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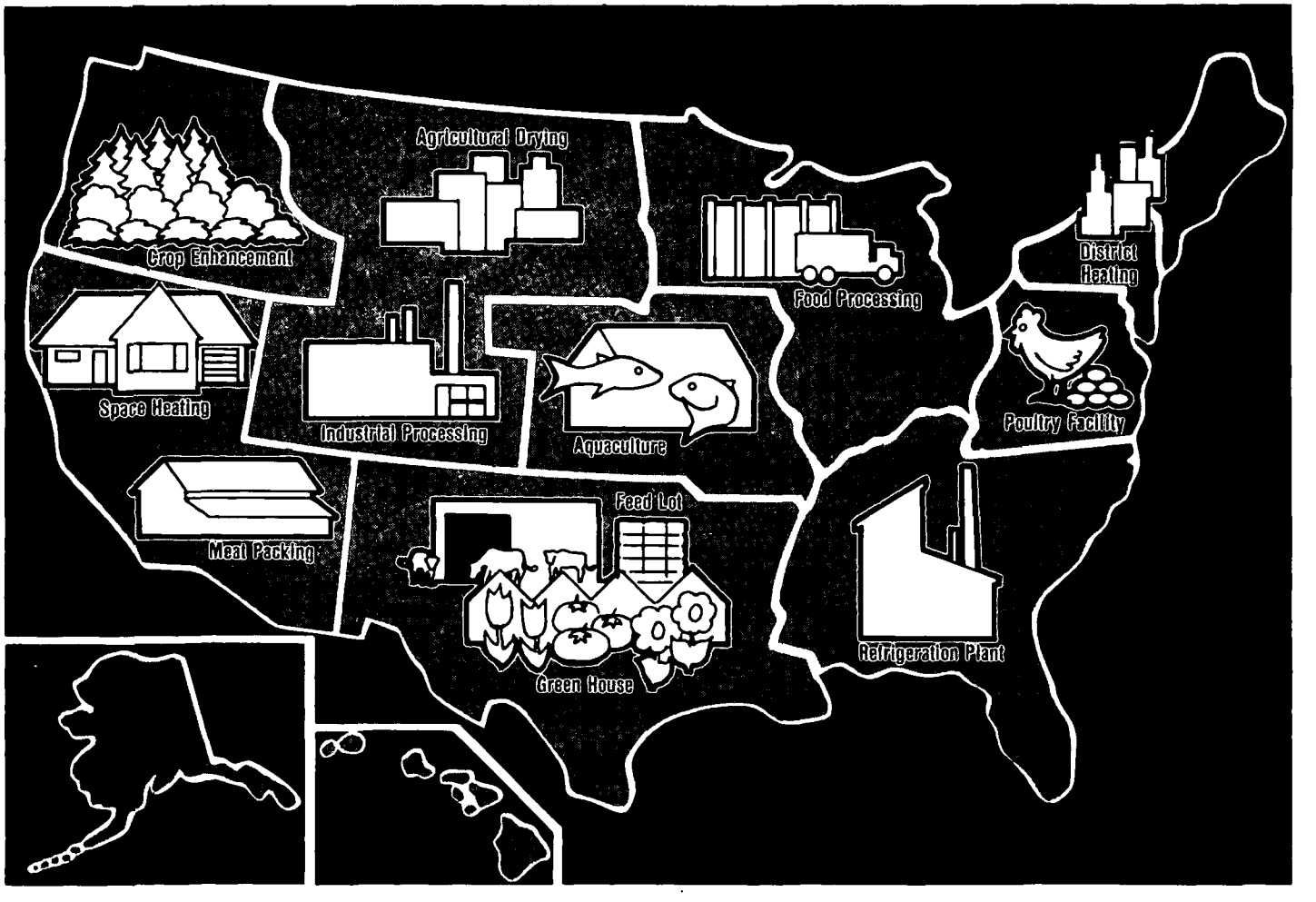
PRELIMINARY DRAFT

National Hydrothermal Direct Applications Program Plan



Division of Geothermal Resource Management

December 14, 1979

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SUMMARY

The use of geothermal energy in Direct Applications has enormous potential. By the year 2020, Direct Applications can displace the energy use equivalence up to 37% of today's oil import requirements. At today's oil prices this displacement equals a $26-billion dollar reduction in the balance of trade deficit. To realize this potential, however, a self-supporting industry must be developed. To date, the development of such an industry has been stiffled by an accumulation of uncertainties, none of which alone would completely retard industry growth but combined together will not allow commercialization to take place in the timely fashion without federal assistance. The major uncertainties are (1) lack of defined resource, (2) profit uncertainty, (3) lack of an established industry, (4) overall assessment of envirnmental issues, (5) policy and regulatory confusion and contradiction and (6) limited technical data. The federal program presented herein addresses each of these areas of uncertainty and sets power on line goals by which the success of the program can be measured. These goals are 0.1 quads by 1985, 1 quad by 2000, and 6 quads by 2020. The elements which comprise this program are summarized:

(1) Reservoir Confirmation: reduce reservoir development risks through cost-shared drilling.

(2) Market Development: reduces financial risks through Geothermal Loan Guarantees; reduces perceived risks through education and user assistance.

(3) State Planning and Developments: reduces development uncertainty through "grass roots" planning and project brokening; reduces financial risks of project development through cost-shared project development.

(4) Technology Demonstrations: expands use potential of resources through technology development and commercial demonstrations.

(5) Environmental Assessment: provides baseline environmental data from which environmental assessments may be made by the private and public sectors.

(6) Policy and Regulatory Issues and Assessments: addresses policy and regulatory issues at federal, state, and local levels to ensure a favorable commercialization environment for geothermal energy.

The program will simultaneously address the range or problems facing the developer from initial resources assessment to ultimate construction and end use. Initial emphasis will be on projects which have a known user and a known resource, next moving to known resources where users must be brought to the energy source, and finally moving to identification of previously unidentified resources.

This program is an eight year program with peak activity centering in fiscal years 1982 through 1985. The program will be completed by 1988. Peak year funding level is estimated to be $182 million in fiscal year 1983 and the total program costs are estimated at $810 million. Approximately 55 percent of the total program cost will be dedicated to reservoir confirmation.

II INTRODUCTION

The Nation's geothermal resources represent a vast energy asset free of foreign capriciousness and interference that should be developed as rapidly and efficiently as possible. If all of the resources identified in the United States Geological survey's Circular 790 were utilized, the total available energy from hydrothermal resources, above 90°C, would be 2500 Quads, which is equivalent to 450 billion barrels of oil. If stimulated, reasonable expectation is that direct applications of hydrothermal energy can provide six Quads in our National energy budget by the year 2020. The United States is currently importing approximately 124 billion gallons of crude petroleum per year at a face value cost of 71 billion dollars. The economic effects are especially acute because most of the petroleum is imported from relatively small underdeveloped nations whose economics cannot absorb an equivalent amount of American exports.

The year 2020 DOE goal of six Quads on line for direct applications of the hydrothermal resource (Figure 1) is equivalent to 1.08 billion barrels or 45 billion gallons of oil. This has a balance of payment replacement value of 26 billion dollars, or can alleviate 37 percent of today's oil import burdon. Directly employed as thermal energy in the economic production of liquid fuels, or used in tertiary oil recovery, geothermal resources loom as a potentially important factor in our National Security as we week means of greater self-reliance in energy production. This potential use of geothermal energy in other direct applications such as space conditioning, industrial processing, water heating, and agribusiness does not dpend on new engineering or scientific advances but requires only the adaptation of existing technology, the environmental consequences of which are relatively benign. To reach this goal a vigorous federal effort is required in cooperation with industry, the States, and local government. This plan is a description of that effort. Program costs are estimated and benefits that would accrue from it's implementation are discussed.

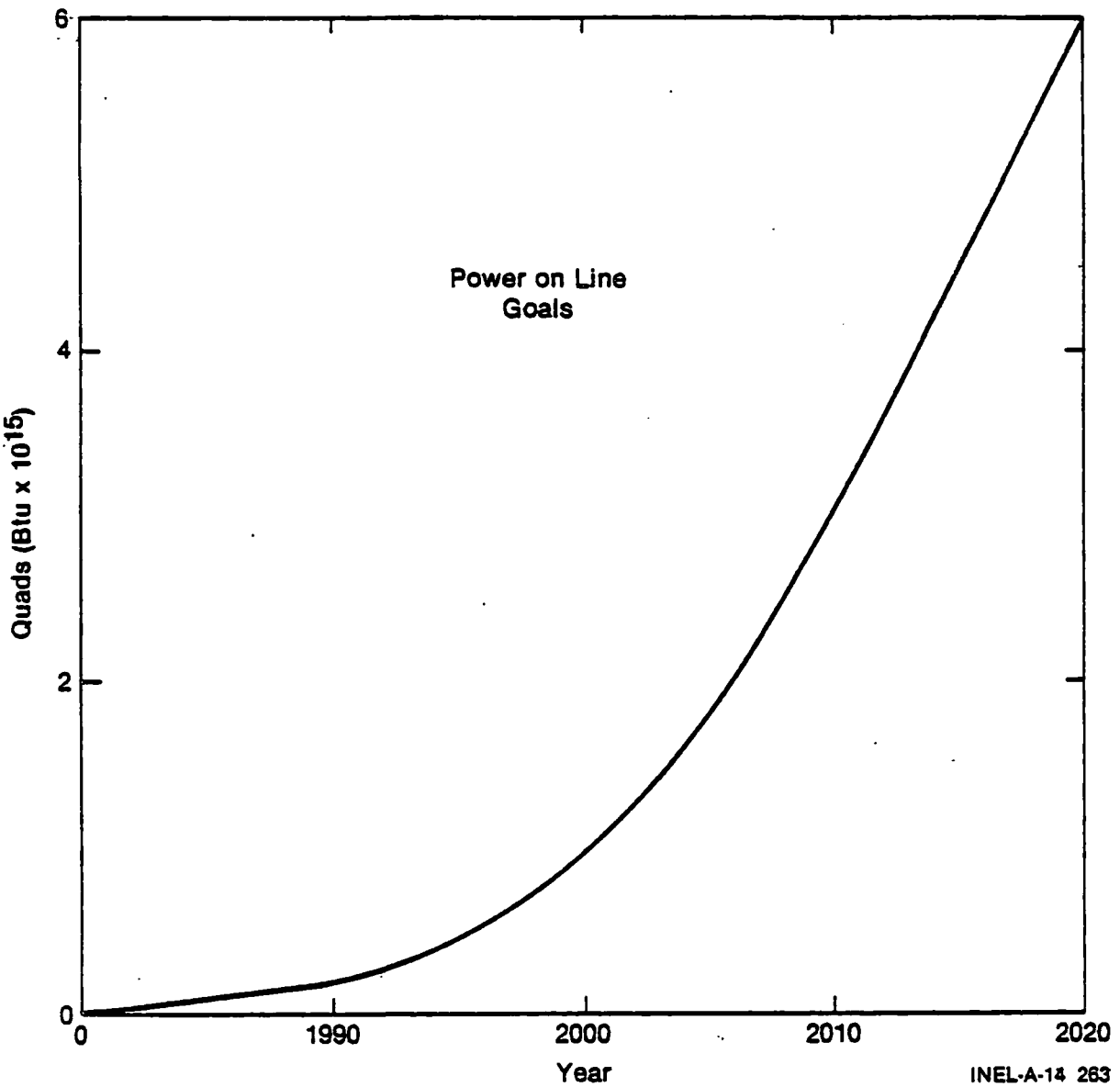

Fig. 1 DOE hydrothermal direct heat commercialization goals

The Market

Nearly 50 percent of the nation's energy temperature requirements are below 150°C, an appropriate range for the direct use of geothermal energy. Many geothermal resource locations, however, could also provide energy for industrial processes requiring temperatures higher than 150°C. Space heating and low-to moderate-temperature industrial processes are two particularly attractive energy use sectors for geothermal. For the nation's stock of buildings, for example, space heating requirements are approximately 14 Quads annually. Geothermal energy could supply about 3-1/2 percent of this demand as 10 percent of the U. S. population lives and works within 40 miles of some 225 known geothermal resource locations in 11 western states (Bloomster, Battelle N. W. Laboratories, 1977). Great potential also exists for the use of geothermal energy in space cooling applications. In the rapidly growing cities of the Southwest, the use of geothermal energy for space cooling may compare favorably, or as shown in some analysis, hold significant economic advantages over solar systems.

Increasing attention is also being devoted to the direct application energy market in eastern states. Of the six principal geothermal resource areas analyzed to date for energy demands, the existing residential, industrial and commercial energy market approaches .2 Quads (36 million barrels of oil annually). (Toth, Applied Physics Laboratory, John Hopkins University, 1979).

Market Penetration Potential

A National market penetration analysis is being formulated; econometric analyses are being developed for states in the Rocky Mountain and high plains states where resource potential is high. Preliminary evaluations indicate a high industrial application potential, as well as a possible unlimited market for ground water heat pump applications, cogeneration, space cooling, and major new industrial complexes that might be attracted to more remote but highly promising geothermal resource locations.

Similar analyses being performed for other states are also expected to show significant market penetration potential for geothermal energy. In the aggregate, the potential economically attainable goal for geothermal energy of six Quads represents a national opportunity of impressive dimensions. The power-on-line goals developed for this program to stimulate direct applications of the Hydrothermal resource are listed below.

	1985	1990	1995	2000	2010	2020
Quads	0.1	0.2	0.4	1.0	3.0	6.0
Equivalent Barrels (Millions)	18	36	72	180	540	1080

Benefit Summary

Benefits from the development and use of the hydrothermal resource through direct applications are nationally important, but vary regionally. Development can mean new employment opportunities, contributions to energy independence, additional tax revenues, increased capital investments and industrial growth, and an improved environment. Many, but not all, of the benefits can be quantified. Unquantifiable benefits have been termed "values" in this document. Included in these values are:

Insurance Value - identifies the potential of the hydrothermal technology to be commercially viable and capable of substituting for other energy technologies that may become more expensive, unavailable, or undesirable.

Environmental Value - identifies the overall favorable environmental impacts of geothermal energy as compared with other energy technologies displaced.

Conservation Value - identifies the measure of importance that the use of geothermal heat has in conserving (replacing) natural gas and liquid fossil fuels.

Decentralizing Value - identifies the advantage to be derived from a geothermal technology that operates effectively in an on-site decentralized mode.

International Value - identifies the advantages in terms of international cooperation and trade, as well as a viable energy option for other countries that will lessen the completition for other energy sources.

Quantifiable benefits include the fiscal benefits that will be derived by federal, state, and local governments if the resource is effectively developed. Using reasonable assumptions and the DOE direct applications goals shown in Figure 1, it is estimated that the return of revenues through federal taxes and royalties will exceed 1.6 billion dollars per year by the year 2020. Summing the revenue for all years yields a total of approximately 19 billion dollars in federal revenue between now and the year 2020. The accompanying tax revenue to state and local governments is estimated to be 25 million dollars by the year 1985, 600 million dollars by the year 2000, and 7.0 billion dollars by the year 2020.

To receive this level of financial benefit, industry must make significant capital investments. By the year 1985, 2.5 billion dollars will be required, 25.1 billion dollars by the year 2000, and 150 billion dollars by the year 2020.

Displacing oil and gas with geothermal energy will be a significant benefit; about 18 million barrels of oil can be displaced in the year 1985, 180 million barrels in the year 2000, and 1.1 billion barrels in the year 2020. Using current oil prices of about ~~$16~~ per barrel, a cumulative balance of payment advantage of over 300 billion dollars would be realized through the year 2020. Figure 2 and 3 illustrate the calculated projections specified above. #24

For this benefit analysis, the following assumptions were made:

a. Barrel of oil costs $24.
b. No inflation on projections.
c. Investment capital is $750/kW installed capacity average for combination of industrial and space heating applications.
d. Geothermal fluid is worth $2.50/MBtu.
e. 40% federal taxation (includes depletion allowance).
f. 10% federal royalty payment (half of development of federal lands).
g. One quad equals 180 million barrels of oil.

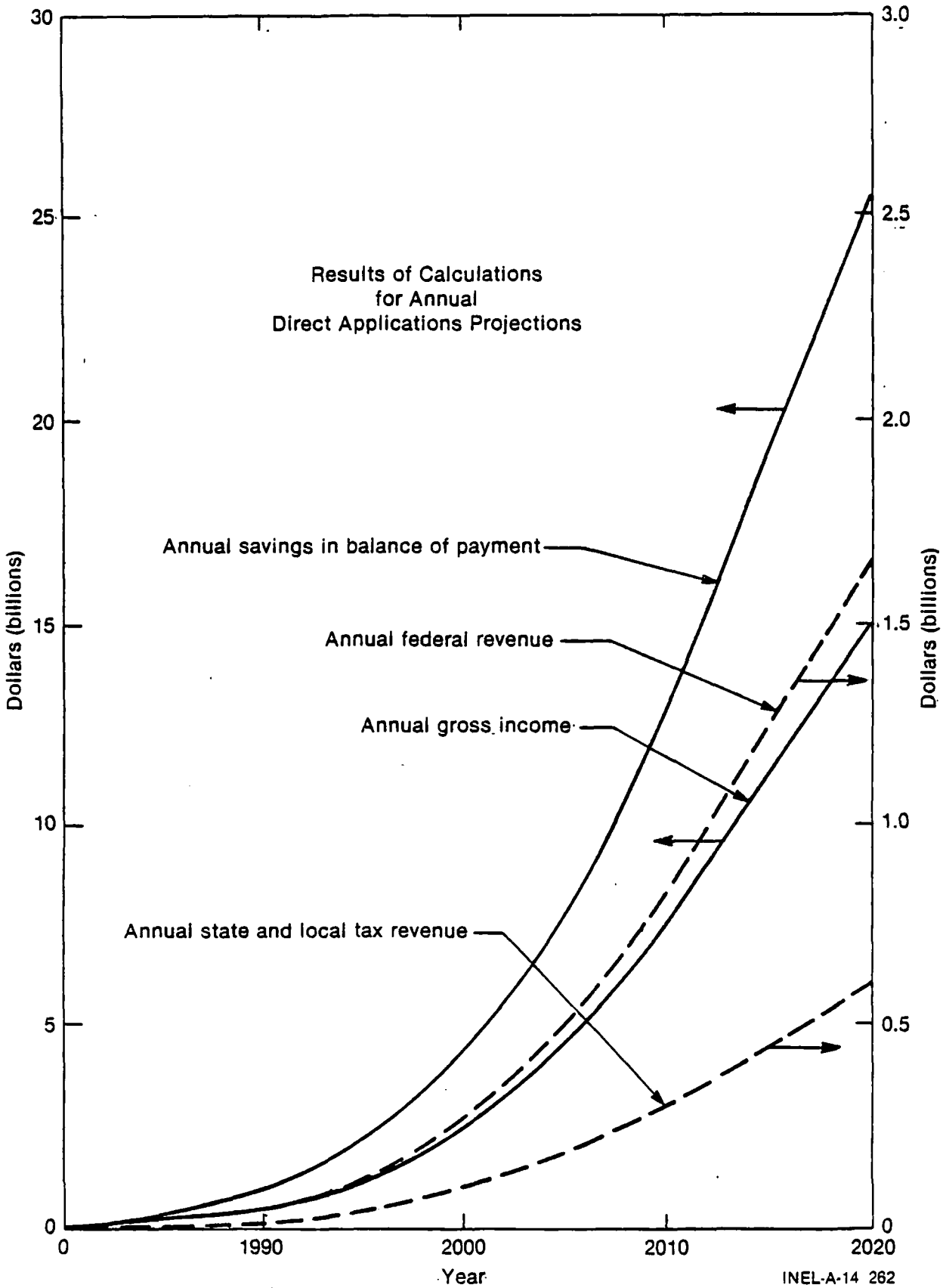

Fig. 2 Annual monetary benefits

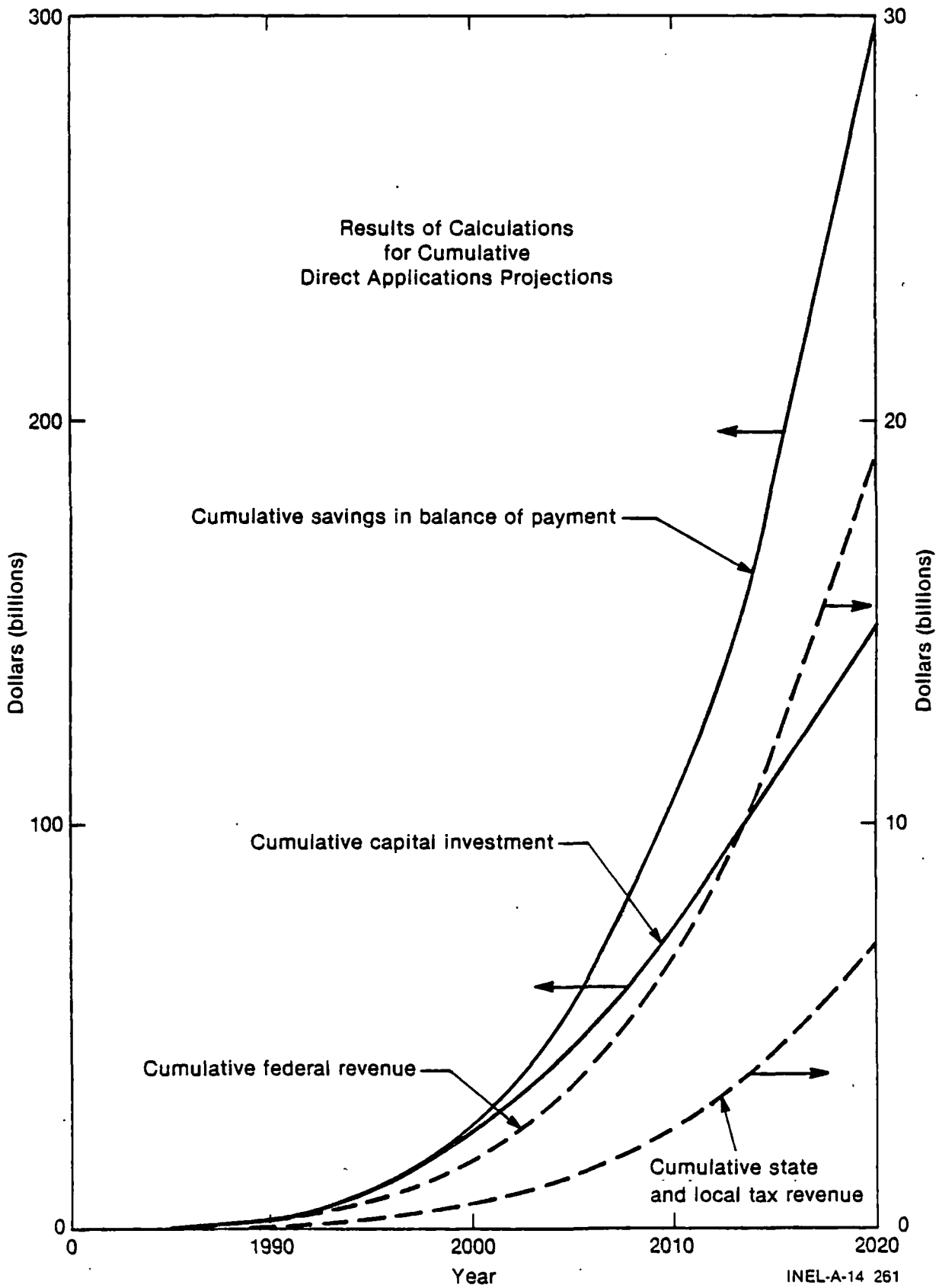

Fig. 3 Cummulative monetary benefits

III COMMERCIALIZATION BARRIERS

The current United States imports of crude petroleum from developing nations presents a large economic imbalance in relationship to the imports and exports between these countries. This has the result of creating a large negative balance of payment. Meeting the DOE geothermal goals will be equivalent to a 37% reduction in the year's import burden.

There are a number of recognizable barriers or problems that must be solved to meet this goal. The Department of Energy's Geothermal Direct Applications Program is structured to alleviate these barriers to the direct use of geothermal energy.

The Need For Defined Resources

The major barrier to geothermal development is the lack of defined resources. Direct applications of hydrothermal energy in the United States represents only about .01 Quad. This is due in part because this important energy source has, in the past, not been assumed to be competitive with fossil fuels and little effort has been expanded in defining resources. Confirmation of hydrothermal reservoirs by drilling is costly, and there is a significant risk of drilling an unproductive well. Present developers of electrical power generation facilities at high-temperature reservoirs are generally large companies that can finance reservoir confirmation by spreading the high risk and cost over many projects. However, these large companies are usually not interested in direct heat applications because of the relatively small scale of such projects. Smaller developers, the ones most interested in direct applications, are unable to spread risk and cost in the same way that a large company can. A single unproductive well can mean financial disaster for them. For these reasons, it is not expected that direct heat users will be able to perform needed reservoir confirmation by themselves until the risks and costs are lowered. Without federal assistance in resource definition there will continue to be very little use of the hydrothermal resource base that exists in the United States.

The Need For Profit Certainty

Profit uncertainty is contributing to the slow involvement by the commercial sector in the geothermal industry. Federal stimulation activities by the federal government are needed to encourage developers, financiers, constructors, manufacturers and others to realize adequate profits so they will become heavily involved in geothermal energy development. Federal assistance is also needed to mitigate the affects of legal, institutional and environmental barriers so that adequate profits can be realized.

Lack Of Established Industry

Development of the Nation's geothermal energy potential requires a supporting industry that has not yet fully evolved. The participation of developers, financiers, builders and operators needs to be expanded for resource exploration and drilling, resource development, energy brokerage, financing, equipment manufacturing and sales, facility development, and utility distribution.

With the exception of the energy broker, this infrastructure currently exists to some extent, but is generally in its infancy and needs to be developed. The place of the energy broker is unique to geothermal energy, and his absence has been a major deterent to its development in the direct applications market. Conventional energy sources (coal, gas, oil, and electricity) require minimal interaction between the energy supplier and user segments. Conventional energy developers and supplier do not wish to be in the energy use business, nor do energy users wish to be in the energy development business, which creates the need for the geothermal broker.

