experience, age, and geographical location. The goal is to determine how ERIP inventors might differ from the adult population at large, and from the population of small business and independent inventors--the clientele served by ERIP. The second section of the chapter attempts to determine the personal characteristics that typify successful inventors, in order to help ERIP staff better evaluate and serve the program's participants. The chapter concludes with an analysis of inventor characteristics, by industry.

6.1 PERSONAL CHARACTERISTICS OF ERIP INVENTORS

This section details some of the personal characteristics of inventors involved with ERIP. Where possible, it compares these traits to those documented by other studies of inventors and technical entrepreneurs, and to statistics on the U.S. population at large. One study, in particular, is emphasized in an attempt to determine how ERIP inventors might differ from the larger population of independent inventors. The study of note was by Gerald Albaum (1976); it describes 103 independent inventors who contacted and sought assistance from the Experimental Center for the Advancement of Invention and Innovation at the University of Oregon. Although 42% of these inventors resided in Oregon, one-third resided outside of the western United States, indicating a reasonably broad base. Since the sample was not screened in terms of the technical or market feasibility of the inventors' ideas, it provides insight into the nature of the inventors who might typically apply to

Table 6.2 Field of study of ERIP inventors

Field of study	Number[a]	Percent
Engineering	85	47
Physics	8	5
Chemistry	6	3
Other physical sciences (general science, biology, geology and applied science)	5	3
Business	8	5
Other (law, architecture, and other)	22	12
No college education	45	25
Totals	179	100

[a]There were 25 cases of missing data.

ERIP inventors have more formal education than one might expect (Table 6.3). Thirty-one percent have Masters or Doctorate degrees, while only 18% of Albaum's sample had any graduate or professional school education. Only 29% of the ERIP inventors lack a college degree compared with 53% of Albaum's sample and 81% of the U.S. adult population (U.S. Department of Commerce, 1985). Thus, a considerable amount of technical college education is characteristic of ERIP's inventors, but is not an across-the-board trait. It is well known that large numbers of non-college educated people invent (Schmookler, 1957), and some of these inventors have received ERIP support.

Table 6.4 suggests that many of the ERIP inventors had little inventing experience prior to ERIP, but they appear to have more experience than the average independent inventor. Twenty-six percent of the ERIP respondents held no U.S. or foreign patents, other than one on their ERIP invention. In contrast, fully 77% of Albaum's sample had none (56%) or only one patent (21%). Of those ERIP inventors with patents on technologies other than their ERIP inventions, the number of U.S. patents per inventor ranges from 1 to 90:

It is interesting to note that the college-educated ERIP inventors are disproportionately represented among the professional inventors. More than one-third (38%) of the college-educated inventors have six or more patents, while less than one-fifth (19%) of those without college degrees have six or more patents. It may be that the organizations in which more highly educated inventors work (e.g., universities) provide the incentives and support to successfully pursue patents. Thus, the difference in numbers of patents across educational levels may or may not reflect differences in the patentability of inventions.

A large percentage of grantees are presently employed in jobs that are closely related to their ERIP invention. Nearly three-fourths (N=123) of 165 respondents replied "yes" to a question of whether their present job was related to the invention they submitted to ERIP. Albuam's study cannot offer comparable statistics since all of his inventors were independent; hence, their work was typically unrelated to their current employment.

A further question asked ERIP inventors for a description of the relationship between their ERIP technology and their current and immediate past jobs. As Table 6.5 shows, the great majority of responses fall into categories which describe a close relationship between the ERIP invention and the respondent's current job. However, it is also true that for many, there is only a tenuous relationship between their ERIP inventions and their present employment. This group might represent inventors with distinct needs for ERIP support services.

The close relationship between ERIP inventions and employment disappears upon inspection of respondents' immediate past employment. Almost half of the ERIP inventors state that their previous job was unrelated to their ERIP invention (Table 6.5). For only 11% of the ERIP inventors did their

we know that to many inventors the CPWs had eye-opening appeal.) While a solid majority of the inventors (79%) reported having started at least one new business in the past, many of the inventors were undoubtedly referring to a new venture recently undertaken to commercialize their ERIP technologies. On the other hand, 18% had started more than two new ventures, indicating that some of the inventors have considerable commercialization experience.

Table 6.6 shows that the current and previous employers of ERIP inventors span the entire range of company size. While all ERIP grantees are independent or small business inventors when they receive their support, at the time of their interview, 11% of them worked for large firms (500+ employees), and 34% were employed by large businesses as part of their immediate past job.

Table 6.6 Company size--ERIP inventors' current and immediate past employment

Number of Employees	Current job		Past job	
	Number of inventors[a]	Percent of inventors	Number of inventors[a]	Percent of inventors
1-15	106	68	39	27
16-49	18	12	18	12
50-99	7	4	13	9
100-499	8	5	27	18
500-999	4	3	5	3
1,000-9,999	10	6	29	20
10,000+	3	2	16	11
Totals	156	100	147	100

[a]There are 48 cases with missing data on the current job, and 57 cases of missing data on the past job.

