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SUBJECT: ASSUMPTIONS IN GEOTHERMAL ENERGY DEVELOPMENT

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ASSUMPTIONS IN GEOTHERMAL ENERGY DEVELOPMENT

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1.0 INTRODUCTION

The Federal geothermal program has grown and developed over the past several years in response to various changing forces both inside and outside the Federal government. Underlying the choice of program strategy have been a set of assumptions about the nature and future of geothermal energy in the United States

In this context, an assumption is taken to be a plausible but essentially unproven idea having a major bearing on the geothermal program, which may or may not have been explicitly expressed in the course of development of the geothermal program. Some assumptions may never have received critical examination in the first place, while others may be due for re-examination due to changing external or internal circumstances.

In any case, it is felt that the time is ripe for a re-examiantion of these assumptions, following the recent reorganization of the geothermal program. This paper attempts to enumerate and examine the major assumptions underlying strategic choices which have been made in the program, and to discuss their likely relevance in the future.

Section 2.0 of this paper enumerates the assumptions which have been clearly identified, and delineates some of their interaction, and Section 3 discusses questions of validity and relevance.

2.0 ASSUMPTIONS AND THEIR INTER-RELATIONSHIPS

Twenty major strategic assumptions have been identified, and are listed in Table I. This is clearly not an exhaustive list of assumptions; in particular, the list has been restricted to assumptions which were felt to be of strategic importance to the geothermal program as a whole. This means that major assumptions whose impact was strictly limited to one program area have been excluded, as have those which were felt to be of less than major significance overall.

Most of these assumptions are fairly self explanatory. Assuptions 14 and 15 relate to the formation of an industry which can be regarded as specifically geothermal , in the sense that an oil and gas industry exists today. This will not necessarily happen; it is conceivable that the industry will never reach the size required, or that different utilizations will be fragmented (e.g., geopressured developers may have little in common with hydrothermal developers).*

Assumption 17 states that the major part of the development effort, however specified (e.g., capital expenditure, manpower, sales revenue) will be devoted to electric generation projects.

Figure 1 illustrates the inter-relationships between the assumptions 1 through 20, and the way in which they impact on

*An example of a fragmented major industry is transportation. Railroad operators, airline operators, bus operators, railroad equipment manufacturers, airplane manufacturers and automobile manufacturers are all independent; compare with the energy industry which is both vertically and horizontally integrated.

TABLE I

List of Major Geothermal Program Assumptions

1. There exists/will exist a need for energy
2. Geothermal energy can help fill this need
3. The Federal government can assist geothermal development
4. Technology exists or can be developed to exploit geothermal energy
5. This technology can be made economically competitive with other major energy sources
6. This technology can be made environmentally acceptable.
7. There exist unknown levels of risk in geothermal development.
8. Federal action can reduce the risks or ameliorate the consequences of adverse events
9. There exist adequate geothermal resources to support development
10. Adequate resources to support geothermal development can be discovered and proved
11. Technology is/will be transferable between different types of geothermal utilization
12. Willing buyers for geothermal energy exist
13. Willing geothermal developers exist
14. A specifically geothermal industry can be developed
15. This geothermal industry will be unified
16. Direct utilization will involve many small projects
17. Electric application will dominate development
18. Hydrothermal resources will be developed before other geothermal resources
19. Natural gas will be in short supply
20. Methane will provide impetus for development of geopressured resources

utilization of geothermal energy (items A through F). Intermediate steps by which the Federal government can make impacts are shown enclosed in oval boxes. It is assumed that there will be some feedback from actual development to modify the assumptions, and it is on this aspect that the next section of this report will concentrate.