The Need To Assess The Environmental Issues and Eliminate Policy and Regulatory Confusion and Contradiction

The developer of a geothermal resource is faced with a confusing, and frequently unreasonable array of environmental laws, permits, regulations, policies, and requirements that restrict development. Promising lands are withheld from leasing and development as a result of potential environmental and other concerns which are often not confirmed nor well-understood. Even when resource development

occurs, problems and uncertainties associated with these issues can escalate the cost and frustrations of development. The elements included in this program are aimed at resolving environmental and policy and regulatory conflicts, coordinating programs to ensure that necessary work is accomplished without duplication of effort, and simplifying environmental policy and regulatory requirements and procedures for developers.

A Need For Technical Development And Demonstrations

A barrier to widespread implementation of geothermal direct heat applications is the need for base economics and system operational information as evidenced by survey results in the private sector (Hanny, INEL, 1979). Many direct uses of geothermal heat and fluids are possible with available technology, but technical feasibility, confidence in economics, and reliability of direct heat systems continue to be concerns and factors of indecision for much of private enterprise. Demonstrations are directed to address these uncertainities. Technical developments are also needed to alter existing technology for geothermal applications, and to apply geothermal heat and fluids in new and innovative ways.

IV PROGRAM DESCRIPTION

The commercial sector, with support from individual states, the federal government and others perform a sequence of activities in order to produce direct applications power on line. This general flow of activity, from initial hydrothermal resource and econometric assessments, leading into reservoir development activities and ultimate facility construction or retrofiting is illustrated in Figure 4. The purpose of this program plan is to identify the need and the work required by the federal government to stimulate these commercial activities to bring hydrothermal direct heat applications power on line as rapidly as possible in order to reduce our dependence upon foreign oil supplies. The federal program, as outlined in Figure 5, is designed to eliminate or minimize the affect of the commercialization barriers identified in Section III. Seven major work elements are selected to define the federal work needed to stimulate commercial activities at strategic points of commercial development. These work elements are Reservoir Confirmation, Market Development, State Planning and Development, Technology Demonstrations, Environmental Assessment, Policy and Regulatory Issues Assessment, and Progress Monitoring. The specific activities that will take place for each of the elements are discussed later in this program plan. The major federal stimulation activities are shown in Figure 4 in relation to the commercial activity in which they have the greatest impact. Some activities, such as environmental, policy, and regulatory issues assessments, will support many different points of the commercialization sequence.

The programmatic activity will first be directed to stimulating the use of our best known resources that are now colocated with potential users. The next emphasis will be placed on bringing users to known resource areas. Thirdly, work will take place to stimulate the identification of new resources. State resource and commercialization teams will be utilized to bring these efforts into fruition. Technical advise will be provided to potential users, risks will be minimized as

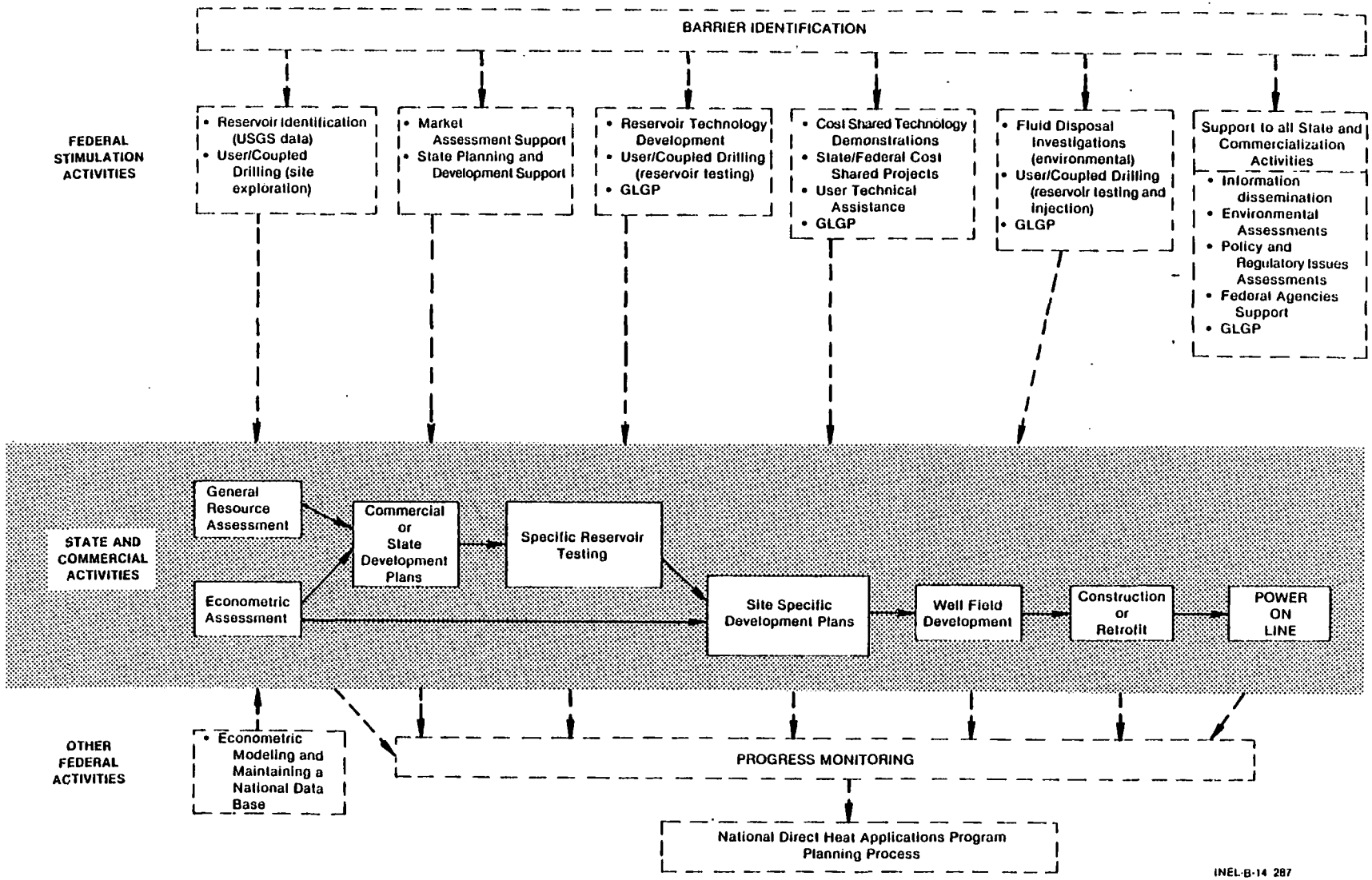

Fig. 4 Commercialization sequence and government stimulation

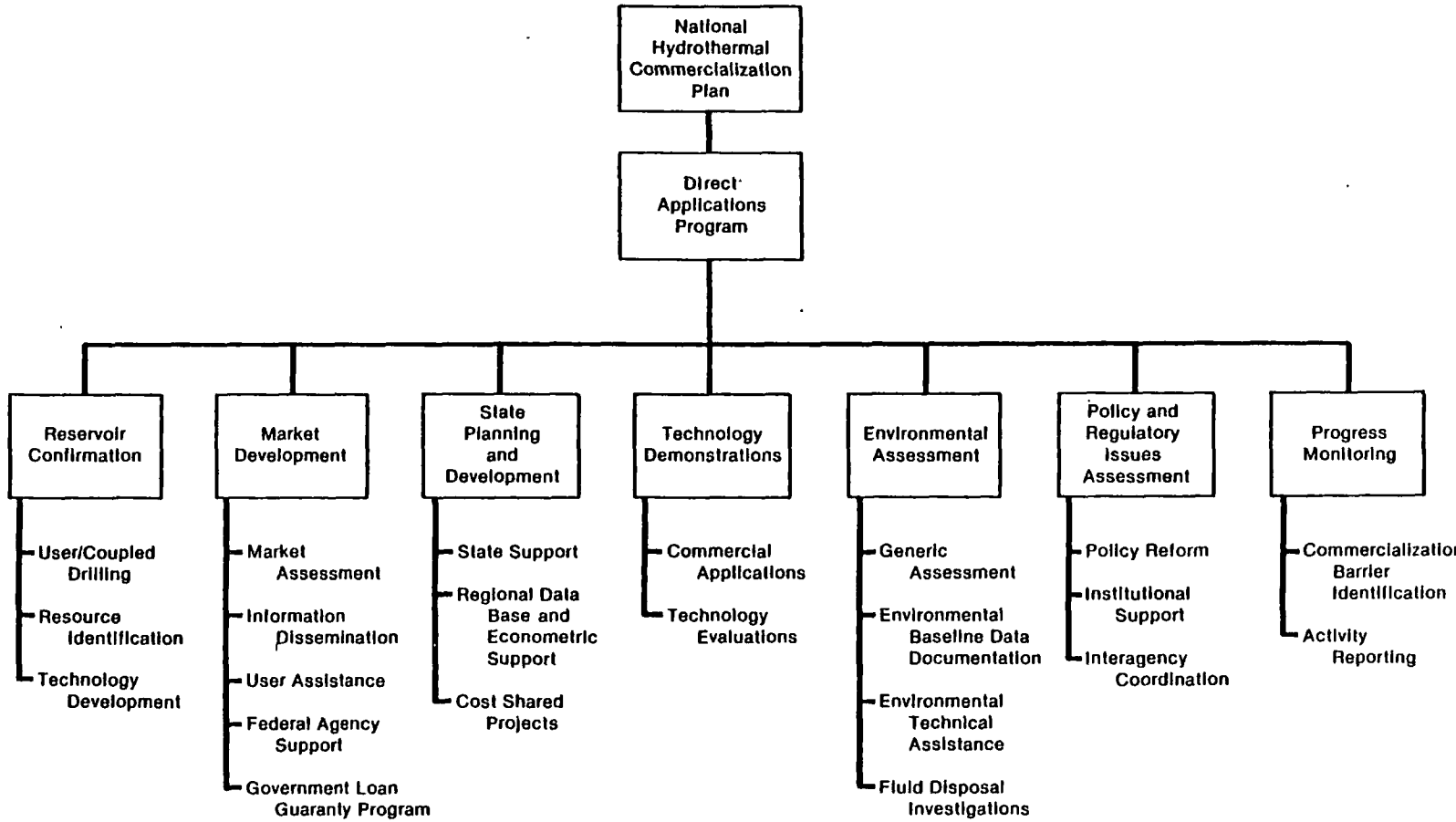

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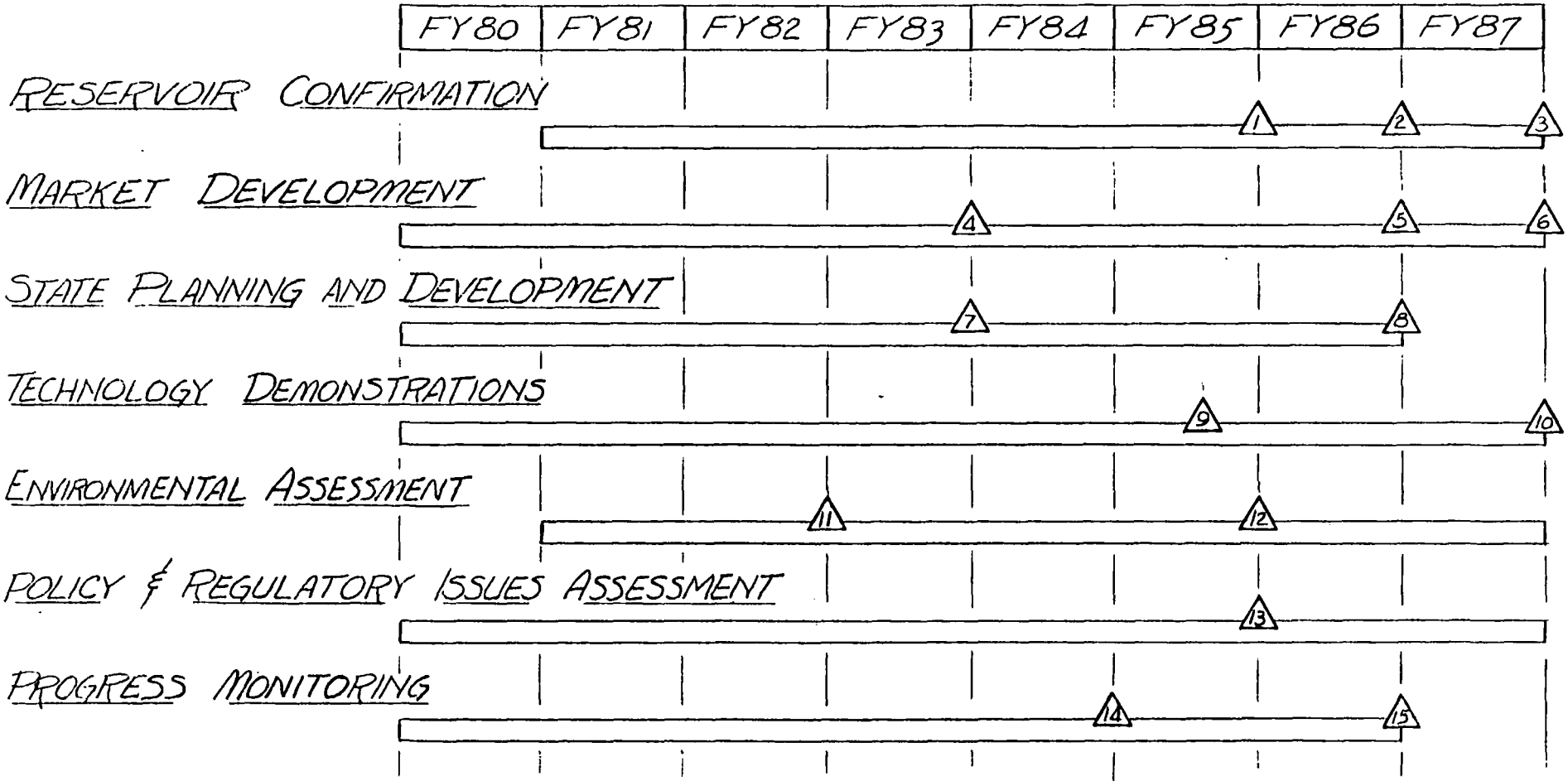
Fig. 5 DOE program work elements

required, legal, institutional and environmental issues will be addressed, and needed action will be implemented. As these activities proceed, the commercial development will be monitored to evaluate the effectiveness of the federal stimulation activities. This is needed so that programmatic actions can be modified when needed, effectiveness of the program can be measured, and federal government involvement can be terminated on a timely basis.

Major milestones for these stimulation activities are shown in Figure 6.



1 - Final user coupled drilling procurements
2 - Complete resource maps
3 - Complete site investigations
4 - Finalize market assessment studies
5 - Phase-out Federal agency support
6 - Phase-out user assistance program
7 - Final state support planning
8 - Complete cost shared projects
9 - Award 7th commercial demonstration project
10 - Phase-out component and system development
11 - Issue generic assessment document
12 - Complete environmental baseline data documentation
13 - Complete work with states on policy reform
14 - Complete commercialization barrier identification
15 - Phase-out monthly monitoring

Fig. 6 Program major milestones

A. RESERVOIR CONFIRMATION

The objective of this program element is to accelerate the confirmation of hydrothermal reservoirs. At the present time, there is little application of direct heat resources in the U.S. because of the high risks and costs of exploring for and confirming hydrothermal reservoirs. Risks and costs are high because of present lack of a knowledgeable and experienced industry infrastructure for exploration and reservoir confirmation. A solution to these problems will be based around a new DOE initiative known as the "User-Coupled Cost Shared Reservoir Confirmation Drilling Program." The new program will reduce risks and costs to prospective developers and users in the near-term through government cost sharing with the developer and user and with their consultants and contractors. Two principal benefits will derive from this plan: 1) direct applications of hydrothermal energy will be accelerated and will make a significant positive impact on the Nation's need for alternate energy sources, and 2) an experienced infrastructure of consultants, contractors, equipment manufacturers and financial institutions, now lacking in the private sector, will be developed. Development of an experienced infrastructure will reduce the real risk and the cost of exploration and reservoir confirmation in the 1987 time-frame so that further industry development will take place without the need for federal government involvement.

High quality sites need to be tested by drilling. Because new geothermal occurrences are being located by field teams on a daily basis, it is apparent that regional assessment of the geothermal resource base is in an early stage in the United States. Resource identification programs will be supported to ensure that high quality resource areas are available for development. Improvement in exploration and reservoir confirmation techniques is needed to help reduce risks and costs.

The tasks to be conducted under reservoir confirmation are illustrated in figure 7.

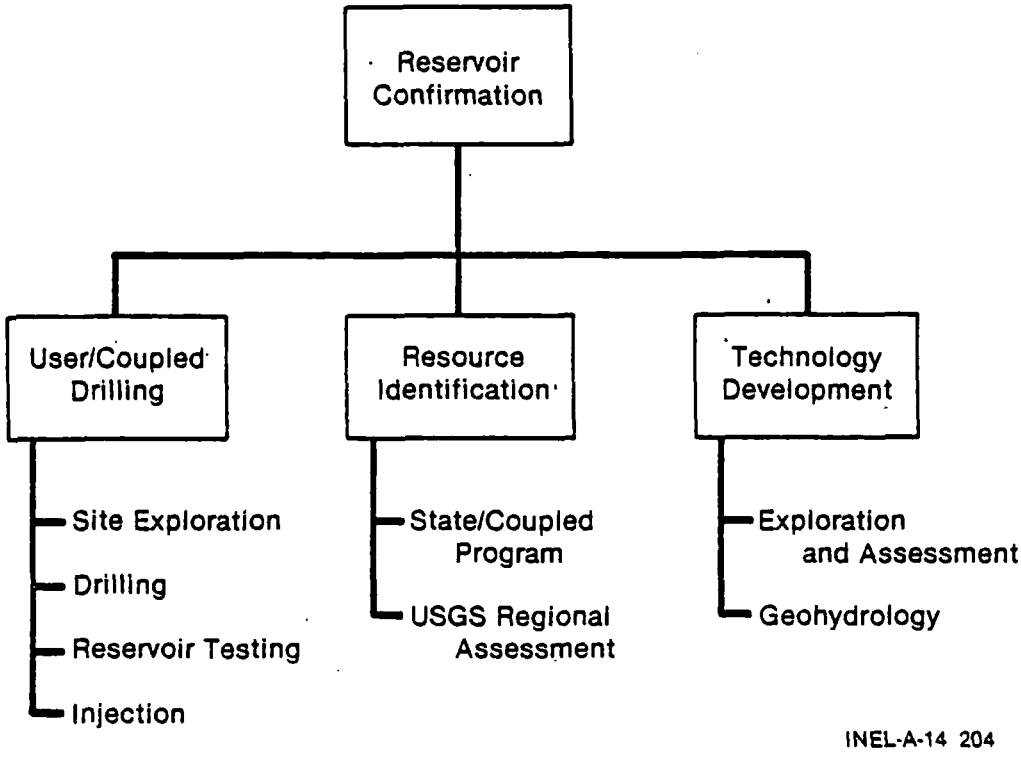


Fig. 7 Resource Confirmation block diagram

User-Coupled Drilling

Confirmation of reservoirs by drilling is costly and there is a significant risk of drilling an unproductive well. Present developers of electrical power generation from high-temperature reservoirs are generally large companies that can finance reservoir confirmation by spreading the high risk and cost over many projects. However, these large companies are usually not interested in direct heat applications because of the relatively small scale of such projects. Smaller developers, the ones most interested in direct applications, are unable to spread risk and cost in the same way that a large company can. A single unproductive well can mean financial disaster for them. For these reasons, it is not expected that prospective direct heat users in the private sector will be able to perform needed reservoir confirmation by themselves until the risks and costs are lowered.

The objective of the User-Coupled Cost Shared Reservoir Confirmation Drilling Program is to decrease risks and cost of reservoir confirmation by developing an experienced infrastructure of exploration, reservoir confirmation and engineering consultants, and contractors in the private sector. Such an infrastructure is now almost totally lacking.

The program will consist of DOE cost-shared surface exploration and drill confirmation of hydrothermal reservoirs. Users and developers in the private sector will share costs with DOE and will perform the work. DOE's cost share will be low for successful projects (a project that intercepts a hydrothermal resource from which useable hydrothermal fluids can be produced) but will be high for unsuccessful projects. Thus the majority of the risk of drilling an unproductive hole will be assumed by DOE. Full development of the hydrothermal resource, once confirmed, will proceed by private investment, perhaps aided by PON or Geothermal Loan Guaranty funds.

The program will be implemented through a series of procurements directed at the non-federal, industrial and local government sectors. The procurements will specify that acceptability of proposals will be based upon 1) having a well-engineered use and one or more users committed to the

project, with either the user or a developer as manager; 2) having a clear land, water use right, and environmental situation; and 3) having a well-conceived exploration and reservoir confirmation program under the direction of appropriate geoscientific expertise at a site or sites where there are good geologic reasons for believing that a reservoir exists. Proposals which address the development of a reservoir will be favored.

During the course of each site project, DOE will monitor progress and will collect data needed for decision making. Publication of the data at the conclusion of each project will help to build the availability of technical literature.

The planned program will result in development of an estimated 25 percent of the total infrastructure that is needed. Federal support for development of this percentage of the infrastructure is believed to be sufficient to catalize further private development. The remaining 75 percent of infrastructure development would come from direct heat applications at an increasing pace, once the total economic picture of direct heat use is better understood and favorably impacted as a result of this program. As a direct result of this program, about 0.15 Quads of direct heat utilization will result by 1987, in line with DOE's near-term goals.

Site Exploration: Exploration projects at several hundred sites per year will be performed by consultants and contractors in the private sector. These projects will include geology, geophysics, geochemistry, hydrology and thermal gradient drilling. The objective of each project will be to select one or more drill test locations.

Drilling: Test wells will be drilled by private sector drilling contractors to determine whether or not a viable hydrothermal resource exists at the

site. If a reservoir is confirmed, further drilling for developement of the reservoir will be carried out.

Reservoir Testing: Production well flow tests and temperature measurements will be conducted on the test wells by private sector contractors. The data resulting from these tests will be evaluated by the project manager and by DOE to determine the viability of the resource and the DOE cost share.

Injection: At sites where a hydrothermal reservoir is confirmed, one or more injection wells will be drilled, if deemed necessary, with DOE cost-sharing.

Resource Identification

Nearly all prospective users of direct heat hydrothermal energy are small compared with the size of large companies whose interest is in hydrothermal electric power generation. Small users cannot, in general, afford to do the regional geologic work or geothermal data compiliation that are needed in order to select sites where reservoir confirmation studies are most likely to succeed. There is a need for federal assistance to collect and interpret regional, reconnaissance geothermal data and related earth science data, and to make these data available to prospective developers and users through publication of maps and reports. Efforts are already underway to do these things through DOE's State-Coupled Program and through the geothermal resource assessment programs conducted by the U.S. Geological Survey.

State-Coupled Program: Prior to the State-Coupled Program, there existed no adequate compilation or publication of geothermal and related geologic data for any state. The State-Coupled Program has been initiated so far in about 20 states, and detailed geothermal resource maps are just now becoming available for a few states. The principal task that each state contractor performs during the first one or two years is compilation of data on geothermal springs and wells, and on geologic features related to geothermal occurrences, such as siliceous and calcareous spring deposits, young volcanic rocks, and active geologic structures. This task is done in cooperation with the U.S. Geological Survey.

Certain Sites are recognized to have hydrothermal potential but are unattractive to the developer because of unfavorable economics due to such considerations as remoteness or newness of the geologic concept. Such sites would not qualify for cost-shared exploration under the User-Coupled Drilling Program. An estimated one-quarter of these sites would hold promise for commercial development if stimulated by appropriate exploration and thermal gradient drilling. The state contractors identify such sites and perform the needed exploration work with subsequent publication of results.

One important untapped source of data is the exploration files of larger resource exploration and development companies that contain geothermal data of no interest to the company. An example is the large amount of data on low- and moderate-temperature resources now proprietary in the files of companies who are exploring for high-temperature resources. DOE provides funding through a so-called "Bounty Program" for acquisition of such data for the purpose of putting it in the public domain.

USGS Regional Assessment: The U.S. Geological Survey bears principal responsibility in the United States for inventory and assessment of geothermal resources. DOE works in cooperation with the USGS in surveying and studying specific areas or regions which have or may have geothermal resource potential. Examples of this work are the efforts in the Snake River Plains of Idaho and the Cascades volcanic areas of California, Oregon and Washington. These regions receive minimal industry exploration because of the highly speculative nature of resource occurrence.

Technology Development

In general, the comparatively smaller user of direct heat hydrothermal resources cannot afford to develop new technology. It is apparent that evaluation and improvement of existing technologies will increase the success ratio for reservoir confirmation programs in the near-term, and that development of new technologies will have the same effect in the longer term. New and improved technologies and development of an experienced industry based direct heat infrastructure are the two keys to decreasing exploration and confirmation risks and costs sufficiently so that commercial direct applications development will proceed without federal assistance.

Exploration and Assessment: Exploration and reservoir assessment techniques for hydrothermal resources have largely been adopted from the petroleum and mining industries. The fledgling geothermal industry is too young and the exploration and research funds expended to date are too few to have developed techniques especially suited to hydrothermal problems. As time passes, it becomes more and more apparent that techniques developed for the petroleum and mineral industries do not necessarily work well in hydrothermal environments. There is a clear need for federal stimulation. DOE's on-going Exploration and Assessment Technology Program funds projects for the improvement of existing techniques and the development of new techniques.

Geohydrology

The user-Coupled Drilling Program will result at first in a single well whose correct testing is critical to continuation and success of the program at that site. Once a hydrothermal reservoir has been confirmed, a number of wells may be needed to develop the resource fully. The siting of production and injection wells and determination of rates of production and injection for each well are critical to efficient reservoir use and to insuring reservoir longevity.

Confirmation of hydrothermal reservoirs requires analysis of temperature and well flow data. Current analysis techniques are borrowed from both the petroleum reservoir engineer and the water well hydrologist. New techniques specifically tailored for hydrothermal reservoirs are needed. The inadequacy of present techniques makes it difficult to convince financial institutions of the viability of the resource, creating an important barrier to geothermal development.

DOE currently supports an on-going program in Reservoir Engineering. This program will be expanded to include problems specific to smaller low- and moderate-temperature resources.

B. MARKET DEVELOPMENT

Development of the Nation's goethermal energy potential is presently limited or slowed by 1) uncertain knowledge of the size of the potential direct applications market, 2) limited awareness of geothermal energy by energy users, and 3) the lack of a developed supporting industry infrastructure. Solutions to these problems are addressed by a series of program initiatives aimed at market development. These "pump priming" initiatives have the objective of accelerating geothermal energy use and the attainment of a self-sustaining level of activity by support industries.