To sum up, the figures clearly show that ERIP serves a wide spectrum of inventors in terms of employment background, education, inventing experience, and other characteristics. This diversity suggests that ERIP should

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The Amount of ERIP Funding by State

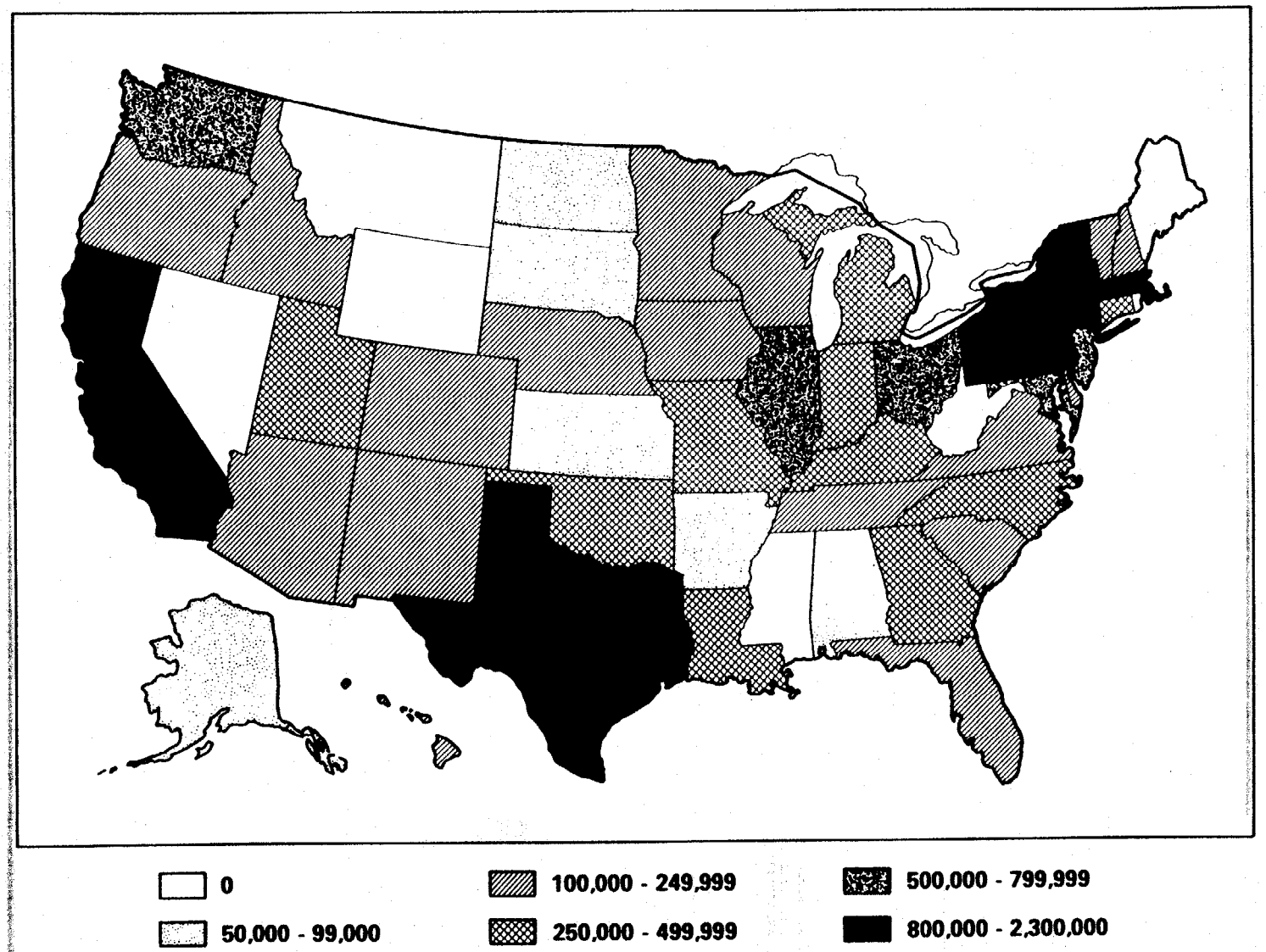


Fig. 6.1 The amount of ERIP funding by state.

of the respondents reported doing almost all the work in all phases of invention development.

Table 6.8 Involvement in aspects of invention development

Task	Almost all (%)	Majority or about half (%)	Little or almost none (%)	Sample size[a]
Research and development	57	33	10	194
Management and administration	74	23	3	189
Raising capital	76	17	7	183
Financial management	72	18	10	183
Sales or marketing	53	37	10	30[b]
Production	39	25	36	28[b]

[a]Sample sizes vary with the number of missing cases for each question.
[b]Only those respondents who are in the production/marketing stage are included for this task.

This finding indicates a suboptimal situation if we assume that ERIP grantees are not uniformly expert in all aspects of invention development. It also suggests that ERIP inventors are unable to devote sufficient time to successfully accomplishing many invention-related tasks. It has been noted by the Invention Coordinators that many inventors are unwilling to sacrifice their equity position in order to obtain the resources necessary to bring their inventions to market. In many cases inventors have not progressed far enough to effectively bargain for venture capital without sacrificing a large share of the equity in their inventions. In other instances, inventors could strike an attractive deal, but are simply unwilling to give up any equity.

section 6.2 discusses the findings, highlighting differences in business and technical expertise, resources, and use of time.

6.2.1 Business and Technical Expertise

As shown in Table 6.9, the ages of unsuccessful and successful inventors do not differ significantly. Both groups of inventors are dominated by individuals who are 45 to 64 years of age. This contradicts the popular wisdom that older scientists generally possess less frontier knowledge and are therefore less successful technical entrepreneurs (Roberts, 1969).

Successful and unsuccessful inventors also do not differ significantly by field of study in college. Engineers do as well as physical scientists and business majors. Yet, ERIP participants with less formal education are more likely to be successful than those with more formal education, regardless of their field of study. This contradicts the finding of Roberts (1969) linking successful technical entrepreneurship to "moderate" education--i.e., a M.S.