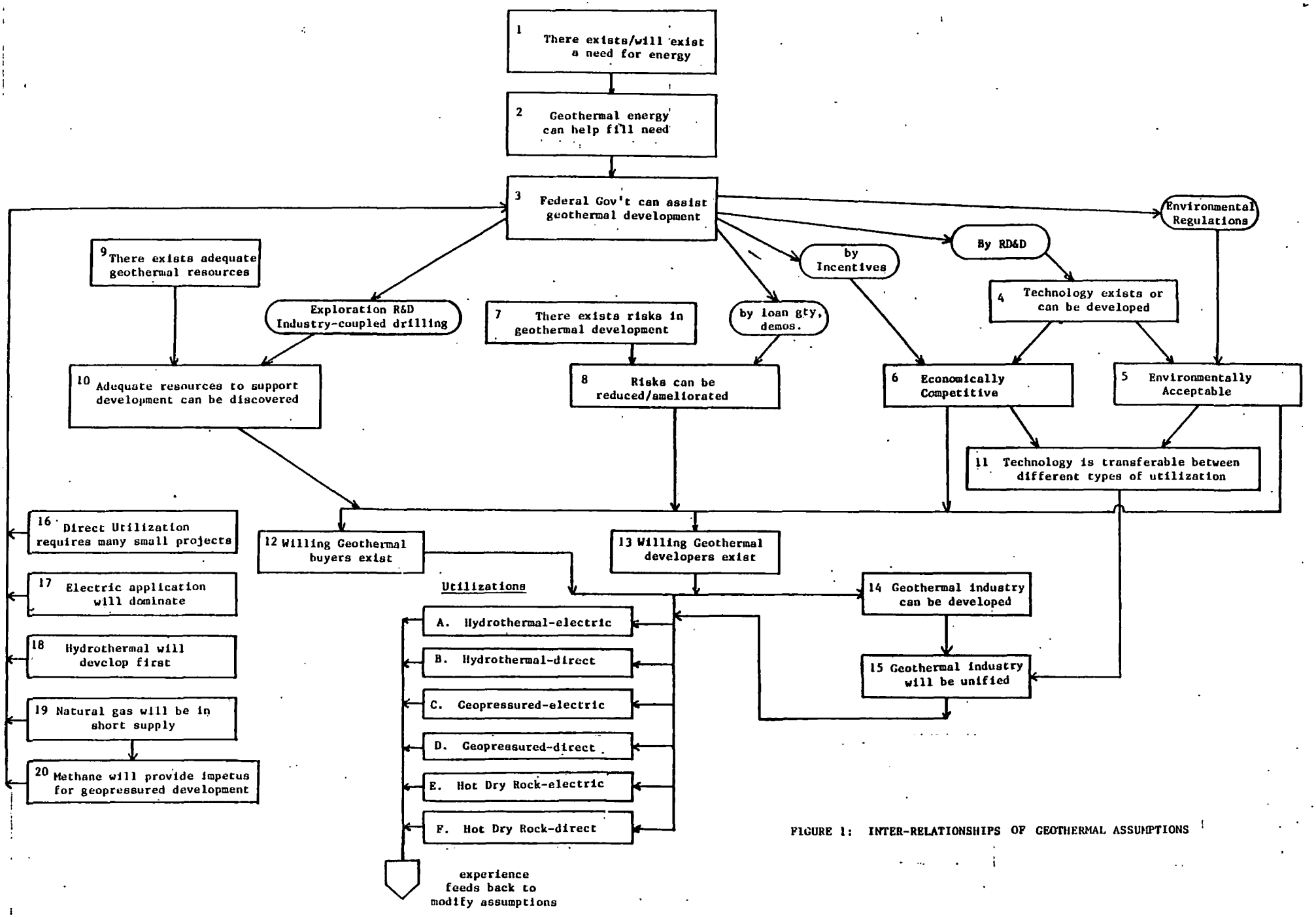

FIGURE 1: INTER-RELATIONSHIPS OF GEOTHERMAL ASSUMPTIONS

3.0 VALIDITY AND RELEVANCE

The purpose of this section is to examine the assumptions to find out which are questionable, and to investigate ways in which questionable assumptions may be verified or disproved. The section starts with a brief case-by-case examination of each assumption.

(1) There exists/will exist a need for energy.