The Market Development Program elements are illustrated in Figure 8. Objectives and workscopes for each of these elements are discussed below.

Market Assessment

The Market Assessment program will identify potential direct application goethermal energy users and estimate the magnitude and characteristics of this market. It will be used for the favorable matching of users and resources. While the upper limits of energy available from geothermal resources have been estimated (USGS Circular 790), the extent to which the potential market may be penetrated under various economic assumptions has not yet been well quantified. Market assessment data will be developed to aid governmental agencies in formulating energy policy and regulations. Similarly, the data will be useful to energy users in their evaluation of geothermal energy.

Market assessment will be made from two prospectives; regional and industrial. The regional market assessment will identify favorable matches of energy consumption and geothermal resource location in terms of aggregate demand by state, starting at the community level. Industrial market assessment will identify energy use by user type (e.g., space conditioning, food processing, mining, etc.).

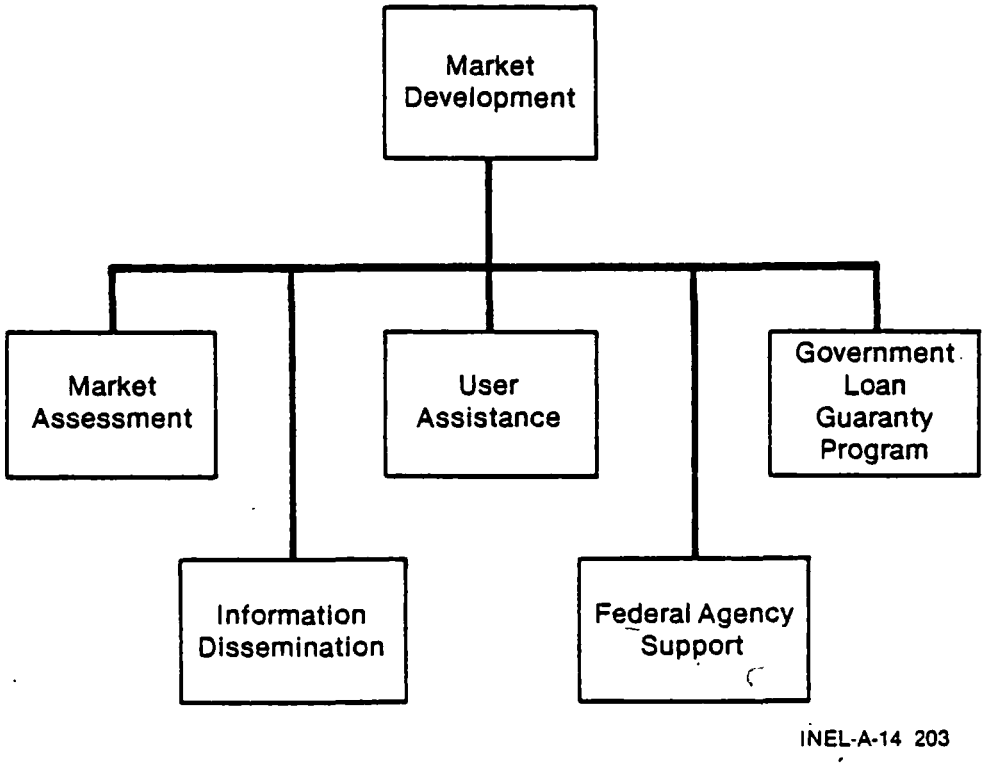


Fig. 8 Market development block diagram

Information Dissemination Program

The Information Dissemination Program will provide technical, economic, and general information to energy users (private and public). The object of the program is to inform these audiences of the potential of geothermal energy. Outside of those actually involved in geothermal energy commercialization, geothermal energy is either unknown or thought of as an exotic future energy source. Widespread recognition of geothermal energy as an economic alternative is essential to its commercialization.

The program will prepare effective strategies for information dissemination which will consider information developed under this program, and will use other information developed by the commercial industry.

The program will prepare outreach materials and disseminate them through such means as government agencies (federal, state, and local), industries, their associations, and government laboratories. These activities will include an appropriate national media program to increase the general public awareness of geothermal energy potential.

Technical information developed through private and government efforts will be monitored, compiled and made available to industry.

User Assistance

A lack of wide spread knowledge of geothermal direct application technology deters many potential users from its consideration as an alternate energy source. A technical infrastructure (consulting engineers, geologists, etc.) has started to emerge, but is still in its infancy. The User Assistance Program provides regional centers of geothermal expertise, which through small grants of aid (up to 100 man-hours), or through available information, assists a potential user with resource assessment, engineering and economic feasibility assessment, and other data. The program objective is to invest a small amount of "seed money" in order to aid a potential user in determining the feasibility of a project. The grant size is limited so as not to compete with the commercial sector. The program thus will help promote development of the technical infrastructure that is needed.

Federal Agency Support

This element will provide technical support to other Federal agencies with energy related programs. Such agencies and their programs include: Housing Urban Development (HUD) Urban Development Action Grants, and EAD; Health Eductation and Welfare (HED) hospital aid programs; Department of Agriculture grant and loan guarantee programs; and other agency alternate energy conservation programs. Support will include assistance in geothermal usage projection, technical data resource identification, application evaluation, etc.

Government Loan Guaranty Program (GLGP)

The purpose of this is to stimulate the commercialization of geothermal energy by minimizing the financial risk incurred by development capital lenders. Under the program, the United States government pledges its full faith and credit to the lender to guarantee the repayment of principal and interest on geothermal development loans. The GLGP objective is to provide financial incentives for the early and rapid development of the geothermal alternative while helping to establish the resources and technologies necessary for a self-sustaining industry. As the industry develops, normal financial relationships between borrowers and lenders will also develop, eliminating the need for the GLGP. In addition, the opportunities afforded by the GLGP should help to stimulate new entrants into the field, helping to foster competition in the industry.

C. STATE PLANNING AND DEVELOPMENT

State and local government agencies are important postures in a geothermal commercialization program. Many regulatory functions are controlled by state and local governments. National energy planning and policies can only be effective with the cooperation and assistance of the several states. State governments, because of their own varied and particular economics and social interests, also have a direct stake in a successful geothermal commercialization program. Figure 9 notes the elements of this project task.

State Support

It is the intent of the Department of Energy to assist the 37 states with known hydrothermal resources, over a period of three years, in the development of an indigenous geothermal planning and project implementation capability. This support will provide for the development of geothermal energy and economic planning tools, industrial marketing exports, technical assistance capabilities, information programs, and other activities helpful to state and federal commercialization objectives.

It is crucial to both federal and state interests that the DOE supported stated resource assessment program achieve a high degree of unity, purpose, and management coordination with the state commercialization planning efforts, so that neither program is conducted in a vacuum, unmindful of the ultimate power-on-line objectives.

Regional Data Base and Econometric Support

It is necessary to establish appropriate regional processing centers to aggregate state data to regional and national levels for planning purposes, and to provide support for state planning efforts. Among the primary objectives for such centers will be the establishment of economic and resource data bases, and the projection of market penetration possibilities for geothermal energy. Appropriate economic models, such

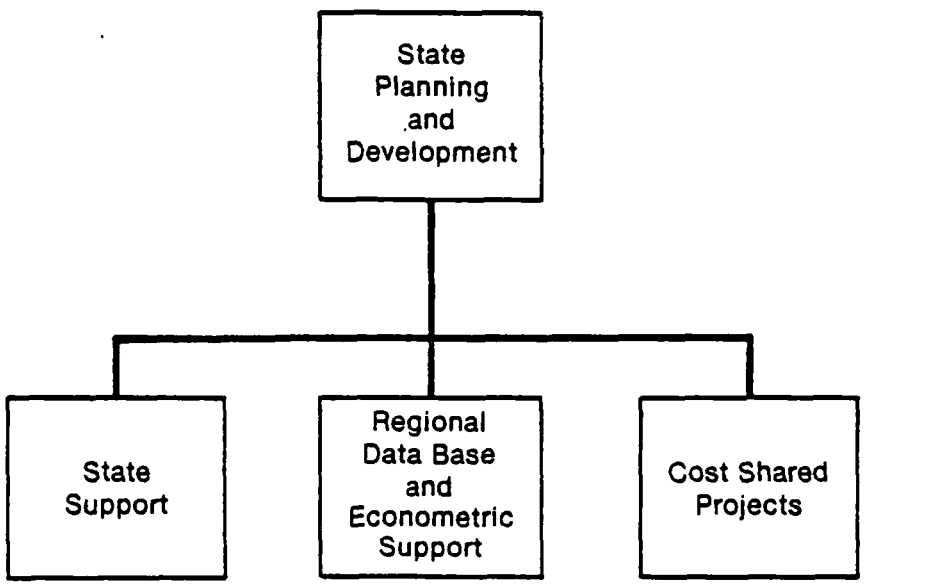


Fig 9 State planning and development block diagram

as industrial process application and municipal system feasibility models, will be developed for site specific support to the participating states. The regional centers will also aid and support state, industry, and federal commercialization efforts.

It is essential that this regional support effort achieve a high degree of purpose and unity between the resource and commercialization state programs mentioned above. Their basic relationship must relate to the flow of commercial and state activities shown in Figure 4.

Cost Shared Projects

Most states have particular concerns about energy production and use. These concerns will vary from state-to-state depending upon the location of "pressure points" exerted by the energy crisis. Some states for example, will be particularly concerned about the tourist trade, others about agriculture, still others on their dependence on oil for space heating. The Department of Energy will entertain recommendations for projects to be cost-shared by the states. The particular geothermal development interests and possibilities are defined during the state planning support activities.

C. TECHNOLOGY DEMONSTRATIONS

The Technology Demonstrations portion of the National Direct Application Program Plan is structured to provide a user oriented technical and economic data base. This emperically based data base should alleviate uncertainties pertaining to development costs and system and equipment performance characteristics.

The various program elements of Technology Demonstrations will identify technical problem areas, address solutions, produce data, and assist in developing an infrastructure committed to the utilization of hydrothermal energy. The specific program elements required to achieve the above goal include demonstration projects, a federal building program, process evaluations, and component and system development. The details of these program elements are discussed as follows and are illustrated in Figure 10.

Commercial Applications

Demonstration Projects: Since hydrothermal energy is perceived as a relative "high risk" form of alternative energy, and private enterprise is reluctant to financially commit to implementation of such "high risk" ventures, methods must be developed to prove the engineering and economic viability of hydrothermal projects.

Demonstration projects provide one method of proving the effectiveness of the utilization of hydrothermal energy. The development of a data base from these demonstration projects is an essential element for the commercialization of public and private sector operating systems that utilize geothermal energy.

The purpose of this program is to provide an opportunity for interested parties, with federal assistance, to engage in direct heat utilization or combined electric/direct use utilization projects for demonstrating single and/or multiple uses of geothermal energy. Demonstration project solicitations will be reserved for new and highly promising market sectors, which economic analysis shows to be particularly promising for geothermal applications or which, by nature of geographic population concentration with

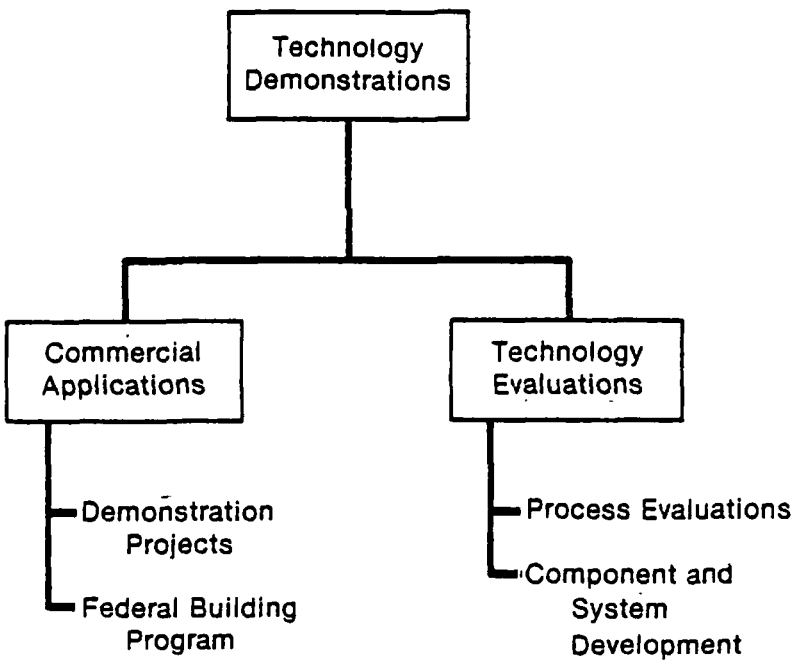


Fig. 10 Technology demonstrations block diagram

respect to hydrothermal systems, holds great potential for energy replacement.

The first two project solicitations focused public attention on (a) individual retrofit space heating projects, (b) district heating systems, and (c) the food processing industry. The geothermal program can be significantly accelerated by structuring subsequent solicitations to prioritize different application considerations, to evaluate new technology, and to enhance national geothermal utilization patterns.

Based on an indicated industrial interest and the potential for a large market, the third solicitation will stress producing liquid fuel from biomass. A fourth will address other industrial process applications. A subsequent fifth solicitation will emphasize new, innovative, or unique technical approaches to encourage continued growth in diverse applications. Space heating will have secondary importance in selection consideration unless unique utilization techniques are applied, since the first two solicitations resulted in several space heating applications.

The remoteness of many identified resources from population centers will force industrial and total community development around viable geothermal resources in the future. Later solicitations will stress this totally integrated, new community/industrial utilization technique.

All demonstration projects, while achieveing power-on-line, will also serve as stimuli to industry and other large energy uses to accelerate development of private sector projects. In addition to project solicitations, utilization analyses will be prepared. These analyses will consist of evaluations of technical, economic, and operating data from demonstration and private section projects now underway or to be initiated. This will be accomplished as on-going projects reach completion and sufficient information becomes available. These analyses will be used to:

- Provide early data and information to industries interested in geothermal developments, and
- Aid national planning and policy decision-making necessary to direct proper program emphasis.

As future projects are completed, additional analyses, data collating, and summarization will be required. In addition to providing guidance to overall program direction, this analysis effort provides excellent feedback to assure that program goals are realistic and can be met. In some cases, feedback may dictate the implementation of additional activities in the direct-use components and systems development work. Starting with FY-81, four or five analyses will be needed per year through FY-87.

Federal Building Program: The federal government, as a large energy user, is committed to investigating the utilization of alternative energy for existing or new federal buildings and installations. The purpose of this program element is to provide technical data to government agencies to stimulate the use of hydrothermal energy to government agencies to stimulate the use of hydrothermal energy by these agencies. DOE assistance is needed if a properly coordinated evaluation of the contribution that hydrothermal energy can make is to be undertaken.

The federal building program element will provide: a) resource definition at selected federal facilities, and b) assessment of the engineering and economic feasibility of utilizing hydrothermal resources for space conditioning or other applications. Project scenarios and costs will be developed and compared to existing or other alternative energy systems. Regulatory and environmental issues will also be considered and included in the evaluation. As additional resource information becomes available, the engineering and economic data will be updated. These evaluations will be concentrated on major institutional energy consumers. The information developed by these evaluations will provide government planners and developers significant technical data concerning the use of hydrothermal energy.

Technology Evaluations

Technology Evaluations include: 1) evaluations of processes for geothermal applications, and 2) component and systems development. These

activities are directed at the identified barrier of the private sector's need for more information on technical feasibility, reliability of systems, and economics.

Process Evaluations: The assessment of particular industrial processes will be conducted at the rate of one or two per year for the present industrial and commercial users of process heat. Selections for assessment will be on the basis of technical potential, economic sensitivity to fuel costs, and innovation. Industries and processes that could use fluids from geothermal sources for both process heat and process fluids will be an important initial consideration. In the case of component development or system alternation, the need will be identified for possible implementation as a component and systems development activity.

Component and Systems Development: The component and systems development activity addresses the barrier identified among the user segment concerning the technical feasibility of direct heat uses. This activity provides for development of equipment or systems, including altering and modifying existing technology for geothermal applications, and the development of new and innovative applications. Also included are technology activities responding to identified environmental problems.

In the area of system modifications and alterations to existing technology, a share of the effort is to be directed at lowering unit and process system operating temperature requirements, thus enlarging the potential for direct heat uses of geothermal energy. Many process temperatures of today are higher than needed becuase of being geared to fossil fuel sources. The change to lower operating temperatures implies changes in some component designs such as heat exchangers, dryer systems, etc., but not changes in basic technology.

In new or advanced technology, component and system development activities will also lead to enlarging the potential uses for geothermal heat. All

of the elements for this activity are not defined, but efforts will be directed to such projects as geothermally assisted biomass to liquid fuel conversion, new lower operating temperature air conditioning units, and systems for beneficial fluid disposal.

Technology development for identified environmental issues will involve monitoring systems, analytical techniques and control or abatement technology.

The component and system work will be pursued through private participants, contracting organizations or federal laboratory facilities and may progress to pilot plant operations or demonstrations in some cases to show that the energy process, equipment, or system is viable and technically and economically sound. Current activities that could progress to demonstrations are in areas of advanced technology biomass to fuel research, an advanced district heating concept, and water disposal alternates (alternate to injection). One or two of these demonstrations is projected per year starting in 1981.

D. ENVIRONMENTAL ASSESSMENT

Environmental concerns, both technical, and institutional, have resulted in major delays in the development of geothermal resources in the United States. Conflicts and delays result from lack of information regarding the resource, potential environmental impacts, and from uncertainties and restrictions in the federal and state regulatory processes. The objective of this environmental assessment program is to evaluate the environmental effects of geothermal development in order to reduce unnecessary delays and expenditures resulting from environmental concerns and limitations. This will be accomplished by providing environmental support to the other programs outlined in this plan. Figure 11 illustrates the elements of work.

The environmental program includes generic environmental assessments, environmental baseline data documentation, environmental technical assistance, and fluid disposal investigations. The development of environmental monitoring, analysis, and control technologies in support of geothermal development has been incorporated into the Technology Demonstrations program. Much of the environmental policy reform and interagency coordination will be accomplished in conjunction with the Policy and Regulatory Issues Assessment Program.

The program as outlined is based on the following assumptions: 1) the institutional picture will not change significantly in turns of regulatory emphasis and the application of policies and procedures, 2) the national program will continue to be structured by region and by state, and 3) most of the environmental issues related to hydrothermal resource development can be resolved. In most cases, existing infrastructures can be utilized to accomplish the program objective.

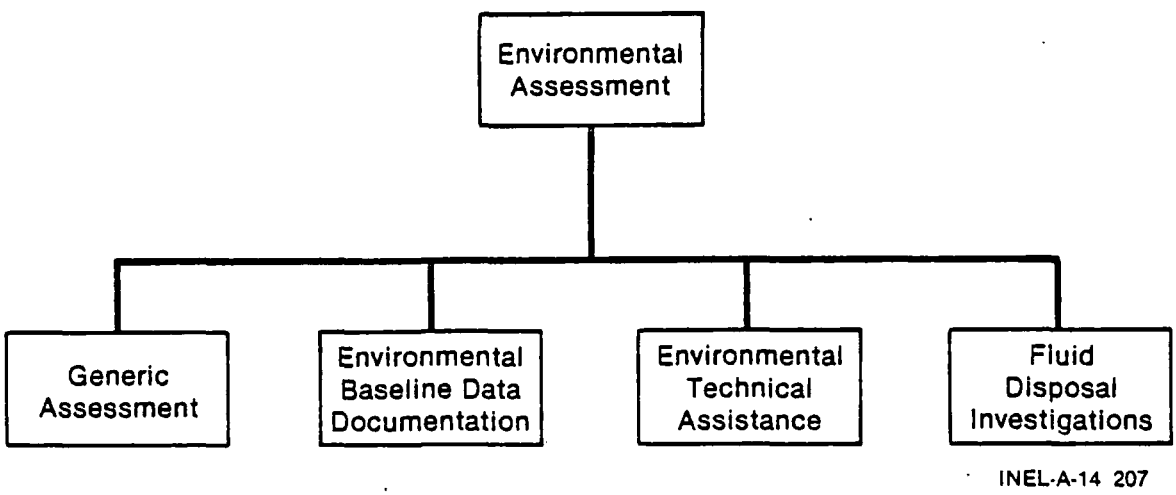


Fig. 11 Environmental assessment block diagram

The elements of the environmental assessment program are discussed below.

Generic Assessment

Most hydrothermal development projects, especially those with federal funding or support, require an environmental assessment or statement. These assessments frequently involve duplication of time and money, both in the preparation and in the review and approval process. The User-Coupled Drilling and Resource Confirmation programs lend themselves to the preparation of a generic environmental assessment to avoid some of this duplication, and to facilitate project approvals.

The assessment will address the types of drilling employed in exploration and development, the programmatic objectives, potential impacts and concerns, control equipment and procedures, and potential mitigation techniques. Emphasis will be placed on analyzing alternatives in compliance with recent NEPA regulations. With an approved generic assessment, only site specific environmental information would need to be provided for individual drilling projects.

The environmental impact assessment for this program will be revised to reflect new program policies and directions, and to incorporate a detailed analysis of alternatives as required by NEPA. This assessment will then serve as the basic environmental document for such programs as the Technology Demonstrations program included in this plan. If it becomes apparent, as other programs develop, that generic assessments are appropriate, then their preparation will also be incorporated.

Environmental Baseline Data Documentation

There are areas with significant geothermal potential where development is delayed or restricted becuase of unresolved environmental issues. These areas include those where 1) there has been no identification of environmental concerns, 2) potential concerns have been identified but not validated, and 3) specific concerns have been identified, but development could occur if mitigation measures could be agreed upon. Many of

the environmental conflicts and uncertainties occur on federal lands and can be resolved through close interagency coordination. The objective of this effort is to identify areas where development is hindered due to environmental considerations, to identify the responsible agencies, and to develop a coordinated program of environmental data evaluation to resolve the conflicts. In those areas where a lead land management agency cannot be identified (e.g., areas where land ownership is very fractionized, or areas where much of the land is privately-owned), DOE will take the lead in resolving the environmental concerns. The program will be implemented for each of the states included in the national program. Only those areas will be considered where it can be shown that environmental concerns or a lack of environmental knowledge are delaying development.

Environmental Technical Assistance

Environmental technical assistance will be provided at the state level. This will include assisting developers, on request, about the format and preparation of environmental assessments, permits and approvals; the identification of environmental concerns; the coordination of institutional requirements, and the dissemination of environmental information pertinent to general areas in each state. State handbooks will be prepared which will define the technical and institutional environmental issues applicable to geothermal development. The handbooks will specify agencies and regulations which may affect the development process, and will outline the steps necessary to obtain all permits and approvals with minimum confusion and frustration. Where appropriate, state personnel will attempt to establish a coordinated review and permitting procedure among state and federal agencies in order to reduce the time and paperwork required. Technical problems related to environmental concerns or restrictions will be coordinated at the regional level through regional laboratories.

Fluid Disposal Investigations

One of the major obstacles facing geothermal developers is the disposal of geothermal fluids. The method of disposal employed is dependent on cost, quality and quantity of the geothermal fluids, and state and federal environmental regulations and water rights policies. Injection,

although often considered the ultimate solution to fluid disposal problems, may not be the best option due to cost or technical considerations. Developers can be faced with disposal options which make the geothermal resource utilization uneconomical or with fluids for which a disposal technique is not readily available. Two tasks to resolve some of these obstacles are included in this program: 1) technical evaluation of disposal options for specific development, and 2) research and evaluation of fluid treatment methods. The first task will be implemented on a regional basis through the national laboratories and coordinated with state programs. The second task will concentrate on developing low-cost methods that can be readily implemented by the industry. A task force will be established to provide program definition and guidance.

E. POLICY AND REGULATORY ISSUES

Policy, environmental, regulatory, leasing, and other "institutional" factors continue to have deterrent effects on commercial development of geothermal energy. Actions need to be taken at all levels of government to ensure that equitable incentives exist and that a regulatory environment conducive to geothermal commercialization is established. This action will be conducted by those in the Department of Energy who are concerned with policy matters, the geothermal committee of the Energy Resource Advisory Board, the Interagency Geothermal Coordinating Council (IAGCC), state officials, and various contractors providing program support to the DOE. The various work elements are noted in Figure 12.

Policy Reform

This task includes the continued examination of policy issues, both nationally and at the state level, including questions of resource definitions, leasing, tax and financial incentives, environmental regulations, and regulatory agency authority as these issues affect the pace of geothermal commercialization. It encompasses action at all levels to amend or formulate legislative and policy changes needed to stimulate project development. Development of national legislation will be primarily conducted by those in the Department of Energy and the IAGCC concerned with policy matters and those who will be working with congressional committees in order to effect favorable legislative initiatives and changes in existing statutes. The State Policy Review task encompasses a continuing review of state policies regarding geothermal energy, including leasing, taxation, district utility system formation, and definitional questions regarding the character of the geothermal resource. Favorable geothermal legislative reform will be sought in two ways: 1) The NCSL Geothermal Policy Project will continue to serve as the principal forum for legislative change in the states. The NCSL will continue work initiated in 1978 in the States of New Mexico, Utah, Oregon, Hawaii, Virginia and Maryland. This will also include expansion of the work to Arizona, Washington, Nevada, and Delaware during 1980. 2) DOE state team members are required to work with and support the NCSL program where that activity is underway. Where it is

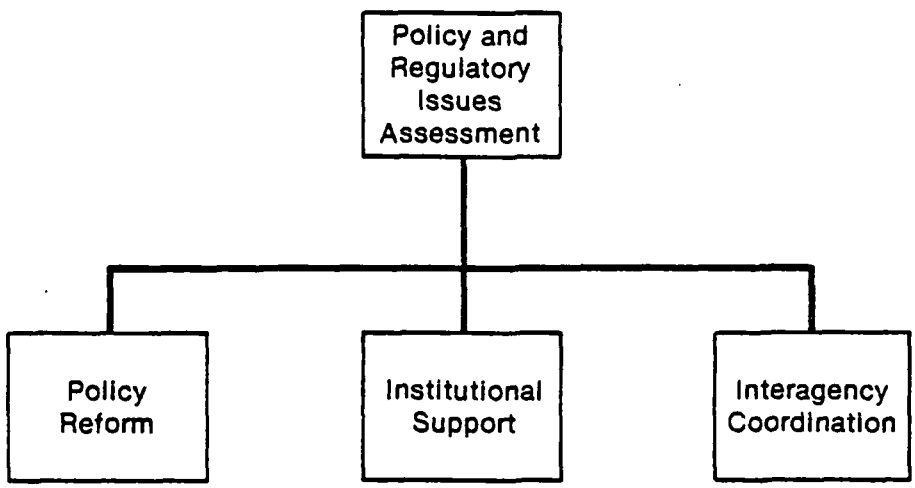


Fig. 12 Policy and regulatory issues assessment block diagrams

not operating, they are required to work independently with appropriate legislative energy and natural resource committees to effect favorable legislative reforms.