Table 6.9 Comparisons of successful with unsuccessful inventors: business and technical expertise[a]

Area of comparison	Unsuccessful		Successful	
	Number[b]	Percent	Number[b]	Percent
Age				
18-24	1	(1)	0	(0)
25-44	23	(17)	9	(24)
45-64	76	(55)	20	(54)
65+	33	(24)	8	(22)
N = 170	133		37	
Field of study in college				
Engineering	63	(57)	11	(46)
Physical sciences	24	(22)	8	(33)
Business and other	23	(21)	5	(21)
N = 134	110		24	

In keeping with Roberts, ERIP inventors with Ph.D.s do not perform well as entrepreneurs. "Their general temperament, attitude and orientation are usually out of line with those needed for successful technical entrepreneurship" (Roberts, 1969, p. 234).

Like education, the numbers of patents held by inventors also is an inverse indicator of success--26% of the unsuccessful inventors hold 11 or more U.S. patents, while only 8% of the successful inventors hold as many patents. This finding suggests that "professional inventors" are less likely to translate their technical ideas into successful commercial products; they may be more interested in the technical than the business aspects of their work.

On a similar note, Table 6.9 shows that inventors with business- or management-related work histories are generally more successful than those with technically-related work experience. (Although this finding does not quite reach statistical significance, it is noteworthy that 80% of the successful inventors had business-related work histories, while only 60% of the unsuccessful inventors had such experience.)

Inventors who worked for small companies (1 to 50 employees) prior to their current job have a high probability of succeeding commercially with their ERIP inventions. Almost half of the inventors who previously worked for firms with fewer than 50 employees were successful with their ERIP inventions. As noted in the introduction of this report, small businesses foster innovation; it may be the past affiliation with the commercialization process that has given these inventors an edge. Perhaps related to this, inventors who have had past experience with new ventures tend to be more successful with their ERIP inventions than do those who have never started a new business.

The pattern of successful inventors having personal funds to invest early in the invention process is repeated for pre-ERIP commercial funds. The difference between successes and nonsuccesses is large both in average funding ($57K vs $34K) and percent of people with $10,000 or more in commercial funding (38% of the successful inventors compared with 7% of the unsuccessful inventors).

A comparison was also made between the amount of money raised by three categories of ERIP inventors--commercial successes, technical successes, and nonsuccesses. (A project that has moved successfully into the prototype stage is said to be a "technical success.") Figure 6.2 presents the results.

The comparison underscores and more fully develops several trends that have already been mentioned. First, it is clear that, on the average, those who are commercial successes were able to raise more capital than the non-successes ($525,000 vs $158,000). Second, having large amounts of money does not ensure success. Third, some of the successful inventors invested very modest amounts of capital, while some unsuccessful inventors poured great amounts of money into their work. Finally, this pattern is also found, although it is less pronounced, when unsuccessful inventions are compared with inventions that were technically, but not commercially successful.

Of course, like all the findings of this section these traits can be applied only in a very general way. For example, some technologies are more expensive to develop than others, a fact which could account for some disparities between the low-capital successes and the high-capital failures. Nevertheless, the data suggest enough shared traits of successful inventors to help ERIP staff to tailor their guidance efforts accordingly.