This assumption seems unchallengeable on the face of it. Closer examination reveals, however, that although energy is in short supply now and for the near-term, it is at least conceivable that in the medium to long-term the country may move again into a position of energy surplus.

(2) Geothermal energy can help fill this need.

This is very likely to be true.

(3) The Federal government can assist geothermal development.

Again, this is very likely to be true.

(4) Technology exists or can be developed to exploit geothermal energy

This seems to be true, at least for hydrothermal resources, from experience elsewhere in the world. There remains some question as to how far this experience is applicable to American conditions.

(5) The technology can be made economically competitive.

This is certainly open to question with respect to some types and qualities of geothermal resources.

(6) The technology can be made environmentally acceptable.

This is probably true, although there is an obvious interaction with (5) above.

(7) There exist uncertain levels of risk in geothermal development.

Undoubtedly true.

(8) Federal action can reduce risks and alleviate consequences of adverse elements.

Such means as loan guaranties, reservoir indemnities, cost sharing, etc., can alleviate consequences, but the extent of possible alleviation is not clear. The risks themselves can probably only be understood and reduced by actual field experience, such as demonstration plants.

(9) There exist adequate geothermal resources to support development

Probably true, but open to some doubt for longer-term development.

(10) Adequate resources to support development can be discovered and proved

In view of the current problems of geothermal development, this assumption must be regarded as questionable.

(11) Technology is/will be transferable between different types of utilization

Questionable. It is by no means clear, for instance, that technology developed for hydrothermal resources will be widely applicable to geopressured resources.

(12) Willing buyers for geothermal energy exist.

It seems doubtful whether such buyers exist in sufficient quantities under present conditions to generate development at the desired levels.

(13) Willing geothermal developers exist.

This seems to be true.

(14) A specifically geothermal industry can be developed.

As noted in the preceding section, this is not a foregone conclusion.

(15) The geothermal industry will be unified.

The same comment applies to this as to (14).

(16) Direct utilization will involve many small projects.

This seems true at present, but it is not necessarily true--for instance, the discovery of hydrothermal resources near large cities (e.g., on the east coast) would yield the potential for very large district heating schemes. Such schemes appear technically feasible (e.g., Reykavik, in Iceland).

(17) Electric applications will dominate development.

This appears true for the near-term; probably true for the mid- to long-term.

(18) Hydrothermal resources will be developed first.

This seems true at present.

(19) Natural gas will be in short supply.

Until recently this appeared virtually unavailable. However, recent trends in gas pricing, the shift of some consumers to other fuels, the likelihood of an Alaska gas pipeline and the increasing attractiveness of relatively unconventional gas fields (e.g., Devonian shales and tight sands) all combine to cast some doubt. It

is probably true that gas will continue to be the preferred fuel because of its clean-burning qualities and ease of handling.

(20) Methane will provide impetus for geopressured development.

This appears true; it does not appear feasible to economically develop geopressured resources for their heat and kinetic energy content alone.

Thus, assumptions (2), (3), (6), (7), (8), (13), (18), (19) and (20) appear true on a preliminary examination. The remainder of this section examines in more detail the remaining 11 assumptions, namely (1), (4), (5), (9), (10), (11), (12), (14), (15), (16) and (17) and discusses means of testing these assumptions.

Table II lists these assumptions, with subjective estimates of their validity in the near, mid and long-term, and suggested procedures for testing the assumptions. Assumptions (14) and (15) have been amalgamated in this table.

The procedures suggested in the table for testing the assumptions are fairly self-explanatory. A discussion follows.