Institutional Support

It is important to have a wide range of policy support services available to Department of Energy program managers, to those engaged in policy reform activities, and to private developers trying to cope with an imposing array of federal and state regulations. These support services will be provided by selected federal contractors with the required expertise, consultants, and state officials.

Special studies will be undertaken to support reform initiatives, both nationally and in concert with requests from the NCSL and state officials. Analyses concerning geothermal omnibus legislation, tax credits and tax system reform, and state leasing policies will be continued. The knowledge of and benefits from these special analyses will be disseminated as widely as possible.

Policy and regulation assistance will be provided. State commercialization teams will complete an institutional handbook for each state. This handbook will be a compilation of federal and state environmental, siting, and other regulations governing geothermal development in that state. The purpose of the handbooks will be to assist developers in the understanding of these regulations, and to facilitate the permitting process. Contracted state officials will also provide cooperation and assistance to Department of Energy programs in these states. As Department of Energy supported drilling activities expand, for example, state officials will become directly involved in generic and site specific environmental evaluations and approvals.

Interagency Coordination

Regulatory officials at all levels of government must be made aware of the need to streamline regulatory procedures, correct jurisdictional overlaps and duplications in order to facilitate the permitting and leasing processes.

This includes: 1) state and federal regulation review. USGS, BLM, EPA, USFS, and other federal agencies with jurisdiction over project development must undertake a concerted effort with appropriate state officials to harmonize and simplify permitting requirements and approval procedures for project developers. The objective is to decide what permitting criteria has to be met that will satisfy both federal and state agencies; and 2) the resolution of interagency policies. The IAGCC will continue to serve as the principal coordinating body to resolve policy issues that overlap the jurisdiction and interests of a number of federal agencies, and also to serve as a focus for the initiation of agency geothermal energy programs.

F. PROGRESS MONITORING

This work element includes identifying barriers to the commercialization of direct heat applications of hydrothermal energy. It also includes monitoring and reporting on the status of commercialization activities.

Commercialization Barrier Identification

The identification of barriers to the commercialization of hydrothermal energy needs to be continued to provide proper and timely program control and direction. This work will continue to be performed through semi-annual surveys of commercial direct-heat users, both current and potential. This will also be accomplished, in part, by attending working group meetings, advisory committee meetings, technical meetings, and through one-on-one discussions. Resource and potential user data, developed by individual states, by DOE contractors and by others will be reviewed for barrier identification. These barriers will be prioritized and translated into commercialization plan requirements. The prioritization will be accomplished with the assistance of industry, and by cost/benefit analyses. These data will be summarized and categorized by industry and application types, including an overall summary, to provide bases for future program emphasis, changes and control.

Activity Reporting

Continuation of the identification of the current status of hydrothermal commercialization development and the reporting of commercialization activities that are taking place is needed to monitor and evaluate progress. The continued preparation and maintenance of state commercialization baseline documents for approximately 37 states considered to have hydrothermal resources is necessary to provide basic data to monitor progress and evaluate programmatic activity effectiveness. The state commercialization baselines will contain information about basic state data, hydrothermal resource locations, leasing status, exploratory activities, operational systems, development plans, government asssisted activities, energy use patterns, leasing and permitting policies, and

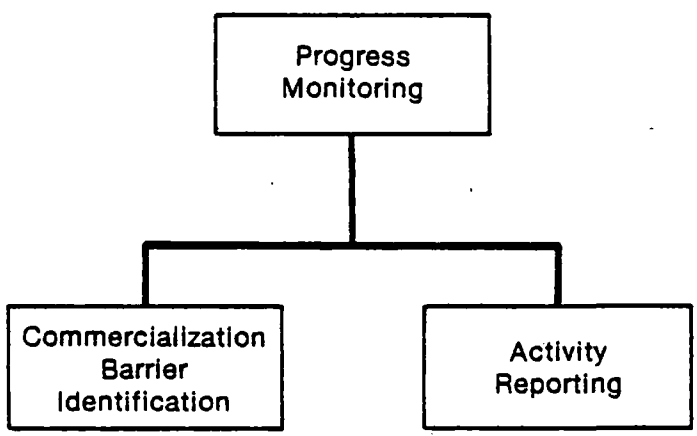


Fig. 13 Progress monitoring block diagram

selected references to publications on hydrothermal topics pertaining to each state. These documents are to be distributed to appropriate DOE-HQ and field offices, federal region directors, state governors, state resource and commercialization team members, the National Conference of State Legislators, and anyone requesting copies. Input for the documents will be primarily obtained from state team members who are performing outreach work in the states. In those states that do not have established state teams working outreach programs, information will be gathered annually from appropriate state agencies. Baseline data documents have been published for 15 of the states during fiscal year 1979, and 5 more state documents are in the process of being prepared. The work remaining requires the initial preparation of 17 additional state data baseline documents, and the updating of approximately 37 state documents on an annual basis. The baseline documents will be updated annually to measure development, evaluate trends, and assess needs in order to determine program effectiveness, and to modify program plans as needed.

As an aid to monitoring the development of hydrothermal energy use, activities affecting commercialization will be reported monthly through appropriate DOE Field Offices to DOE Headquarters. These news items will be obtained from the states that have established commercialization teams. Events reported and tracked will include leasing, permitting, drilling and other commercial activities, state agency activities, and DOE significant activities within each state. In order to further help define problems that become identified in the commercialization program, hydrothermal tracking systems will be updated annually and the data analyzed in order to take appropriate programmatic actions.

V COST AND SCHEDULE SUMMARY

The program schedule is presented in Figure 14 and the cost estimate is presented in Table I. The program is designed to stimulate the commercialization process at various stages where barriers exist and uncertainties delay full utilization of this valuable resource. Approximately 55% of the total budget will be directed to reservoir confirmation and 22% will provide for technology demonstrations. State planning and development requires 12% of the budget and the remaining 11% will be used for market development, environmental assessment, policy and regulatory issues assessment and progress monitoring.

The fiscal years 1982 thru 1985 require $100 million to $200 million per year to fully stimulate the commercial sector. The heavy emphasis during this period is primarily due to the demands for user coupled drilling and technology demonstrations. After 1985 the government funding requirements will drop rapidly for an additional two year period while commercial investments increase rapidly. Government stimulation will not be required after 1987 and by 2020 hydrothermal energy will replace the need for 1.08 billion barrels of oil annually.

TABLE I NATIONAL HYDROTHERMAL DIRECT APPLICATIONS PROGRAM

(DOLLARS IN MILLIONS)

	FY-80	FY-81	FY-82	FY-83	FY-84	FY-85	FY-86	FY-87
RESERVOIR CONFIRMATION	5.3	39.0	74.0	100.0	90.0	69.0	45.0	23.0
MARKET DEVELOPMENT	5.3	9.4	11.5	11.5	11.3	10.5	6.0	2.5
STATE PLANNING & DEVELOPMENT	3.7	9.7	15.2	21.4	21.0	16.0	11.0	-
TECHNOLOGY DEMONSTRATIONS*	14.2	28.5	39.2	44.1	33.1	14.9	1.0	0.9
ENVIRONMENTAL ASSESSMENT**	-	0.7	2.2	1.8	2.2	1.7	1.2	0.2
POLICY & REGULATORY ISSUES ASSESSMENT	0.3	0.7	0.6	0.6	0.4	0.4	-	-
PROGRESS MONITORING	1.4	1.6	1.9	2.0	1.4	1.0	1.0	0.6
	30.2	89.6	144.6	181.4	159.4	113.5	65.2	27.2

*Excludes cost of GLGP which does not come from operating funds.
**Excludes Environmental Baseline Data Cost Estimate of 2.0M/YR which will be received from DOE-EV.

NATIONAL HYDROTHERMAL DIRECT APPLICATIONS PROGRAM PLAN SCHEDULE

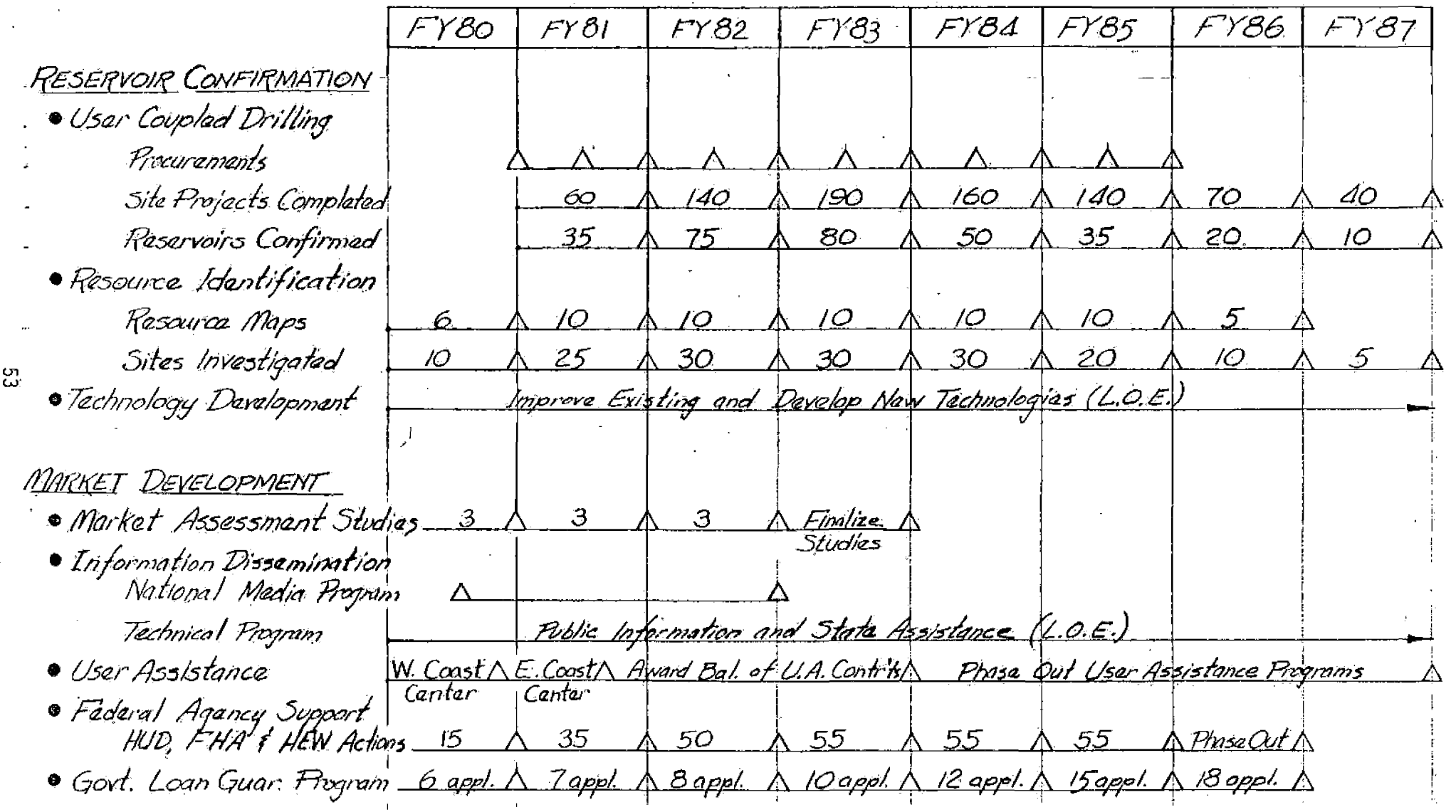


Figure 14 Program Schedule

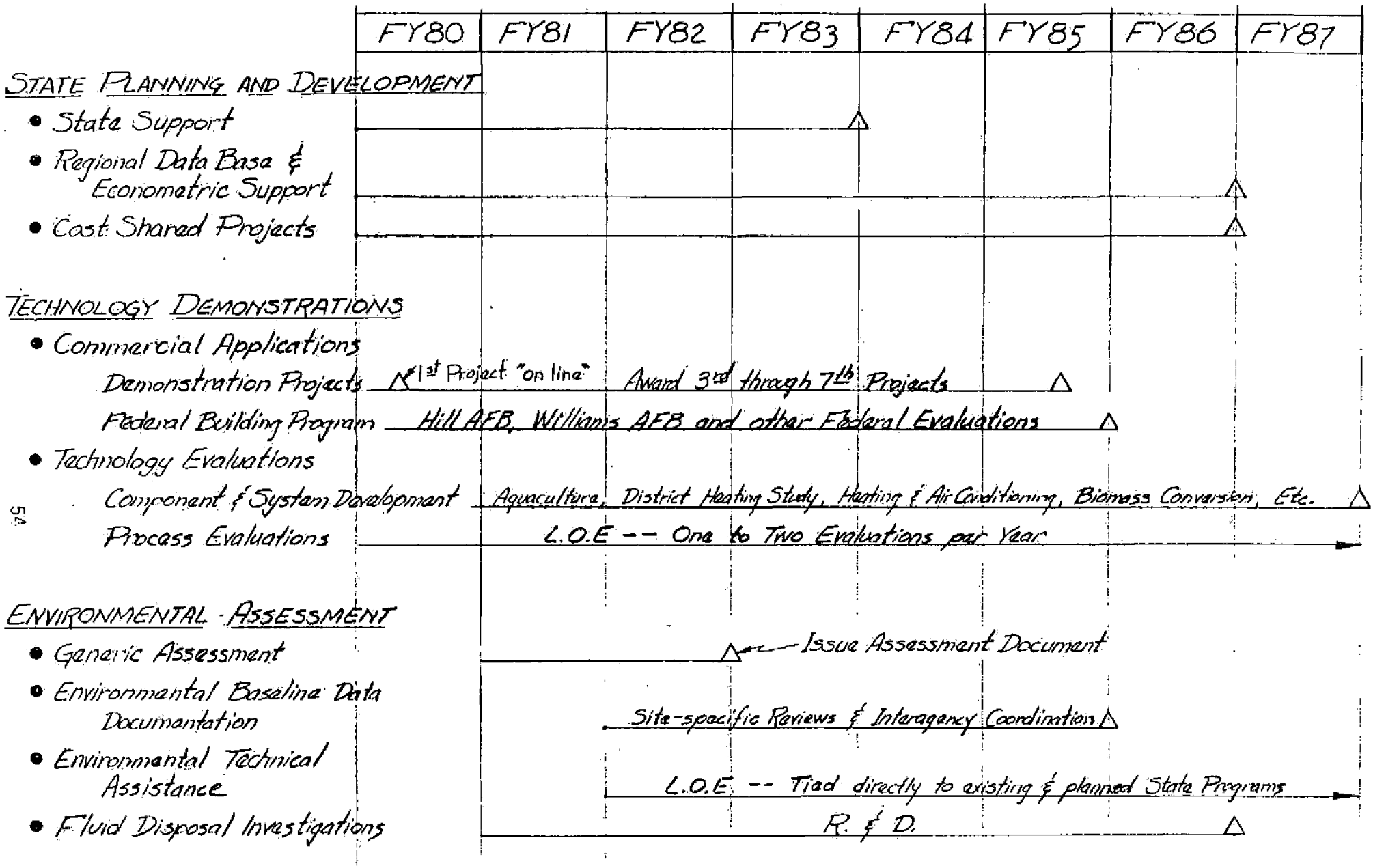


Figure 14 Program Schedule (continued)

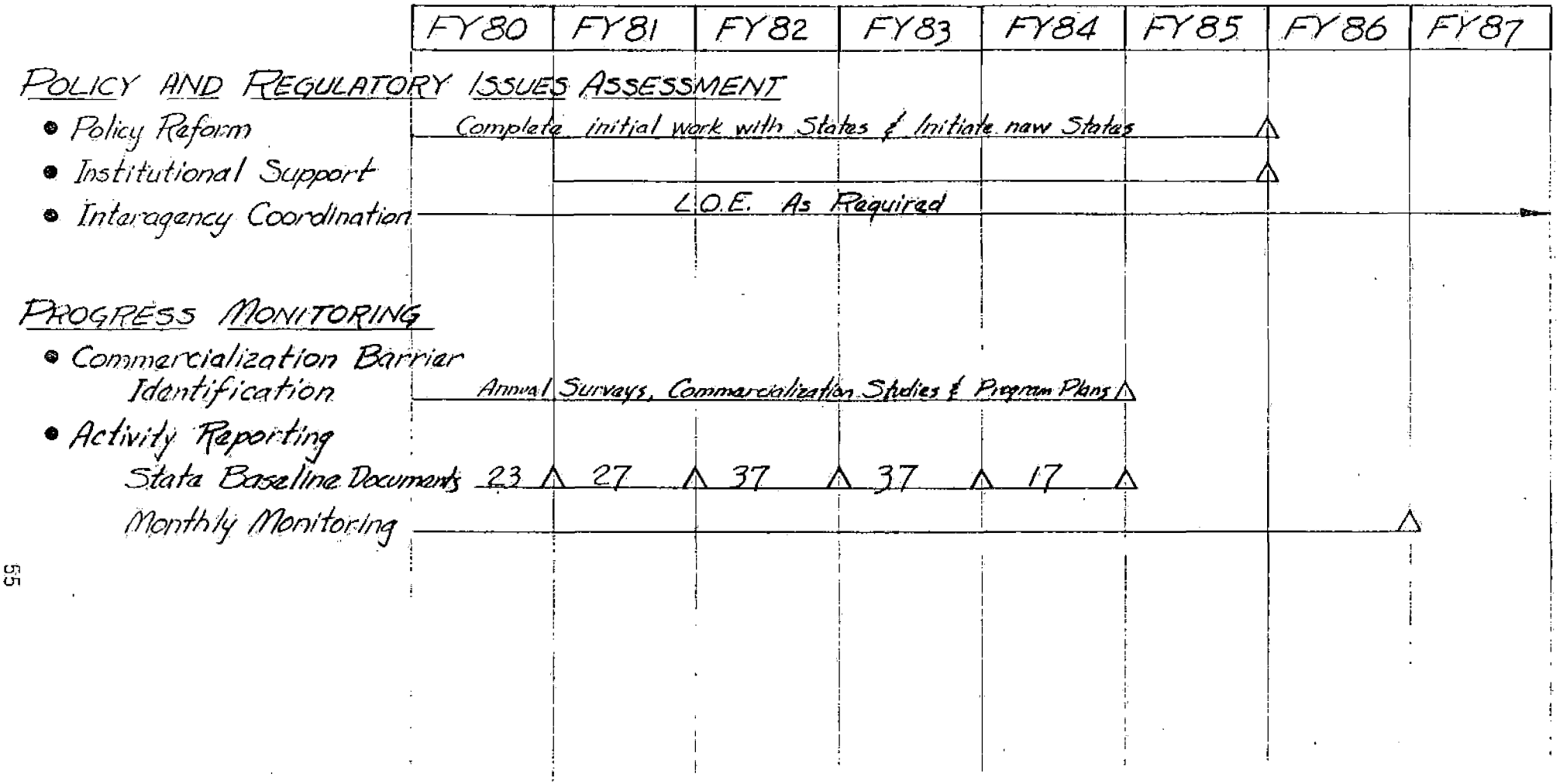


Figure 14. Program Schedule (continued)

VI PROGRAM IMPLEMENTATION

The implementation of the Program Plan will be outlined in detail in the Program Management Plan. The management plan will spell out its objectives and responsibilities, and will include a description of the functional organization identifying the key participants of the program. The responsibilities of the participants will be defined and interfaces between government agencies and others will be described. It will outline the method in which the work will be processed. Detailed work schedules and program review cycles will be included. The program control system, including the necessary Work Breakdown Structure, will be called out. The cost control system will be defined, and reporting requirements will be described.

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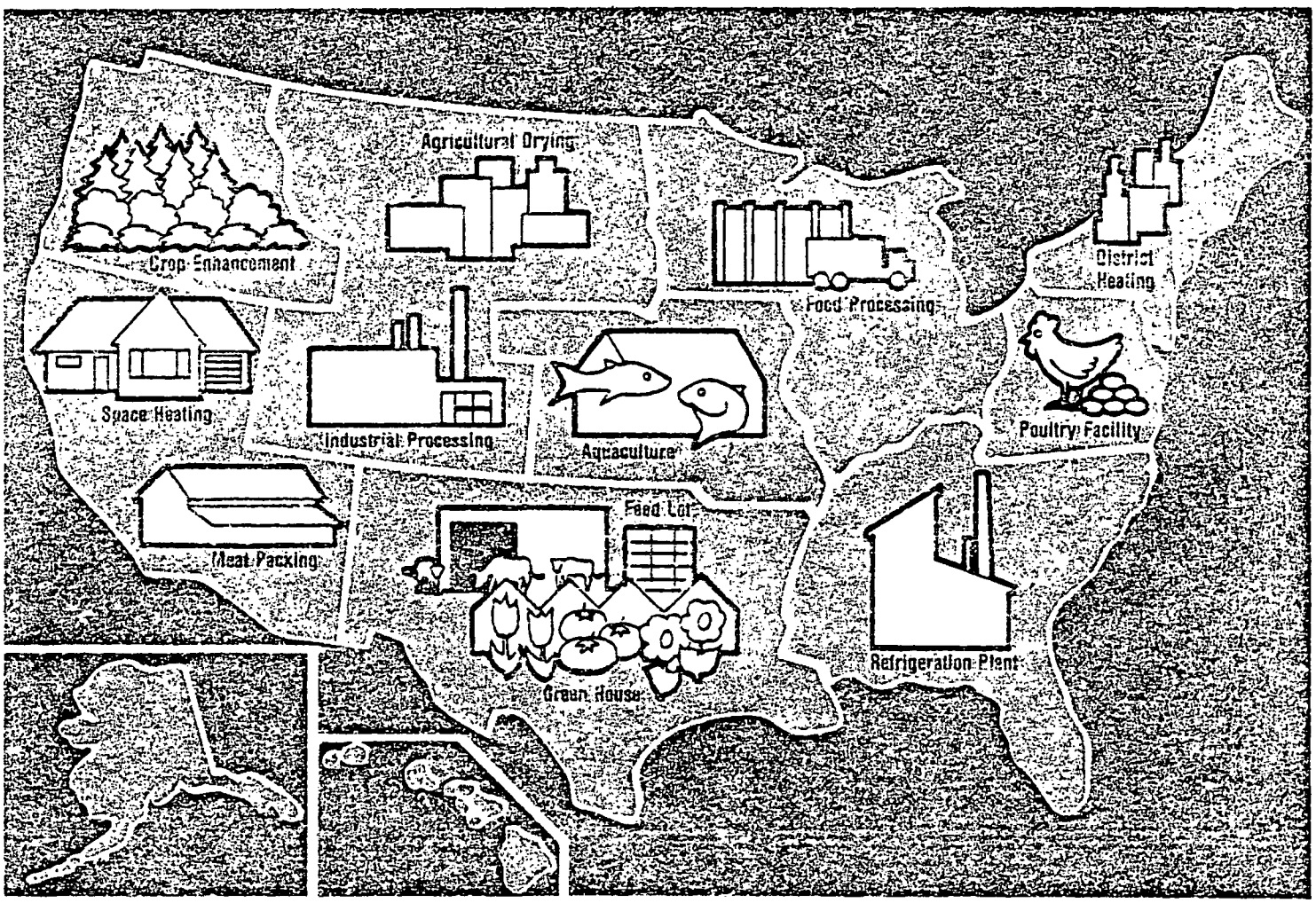
National Hydrothermal Direct Applications Program Plan



Division of Geothermal Resource Management
April 16, 1980

NATIONAL

HYDROTHERMAL

PROGRAM PLAN

April 16, 1980

Division of Geothermal Resource Management

U. S. Department of Energy

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I. SUMMARY

The use of hydrothermal energy in Direct Applications has enormous potential. By the year 2020, Direct Applications can provide the energy-use equivalence of up to 36% of the oil imported in 1979. Using an oil price of $24 per barrel, this displacement equals a $26-billion annual reduction in the balance of trade deficit. To realize this potential, however, a self-supporting industry must be developed. As of this date, development of such an industry has been stifled by an accumulation of uncertainties, none of which alone would completely retard industry growth, but which taken together will not allow industrialization to take place in a timely fashion. These uncertainties or major barriers are (1) lack of confirmed reservoirs, (2) lack of an established industry, (3) limited technical data, (4) policy and regulatory confusion, and (5) environmental impact uncertainties.

The Federal program presented herein addresses each of these areas of uncertainty and sets "energy in place" goals by which the success of the program can be measured. These goals are 0.1 quad/year by 1985, 1 quad/year by 2000, and 6 quads/year by 2020. The elements which comprise this program include:

1. Market Development: reduces financial risks through Geothermal Loan Guarantees; reduces perceived risks through education and user assistance.

2. State Planning and Development: reduces development uncertainty through "grass roots" planning and project brokering; reduces financial risks through cost-shared project development.

3. Reservoir Confirmation: reduces reservoir development risks through cost-shared drilling; provides hydrothermal data and maps on a state-by-state basis.

4. Technology Demonstration: expands use potential of resources through technology development and commercial demonstrations.

5. Environmental Assessment: provides baseline data from which environmental assessments may be made by the private and public sectors.

6. Policy and Regulatory Issues Assessment: addresses policy and regulatory issues at Federal, State, and local levels to ensure a favorable commercialization environment for geothermal energy.

7. Progress Monitoring: ensures that barrier identification and program-related activity reporting will be ongoing tasks whose output will be used in managing and controlling the program.

The program will simuiltaneously address the range of problems facing the developer, from initial resource assessment to ultimate construction and end use. Initial emphasis will be on projects that have a known user and a known resource, next moving to known resources where users must be brought to the energy source, and finally moving to identification of previously unidentified resources.

This program is an eight-year program with peak activity centering in fiscal years 1982 through 1985. The program will be completed by 1988. Peak-year funding level is estimated to be $129 million in fiscal year 1983, and the total program costs are estimated at $655 million. Approximately 67 percent of the total program cost will be dedicated to reservoir confirmation, which will remove the principal uncertainty retarding industrialization.