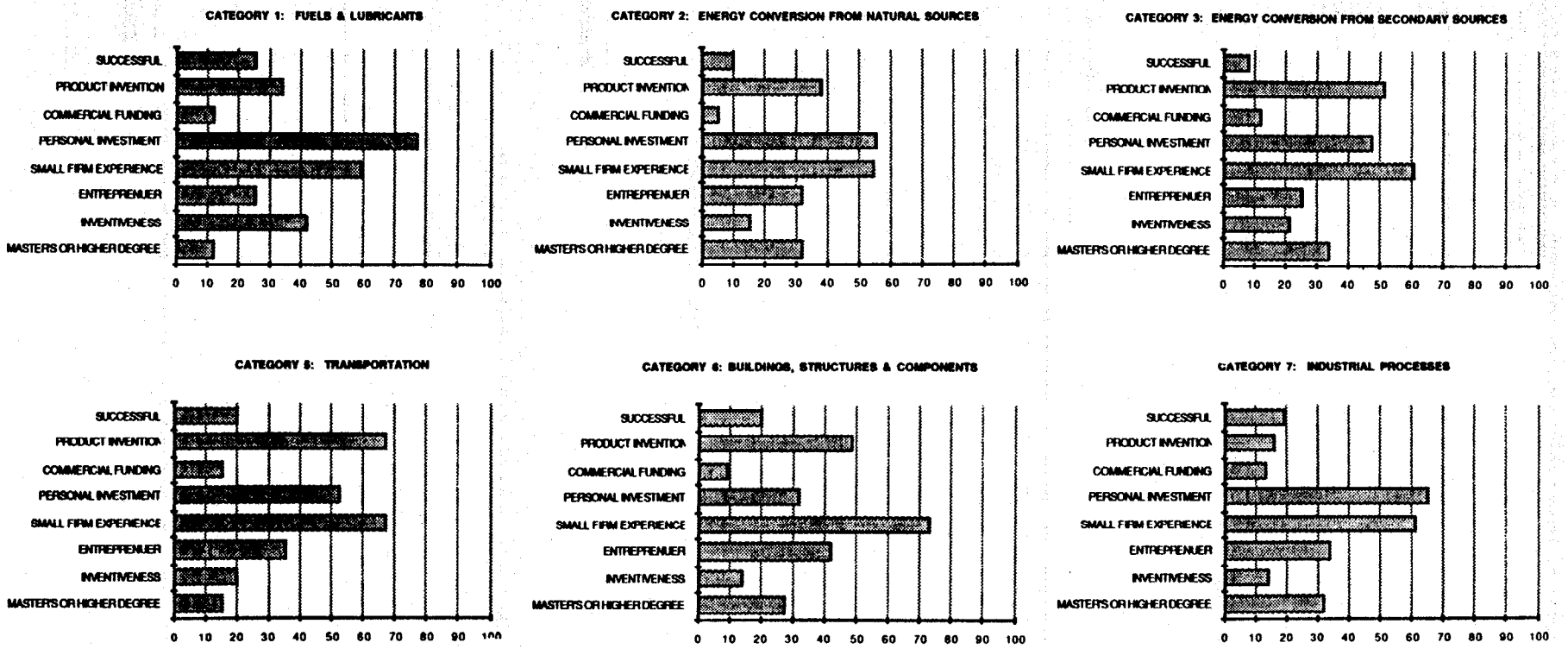
6.2.3 Inventors' Use of Time

Successful ERIP inventors are more likely than others to share the responsibilities of management and administration, financial managements, sales and marketing, and production. Table 6.11 gives the percentages of successful and unsuccessful inventors who perform "almost all" of various tasks related to commercializing their ERIP inventions. The table shows that for each task, a larger percentage of unsuccessful inventors were performing almost all of the related work, compared with successful inventors. It is not known whether this sharing results from success (a successful project would put greater demands on the inventor's time and greater resources at his disposal), or causes it (as when good time management and delegation of responsibility leads to success).

Table 6.11 Number and percent of successful and unsuccessful inventors performing "almost all" of the invention-related work

	Unsuccessful			Successful		
	Number performing almost all	Number of respond-ents	%	Number performing almost all	Number of respond-ents	%
Research and development	76	131	58	20	37	54
Management and administration	99	126	78	24	37	65
Raising capital	96	120	80	25	37	68
Financial management	92	121	76	23	37	62
Sales and marketing[a]	8	11	73	6	13	46
Production[a]	7	11	64	4	12	33

[a]Includes only those respondents in the production/marketing stage.



SUCCESSFUL	% with >$5,000 in cumulative royalties or > $50,000 in annual sales.	COMMERCIAL FUNDING	% receiving > $10,000 in commercial funds prior to ERIP	SMALL FIRM EXPERIENCE	% from firms with < 100 employees	INVENTIVENESS	% with 11 or more patents
PRODUCT INVENTION	% product-oriented inventions	PERSONAL FUNDING	% investing > $10,000 in personal funds prior to ERIP	ENTREPRENUER	% having started 2 or more firms	MASTERS' OR HIGHER DEGREE	% with Masters' degrees or higher

Fig. 6.3 Inventor characteristics by industrial sector.

7. CONCLUSIONS AND RECOMMENDATIONS

Based on the evaluation findings, a set of recommendations for improving ERIP operations was developed. These recommendations center on four main topics:

- targeting grants and services to inventors;
- alternative ERIP services and assistance;
- continuity and operational efficiency within ERIP; and
- future evaluation efforts.

7.1 TARGETING GRANTS AND SERVICES

Currently ERIP selects energy-related inventions for participation in the program primarily on the basis of technical considerations, with some attention given to potential markets. It is possible that by broadening these criteria, ERIP grants and services can be more effectively targeted.

For example, the program should support projects which are unlikely to receive timely and adequate commercial funding. The likelihood of obtaining such private-sector support increases as inventions reach more advanced stages and is greater for inventors with previous commercialization successes. Thus, greater concentration upon inexperienced inventors and inventions in concept development and feasibility testing stages would reduce possible duplication of services from the normal operation of the venture capital market. If inventions in later stages of development are supported, ERIP could provide nonmonetary forms of assistance rather than grants. Alternatively, grants could be awarded to late-stage inventions on a cost-shared basis, contingent on the inventor's raising support from other sources and thereby leveraging the program's grant monies.

Another consideration in allocating funds is an invention's potential impact on the efficiency of energy production, conversion, distribution, and

frequent checks on where a grant approval is in the procurement process, and for special occasions, requests for moving approvals to the front of the line.

Throughout this section suggestions have been made for collecting new information. The earliest that information could be collected is upon initial application to NBS. The latest date to enable targeting is after an applicant has been recommended to DOE for funding. Early data collection increases the paperwork burden on people who will not subsequently receive funding, and the paperwork burden on the program could be quite large. Later data collection offers fewer opportunities to expedite cases which deserve special attention. A compromise would be for NBS to collect additional information from people whose inventions receive high ratings during the first stage of the evaluation.

In all cases, more frequent communication with the inventors during the evaluation and procurement process would be helpful. It would allow the inventors to stay abreast of their applications and would help to identify special requirements for an accelerated review process.

7.2 ALTERNATIVE ERIP SERVICES AND ASSISTANCE

This report has documented the diversity among ERIP inventors, suggesting that the program needs to be broad and flexible enough to offer packages of services tailored to the specific needs of individual inventors. One way to ensure access to a diversity of technical and commercialization assistance is to establish a special fund to pay consultants for short-term, quick-response assistance to inventors. For example, an inventor may need help with a business plan or with a special technical analysis. Consultants should be dispersed throughout the country so that inventors can find help close to home, and to encourage the development of mentoring relationships.

7.4 FUTURE EVALUATION EFFORTS

Many questions have been left unanswered by ERIP evaluation efforts to date. The following discussion of possible future evaluation activities is organized around a model of the program's operations, services, and impacts shown in Fig. 7.1.