(1) The future need for energy can be estimated by examining jointly the many projections which have been made over the past few years. It is probable that anything produced before the oil price rises of 1973-4 is invalid--the basic structure of energy supply and demand has changed so much. Many projections, of course, do not explicitly consider geothermal,

TABLE II

Questionable Assumption, And Suggested Procedures for Testing These

No.	Assumption	Subjective Estimate of Degree of Validity Near-Term	Mid-Term	Long-Term	Testing Procedure
1	Exists (will exist need for energy)	H	H	M	Examine long-range national and regional energy projections. Develop consensus and other scenarios
4	Technology exists/can be developed	M	H	H	Conduct detailed assessments of technologies available and likely to become available for all resource types. Examine R&D program
5	Technology can be made economically competitive	M	M	M	Conduct detailed and realistic economic analyses of available technologies, R&D impacts, fiscal impacts
9	Exist adequate resources	H	H	M	USGS?
10	Adequate resources can be proved	M	M	M	Technology assessment of exploration and resource confirmation; economic analyses of geothermal industry
11	Technology is/will be transferable	M	M	M	See (4) above
12	Willing buyers for geothermal exist	L	M	M	Market penetration analysis with emphasis on actual behavior of potential buyers
14,15	Unified, specifically geothermal industry can be developed	M	M	M	Examine industry dynamics
16	Direct utilization will involve many projects	H	M	M	Examine longer-term potential for large direct use (e.g., district heating) projects, and potential effects on rest of geothermal program if these are viable
17	Electric application will dominate	H	H	M	Examine longer-term potential for large direct use (e.g., district heating) projects, and potential effects on rest of geothermal program if these are viable

or even advanced energy sources as a whole. One possible method for including geothermal is to make separate projections of supply and demand under given price structures, and then examine the shortfall, if one exists, as a potential market for geothermal and other advanced sources.

(4) The existence of hydrothermal technology is quite well established for higher-temperature resources. Technology is not currently available (and is unlikely to become available in the near term) for lower-temperature hydrothermal electric, geopressured and hot dry rock resor ces (this accounts for the M in the near-term subjective validity estimate). The eventual emergence of suitable technology is likely and this could be validated by detailed examiantion of the technologies involved, and the R&D program.

(5) Validation of this assumption is complex. There exists a whole spectrum of geothermal resources, ranging economically from the highly competitive to the very uncompetitve. Detailed economic analyses, in conjunction with the technology assessments in (4) above, would help resolve the extent to which economic competitiveness may be expected. In the medium- and long-term the price trends of competing conventional and advanced energy sources relative to geothermal become critical, so that the choice of the overall national energy supply, demand and price scenario is important.

(9) The existence (or nonexistence) of adequate resources is strictly a matter for resolution by the United States Geological Survey.

(10) The question of proving the existence of an adequate resource base vents on two criteria; the technical adequacy of the tools and methods available, and the economic forces driving investment in exploration activities. Both should be examined in detail. Particular emphasis should be paid to the problem of reservoir modelling, and whether sufficient confidence can be developed in reservoir confirmation techniques to spur rapid investment in utilization of new resources. At present, potential users (as opposed to developers) have adopted a very cautious attitude and appear unconvinced of the longevity of geothermal resources.

(11) This assumption could be tested by the same type of analyses used for (4).

(12) The existence of willing buyers for geothermal is obviously dependant on many factors, such as demand for energy, economic competitiveness, general state of the economy and government actions. The actual dynamics of the process by which buyers will commit themselves to geothermal energy appears to be little understood, even with regard to the decision-making process of utility companies. A detailed market penetration

analysis, with emphasis placed on the actual behavior patterns of potential buyers would be most useful.

(14) & (15) These assumptions have been linked because they represent basically two phases of the same process, namely the development of a unified industry which is recognizable and specifically geothermally oriented. Their validity depends upon the transferability of geothermal technology between different resource types and applications, and upon the dynamics of the industries now involved in developing geothermal energy. One possible approach to testing the validity is by examiantion of the roles and interaction of potential developers and users of geothermal energy (i.e., oil companies, geothermal resource companies, engineering design and construction companies, utilities, etc.). Emphasis should be placed on factors which might impede the development of a unified industry.

(16) Validation of this assumption could be obtained by an examination of the longer-term prospects for direct utilization, including all aspects (industrial processing, district heating, etc.).

(17) This assumption is quite closely linked with the preceding one (16), and may be analysed by an extension of the same examination.