II. INTRODUCTION

The Nation's hydrothermal resources represent a vast energy asset that is free of foreign control or interference. These resources should be developed as rapidly and efficiently as possible. If all of the hydrothermal resources identified in the United States Geological Survey's Circular 790 were utilized, the total energy available at the wellhead from resources above 90°C would be 2500 quads, which is equivalent to 450 billion barrels of oil -- more than 16 times the known oil reserves of the entire Nation.[1]

The United States currently imports approximately 3 billion barrels of crude petroleum per year at a cost of $72 billion. The economic impacts are especially acute because most of the petroleum is imported from relatively small, underdeveloped nations that cannot absorb an equivalent value of American exports. The year 2020 Department of Energy (DOE) goal of six quads on line for direct applications of our hydrothermal resource (Figure 1) is equivalent to 1.08 billion barrels of oil, although in fact some of the displaced energy will be coal, some will be electricity, and some will be natural gas. If all of the equivalence were direct oil displacement, this level of hydrothermal utilization would have a balance of payments replacement value of $26 billion, which would alleviate 36 percent of today's oil import burden. Thus, employed directly as thermal energy or applied to the economic production of liquid fuels, geothermal resources promise to be an important factor as we seek self-sufficiency in energy production.

Unlike development of some alternative energy resources, the use of hydrothermal energy does not depend on new engineering or scientific advances, but requires only the minor adaptation of existing technology, the environmental consequences of which are relatively benign. However, to reach this goal, a vigorous Federal effort is required in cooperation with industry and with State and local governments. This plan is a description of that effort; it identifies the Federal activities necessary to stimulate early commercialization of the Nation's hydrothermal resources for direct heat applications. Program costs are estimated and benefits that would accrue from its implementation are discussed.

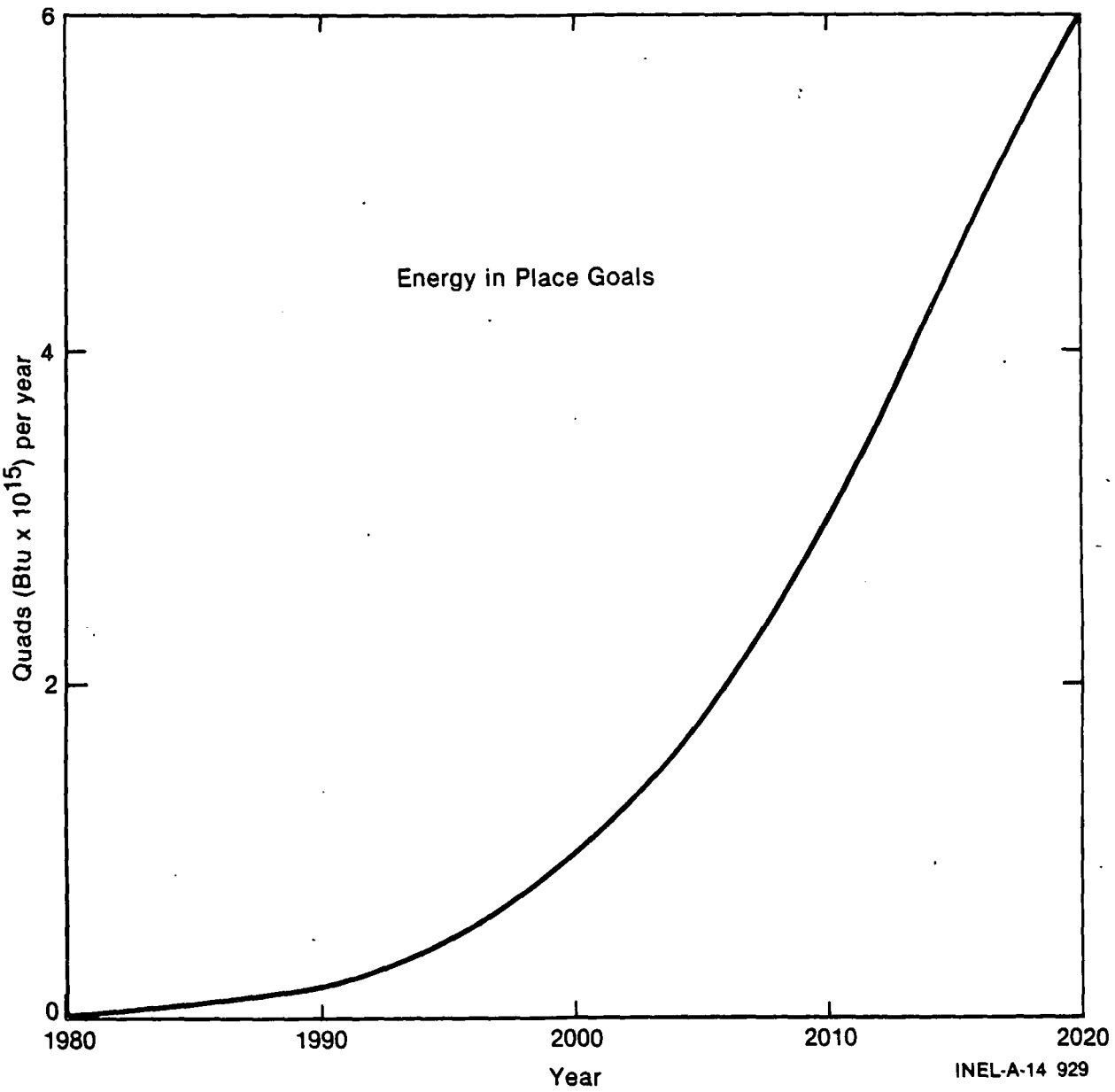

Figure 1. Hydrothermal direct heat commercialization goals

The Market

Nearly 50 percent of the Nation's energy requirements utilize temperatures below 150°C. Hydrothermal resources that meet this requirement are many and widespread, as can be seen in Figure 2. There are fewer high-temperature resources, but industrial processes that require temperatures up to 360°C can also be considered as potential users for direct applications of hydrothermal energy.

Because of the colocation of users and known resources, space heating and low- to moderate-temperature industrial processes are two particularly attractive use sectors for hydrothermal energy. For example, space heating requirements for the Nation's stock of buildings are approximately 14 quads annually. Since 10 percent of the U.S. population lives and works within 40 miles of some 225 known hydrothermal resource locations in 11 western states,[2] hydrothemal energy could supply at least 3 percent of the 14-quad space-heating demand. Great potential also exists for the use of hydrothermal energy in space cooling. In the rapidly growing cities of the Southwest, the use of hydrothermal energy for space cooling may hold a significant economic advantage over the use of other energy sources.

Increasing attention is also being devoted to the direct application energy market in the Eastern States. Of the six principal Eastern geothermal resources areas analyzed to date for energy demands, the existing residential, industrial, and commercial energy market approaches 0.2 quad annually.[3]

Market Penetration Potential

A national market penetration analysis is being formulated, and econometric analyses are being developed for States in the Rocky Mountains and High Plains States where resources potential has been demonstrated. Refer to the Appendix. Preliminary evaluations indicate a large industrial application potential as well as a possibly unlimited market for ground water heat pump applications, cogeneration, space cooling, and major new industrial complexes that might be attracted to more remote but highly promising geothermal resource locations.

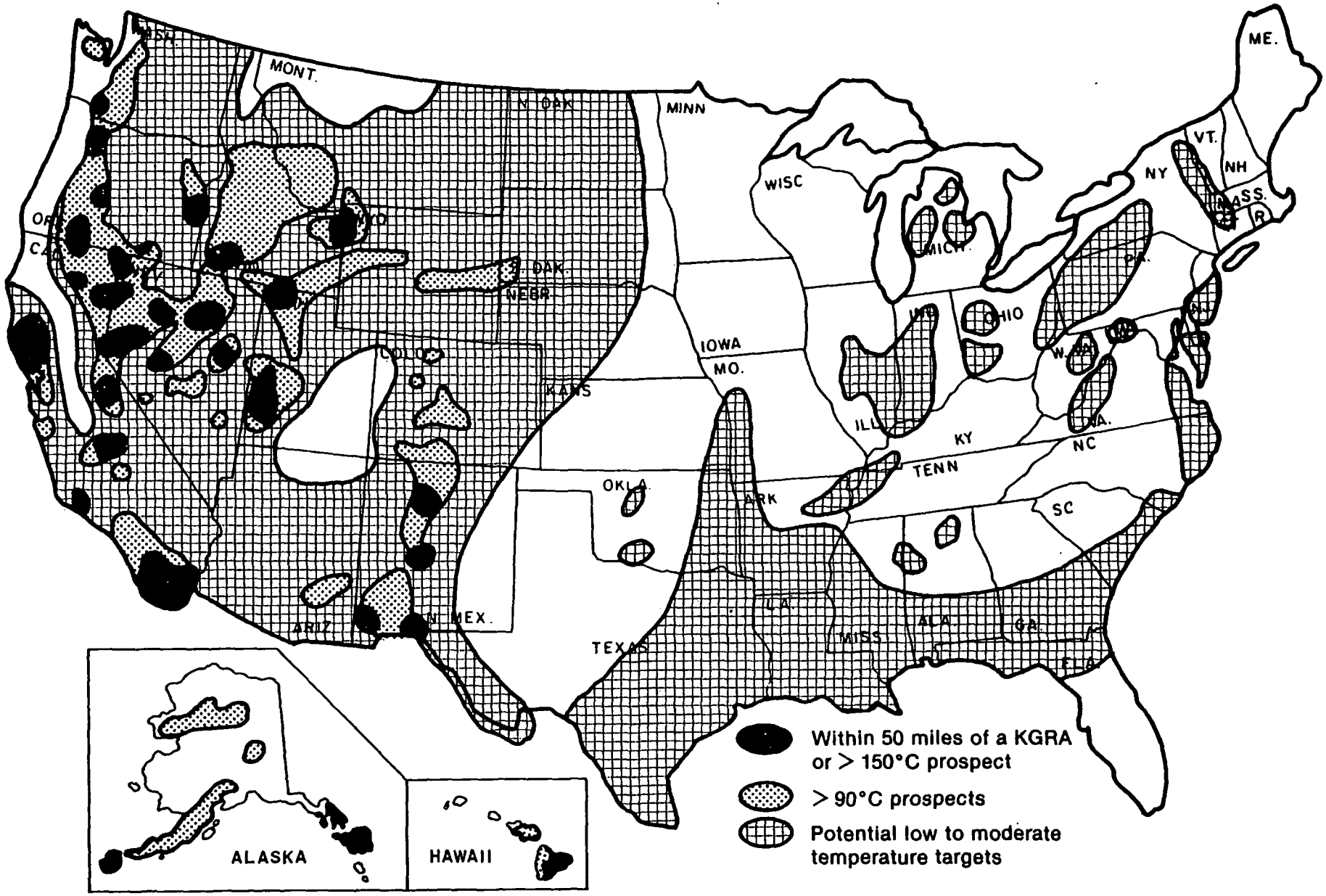

Figure 2. Known and potential hydrothermal resources

Similar analyses being performed for other states are also expected to show significant market penetration potential for hydrothermal energy. In the aggregate, the potential, economically attainable goals established here for the direct applications of hydrothermal energy represent a national opportunity of impressive dimensions. The "energy in place" goals are as follows (see Figure 1):

why call them goals? why not "opportunity"? Extent of development depends on funding

	1985	1990	1995	2000	2005	2010	2015	2020
Quads/year	0.1	0.2	0.4	1.0	1.8	3.0	4.5	6.0
Equivalent barrels of oil (millions)	18	36	72	180	324	540	810	1080

Benefit Summary

Benefits from the development and use of the hydrothermal resource through direct applications are nationally important, but vary regionally. Development can mean new employment opportunities, contributions to energy independence, additional tax revenues, increased capital investments and industrial growth, and an improved environment. Many, but not all, of these benefits can be quantified. Unquantifiable benefits have been termed "values" in this document. Included in these value categories are:

Insurance Value: identifies the potential of the hydrothermal technology to be commercially viable and capable of substituting for other energy technologies that may become more expensive, unavailable, or undesirable.

Environmental Value: identifies the overall favorable environmental impacts of hydrothermal energy as compared with most other energy sources, including coal, oil, and nuclear.

Conservation Value: identifies the measure of importance that the use of hydrothermal energy has in conserving (replacing) natural gas and liquid fossil fuels.

Decentralizing Value: identifies the advantage to be derived from a hydrothermal technology that operates effectively in an on-site decentralized mode.

International Value: identifies the benefit in terms of international cooperation and trade, and considers hydrothermal energy as a viable energy option for other countries that will lessen the competition for conventional energy sources.

Quantifiable benefits include the fiscal benefits that will be derived by Federal, State, and local governments if the resource is effectively developed. Using reasonable assumptions and the Department of Energy direct applications goals shown in Figure 1, it is estimated that the return of revenues through Federal taxes and royalties will exceed $1.6 billion per year by the year 2020. Summing the revenue for all years yields a total of approximately $19 billion in Federal revenue between now and the year 2020. The accompanying tax revenue to State and local governments is estimated to be $25 million by the year 1985, $600 million by the year 2000, and $7 billion by the year 2020. To reach this level of fiscal benefits, however, industry must make significant capital investments: $2.5 billion by the year 1985, $25.1 billion by the year 2000, and $150 billion by the year 2020. (See Figures 3 and 4.)

For this benefit analysis, the following assumptions were made:

1. Investment capital is figured at an average installed capacity cost of $750 per kilowatt for industrial and space heating applications combined.

2. Geothermal fluid is valued at $2.50 per million Btu.

3. Projections do not include an inflation factor.

4. Federal taxes plus depletion allowance equal 40 percent of net annual profit.

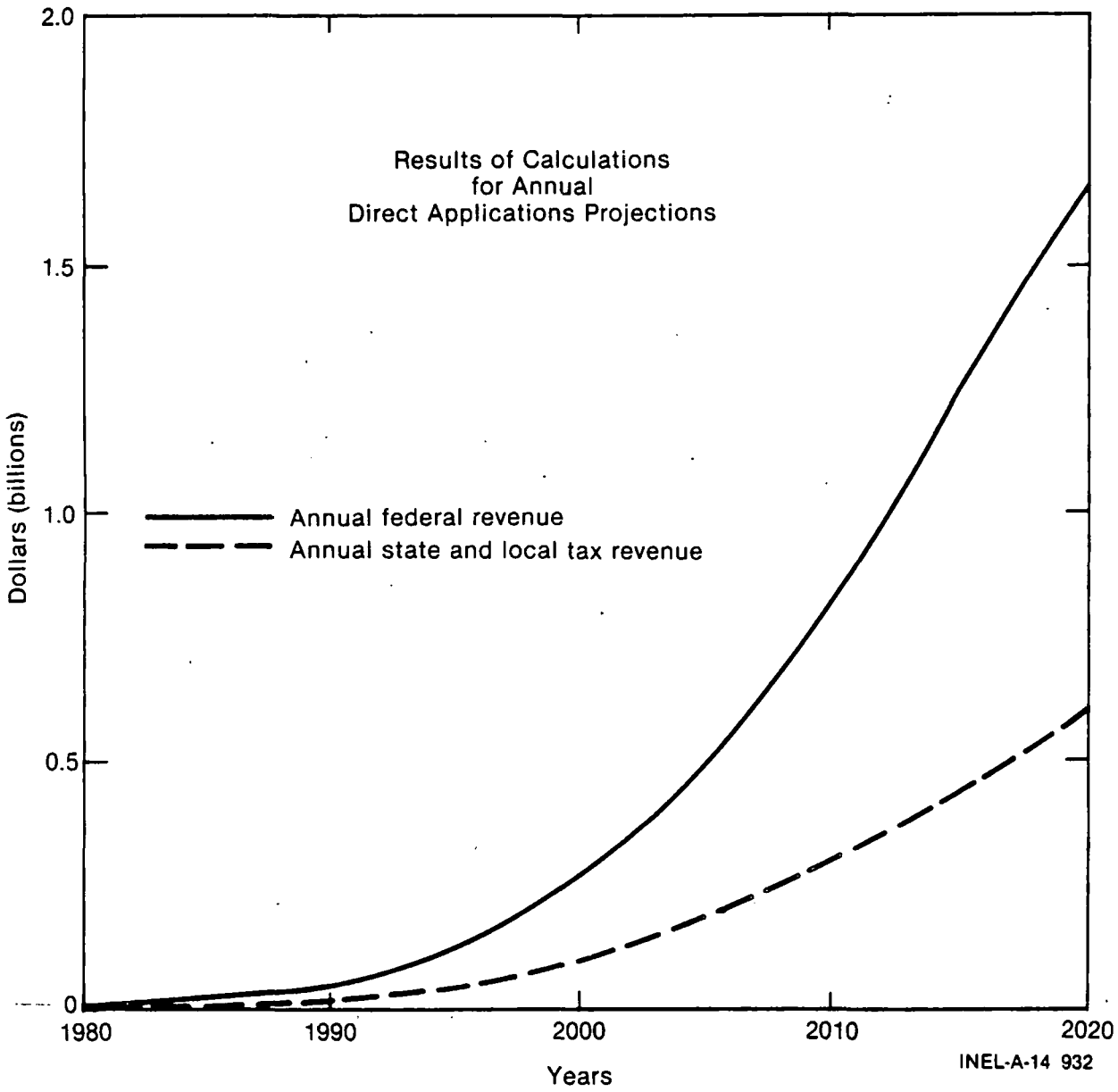

Figure 3. Annual monetary benefits

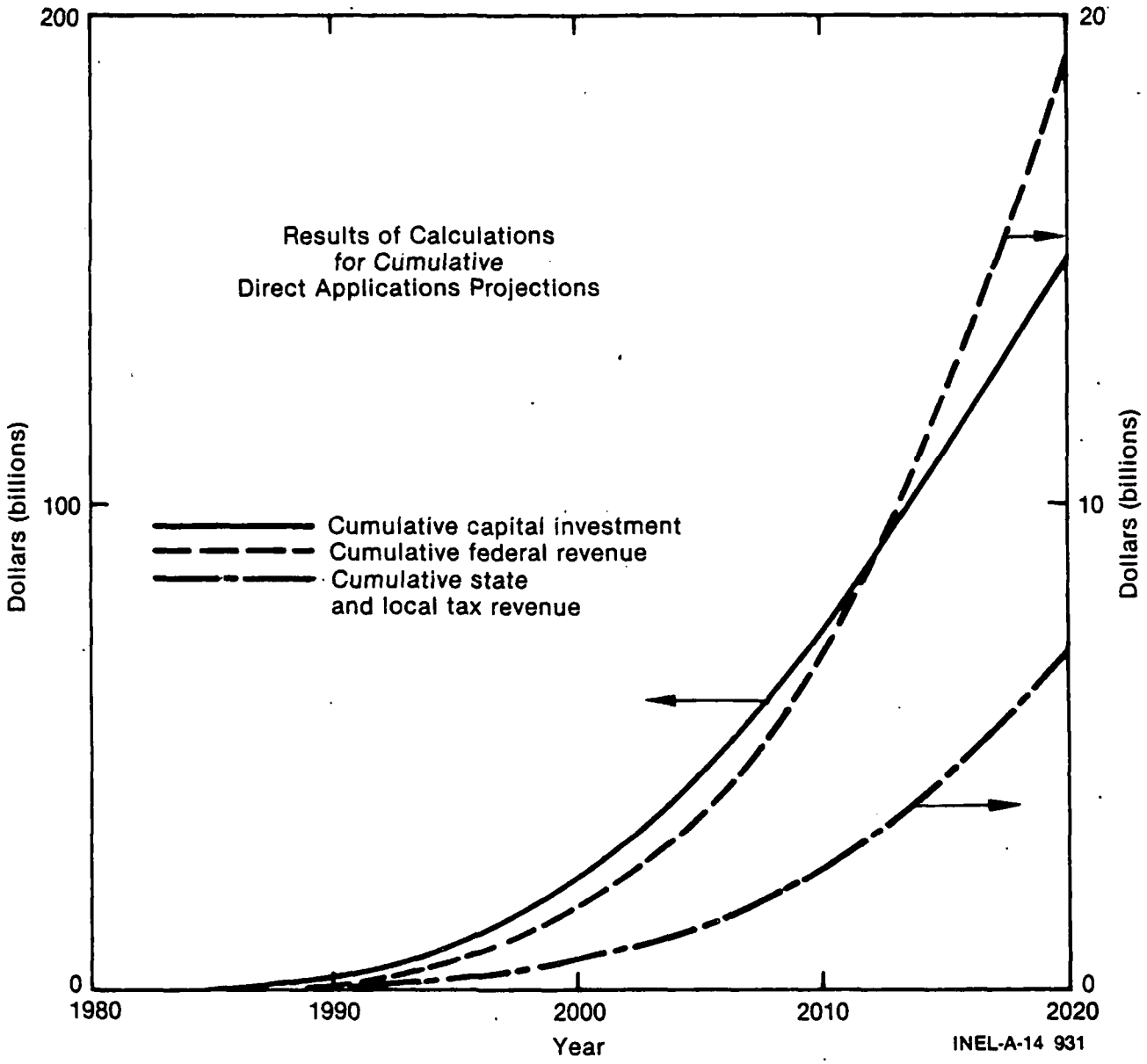

Figure 4. Cumulative monetary benefits

5. One-half of the development will be on Federal lands, for which the royalty payments will equal 10 percent of the annual gross income on these lands.

6. State and local taxes equal 4 percent of the annual gross income.

III. COMMERCIALIZATION BARRIERS

A number of recognizable barriers, or problems, must be overcome in order to meet the Department of Energy's National hydrothermal goals for direct applications. These barriers are discussed in subsequent paragraphs.

The Need for Confirmed Reservoirs

The major barrier to hydrothermal development is the lack of confirmed reservoirs. Direct applications of hydrothermal energy in the United States today represent only about 0.01 quad. This is due in part to the fact that this important energy source has not, in the past, been assumed to be competitive with fossil fuels. As a consequence of this assumption, little effort has been expended in confirming reservoirs. Confirmation of hydrothermal reservoirs by drilling is costly, and risk of drilling an unproductive well is significant.

Developers of electrical power generation facilities at high-temperature reservoirs are generally large, well-capitalized companies that can finance reservoir confirmation by spreading the cost and risk over many projects. However, such companies are generally not interested in direct applications because of their relatively small scale. Smaller developers, the ones most interested in direct applications, are typically unable to spread risk and cost as large companies do. One or two unproductive wells can mean financial disaster for the small developer, so it is unlikely that direct heat users will have the opportunity to utilize the widespread lower-temperature reservoirs until the costs and risks become sufficiently low to be acceptable to developers. Without Federal assistance in reservoir confirmation, therefore, it is apparent that very little use will be made of the widespread moderate-temperature hydrothermal resource base that exists in the United States.

Lack of an Established Industry

Another barrier to development of the Nation's geothermal energy potential is the lack of a viable supporting industry. The participation of

developers, financiers, builders, and operators needs to be expanded for resource exploration and drilling, resource development, energy brokerage, financing, equipment manufacturing and sales, facility development, and utility distribution. This infrastructure is generally in its infancy and needs to be fostered.

Limited Technical Data

A barrier to widespread implementation of hydrothermal direct heat applications is the need for base economics and system operational information. This need is apparent in survey results obtained from the private sector.[4] Many direct uses of hydrothermal energy are possible with available technology; but technical feasibility, confidence in the economics, and the reliability of direct heat systems continue to be concerns and factors of indecision for many potential users in private industry. Demonstrations are necessary to address these uncertainties. Technical developments are also needed to alter existing technology for hydrothermal applications so that this energy source can be used in innovative ways.

Policy and Regulatory Confusion and Environmental Impact Uncertainties

The confusing and frequently unreasonable array of environmental laws, permits, regulations, policies, and requirements that restrict development, also deter the hydrothermal developer. Promising lands are withheld from leasing and development as a result of potential environmental and other concerns which are often neither confirmed nor well understood. Even when resource development occurs, problems and uncertainties associated with these issues can escalate the cost and frustrations of development. A federally directed effort is needed to resolve environmental and policy and regulatory conflicts, to coordinate programs to ensure that necessary work is accomplished without duplication of effort, and to simplify environmental policy and regulatory requirements for developers.

IV. PROGRAM DESCRIPTION

The National Hydrothermal Direct Applications Program Plan defines a program designed to eliminate or minimize the effects of the barriers to commercialization identified in Section III. Seven major program elements are included in the plan; these are shown in matrix form in Figure 5, along with the barriers that they will attack. In the figure primary impacts are indicated by a double "X," while secondary impacts are indicated by a single "X." The plan, with its major program elements and work subsets, is shown diagrammatically in Figure 6. A discussion of these major program elements follows. A cost and schedule summary is presented in Section V.

A. Market Development

Development of the Nation's hydrothermal energy potential is presently limited or slowed by (1) uncertainties concerning the size of the potential direct applications market, (2) limited awareness of hydrothermal energy by energy users, and (3) lack of a developed supporting industry infrastructure. Removal or reduction of these limiting factors is addressed by a series of program initiatives aimed at market development. These "pump priming" initiatives will accelerate hydrothermal energy development and use and will lead to a self-sustaining level of activity by support industries.

The Market Development program elements are illustrated in Figure 7. Objectives and workscopes for each of these elements are discussed in subsequent paragraphs.

