JPL

5106-13

Planning and Technology Transfer Project
for the U.S. Department of Energy
Solar Thermal Energy Systems Division

A Survey of Solar Thermal Energy Systems Manufacturers

Summary Results

Ned Levine
Manager, Survey Research

Marie L. Slonski

October 1981

Prepared for the U.S. Department of Energy through an agreement
with the National Aeronautics and Space Administration,
by the Jet Propulsion Laboratory, California Institute of Technology,
Pasadena, California

JET PROPULSION LABORATORY *California Institute of Technology • 4800 Oak Grove Drive, Pasadena, California 91109*

December 4, 1981

Refer to: ESD:glr

Kirk Battleson
Division of Solar Thermal Technology
1000 Independence Avenue S.W.
Washington, D.C. 20585

Dear Kirk:

During July and August of 1981 we at JPL conducted a survey of all solar thermal technology suppliers that we could identify. The more general findings of this survey have been used by DOE to help evaluate the Solar Thermal Program. Evaluation of all DOE's program at this time was mandated by the DOE Organization Act and has been commonly referred to as the "Sunset Review".

As a member of the Solar Thermal leadership community, I believe that you will find the results both interesting and useful. A copy of a report summarizing our analysis of the responses to the survey is enclosed.

If you have any questions or comments concerning this report, I would be happy to discuss them with you.

Sincerely,

Ab Davis

E. S. (Ab) Davis, Manager
Planning & Technology
Transfer Project
(213) 577-9392

Enclosure

cc: G. W. Braun

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The JPL Solar Thermal Power Systems Project is sponsored by the U.S. Department of Energy and forms a part of the Solar Thermal Program to develop low-cost solar thermal and electric power plants.

Contents

A SURVEY OF SOLAR THERMAL ENERGY SYSTEMS MANUFACTURERS

Summary Results

by

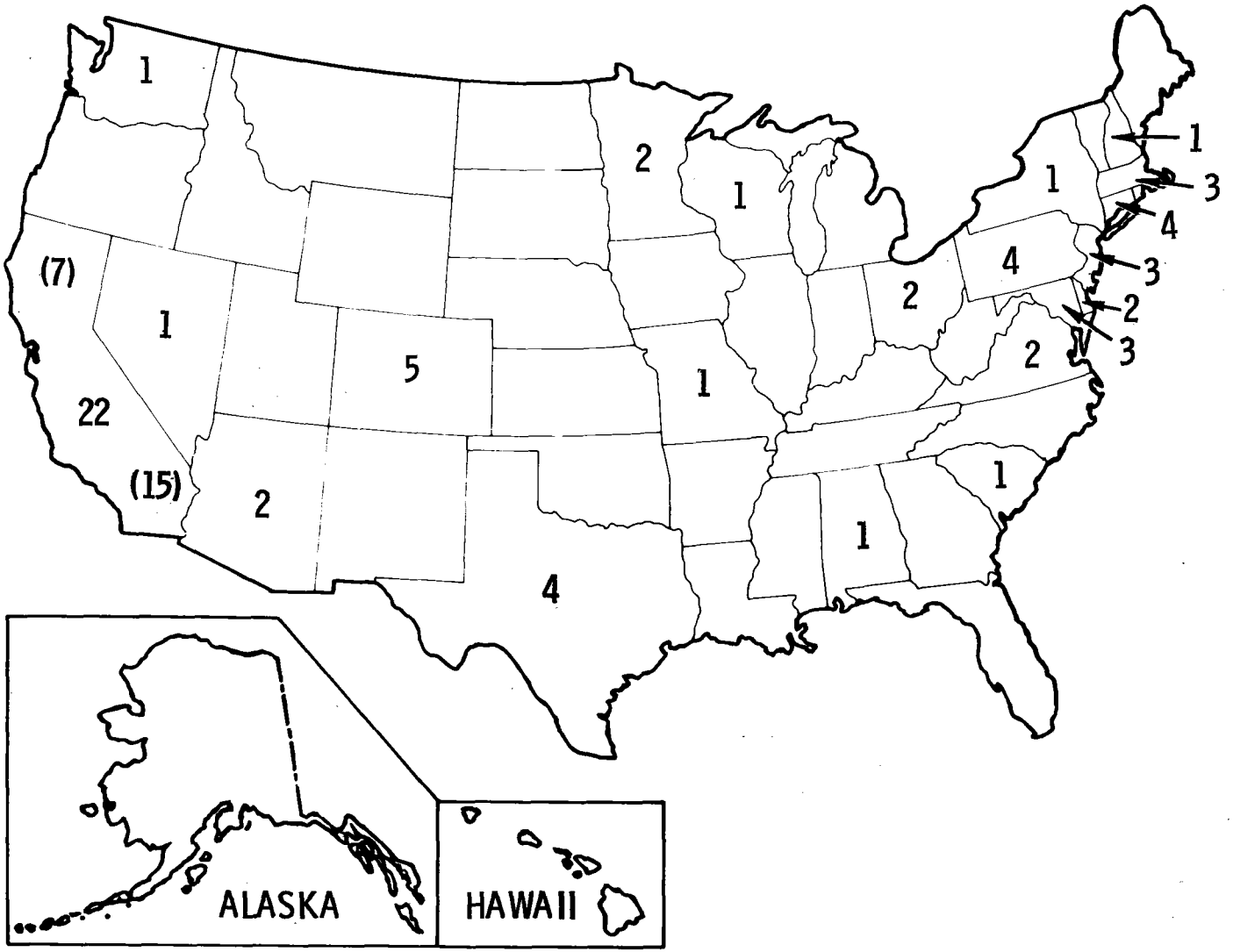
Ned Levine
Manager, Survey Research
and
Marie L. Slonski