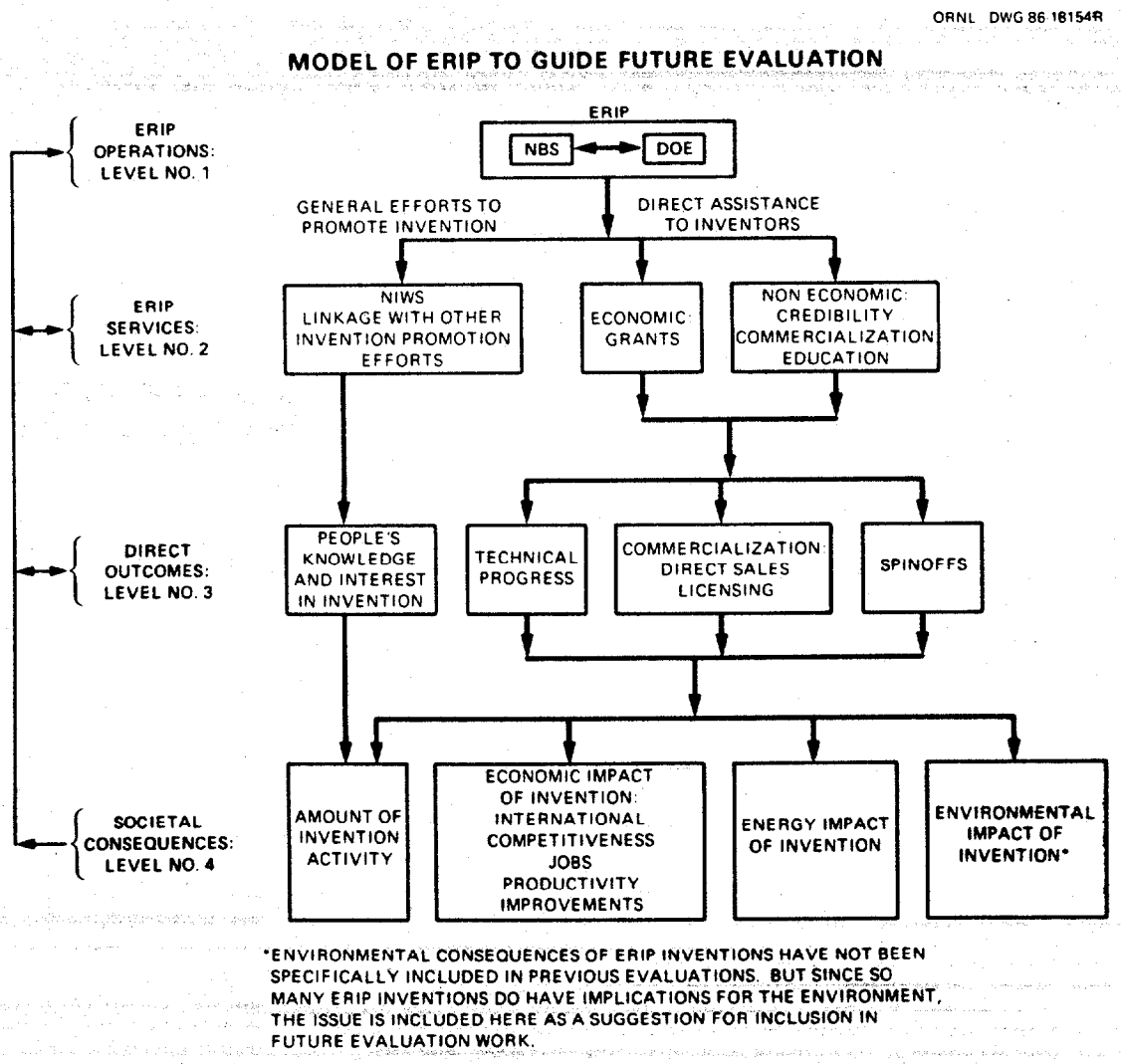


Fig. 7.1 Model of ERIP to guide future evaluation.

7.4.3 Level #3 - Direct Outcomes

Evaluation at this level of the model is an effort to assess the impact of ERIP on outcomes that are directly affected by the program's operation. The question is whether or not ERIP has had a discernible impact on people's interest in inventing; on the technical progress made by ERIP inventors; on movement toward the market by grantees; and on the development of spinoffs from ERIP inventions. While some insight has been forthcoming from this and previous evaluations, ERIP evaluations have not yet had sufficient data on comparison groups against which to judge the success of supported inventors. Future work should consider one of the following sampling frames from which to develop a comparison/control group.

- NBS second-stage rejections;
- inventions that are "nearest neighbors" to the ERIP technologies based on citations in patent disclosures;
- members of a small number of inventor associations; and
- participants in a small number of innovation or incubation centers.

An analysis of the rate and speed of market entry among a comparison group would provide a basis for judging the relative performance of ERIP inventors.

If a study of NBS selection criteria showed high degrees of inconsistency in who is actually recommended, a random experiment could be justified. A pool of applicants who have made it through the stage-two technical review and thus are about equally viable, could be randomly allocated to one of four conditions: grants plus nonmonetary services, grants only, nonmonetary services only, and no services. This tactic would be an effective test of ERIP's impact on invention development.

Also, more up-to-date estimates of the economic impacts of ERIP are needed. At a minimum, sales and employment data on ERIP inventors should be collected for 1985 and 1986, and information on the most recent ERIP participants should be compiled.

8. REFERENCES

Albaum, Gerald. 1976. *The Independent Inventor.* Eugene, Oregon: University of Oregon, College of Business Administration.