Market Assessment

The Market Assessment program element will alleviate problems resulting from uncertainties of potential market size. Potential direct application hydrothermal energy users will be identified and estimates will be made concerning the magnitude and characteristics of the market. Information developed about potential users and market characteristics will allow matching of users and resources. While the upper limits of energy

Program Development Matrix

Barriers → / Program Elements	Lack of confirmed reservoirs	Lack of an established industry	Limited technical data	Policy and regulatory confusion	Environmental impact uncertainties
Market Development		XX	X		
State Planning and Development	X	XX	X	XX	X
Reservoir Confirmation	XX	XX	XX		X
Technology Demonstrations		XX	XX	X	X
Environmental Assessment		X	X	XX	XX
Policy and Regulatory Issues Assessment		X		XX	X
Progress Monitoring	X	X	X	X	X

XX Primary impact X Secondary impact INEL-A-14 928

Figure 5. Program development matrix

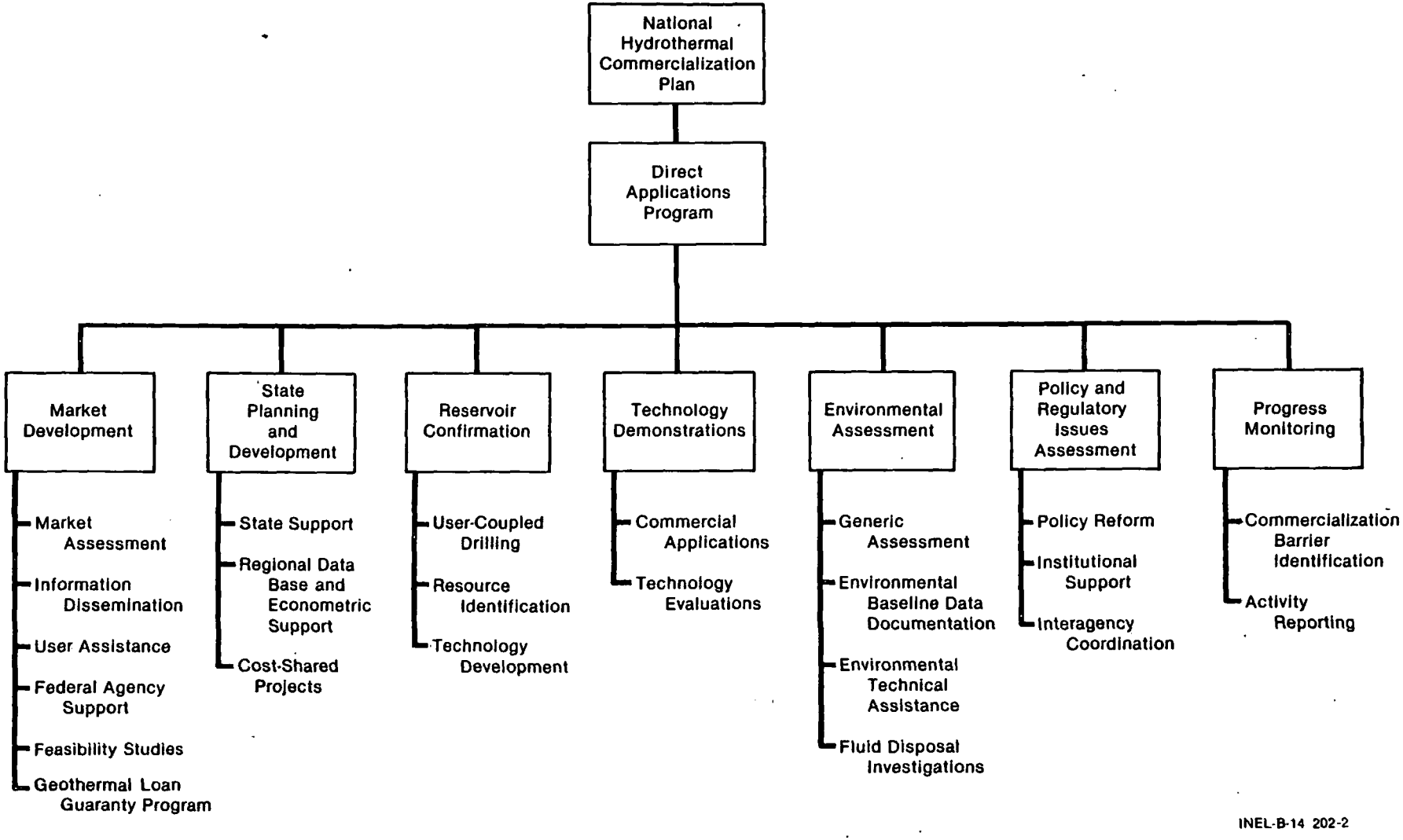

Figure 6. Program work elements

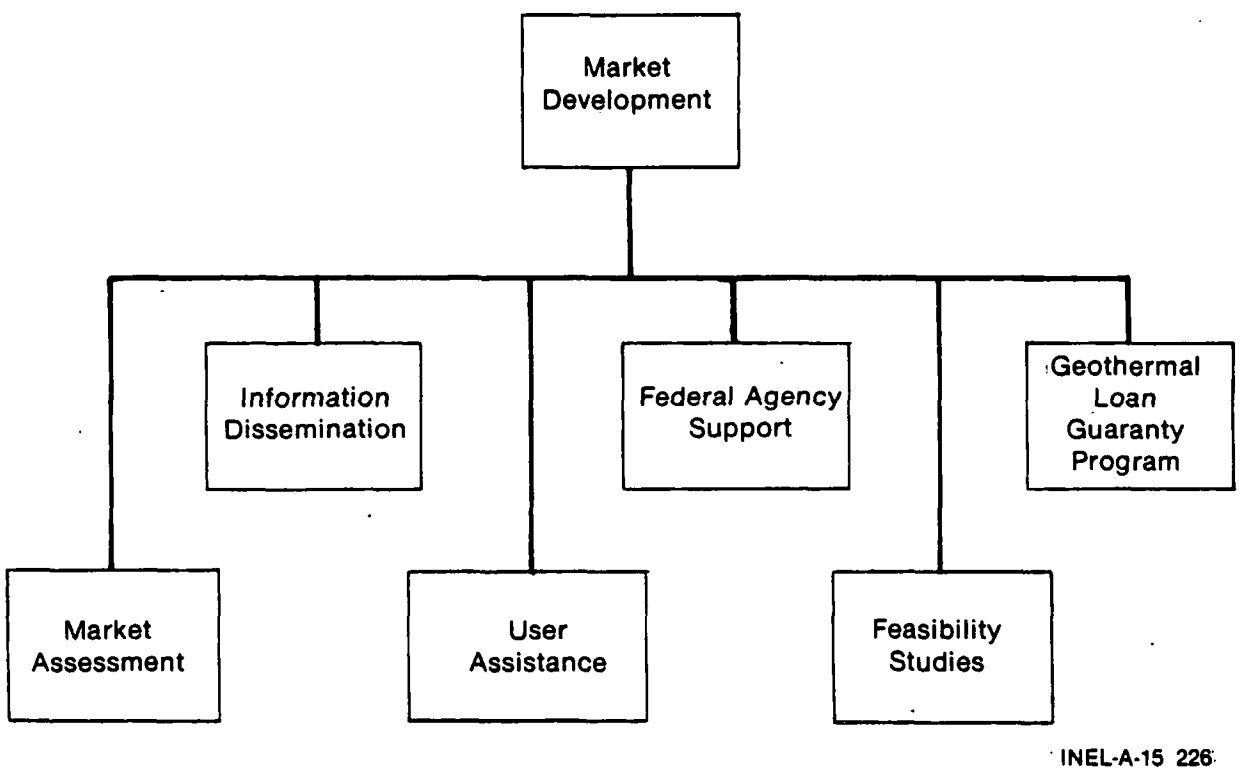

Figure 7. Market Development block diagram

available from our Nation's geothermal resources have been estimated (USGS Circular 790), the extent to which the potential market may be penetrated under various economic assumptions has not yet been well quantified. Market assessment data will be developed to aid governmental agencies in formulating energy policy and regulations. Similarly, the data will be useful to energy developers in setting and evaluating their hydrothermal energy marketing strategy.

Market assessment will be made from two perspectives: regional and industrial. The regional market assessment will identify favorable matches of energy consumption and hydrothermal resource location in terms of aggregate demand by state, starting at the community level. Industrial market assessment will identify energy use by user type (e.g., space conditioning, food processing, mining) and will then identify barriers to market penetration, target information dissemination, etc.

Information Dissemination

The Information Dissemination program element will attack problems caused by inadequate knowledge about hydrothermal energy. Technical, economic, and general information will be provided to energy developers and users, both private and public. The object of this work element will be to inform these audiences of the potential uses and economics of hydrothermal energy. Outside of those actually involved in hydrothermal energy industrialization, hydrothermal energy is either unknown or thought of as an exotic future energy source. Widespread recognition of hydrothermal energy as an economic alternative is essential to its commercialization.

The work will include preparation of outreach materials and dissemination of these materials through such means as government agencies (Federal, State, and local), industries, their associations, and National laboratories. These activities will include an appropriate media program to increase the general public awareness of hydrothermal energy direct use potential.

Technical information developed through private and Government efforts will be monitored, compiled, and made available to all interested sectors.

User Assistance

A lack of widespread knowledge of hydrothermal direct application technology deters many potential users from employing hydrothermal as an alternate energy source. A technical infrastructure (consulting engineers, geologists, etc.) has started to emerge, but this infrastructure is not well established. The User Assistance program element provides regional centers of geothermal expertise. Through small grants of aid (up to 100 hours), these centers assist potential users with resource assessment, conceptual engineering and economic feasibility assessment, and so on. The program element objective is to invest a small amount of "seed money" in order to aid potential users in determining the feasibility of their projects. The size of the grant is intentionally small so as not to interfere with the commercial sector which the user must turn to for project support once he has decided to proceed. User Assistance will therefore help promote development of the technical infrastructure essential for spontaneous commercialization.

Federal Agency Support

Federal agencies other than the Department of Energy sponsor energy-development programs that may have hydrothermal implications. In such cases, an agency may require hydrothermal expertise support in program review and implementation. Examples of agencies and programs where such assistance may be desired are the Department of Housing and Urban Development's urban development grants; the Department of Health, Education and Welfare's hospital aid programs; the Department of Agriculture's grant and loan guarantee programs; and alternate energy/energy conservation programs managed by several agencies.

The Federal Agency Support program element is designed to ensure the availability of hydrothermal expertise to all other Federal agencies for application/proposal evaluation, for hydrothermal usage projections, and

for related data of value to energy-development programs. The result of this effort will be to ensure that viable hydrothermal projects receive proper Federal consideration and support.

Feasibility Studies

Before a prospective developer or user can enter into any meaningful negotiation with a financial institution or with the Department of Energy for monetary assistance, the developer or user must have already performed an economic and engineering study of the proposed project. Although this type of evaluation is normally performed at the expense of the prospective developer or user, in the infant hydrothermal industry it appears that financial assistance may be necessary.

The purpose of this program element is to provide incentive and financial assistance for feasibility studies that will lead to the construction and operation of commercial-scale hydrothermal direct application projects. Prospective developers or users will respond to "Feasibility Study Solicitations," and successful proposers will be awarded grants of aid. Such grants will not include fee or profit. Awards will be on a competitive basis, with each successful proposer having a well-defined statement of work leading to a commercialization goal. This program element is designed to accelerate the pace of early development work and thus to speed the completion and operation of commercial-scale direct application projects.

Geothermal Loan Guaranty Program

Some lenders are reluctant to finance geothermal projects because of the perceived risks. The purpose of the Geothermal Loan Guaranty Program (GLGP) element is to stimulate the commercialization of geothermal energy by minimizing the financial risk incurred by development capital lenders. Through the GLGP, the United States Government pledges its full faith and credit to the lender to guarantee the repayment of principal and interest on geothermal development loans. The GLGP objective is to provide financial incentives for the early and rapid development of geothermal

resources and to aid the establishment of a self-sustaining industry. As the industry develops, it is expected that normal financial relationships between borrowers and lenders will also develop, which will eliminate the need for the GLGP. In addition, the security afforded by the GLGP should encourage financial institutions to back geothermal development projects.

B. State Planning and Development

The viability of the National Hydrothermal Direct Applications Program requires that the States participate in planning and development, in order to ensure that the varied and particular economic and social concerns of the individual States and the National goals are compatible. To address these needs, three program elements exist, as illustrated in Figure 8 and discussed in subsequent paragraphs.

State Support

Realistic planning and policy development require the concurrence of State and local governments. Furthermore, those people working most closely with a given locale are most likely to have an accurate understanding of events and conditions bearing upon hydrothermal energy development within that locale. Most importantly, people working in the field, particularly when they are legitimate representatives of the local or state-wide interest, can help expand the industrialization of hydrothermal energy through education, marketing, and technical assistance activities.

To obtain state and local participation, DOE provides support for State hydrothermal programs. Cooperative agreements with agencies of State government are in place in a number of states. These agreements establish planning, analysis, and marketing efforts for hydrothermal energy and also provide technical assistance for prospective developers and users. Closely related to these State commercialization programs are the state-coupled resource assessment programs that provide inventories and preliminary data about the hydrothermal resource areas. Coordination of these two sets of programs will ensure that they are both directed toward the single goal of hydrothermal energy in place. Once the DOE-assisted programs are well

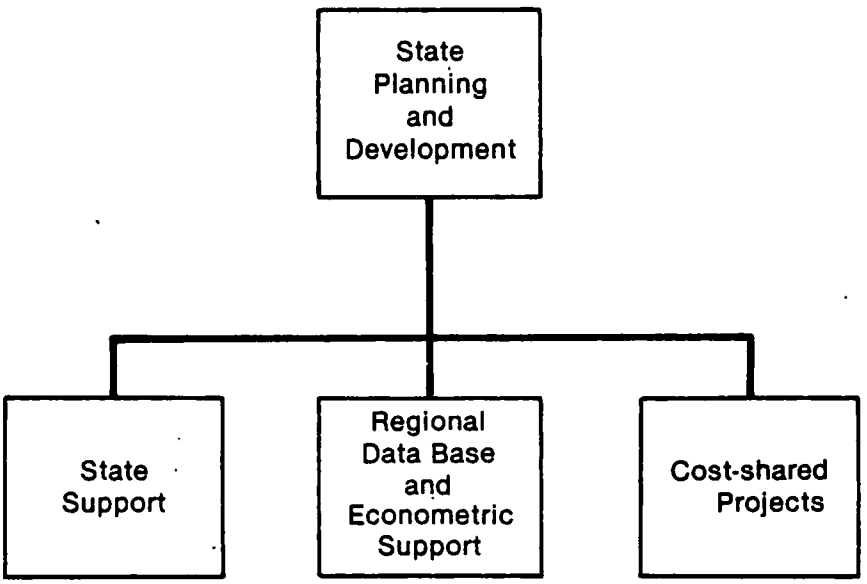

Figure 8. State Planning and Development block diagram

established, State and local governments will have the expertise available to continue programs on their own, to provide both technical information and funding assistance to prospective developers and users.

Regional Data Base and Econometric Support

To be effective, the hydrothermal industrialization program requires detailed resource and economic data. Once collected, these data must be available to support State, regional, and National planning efforts. To achieve this, regional processing centers must be established. Among the primary objectives of such centers will be the development and maintenance of economic and resource data bases, and the projection of market penetration possibilities for hydrothermal energy. Appropriate economic models, such as industrial process applications and municipal system feasibility models, will be developed for site-specific support to the participating States. The regional centers will also aid and support industry, State, and Federal commercialization efforts.

Cost-Shared Projects

As has already been discussed, the States must play an active part in the hydrothermal industrialization program. The importance of their participation increases dramatically when one considers that the individual States have particular energy production and use concerns. These concerns vary from State to State, depending upon the location of "pressure points" exerted by the energy crisis. Some States, for example, will be primarily concerned about tourism, others about agriculture, and still others about their dependence on oil for space heating. The Department of Energy will entertain recommendations for projects to be cost-shared by the States. The particular hydrothermal development interests and possibilities will be defined during the State planning support activities.

C. Reservoir Confirmation

The most serious problem with the commercialization of the Nation's hydrothermal resources is the lack of confirmed reservoirs. Even though

there are many more low- and moderate-temperature resources than high-temperature resources (refer to Figure 2), the cost and risk associated with exploration and confirmation have kept the reservoir confirmation effort at an unacceptably low level.

To reduce financial risks to potential developers and users, three program elements have been established: Resource Identification, User-Coupled Drilling, and Technology Development. These elements are illustrated in Figure 9 and discussed in subsequent paragraphs.

Resource Identification

Nearly all prospective users of direct heat hydrothermal energy have limited financial resources when compared with those companies whose interest is hydrothermal electric power generation. Potential direct heat users cannot, in general, afford to do the regional geologic work or geothermal data compilation that is needed to identify those sites where reservoir confirmation studies are most likely to succeed. There is a clear need for Federal assistance in the collection and interpretation of reconnaissance geothermal and related earth science data, as well as in making these data available to prospective developers and users. The United States Geological Survey (USGS) and the States are the principal organizations involved in this effort.

USGS Regional Assessment: The first necessary step in resource identification is development of a regional-scale evaluation of geothermal data. The USGS learns primary responsibility for inventorying and assessing the Nation's geothermal resources. The Department of Energy works in cooperation with the USGS in surveying and studying specific areas or regions which have or may have geothermal resource potential. Examples of this work are the efforts in the Snake River Plain of Idaho and in the Cascades volcanic areas of California, Oregon, and Washington. These regions receive minimal industry exploration because of the highly speculative nature of resource occurrence as well as because of institutional and environmental barriers to industry activity.

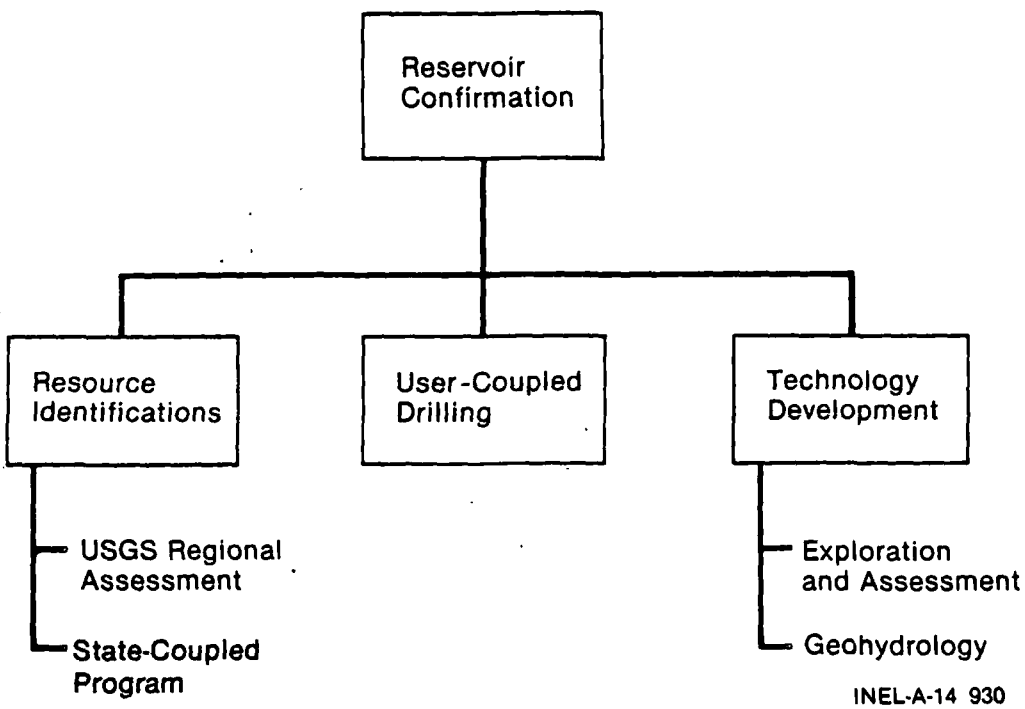

Figure 9. Reservoir Confirmation block diagram

The "big picture" that results from the work of the USGS forms the starting point for the detailed studies done under the State-Coupled Program.

State-Coupled Program: Prior to the State-Coupled Program, there existed no adequate compilation or publication of geothermal or related data for any individual state. With the operation of the State-Coupled Program, however, this situation is now starting to change. Approximately 20 States are now involved, and detailed State geothermal resource maps are becoming available. The principal task that each State contractor performs during the first one or two years is the compilation of data on geothermal springs and wells, and on geologic features related to geothermal occurrences, such as siliceous and calcareous spring deposits, young volcanic rocks, and active geologic structures. These tasks are done in cooperation with the USGS.

User-Coupled Drilling Program

Well drilling, the only way in which a reservoir can be confirmed, is costly and there is a significant risk of drilling an unproductive well. Present developers of electrical power generation from high-temperature reservoirs are generally large companies that can finance reservoir confirmation by spreading the high cost and risk over many projects. However, these large companies are usually not interested in direct heat applications because of the relatively small scale of such projects. Smaller developers, the ones most interested in direct applications, are unable to spread cost and risk in the same way that a large company can. For these reasons, it is not expected that prospective direct heat users will have confirmed reservoirs available until the risks are reduced for the developers.

The objective of the User-Coupled Cost-Shared Reservoir Confirmation Drilling Program is to stimulate confirmation and use of low- and moderate-temperature resources for direct applications by the development of an experienced infrastructure. This infrastructure will consist of people and organizations that will cover the entire sequence from exploration to reservoir confirmation to equipment installation and operation. This infrastructure is now almost totally lacking.

The program will consist of DOE cost-shared surface exploration and drilling confirmation of hydrothermal reservoirs. Users and developers will share costs with DOE and will perform the work. The Department of Energy's cost share will be low for a successful project (i.e., a project that intercepts a hydrothermal resource from which usable hydrothermal fluids can be produced), but high for an unsuccessful project.

Implementation of the program will be through a series of competitive procurements directed at industry and State and local government sectors. The procurements will specify that acceptable proposals will include the following four features: (1) a well-engineered use and one or more users who are committed to the project, with either the user or the developer as the project manager; (2) clear land/water-use rights; (3) a well-conceived exploration and reservoir confirmation program under the direction of recognized geoscientific expertise at a site or sites where there are good geologic reasons for believing that a reservoir exists; and (4) a favorable environmental situation.

During the course of each project, DOE will monitor progress and will collect data needed for project decision points and for information relevant to future projects. Publication of the data at the conclusion of the project will help to build a body of knowledge concerning the attributes of the geothermal reservoir and the specific exploration techniques that proved to be successful in locating it.

The planned program will result in the direct development of an estimated 25 percent of the total number of sites and infrastructure needed to meet the goals set forth in this plan. Federal support for development of these sites and infrastructure will provide the catalyst needed for private development of both sites and infrastructure.

Technology Development

The user of direct heat hydrothermal resources cannot generally afford to develop new technology. Nevertheless, it is apparent that evaluation and improvement of existing technologies will increase the success ratio for

reservoir confirmation programs in the near term, and that development of new technologies will have an even greater effect in the far term. New and improved technologies and development of an experienced industry infrastructure are the two keys to commercial direct applications development that will not proceed without Federal assistance. The program plan specifies two elements, discussed in subsequent paragraphs, to achieve these results.

Exploration and Assessment: The problem with exploration and assessment of hydrothermal resources is that the techniques used by the petroleum and mining industries do not necessarily yield satisfactory results when the object is to find hot water. The fledgling hydrothermal industry is too young, and the exploration and research funds expended to date are too little, to have developed techniques that are especially suited to hydrothermal problems. There is a clear need for continuation of the Department of Energy's Exploration and Assessment Technology Program that funds projects for the improvement of existing techniques and for the development of new techniques.

Geohydrology: Another important barrier to hydrothermal development is that the analysis techniques used in the confirmation of hydrothermal reservoirs are borrowed from both the petroleum engineer and the water well hydrologist. These techniques are not necessarily accurate when applied to hydrothermal reservoirs. Analysis techniques that are specially tailored to hydrothermal reservoirs are urgently needed.

An example of this need for analysis techniques is related directly to the User-Coupled Drilling Program. A successful bidder's first efforts will result in a single well at a given site, and the success or failure of the well will be judged by the results of the tests and the subsequent analysis of temperature and well flow data.

The importance of a valid analysis cannot be overstated, for the future development of that particular reservoir could very well depend on the results. Subsequent siting of production and injection wells will be dictated by the geohydrologist and his interpretation of the analytical

results. Efficient use and longevity of the reservoir thus depend in large part on valid analytical techniques of the type whose development arises from the Technology Development program element.

D. Technology Demonstrations

An examination of the Program Development Matrix shown in Figure 5 shows that Technology Demonstrations will remove two major barriers -- lack of an established industry and limited technical data. The Technology Demonstrations portion of the National Hydrothermal Direct Applications Program is structured to provide a user-oriented technical and economic data base. This empirical data base is necessary to alleviate uncertainties pertaining to development costs and system and equipment performance characteristics.

The various program elements of Technology Demonstrations will identify technical problem areas, address solutions, produce data, and assist in developing an infrastructure committed to the utilization of hydrothermal energy. The specific program elements required to achieve these goals include Commercial Applications and Technology Evaluations, which are illustrated in Figure 10 and discussed in subsequent paragraphs.

Commercial Applications

As of the writing of this plan, there have been relatively few demonstrations of the enormous potential of our Nation's hydrothermal resources in commercial direct applications. There are many reasons for this, but probably the most important one is that there is no data base for investors and potential users.

Demonstration Projects: Since hydrothermal energy is preceived as a relatively "high risk" alternative energy, private enterprise is reluctant to commit to the financing of projects that use this energy source. Therefore, methods must be developed to prove the engineering and economic viability of hydrothermal energy in order to reduce the "high risk" image. One such method is the funding of demonstration projects, which can serve as a stimulus to private industry by the development of performance data.

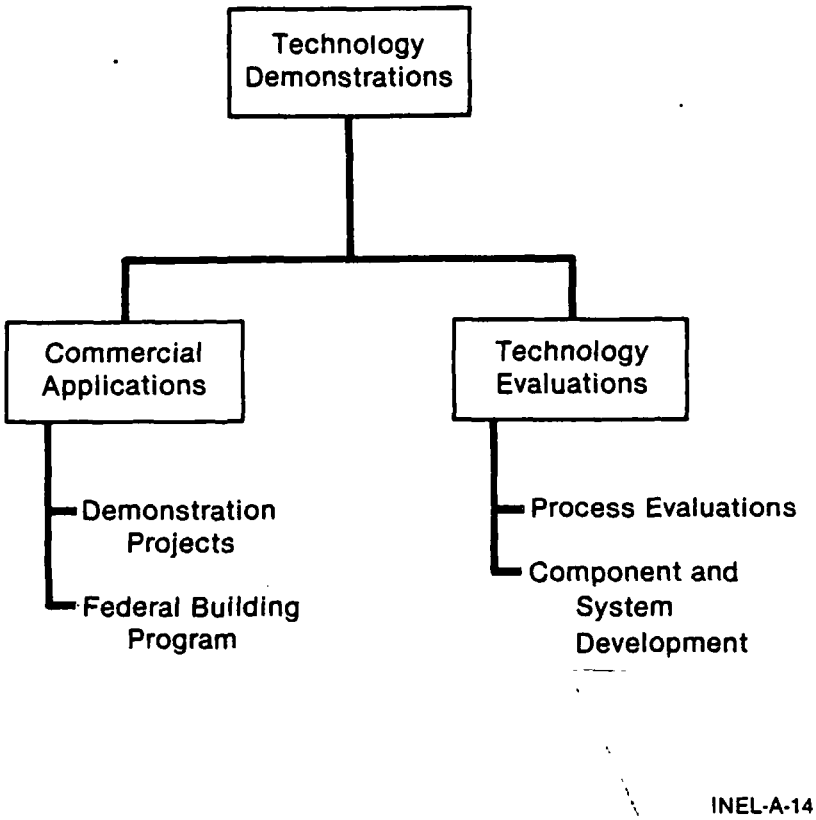

Figure 10. Technology Demonstrations block diagram

The Department of Energy has already funded some demonstration projects. These projects will provide data on retrofit space heating systems, district heating systems, and the food processing industry. Future demonstration projects will be reserved for market sectors that have a high potential for energy displacement of fossil fuels, those that produce liquid fuels from biomass, and those that emphasize new or unique technical approaches that will encourage growth of the hydrothermal industry.