A survey of 67 firms who had received U.S. Department of Energy funding for the development of solar-thermal energy systems (STES) was carried out in the summer of 1981. The purpose of the survey was to document the current state of technology development and future marketing plans, evaluate the effect of the Department of Energy Solar-Thermal Technology (STT) program in accelerating development of solar-thermal energy systems, and assess the response to possible discontinuation of the program. Of the 67 firms contacted, 54 were still involved in the development solar-thermal energy systems, while 13 were no longer working on these technologies.

GEOGRAPHICAL DISTRIBUTION OF STES MANUFACTURERS

The geographical distribution of the manufacturers contacted tended to concentrate in California, Colorado, the northeast corridor, and around the Washington, D.C. areas with pockets in Texas and the Midwest.

GEOGRAPHICAL DISTRIBUTION OF FIRMS WHICH RECEIVED DOE FUNDING FOR THE DEVELOPMENT OF STES



DISTRIBUTION OF TECHNOLOGIES

Most firms were working on more than one technology, and more firms were working on central receivers and parabolic dishes than on the other technologies. There is also a significant overlap between parabolic trough and parabolic dish manufacturers, with 80% of the trough manufacturers working on dishes and 60% of the dish manufacturers working on troughs. Unfortunately, this overlap resulted in the responses regarding the two technologies being virtually indistinguishable in the analysis. Consequently, the responses have been grouped together under the heading "distributed systems" throughout most of this report.

A significant number of dish manufacturers were also working on the central receiver technology. Since troughs and central receivers were the earliest technologies to be developed, this suggests that manufacturers are expanding their efforts into new technologies (e.g. the parabolic dish) as they develop. This seems especially apparent since neither central receiver manufacturers nor trough manufacturers tended to work on the other technology.

DISTRIBUTION OF TECHNOLOGIES

CENTRAL RECEIVERS	33
DISHES	32
TROUGHS	24
BOWLS	8
OTHER	14
EVACUATED TUBES	3
SOLAR PONDS	2

DISTRIBUTION OF PRODUCTION FUNCTIONS

Most firms were providing research and development (R&D) to the government. Also, most firms were providing architectural and engineering services (A&E). About half of the firms were manufacturing sub-systems or components, while only about one-quarter were producing entire "turnkey" systems. The heavy concentration of R&D to the government is a function of government sponsorship of STES research, of course. The extent of A&E services suggests that most projects require extensive design and conceptualization. As one would expect, there are also more component and sub-systems manufacturers than "turnkey" system suppliers.