Bailey, Martin Neil. 1986. "What Has Happened to Productivity Growth?" *Science*, 234: 443-450, October.

Blair, Homer O. 1978. *Understanding Patents, Trademarks and Other Proprietary Assets and Their Role in Technology Transfer and Licensing.* Lexington, Massachusetts, Library of Congress Catalog Number 77-94159.

Booz, Allen and Hamilton. 1968. *Management of New Products.* New York: Booz Allen and Hamilton.

Brown, Marilyn A. et al. 1985. "A Strategy for Accelerating the Use of Energy-Conserving Building Technologies." *Journal of Technology Transfer*, 10(1): 35-50.

Bronfman, L. M., et al. 1982. *Evaluation of the Energy-Related Inventions Program: Case Studies of Supported Projects*, ORNL/CON-92/v2, Oak Ridge, Tenn.: Oak Ridge National Laboratory, May.

Congressional Budget Office. 1984. *Federal Support for R&D and Innovation.* Washington, DC: Congressional Budget Office.

Gellman Research Associates, Inc. 1982. *The Relationship Between Industrial Concentration, Firm Size, and Technological Innovation.* Washington, D.C.: U.S. Small Business Administration, Office of Advocacy, May, NTIS #PB82226119.

Gore, Albert, Jr. 1981 "*Statement of Albert Gore Jr., Chairman, Before the Subcommittee on Investigations and Oversight of the Committee on Science and Technology, U.S. House of Representatives.*" July 21-22.

Gupta, 1985. *Venture.*

Kierulff, Herbert E., et al., 1984. *Evaluation of the Energy-Related Inventions Program: Case Studies.* Lake Forest, Illinois: Mohawk Research Corporation, September.

Mansfield, Edwin, et al. 1977. *The Production and Application of New Industrial Technology.* New York, New York: W. W. Norton.

Moavenzadeh, Fred. 1985. "Construction's High-Technology Revolution." *Technology Review*, pp. 32-41, October.

Myers, S., and Marquis, D. G. 1969. *Successful Industrial Innovations: A Study of Factors Underlying Innovations in Selected Firms* (NSF 69-17). National Science Foundation.

Myers, Sumner and E. E. Sweezy. 1976. *Why Innovations Falter and Fail: A Study of 200 Cases* (Denver Research Institute, University of Denver), Report R 75-04, NTIS.

Shapero, Albert. 1981. "Statement of Albert Shapero, Professor, Ohio State University, Before the Subcommittee on Investigations and Oversight of the Committee on Science and Technology, U.S. House of Representatives." July 21-22.

Soderstrom, E. J., L. M. Bronfman, and M. L. Rorke. 1984. *The Energy-Related Inventions Program: An Overview of the Evaluation,* ORNL/CON-92/V3, Oak Ridge, Tenn.: Oak Ridge National Laboratory.

Soderstrom, E. J., M. L. Rorke, H. Livesay, and S. Myers. 1984. *A Review of Alternative Services and Approaches for the Energy-Related Inventions Program,* ORNL/CON-157, Oak Ridge, Tenn.: Oak Ridge National Laboratory.

Soderstrom, E. J., and M. L. Rorke. 1984. *Evaluation of the Energy-Related Inventions Program: An Update for 1984,* ORNL/CON-183, Oak Ridge, Tenn.: Oak Ridge National Laboratory, unpublished manuscript, December.

Soltanoff, Louis. 1978. "Are You Ready to Become an Inventor?" *Technology Review,* pp. 47-50, May.

U.S. Department of Commerce. 1985. *Statistical Abstract of the United States: 1986* (106th edition), Washington, D.C., U.S. Bureau of the Census.

U.S. Department of Energy. 1985. *National Energy Policy Plan.* Washington D.C.: U.S. Department of Energy.

U.S. Department of Energy. 1986. *FY 1988 Energy-Conservation Multi-Year Plan.* Washington, D.C.: U.S. Department of Energy, Office of Conservation.

U.S. General Accounting Office. 1985. *Federal Agencies' Policies and Practices are in Accordance with Patent and Trademark Amendments of 1980.* Washington, D.C.: U.S. General Accounting Office.

U.S. General Accounting Office. 1986. *Research and Development: A Profile of Selected Firms Awarded Small Business Innovation Research Funds.* Washington, D.C.: U.S. General Accounting Office, March.

Wilken, P. H. 1979. *Entrepreneurship: A Comparative and Historical Study.* New Jersey: Ablex Publishing Corporation.

U.S. Small Business Administration. 1986. *Innovation in Small Firms.* Washington, D.C.: U.S. Small Business Administration, Office of Advocacy, July.

Vitullo, A. Jack. 1986. *A Statement of A. Jack Vitullo, Director of Inventions and Innovation Programs, U.S. Department of Energy, Before the Subcommittee on Energy, Nuclear Proliferation, and Government Processes of the Committee on Governmental Affairs, U.S. Senate, July 30, 1986.* Washington, D.C.: U.S. Department of Energy.

APPENDIX A

TELEPHONE QUESTIONNAIRE

Name of Interviewer:_____ Time of interview:_____

Date of interview: _____ Length of interview:_____

PART 1 - BACKGROUND

1. Name of person being contacted: _____ (1.0)

2.0 What is the best mailing address where we can reach you?

2.1 Organization (if applies)..... _____ (2.1)

2.2 Street address..... _____ (2.2)

2.3 City..... _____ (2.3)

2.4 State..... _____ (2.4)

2.5 Zip..... _____ (2.5)

3. What is the best phone number where we can reach you?..... _____ (3.0)

4. What is the zip code of your residence?..... _____ (4.0)

5. Please give us a short descriptive title of your invention. (NOTE: Some R's may have submitted more than one invention. Make it clear that we are interested in their most recent submission.)..... _____ (5.0)

6. Have you been primarily responsible for the technical development of this invention?.....YES (1) (6.0)

NO (2)

If YES: go to 8.
If NO: ask 7.