Federal Building Program: As a large energy user, the Federal Government is committed to conservation and effective use of alternate energy sources for Federal installations. This program element will provide an incentive to Government agencies to use the alternate energy sources that are available.

For selected Federal facilities, the Federal Building Program will provide resource definition and evaluation of the engineering and economic feasibility of utilizing hydrothermal resources for space conditioning or other applications. Project scenarios and costs will be developed and compared to existing or other alternative energy systems. Regulatory and environmental issues will also be considered. As additional resource information becomes available, the engineering and economic data will be updated. These evaluations will be concentrated on major Federal energy consumers. The information developed in these evaluations will provide planners and developers with significant technical data concerning the use of hydrothermal energy.

Technology Evaluations

Technology Evaluations address the problem of the private sector's need for more information about technical feasibility, reliability, and economics. The evaluations are directed at processes as well as at developments in components and systems.

Process Evaluations: Many industrial processes are energy intensive, thus requiring substantial quantities of fuel -- either directly or through the consumption of electricity -- to produce the requisite process heat.

This program element involves the evaluation of process systems in order to identify those processes that are potentially prime candidates for hydrothermal energy. In some cases, system operating temperatures could be lowered (there is often a simple trade-off between time and temperature); such systems could be converted to hydrothermal with relatively small changes. Some process systems, on the other hand, may require redesign to be compatible with hydrothermal energy; such redesign is part of the Component and System Development program element.

Component and System Development: As mentioned above, many existing industrial processes are geared to the use of fossil fuels or electricity, and the equipment is sized for temperatures higher than those usually found in hydrothermal fluids. Work conducted through this program element will lead to development of equipment and systems including modification of existing technology for hydrothermal applications, as well as to development of innovative applications. Technical activities that address identified environmental problems are also included. Specific components that will be investigated -- the object being lower operating temperatures -- include heat exchangers, dryer systems, valves, piping, and vessels.

E. Environmental Assessment

Environmental concerns, both technical and institutional, have resulted in major delays in the development of geothermal resources in the United States. Conflicts and delays result from lack of information regarding the resource, from potential environmental impacts, and from uncertainties and restrictions in the Federal and State regulatory processes. The objective of this Environmental Assessment program element is to evaluate the environmental effects of hydrothermal development in order to eliminate unnecessary delays and expenditures resulting from environmental concerns and limitations. This will be accomplished by providing environmental support to the other program elements outlined in this plan. Figure 11 illustrates the elements of this work, which are described below.

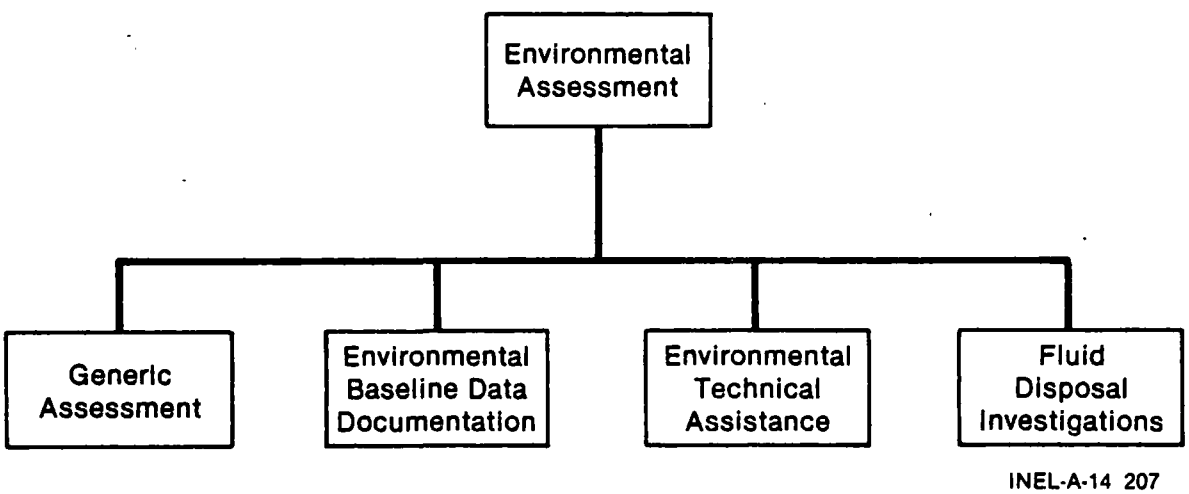

Figure 11. Environmental Assessment block diagram

The work includes generic environmental assessments, environmental baseline data documentation, environmental technical assistance, and fluid disposal investigations. The development of environmental monitoring, analysis, and control technologies in support of hydrothermal industrialization has been incorporated into the Technology Demonstrations program element. Much of the environmental policy reform and interagency coordination will be accomplished in conjunction with the Policy and Regulatory Issues Assessment program element, which is discussed later in this plan.

The work described here is based on the following assumptions:

1. The institutional picture will not change significantly in terms of regulatory emphasis and application of policies and procedures.

2. The National program will continue to be structured by region and by state.

3. Most of the environmental issues related to hydrothermal resource development can be resolved; in most cases, existing infrastructures can be utilized to accomplish the program objectives.

The elements of the Environmental Assessment effort are discussed below.

Generic Assessment

Most hydrothermal development projects, especially those with Federal funding or support, require an environmental assessment or statement. These assessments frequently involve duplication of time and money, both in the preparation and in the review and approval process. The User-Coupled Drilling and Resource Confirmation program elements lend themselves to the preparation of a generic environmental assessment to minimize duplication and to facilitate project approvals.

The assessment will address the types of drilling employed in exploration and development, the programmatic objectives, potential impacts and concerns, control equipment and procedures, and potential mitigation

techniques. Emphasis will be placed on analyzing alternatives in compliance with recent National Environmental Policy Act regulations. With an approved generic assessment, only site-specific environmental information would need to be provided for individual drilling projects. If it becomes apparent, as other programs develop, that generic assessments are appropriate, then their preparation will also be incorporated.

Environmental Baseline Data Documentation

In some areas of significant geothermal potential, development is delayed or restricted by unresolved environmental issues. These areas include those where (a) no identification of environmental concerns has occurred, (b) potential concerns have been identified but not validated, and (c) specific concerns have been identified, but development could occur if mitigation measures could be agreed upon. Many of the environmental conflicts and uncertainties occur on Federal lands and can be resolved through close interagency coordination. The objectives of this effort are to identify areas where development is hindered due to environmental considerations, to identify the responsible agencies, and to develop a coordinated program of environmental data evaluation to resolve the conflicts. In those areas where a lead land-management agency cannot be identified (e.g., areas where land ownership is very fractionized, or areas where much of the land is privately owned), DOE will take the lead in resolving environmental concerns. The program will be implemented for each of the states included in the National program. Only those areas will be considered where it can be shown that environmental concerns or lack of environmental knowledge is delaying development.

Environmental Technical Assistance

The would-be hydrothermal developer must confront a host of environmental technical problems that may range from what agencies exercise what controls over a specific site to regional environmental concerns. To simplify as much as possible the process of obtaining environmental permits and so on, environmental technical assistance will be provided at the State level. This program element will include assistance to developers, on request,

with the preparation of environmental assessments and permit applications; the identification of environmental concerns; the coordination of institutional requirements; and the dissemination of environmental information pertinent to general areas in each State. State handbooks will be prepared which will define the technical and institutional environmental issues applicable to hydrothermal development. The handbooks will specify agencies and regulations which may affect the development process, and will outline the steps necessary to obtain all permits and approvals with minimum confusion and frustration. Where appropriate, State personnel will attempt to establish a coordinated review and permitting procedure among State and Federal agencies in order to reduce the required time and paperwork. Technical problems related to environmental concerns or restrictions will be coordinated at the regional level through National laboratories.

Fluid Disposal Investigations

One of the major obstacles facing hydrothermal developers is the disposal of geothermal fluids. The method of disposal employed for any project depends on the quality and quantity of the geothermal fluids, on State and Federal environmental regulations and water rights policies in force at a specific site, and on the relative cost of possible disposal methods. Injection, although often considered the ultimate solution to fluid disposal problems, may not be the best option due to cost or technical considerations. Developers can be faced with disposal options that make hydrothermal resource utilization uneconomical or with fluids for which a disposal technique is not readily available. Two tasks aimed at removing these obstacles are included in this program: first, technical evaluation of disposal options for specific development and, second, research and evaluation of fluid treatment methods.

F. Policy and Regulatory Issues

Institutional factors continue to deter commercial development of hydrothermal resources. Actions need to be taken at all governmental levels to ensure that equitable incentives exist, that a regulatory

framework condusive to hydrothermal commercialization is established, and that developers learn how to operate within that framework. These actions must be taken by Department of Energy policy-makers and program managers, by the Geothermal Committee of the Energy Resource Advisory Board (ERAB), by the Interagency Geothermal Coordinating Council (IAGCC), by State officials, and by various contractors who provide program support to DOE. The various work elements are illustrated in Figure 12 and discussed in subsequent paragraphs.

Policy Reform

Confusing, conflicting, and unfavorable laws continue to form the basis for much of Federal and State policy toward hydrothermal commercialization. Issues to be resolved include resource definition, leasing policy, tax and other financial incentives, environmental constraints, formation of district utility systems, and regulatory agency authority. Under this program element, the development of National legislation will be primarily the function of DOE and IAGCC; these agencies will work closely with appropriate Congressional committees. Changes in existing laws and favorable new incentives are both needed.

At the State level, legislative reform will be sought in three ways: (1) The Geothermal Policy Project of the National Council of State Legislators (NCSL) will continue to serve as the principal forum for legislative change in the States. Work initiated in 1978 will continue in New Mexico, Utah, Oregon, Hawaii, Virginia, and Maryland and this work will be expanded to Arizona, Washington, Nevada, and Delaware during 1980. (2) DOE State Team members are required to work with and to support the NCSL program where that activity is underway. Where it is not, team members are required to work independently with appropriate energy and natural resource legislative committees to effect favorable legislative reform. (3) The State Policy Review task encompasses a continuing review of state policies regarding geothermal energy, including leasing, taxation, district utility system formation, and definitional questions regarding the character of the geothermal resource.

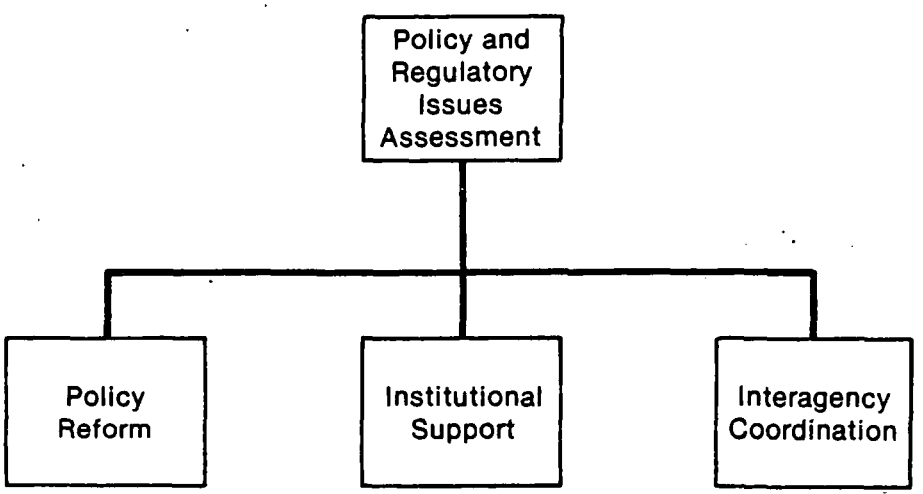

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Figure 12. Policy and Regulatory Issues Assessment block diagram

Institutional Support

Unsatisfactory legislation proliferates into inadequate, unclear, and restrictive regulation, with which developers are unable or unwilling to cope. For this reason, it is important to have a wide range of institutional support services available to DOE program managers, to those engaged in preparation of regulations, and to developers trying to cope with these regulations. Such support services will be provided by selected Federal contractors with the required expertise, by consultants, and by contracted State officials.

Analyses concerning geothermal omnibus legislation, tax credits and tax system reform, and State leasing policies will be continued. The information about and benefits of hydrothermal energy developed in these analyses will be disseminated as widely as possible, both to regulators and to developers.

In each State, a State Commercialization Team will complete an institutional handbook. This handbook will present a compilation of Federal and State environmental, siting, and other regulations governing hydrothermal development in that State. The purpose of the handbooks will be to assist developers in understanding applicable regulations and to facilitate the permitting process. Contracted State officials will provide assistance to DOE efforts in this work. For instance, as DOE-supported drilling activities expand, these State officials will become directly involved in generic and site-specific environmental evaluations and approvals.

Interagency Coordination

Regulatory officials at all governmental levels must be made aware of the need to streamline regulatory procedures and to correct jurisdictional overlaps and duplications in order to facilitate the permitting and leasing processes. To ensure that this is done, the IAGCC will continue to serve as the principal coordinating body to resolve policy issues that involve overlapping jurisdiction and the interests of a number of Federal

agencies. The IAGCC will also serve as a focal point for the initiation of Federal agency geothermal energy programs. In addition, the U.S. Geological Survey (USGS), the Bureau of Land Management (BLM), the Environmental Protection Agency (EPA), the U.S. Forest Service (USFS), and other Federal agencies with jurisdiction over project development must undertake a concerted effort with the appropriate State officials to simplify permitting requirements and approval procedures for project developers. The objective of this work is twofold: first, to decide what permitting criteria must be met to satisfy both Federal and State agencies and, second, to bring about the resolution of interagency conflicts.

G. Progress Monitoring

All concerned with hydrothermal commercialization need to be aware of the changing barriers to development; understanding of these barriers must be dynamic. Without such understanding on the part of DOE, other Government agencies, and decision-makers in both the public and private sectors, the Hydrothermal Direct Applications Program cannot be responsive to changing conditions.

Two elements, Commercialization Barrier identification and Activity Reporting, are included in the program to provide the coninuing understanding necessary to a vital program of hydrothermal commercialization. These elements are illustrated in Figure 13 and discussed in subsequent paragraphs.

Commercialization Barrier Identification

Failure to understand changes in barriers to commercialization and to identify new barriers as they develop is itself a barrier to a successful commercialization program. Thus, the identification of barriers to commercialization needs to be continued in order to ensure proper and timely program control and direction. This work will continue to be performed through semiannual surveys of commercial direct heat users, both current and potential. The surveying will be accomplished, in part, by attendance at working group meetings, advisory group meetings, technical

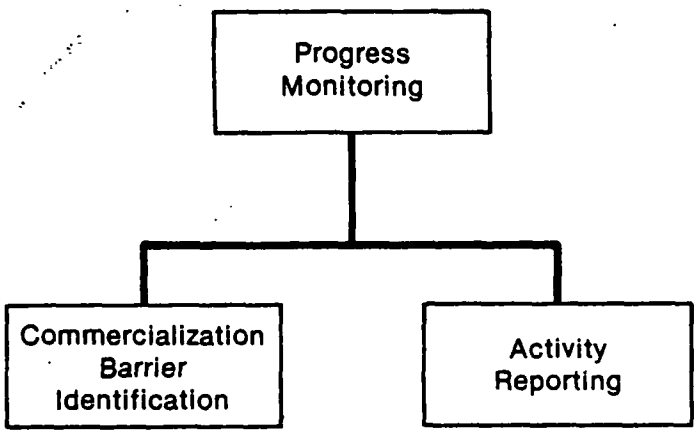

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Figure 13. Progress Monitoring block diagram

meetings, and one-on-one discussions. Resource and potential user data developed by individual States, by DOE contractors, and by others will be reviewed for barrier identification. Identified barriers will be prioritized and translated into commercialization planning requirements. The prioritization will be accomplished with the assistance of industry, and by cost/benefit analyses. These data will be summarized and categorized by industry and application type, including an overall summary, to provide the basis for future program emphasis, changes, and control.

Activity Reporting

Decision makers in both the public and private sectors must be made knowledgeable about the opportunities in and the benefits of hydrothermal development. The purpose of this work element is to collect progress information and to disseminate it as widely as possible. Continued identification of the current status of hydrothermal commercialization and the reporting of commercialization activities that are taking place is also needed by DOE for progress monitoring and evaluation.

Continued preparation and maintenance of State commercialization baseline documents will provide basic data and thus allow ongoing progress monitoring and evaluation of programmatic activity effectiveness. Information to be maintained in the State commercialization baselines will include such basic data as hydrothermal resource locations, leasing status, exploratory activities, operational systems, development plans, Government-assisted activities, energy use patterns, leasing and permitting policies, and selected references to publications on hydrothermal topics of interest to the States. These documents are to be distributed to appropriate Department of Energy Headquarters and Field Offices, Federal Region directors, State governors, State resource and commercialization team members, the National Conference of State Legislators, and anyone who requests copies.

Primary input for the documents will be obtained from State Team members who are performing outreach work. In those states that do not have established outreach programs, information will be gathered annually from

appropriate State agencies. Approximately one-third of all State baseline data documents have been published or exist in draft form; baseline documents for all other states with hydrothermal resources have yet to be developed. Once developed, each baseline document will require annual updating, which will allow development to be measured, trends to be evaluated, and needs to be assessed, so that program effectiveness can be determined and program plans can be modified to fit changing needs.

As a further (and more timely) aid to monitoring the development of hydrothermal energy use, activities affecting commercialization will be reported monthly through appropriate DOE Field Offices to DOE Headquarters. These news items will be obtained from those States that have established commercialization teams. Events reported and tracked will include leasing, permitting, drilling, and other commercial activities, State agency activities, and significant DOE activities within each State.

V. COST AND SCHEDULE SUMMARY

The program cost estimate is presented in Table 1 and the schedule is presented in Figure 14. The program is designed to stimulate the commercialization process at various stages where barriers impede full utilization of this valuable resource. Approximately 67 percent of the total budget will be directed to reservoir confirmation and 11 percent will provide for technology demonstrations. State planning and development requires 9 percent of the budget, and the remaining 13 percent will be used for market development, environmental assessment, policy and regulatory issues assessment, and progress monitoring.

In fiscal years 1982 through 1985, approximately $100 million to $130 million per year will be necessary to fully stimulate the commercial sector. The heavy emphasis on funding during this period is due primarily to the demands for user-coupled drilling (a sub-element of reservoir confirmation). After 1985 the Government funding requirements will drop rapidly for a two-year period while commercial investments increase rapidly. Government stimulation will not be required after 1987.

If the resource is effectively developed it is estimated that by the year 2020 hydrothermal energy will have a total revenue return to Federal, State, and local governments on the order of $26 billion. A cumulative balance of payment advantage of more than $300 billion could also be realized through the same year. In order to accomplish this it is estimated that the Federal Government will need to support the program at a total level of $655 million through fiscal year 1987. Industry will also have to invest in the neighborhood of $150 billion by the year 2020.

TABLE 1. NATIONAL HYDROTHERMAL DIRECT APPLICATIONS PROGRAM
(Millions of Dollars)

	FY-80	FY-81	FY-82	FY-83	FY-84	FY-85	FY-86	FY-87
Market Development[a]	6.1	9.2	12.3	12.7	11.2	9.2	6.0	2.5
State Planning and Development	3.7	7.7	10.2	11.4	11.0	8.0	4.0	---
Reservoir Confirmation	5.3	19.0	77.0	90.0	90.0	74.0	50.0	33.0
Technology Demonstrations	14.2	20.0	12.9	10.3	7.7	1.2	1.0	0.9
Environmental Assessment[b]	---	0.7	1.6	1.8	2.2	1.7	1.2	0.2
Policy and Regulatory Issues Assessment	0.3	0.7	0.6	0.6	0.4	0.4	---	---
Progress Monitoring	1.4	1.6	1.9	2.0	1.4	1.0	1.0	---
	31.0	58.9	116.5	128.8	123.9	95.5	63.2	36.6

a. Excludes cost of GLGP, which does not come from operating funds.

b. Excludes Environmental Baseline Data cost estimate of $2 million per year, which will be requested from DOE-EV.

NATIONAL HYDROTHERMAL
DIRECT APPLICATIONS
PROGRAM PLAN SCHEDULE

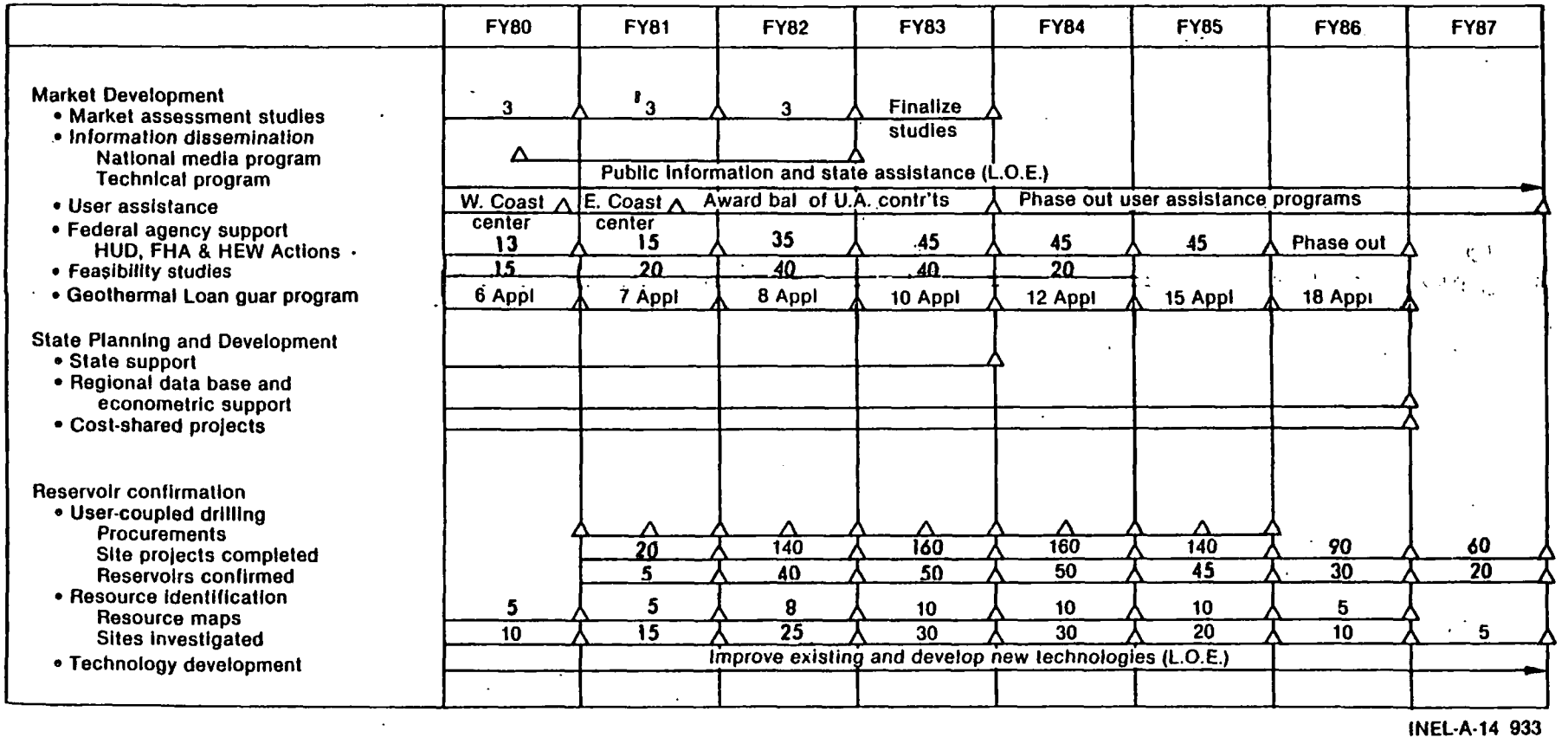

Figure 14. Program Schedule

NATIONAL HYDROTHERMAL
DIRECT APPLICATIONS
PROGRAM PLAN SCHEDULE

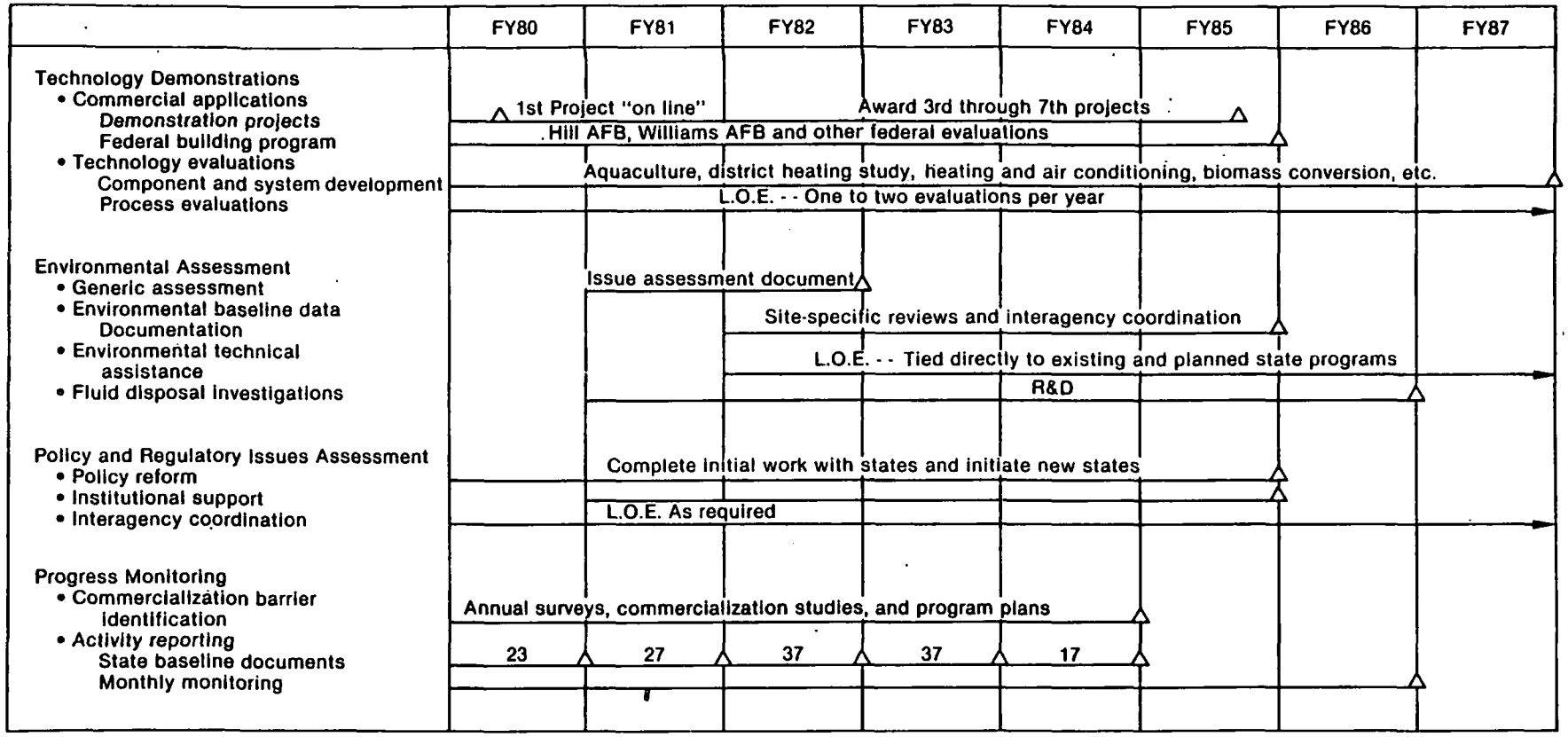

Figure 14. Program Schedule (Continued)

APPENDIX

Several analyses have been made to estimate the market potential of hydrothermal energy direct heat applications. Analyses for the ten states in the Rocky Mountain Basin and Range* were done by the EG&G Idaho, Inc. Geothermal Division[1] and by the New Mexico Energy Institute (NMEI) Physical Science Laboratory.[2,3] For California and Hawaii, anlyses were done by Science Applications, Inc.[4] and Action Resources, Inc.[5] respectively.