DISTRIBUTION OF PRODUCTION FUNCTIONS

R&D TO GOVERNMENT	43
A&E SERVICES	40
SUBSYSTEMS OR COMPONENTS	24
"TURNKEY" SYSTEMS	14
USING STES ENERGY	8
OTHER	7

PRODUCTION TYPOLOGY

TECHNOLOGIES

In general, there is little relationship between the technologies that manufacturers were working on and the type of production functions they adopted. Thus, a specific technology cannot be treated as a single 'entity'. Rather, each technology can be at a different stage of development. To illustrate this, we have grouped firms into a production typology that compares the technologies with the functions. For each of the three major technologies - distributed systems (dishes, troughs), bowls, and central receivers, there are three functions: "turnkey" systems, engineering sub-systems and components, and "pure" R&D. Thus, the production typology has 9 different possibilities, that are labeled Type 1 through Type 9.

PRODUCTION TYPOLOGY

TECHNOLOGIES / FUNCTIONS	DISTRIBUTED SYSTEMS	BOWLS	CENTRAL RECEIVERS
"TURNKEY" SYSTEMS	TYPE 1	TYPE 4	TYPE 7
"TURNKEY" SUBSYSTEMS AND COMPONENTS	TYPE 2	TYPE 5	TYPE 8
"PURE" R AND D	TYPE 3	TYPE 6	TYPE 9

DISTRIBUTION OF PRODUCTION TYPOLOGIES

Since firms may be working on more than one technology or function, each could be grouped into at least 2 different types; however, it was found that the amount of double categorization is small. When the firms were classified according to the production typologies, it was found that three types were most frequent. The most common type was engineering, sub-systems and components for central receivers (Type 8) where 24 firms were involved in this production function; second were engineering, sub-systems and components for distributed systems (Type 2) with 19 firms, followed by "turnkey" systems for distributed systems (Type 1) with 11 firms. A small number of firms were "pure" R&D firms, either for distributed systems or central receivers (Types 3 and 9, respectively), while only a scattering were working in the other four categories (Types 4, 5, 6, and 7).

DISTRIBUTION OF PRODUCTION TYPOLOGIES
NUMBER OF FIRMS INVOLVED IN EACH CATEGORY

	DISTRIBUTED SYSTEMS		BOWLS	CENTRAL RECEIVERS
"TURNKEY" SYSTEMS	11	(8 BOTH 2 TROUGH 1 DISH) TYPE 1	2 TYPE 4	3 TYPE 7
ENGINEERING, SUBSYSTEMS AND COMPONENTS	19	(8 BOTH 3 TROUGH 8 DISH) TYPE 2	4 TYPE 5	24 TYPE 8
"PURE" R AND D	7	(3 BOTH 4 DISH) TYPE 3	2 TYPE 6	6 TYPE 9

TIME HORIZON FOR DIFFERENT PRODUCTION TYPOLOGIES

There are also differences in the marketing time horizon associated with each of the production types. Firms were asked to estimate how many years it would be until they could market their first STES product without government support. Type 1 firms - "turnkey" distributed systems, were nearest to marketing, with the average firm already marketing. On the other hand, Type 3 firms - "pure" R&D on distributed systems were farthest from marketing. Thus, within distributed systems, we have products that were being marketed or were very close to being marketed, and we have products that were farthest from marketing. The difference seems to be that the near term technologies comprise the trough and the low-temperature dish, whereas the long term technology is the high-temperature dish, which is in the design stage.

Across all the technologies, companies offering "turnkey" systems were closest to marketing. Engineering, sub-systems and components manufacturers were closer to marketing than those firms that were only working on research and development.