PART 2 - DEMOGRAPHICS

10. In what year were you born? (Enter only last two digits)....._____ (10.0)

11. Did you receive <u>any</u> engineering or physical science training in any of the following educational settings?

11.1 High school — YES (1) NO (2) (11.1)

11.2 Undergraduate college — YES (1) NO (2) (11.2)

11.3 Graduate level (post bachelors degree) — YES (1) NO (2) (11.3)

11.4 Vocational or technical training in military or civilian life. — YES (1) NO (2) (11.4)

12. Did you hold any graduate or undergraduate degrees at the time you submitted your invention to the National Bureau of Standards? — YES (1) NO (2) (12.0)

If YES ask 13.
If NO go to 16.

13.....What degrees did you hold?....._____ (13.00)

_____ (13.01)

_____ (13.02)

14.....What was your undergraduate major?....._____ (14.0)

18.5 Does your organization deal with any products or services that are related to the invention you submitted to the Energy-Related Inventions Program?
(NOTE: "Deal with" = sell, use, teach about, etc.).....YES (1) (18.5)
NO (2)

If YES go to 18.6.
If NO go to 18.7

18.6 Please briefly explain the nature of that involvement. (18.6)

18.7 Is your present job related in any way to the invention you submitted to the National Bureau of Standards?.....YES (1) (18.7)

NO (2)

If YES go to 18.8.
If NO go to 19.

18.8 Please briefly explain the nature of that relationship. (18.8)

19.....In addition to the job you just told us about, are you currently working at any other jobs?.....YES (1) (19.0)

NO (2)

If YES go to 20.
If NO go to 21.

21.1 What year did you begin to work there? (Last 2 digits)....._____(21.1)

21.2 What year did you stop working there? (Last 2 digits)....._____(21.2)

21.3 Approximately how many full time employees did the organization have?....._____(21.3)

21.4 Please give us a descriptive title for the position you had with the organization....._____(21.4)

21.5 What were the organization's primary products or services?....._____(21.50)

_____(21.51)

_____(21.52)

21.6 Was your job related in any way to the invention you submitted to the National Bureau of Standards?.....YES (1) (21.6)

NO (2)

21.7 If YES to 21.6 please explain. (21.7)

22. Prior to the job you just told us about, was there another job that represented your major source of employment?.....YES (1) (22.0)

NO (2)

If YES go to 23.
If NO go to 24.

23. What is the name of the organization?....._____(23.0)

23.1 What year did you begin to work there? (Last 2 digits)....._____(23.1)

23.2 What year did you stop working there? Last 2 digits)....._____(23.2)

28. Have your ever operated or held a management position in a new business that you or others have started?.....YES (1) (28.0)

NO (2)

29. Developing an invention is a complicated effort with many tasks delegated to others. We are interested in how you put your personal effort into the invention you submitted to the National Bureau of Standards. I will read six aspects of invention related work, and I would like you to rate the extent of your personal involvement in each one. Please use the following rating scale: (NOTE: Do not read "6" but score it if necessary.)

1- I do/did almost all the work related to those tasks.

2- I do/did the majority of work related to those tasks.

3- I do/did about half the work related to those tasks.

4- I do/did little of the work related to those tasks.

5- I do/did almost none of the work related to those tasks.

6- no response,or don't know.

29.1 management and administration....._____ (29.1)

29.2 raising capital....._____ (29.2)

29.3 financial management....._____(29.3)

29.4 sales and marketing....._____(29.4)

29.5 research and development....._____ (29.5)

29.6 production....._____ (29.6)

33. Has any outside source estimated how much energy your invention will produce and/or save?.....YES (1) (33.0)

NO (2)

If YES go to 34.
If NO go to 35

34.....What is that estimate?
(NOTE: We want estimate in terms of unit of device or application of a process. After R gives response ask if it is per unit, or if he can state it in those terms. If he cannot, collect as much information as possible to help us do the conversion.)

amount....._____

unit....._____

amount in common metric....._____ (34.0)

34.1 What is the name of the person who made the estimate?...._____ (34.1)

34.2 What organization does the person work for?....._____ (34.2)

34.3 Street address....._____ (34.3)

34.4 City....._____ (34.4)

34.5 State....._____ (34.5)

34.6 Zip....._____ (34.6)

34.7 Telephone number....._____ (34.7)

34.8 Is there any test data available for the estimate that has been made?.....YES (1) (34.8)

NO (2)

34.9 If YES, can we see it?.....YES (1) (34.9)

NO (2)

39. I am going to read six aspects of status for a patent. Please tell me which one best describes the status of your invention....._____ (39.0)

No patent has been applied for on this invention.....(1).

A patent was applied for.....(2).

A patent application is pending.....(3).

The patent was granted.....(4).

The patent application was denied.....(5).

The patent application was withdrawn.....(6).

40. Prior to submitting this invention to the Energy-Related Inventions program, have you ever <u>applied</u> for a patent on another invention?.....YES (1) (40.0)
NO (2)

If YES go to 41.
If NO go to 45.

41.....Have you ever been granted a patent?.....YES (1) (41.0)
NO (2)

If YES go to 42.
If NO go to 45.