The EG&G Idaho analysis involved matching hydrothermal resources with potential uses on a county-by-county basis in the ten states. Guidelines used in compiling the industrial data were:

1. The lower and upper temperature limits for processes compatible with hydrothermal energy were 40 and 275°C respectively.

2. Hydrothermal energy could be supplied as hot water, steam, or hot air, depending on process needs, and could involve the use of intermediate heat exchangers.

3. Process energy requirements need not be met totally by hydrothermal energy to consider an industry as a candidate for hydrothermal energy use.

4. Only industries within Standard Industrial Classification (SIC) four-digit categories were considered, to ensure availability of supporting data.

The region's hydrothermal resources, as defined by the University of Utah Research Institute's Earth Science Laboratory, were mapped for each of the ten states. Next, the counties overlying the resource areas were identified. The listing of SIC industries for each of these counties was reviewed to identify the process industries located there that could use hydrothermal energy.

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* The states included are Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, North Dakota, South Dakota, Utah, and Wyoming.

County-level data on the number of employees in each such industry were multiplied by an energy intensity coefficient (millions of Btu per year per employee) developed through a regional Northwest study.[6] This coefficient was used to establish energy consumptions by those industries having processes compatible with hydrothermal energy. This value was multiplied by a factor for each SIC category in order to exempt such energy consumptions as product sizing, packaging, handling, and transportation. (While this factor is based on engineering value analysis, several cases were correlated with data developed in a solar energy applications study performed for DOE by Intertechnology Corporation.[7] These cases were found to be consistent.)

Since the energy intensity coefficient did not consider waste heat, an assumption of 50 percent cycle efficiency was applied to all processes. Energy use and employment data were available for the period 1972 to 1975. For each survey, all available data were conservatively assumed to be representative of 1975, and that year was set as the base year for growth projections.

The county-level detail was summed by State and region to establish the 1975 total (industrial, residential/commercial) market for potential conversion to hydrothermal energy. This baseline market thus consists of industries whose processes are readily adaptable to hydrothermal energy in counties with good promise of usable resources.

Several energy growth components (and other factors) must be considered in order to forecast use of hydrothermal energy in the region for the years 1985, 2000, and 2020. These factors include:

1. Hydrothermal retrofit of the existing baseline market

2. Normal growth of the baseline market and capture of a portion of that growth by hydrothermal energy

3. Additional industrial growth resulting from new related industries suited to hydrothermal energy

4. Development of hydrothermal resources in counties not previously thought to have such promise

5. Relocation of existing firms to the region's hydrothermal resources.

The following assumptions were made in determining the factors listed above:

1. Starting in 1980, the total 1975 baseline market (industrial plus R/C) was assumed to be retrofitted at the rate of 1 percent per year. This retrofit was assumed to continue until a maximum of 25 percent of the 1975 baseline market has been converted to hydrothermal energy (i.e., in the year 2005).

2. From a Ford Foundation report on industrial growth patterns in the United States, a growth rate was developed for each of the SIC categories that make up the industrial 1975 baseline market. This growth rate was assumed constant to the year 2020 and was used to calculate the energy use in each SIC category in each State. The resulting values from 1985 through 2020 were summed to obtain a value for each State's industrial baseline market adjusted for industry growth to these future years. An additional growth factor based on the traditional increase in per capita energy consumption was added. This assumed growth rate was 3 percent compounded annually, based on the 1975 industrial baseline figures. Hydrothermal energy was assumed to capture none of the total projected normal growth until 1980. Beginning in 1980, the capture was assumed to be 80 percent of all such growth.

Normal growth projections for the R/C sector were assumed approximately 4 percent per year based on the Federal Project Independence Report.[8] Per capita consumption was assumed to increase at a compounded rate of 3 percent a year for the R/C sector, as for the industry sector. Capture in the R/C sector was assumed also to start in 1980 but the capture percentage was assumed to be 70 percent rather than the 80 percent capture assumed for the industrial sector.

3. The stimulated industrial growth resulting from the availability of an economical, stable hydrothermal energy resource base was assumed to attract, by 1985, new allied suppliers and service industries not currently part of the basline market. To account for these new enterprises, 5 percent per year compounded annually was added to the predicted market size starting with the year 1985. Hydrothermal energy was assumed to capture 80 percent of such growth as well.

4. The impact of newly discovered hydrothermal resources was assumed to start in the year 2000. For that year and the year 2020 the impact of such new discoveries was taken as a percentage of the total adjusted baseline (industrial and R/C) in those years. Percentages used for the states: 0 percent (no impact) for Arizona, 1 percent for Nevada, 5 percent for Idaho, 15 percent for Colorado, and 20 percent for the remaining six states. Again, the capture rate due to these new discoveries was taken to be 80 percent for the industrial component and 70 percent for the R/C component.

5. The relocation of existing firms to the region's hydrothermal resources was estimated on a regional basis. The additional market due to this relocation was derived as follows: On a national average, 68 percent of the total industrial energy consumption could be served by hydrothermal energy, because

40 percent of all use is process steam and 28 percent is direct process heat. Therefore, 68 percent of the region's increase in total industrial energy consumption, less the increase in that portion already colocated with hydrothermal resources, forms the "industrial relocation market." For each of the years 2000 and 2020, the analysis assumed that 40 percent of this market would, in fact, relocate.

Table A-1 is a summary of EG&G's analysis of the hydrothermal potential for the ten states of the Rocky Mountain Basin and Range. The table shows (1) energy use for the industrial and R/C sectors; (2) potential hydrothermal use (from the 1975 baseline adjusted for the various growth factors discussed in the previous paragraphs); and (3) forecasted geothermal capture for these sectors. Three important considerations are omitted from these values, however -- the potential market for cogeneration, geothermal heat pumps, and new process development markets, such as process energy for motor-fuel-grade alcohol production. Figure A-1 shows the county-by-county crossmatch of hydrothermal resources and potential users. Figure A-2 illustrates the market growth projections for hydrothermal energy in the Rocky Mountain Basin and Range Region.

NMEI used an economic-engineering computer simulation model (the code is called BTHERM) to aid in assessing the economic feasibility of low-temperature hydrothermal energy for residential and commercial district space heating, water heating, and industrial process heating. The model provides a framework for determining the effects of policy and economic variables in hydrothermal direct use development.

The model requires four inputs:

1. Heat requirements at a specific location

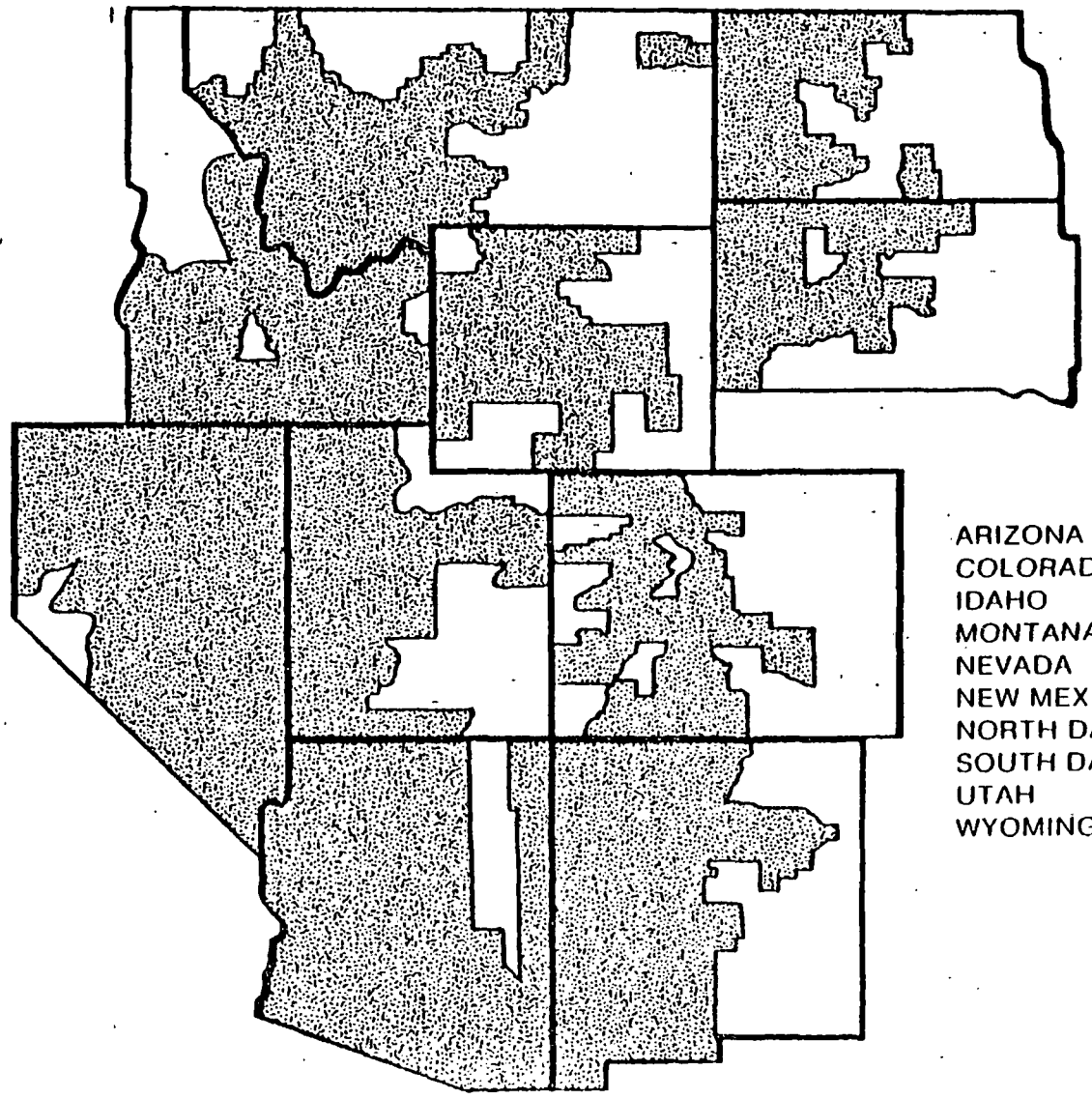
2. Engineering parameters and costs required to meet heating needs

3. Geophysical inputs of the geothermal anomaly (resource data file)

4. Financial and policy variables.

TABLE A-1. ROCKY MOUNTAIN BASIN AND RANGE
HYDROTHERMAL FORECAST FOR YEAR 2000

	Regional Energy Use (quad/yr)	Potential Geothermal Use (quad/yr)	Forecast Geothermal Capture (quad/yr)
Industrial	2.81	0.32	0.21
Residential/commercial	2.57	1.18	0.60
Industry relocating	—	0.52	0.21
TOTAL	5.38	2.02	1.02



	Number Of Counties	Counties With Resources/ User Match	Counties With Some Potential Resource/ User Match	Counties With No Known Resources
ARIZONA	14	7	6	1
COLORADO	63	17	9	37
IDAHO	44	20	11	13
MONTANA	56	20	7	29
NEVADA	17	15	0	2
NEW MEXICO	32	14	4	14
NORTH DAKOTA	53	19	1	33
SOUTH DAKOTA	67	21	7	39
UTAH	29	18	0	11
WYOMING	24	12	0	12
	399	163	45	191

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Figure A-1. County-by-county crossmatch of potential resources and users in the Rocky Mountain Basin and Range

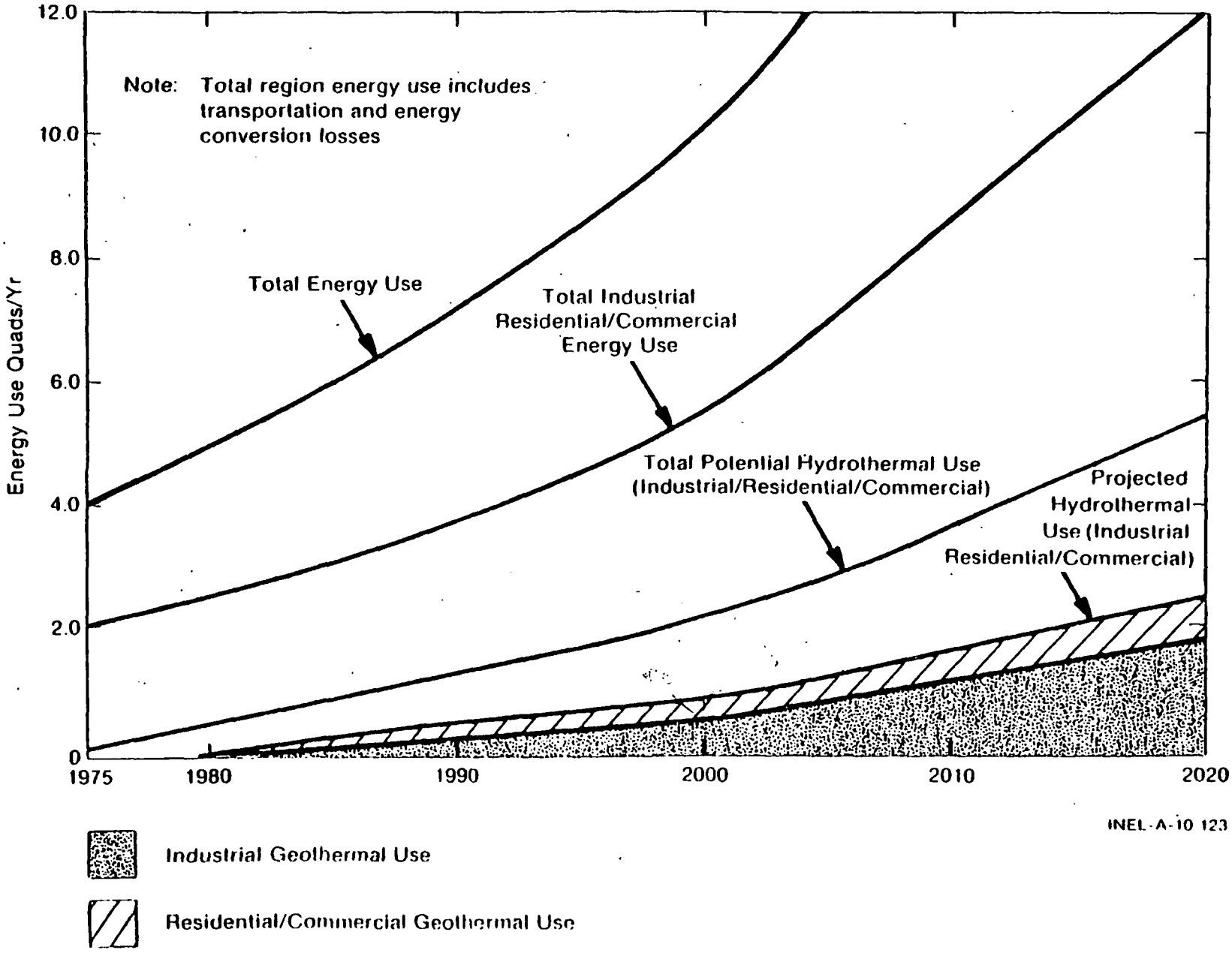

Figure A-2. Market growth projections for hydrothermal energy in the Rocky Mountain Basin and Range

The output of the model are:

1. The delivered price of geothermal energy charged by either a city or a private developer for existing or new growth consumers.

2. The estimated investment costs by category of investment.

3. Comparison of taxes, royalties, and consumer savings generated by hydrothermal energy for that city or industrial user versus the usual fuel type for that particular locale.

The NMEI analysis considered four different policy options, classified as high, medium, low, and low-low. These options, along with the projected economically possible market penetration for each, are given in Table A-2. The values given in the table for possible market penetrations are sums for the ten Rocky Mountain Basin and Range States for the year 2000. These values do not include the market potential for space cooling, industrial relocations, cogeneration, and geothermal heat pumps.

The methodology for the California and Hawaii studies was similar to that of EG&G. The studies both matched potential geothermal resources with potential uses; i.e., industries were colocated with resources. The matching was done by geographical areas and SIC categories.

The California analysis involved a survey questionnaire. Two groups of companies were queried. The first mailing consisted of companies in the following four SIC categories: (1) food and kindred products, (2) lumber and wood, (3) paper and allied products, and (4) chemicals and allied products.

These four categories were identified as major targets for the direct use of hydrothermal energy. They account for 35 percent of the purchased fuels and electric energy used for industrial heat and power in California.

TABLE A-2. POLICY OPTIONS WITH PROJECTED ECONOMICAL HYDROTHERMAL MARKET PENETRATION[a]

Federal Stimulus	Actions Involved	Economically possible Market Penetration for Year 2000 (quads/year)
High	100% reservoir confirmation 25% matching fund Investment and depletion credits	0.78
Medium	100% reservoir confirmation Investment and depletion credits	0.50
Low	50% reservoir confirmation Investment and depletion credits	0.12
Low-Low	Investment credits and depletion allowance expire per current legislation	0.03

a. All four cases assume a synthetic fuel price limit of $20 per million Btu's ($100-$120 per barrel of oil).

The second group of companies was not limited to the four SIC categories of the first group. Instead, companies located within twenty miles of known thermal springs or wells were selected. The California Manufactures Register was used for company information organized by SIC as well as by geographical location.

Assuming that 10 to 20 percent of the companies could actually utilize hydrothermal resources (a conservative figure), the survey showed that between 23 to 69 trillion Btu would be used for geothermal energy. For the base year 1980, 56 trillion Btu was taken as the most likely amount of energy to be displaced by hydrothermal. The survey indicated an average annual production growth rate of 4 percent over the next five years. It was assumed that following this five-year period, recessionary activity and conservation would slow down the growth of energy use. Thus, a further production growth rate of 2 percent was assumed after 1985. The "best estimate" for hydrothermal utilization by the industrial sector by the year 2020 was 0.038 quad/year.

The Hawaii analysis resulted in a breakdown of gross Btu consumption by the R/C and industrial sectors for each county. Twenty potential geothermal sites identified by the Hawaii Institute of Geophysics were used as the resource base. Areas within a twenty-mile radius of each site were considered potential geothermal market areas. Adjustments were made for physical barriers such as high mountain ranges and the ocean. Industries involving processes requiring direct heat applications or preheating were selected and classified by SIC and location. Potential market growth was derived through forecasting based on projections (by the State of Hawaii Department of Planning and Economic Development) for energy demands, population, and tourism, as well as an industry surveys.

Industry growth rates were developed for each of the SIC categories from company interviews, industry projections, and State projections.

New discovery factors were not applied to potential geothermal growth since all major population, commercial, and industrial areas of the State are located within potential geothermal market areas.

Industrial relocation to geothermal resources was not considered. The state was assumed to attract no industries requiring energy-intentive processes. If industrial relocations were added to the projection, the hydrothermal growth rate could increase dramatically.

The market capture potential estimates were developed on a county basis. An estimated 20 percent industrial retrofit was assumed by the year 2000. Geothermal was projected to capture 50 percent of the new growth in the year 1985 on Hawaii, Honolulu, and Maui, and in the year 2000 on Kauai.

The potential capture for R/C was based on an assumed 1 percent per year retrofit rate, beginning in 1990 for Hawaii, Honolulu, and Maui, and 2005 for Kauai. Starting in 1985, new growth on Hawaii, Honolulu, and Maui was estimated to be a maximum of 30 percent by 2000.

For the study it is forecasted that the geothermal capture in Hawaii for the year 2000 would be 0.02 quad/year.

Table A-3 summarizes the projections given in these studies of the hydrothermal energy that could be used by the year 2000. Since NMEI did not include factors for industry relocation and space cooling, the EG&G study[3] and a Brookhaven National Laboratory report[9] were used to estimate these two values. The values were then added to the NMEI estimate to provide a comparison between the two 10-state analyses. None of the studies included a market penetration for the use of geothermal heat pumps, cogeneration, or new process development. The California and Hawaii analyses did not project industry relocation, and the Hawaii study did not estimate space cooling.

Since these studies include only 12 states, it was necessary to make some National projections. Using the data in USGS Circular 790, a ratio of 0.11 was obtained for the beneficial heat from geothermal energy in the 38 states not included in the studies. A ratio was also taken with wellhead thermal energy, with the same result. The ratio was then multiplied by the estimated total energy capture in the United States to obtain a projected value of 0.1 quad/year for the states not included in the studies.

TABLE A-3

ESTIMATE OF ENERGY CAPTURE IN THE UNITED STATES USING HYDROTHERMAL BY THE YEAR 2000

		Quad/Year	
I.	EG&G Analysis 10 States RMB&R	1.0	
II.	NMEI "Mid Case" 10 States RMB&R	0.5	
	- Addition for Industry relocation	0.2	
	- Addition for Space Cooling	0.08	
	NMEI Mid-Case Subtotal	0.8	
	Range of Case I and Case II		0.8-1.0
III.	SAI Analysis of California "Best Estimate"		0.05
IV.	Action Resources Inc. Analysis of Hawaii		0.02
V.	Estimate 38 States Not Analyzed (Ratio Beneficial Heat in 38 States/Total US from USGS Circular 790 = 0.11)		0.1
	TOTAL ESTIMATED U.S. CAPTURE		0.97-1.17

These estimates are based on the best information available today, but the actual penetration rate will depend on the overall United States energy policy and incentives available for alternative energy developments. From these analyses and with the emphasis placed on the development of hydrothermal resources as specified in the assumptions, it is reasonable to project a direct heat application goal of 1 quad per year in the United States by the year 2000.

In an attempt to better identify the goals for direct heat application, a model by Technecon Analytic Research, Inc., will be used. Technecon has developed a quantitative decision model which estimates the likelihood of positive industry decisions to invest in the development of specified hydrothermal resources. This computerized instrument was developed for the Division of Geothermal Resource Management of the U.S. Department of Energy for use in Federal program policy and assessment.[10]

The hydrothermal decision model comprises two primary submodels: One performs a stochastic cash flow analysis of a specified hydrothermal well field venture. The other estimates the probability of industry investment based upon results from the cash flow analysis. The model incorporates updated well field cost data, geologic reservoir data, and competitive regional energy prices to provide current and realistic cash flow parameters. The investment decision submodel embodies conclusions from extensive field interviews with industry decision-makers, and results from multiple regression analyses of industry-supplied decision data.

The model represents a new approach to investment and policy analysis. The modeling approach is based upon an integration of two factors: multiattribute utility methods for multiobjective decision analysis, and logic methods for probabilistic choice estimation.

At present, the operational model estimates investment decisions by hydrothermal resource developers to develop well fields. Efforts are underway to develop an instrument to estimate the likelihood of industry decisions to select hydrothermal energy for direct process applications.

REFERENCES

1. EG&G Idaho, Inc., Rocky Mountain Basin and Range Regional Hydrothermal Market Penetration Analysis, October 13, 1978 (updated January 23, 1979; unpublished).

2. Roy Cunniff et al, Geothermal Energy for Residential, Commercial, Industrial Users, New Mexico Energy Institute, NMEI 30-5.

3. Roy Cunniff et al, "Geothermal Market Penetration Assessment," included in the Proceedings of the DGE/DGRM Resource Assessment/ Commercialization Planning Meeting, Salt Lake City, January 21-24, 1980.

4. Science Applications, Inc., "Market Survey for Direct Utilization of Geothermal Energy in California," January 17, 1980 (unpublished).

5. Action Resources, Inc., "Hawaii Hydrothermal Market Penetration Analysis," October 1979 (unpublished).

6. Rocket Research Co., Inc., "Industrial Waste Heat for Adjacent Communities and Industrial Application Task I," draft, RRC-78-H-181, December 21, 1977.

7. Intertechnology Corporation, "Analysis of the Economic Potential of Solar Thermal Energy to Provide Industrial Process Heat," vol. III, COO/2829-76/1, February 7, 1977.

8. Federal Energy Administration, Project Independence Report, November 1974.

9. M. Beller, ed., Sourcebook for Energy Assessment, Brookhaven National Laboratory, BNL 50483, December 1975.

10. T. A. V. Cassel et al, "Geothermal Investment and Policy Analysis with Evaluation of California and Utah Resource Areas," Document No. DOE/RA/ 4713-1, October 1979. (Available from National Technical Information Service, Springfield, VA 22161.)