TIME HORIZON FOR DIFFERENT PRODUCTION TYPOLOGIES

NUMBER OF YEARS UNTIL MARKET STES WITHOUT DOE SUPPORT

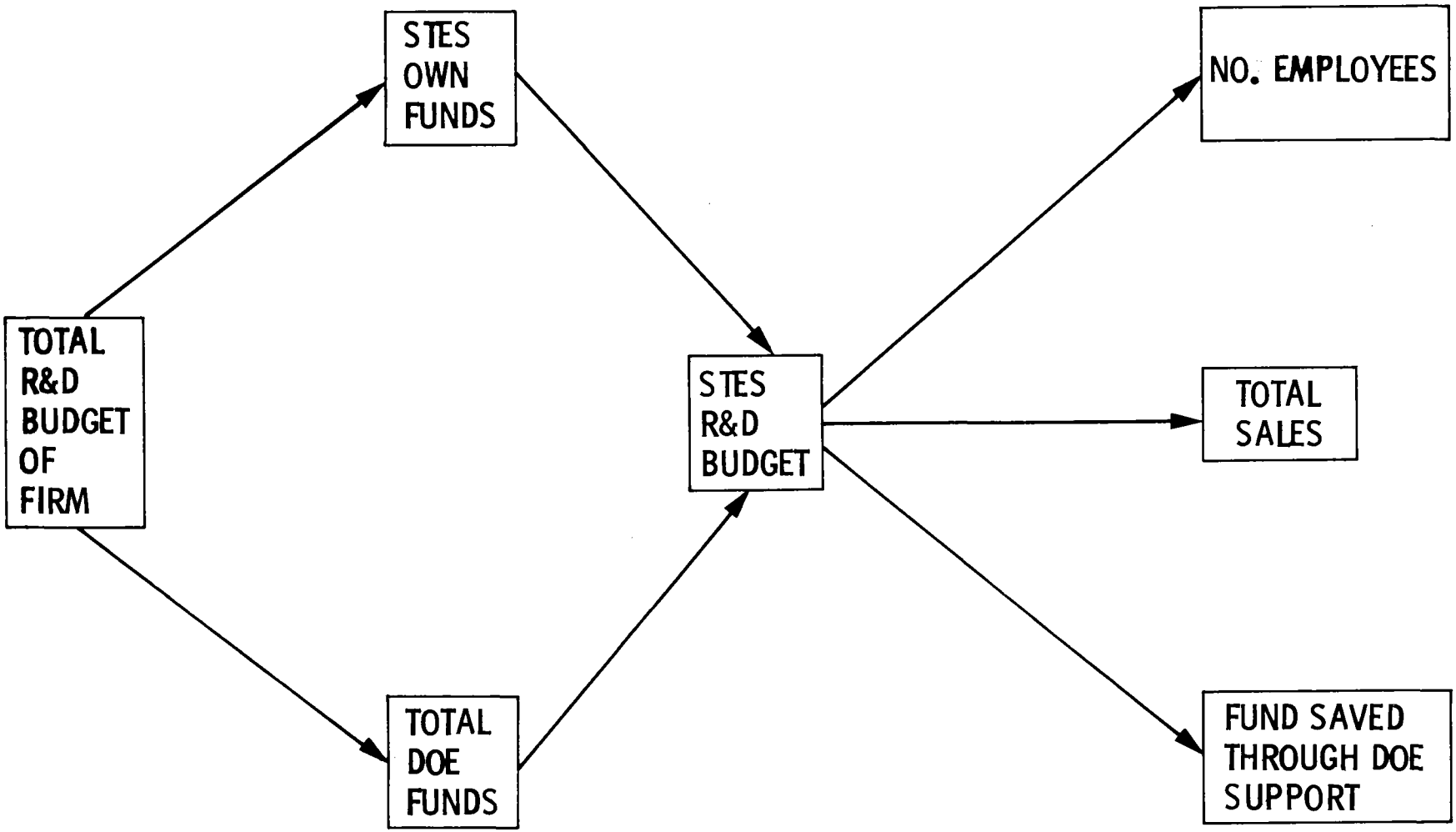
MEAN (STANDARD DEVIATION)

	DISTRIBUTED SYSTEMS	BOWLS	CENTRAL RECEIVERS
"TURNKEY" SYSTEMS	-0.3 (4.0) TYPE 1	2.0 (7.1) TYPE 4	1.3 (5.1) TYPE 7
ENGINEERING, SUBSYSTEMS AND COMPONENTS	3.8 (4.6) TYPE 2	4.5 (3.1) TYPE 5	3.9 (4.1) TYPE 8
"PURE" R AND D	4.8 (2.8) TYPE 3	TYPE 6	4.5 (2.1) TYPE 9

SCHEMATIC MODEL OF FIRM SIZE

The size of the firm is an important factor for production decisions. The size of the firms in the sample included several very large firms, some medium-size firms, and some small and very small firms. Generally, the larger firms had more research assets, hired more staff, developed more projects, approached larger-scale projects, attracted more Department of Energy funding, put more capital into STES, and planned to sell more than small firms. The strength of the correlations among these variables is very high. This viewgraph illustrates the relationships.