42.....How many U.S. patents have you been granted?....._____ (42.0)

43.....How many foreign patents have you been granted?....._____ (43.0)

44.....Are any of your patents currently in the marketplace?.....YES (1) (44.0)
NO (2)

49.....Please briefly describe the progress you have made. (PROBE for dates and relationship to NBS & DOE assistance.)
(NOTE: After this question go to 51) (49.0)

50.....Please briefly describe the major reasons why you have not made substantial progress. (50.0)

51. Since you applied to the National Bureau of Standards, do you believe you have made any progress on the marketing and production aspects of your invention?.....YES (1) (51.0)

NO (2)

If YES go to 52.
If NO go to 53.

52.....Please briefly describe the progress you have made. (PROBE for dates and relationship to NBS & DOE assistance.)
(NOTE: After this question go to 54) (52.0)

53.....Please briefly describe the major reasons why you have not made substantial progress. (53.0)

56. Inventions can be commercialized by means of three basic strategies. An inventor can run his own company, license or sell the invention to another company, or enter in a joint venture. Which of these is your major strategy?....._____ (56.0)

run own company.....(1).

licensing/selling.....(2).

joint venture.....(3).

57. Have you concluded a licensing agreement for your invention?.....YES (1) (57.0)

NO (2)

If YES go to 58.
IF NO go to 61.

58.....Please briefly describe the terms of the licensing agreement..._____ (58.0)

_____

_____

59.....About how much have you received in royalties from the licensing agreement?....._____ (59.0)

60.....Is your agreement with a firm that can be characterized as American, Foreign, or Both?.....American (1). (60.0)

Foreign (2).

Both (3).

61. Have your sold any units of product (or units of service) from your invention?.....YES (1) (61.0)

NO (2)

If YES go to 65.
If NO go to 62.

65. About what were the gross sales for your invention in calendar year 1984?..... _____ (65.0)

66. About what were the gross sales for your invention in calendar year 1983?..... _____ (66.0)

67. About what were the gross sales for your invention in calendar year 1982?..... _____ (67.0)

68. About what were the gross sales for your invention in calendar year 1981?..... _____ (68.0)

69. About what were the gross sales for your invention in calendar year 1980?..... _____ (69.0)

70. About how many units of your product (or service) did you sell in calendar year 1984?..... _____ (70.0)
(NOTE: For 70-74, also obtain information on what metric inventor is using. Record as much detail as possible.)

71. About how many units of your product (or service) did you sell in calendar year 1983?..... _____ (71.0)

72. About how many units of your product (or service) did you sell in calendar year 1982?..... _____ (72.0)

73. About how many units of your product (or service) did you sell in calendar year 1981?..... _____ (73.0)

74. About how many units of your product (or service) did you sell in calendar year 1980?..... _____ (74.0)

79.....We are interested in how your invention compares to its major competition. Please rate each of the following using this five point scale:

1- My invention is very much superior to its competition.

2- My invention is better than its competition.

3- My invention is about as good as its competition.

4- My product is worse than its competition.

5- My product is much worse than its competition.

79.1 esthetics (e.g.,consumer appeal)..... _____ (79.1)

79.2 utility (e.g.,new uses not in existing products or processes)..... _____ (79.2)

79.3 durability (e.g.,fewer break-downs, longer performance)..... _____ (79.3)

79.4 performance (e.g.,accuracy, reliability)..... _____ (79.4)

79.5 cost..... _____ (79.5)

79.6 other (please specify)..... _____ (79.6)

80. What are the major market barriers to the success of your invention..... _____ (80.00)

_____ (80.01)

_____ (80.02)

81. Please tell us the major channels of distribution for your invention..... _____ (81.00)

_____ (81.01)

_____ (81.02)

85. Can you name one or two people you consider especially important in helping you with your invention work?..... _____ (85.00)

_____ (85.01)

86. Can you briefly explain why these people were so important for your invention work? (86.0)

87. Would you recommend that others submit inventions to the Energy-Related Inventions Program?.....YES (1) (87.0)

NO (2)

If YES go to 88.
If NO go to 89.

88.....Have you recommended someone else to ERIP?.....YES (1) (88.0)

NO (2)

89. Would you submit another invention to ERIP?.....YES (1) (89.0)

NO (2)

If YES go to 90.
If NO go to 91.

90.....Have you submitted another invention to ERIP?.....YES (1) (90.0)

NO (2)

95. Did assistance from ERIP have any effect on your decision to continue or discontinue work on your invention?.....YES (1) (95.0)

NO (2)

If YES go to 96.
If NO go to 97.

96.....Please briefly describe how ERIP affected your decision about working on your invention. (96.0)

97. We all know that often inventions have unintended worthwhile "spin-offs" that were not forseen as part of the invention process. Did your invention have any of these?.....YES (1) (97.0)

NO (2)

If YES go to 98.
If NO go to 99.

98.....Please briefly describe the spinoffs from your invention. (98.0)

99. Do you see a significant international market for your invention?.....YES (1) (99.0)

NO (2)

If YES go to 100.
If NO go to 102.

100.....Have you entered or tried to enter the international market?.....YES (1) (100.0)

NO (2)

PART 6 - INFORMATION TO BE GATHERED FROM SOURCES OTHER THAN THE INVENTOR

103. DOE #..... _____ (103.0)

104. Amount of money received..... _____ (104.0)

105. Year that money was received..... _____ (105.0)
(Enter last 2 digits)

106. Status of review:..... _____ (106.0)

1- analysis 1

2- analysis 2

3- decision phase

4- award

5- complete

6- other assistance

7- no DOE support

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