SCHEMATIC MODEL OF FIRM SIZE



SIZE OF FIRM BY PRODUCTION TYPOLOGY

Production decisions are also related to the size of the firm. The survey sample was roughly divided into three groups based on the total amount of STES funding (both DOE funding and internal funding). The large firms tended to work on central receiver technologies (Types 7-9) and distributed system technologies (Types 1-3) to an equal degree. The smaller firms tended to work primarily on central receiver technologies (Types 7-9) and, to a lesser extent, on distributed system technologies (Types 1-3). The medium-size firms, on the other hand, worked almost exclusively on distributed systems (Types 1-3). This dichotomy suggests that there is a manufacturers "division of labor" operating for STES development. The large-scale nature of central receiver projects attracts large firms that have the resources to deal with the technology. These firms, in turn, sub-contract with small firms. Medium-size firms, on the other hand, have sufficient resources to develop distributed systems since the capital outlay is not as extensive. "Pure" R&D also appears to be the purview of small firms. Thus, the longest-term research is carried out by small firms, rather than by medium or large firms.

SIZE OF FIRM BY PRODUCTION TYPOLOGY
STES R&D BUDGET

TECHNOLOGY - PROD. FUNCTION	TYPE	SMALL	%	MEDIUM	%	LARGE	%
DIST. - "TURNKEY"	1	2		5		4	
DIST. - DESIGN	2	5	(59%)	6	(75%)	3	(75%)
DIST. - R&D	3	3		1		2	
BOWLS - "TURNKEY"	4	0		0		2	
BOWLS - DESIGN	5	1	(18%)	1	(6%)	1	(25%)
BOWLS - R&D	6	2		0		0	
C.R. - "TURNKEY"	7	1		0		2	
C.R. - DESIGN	8	7	(71%)	5	(31%)	6	(75%)
C.R. - R&D	9	4		0		1	
OTHER		1	(6%)	2	(13%)	0	(0%)
TOTAL NO. FIRMS:		17		16		12	

MARKETING TIME HORIZON FOR SIZE OF FIRM

The difference in production decisions among the different size firms and whether or not the firm was currently marketing also lead to different time horizons for marketing. Medium-size firms were the closest to marketing STES because they were working primarily on distributed systems. Large firms, on the other hand, were farthest from marketing, with small firms nearly as far-term.

Central receivers require an extended development period over the next 3 to 7 years. The Type 3 firms - "pure" R&D on distributed systems are the longest term of all. This technology appears to be the high-temperature dish.

MARKETING TIME HORIZON FOR SIZE OF FIRM
TIME TILL COMPETITIVE WITHOUT DOE

STES R&D BUDGET	MEAN YEARS		STANDARD DEVIATION
LARGE	3.0	±	4.0
MEDIUM	1.9	±	5.5
SMALL	2.7	±	3.1

CURRENT MARKETING FOR DIFFERENT PRODUCTION TYPOLOGIES

Overall, 52% of the firms were currently marketing STES products. However, there were large differences among the different production types. Almost three-fourths of the Type 1 firms - "turnkey" distributed systems, were currently marketing, whereas none of the "pure" R&D firms (for all three technologies) were currently marketing. For distributed systems and central receivers, the "turnkey" producers were more likely to be currently marketing than those producing engineering, sub-systems and components; the latter, however, were more likely to be currently marketing than "pure" research types. In addition, firms that were developing STES prior to their first contract with the Department of Energy were more likely to be currently marketing. Since these firms were in the field earlier, they were generally closer to marketing.

CURRENT MARKETING FOR DIFFERENT PRODUCTION TYPOLOGIES

PERCENT WHO ARE CURRENTLY MARKETING

	DISTRIBUTED SYSTEMS	BOWLS	CENTRAL RECEIVERS
"TURNKEY" SYSTEMS	73% TYPE 1	50% TYPE 4	67% TYPE 7
ENGINEERING AND SUBSYSTEMS COMPONENTS	63% TYPE 2	100% TYPE 5	63% TYPE 8
"PURE" R AND D	0% TYPE 3	0% TYPE 6	0% TYPE 9

STES UNCERTAINTIES

Each firm contacted was asked to specify the major uncertainties affecting the development of STES. The "general economy" was perceived to be more of an uncertainty, followed closely by the "cost of competing energy sources". On the other hand, less than half the firms perceived "solutions to R&D problems" to be an uncertainty. For many of these manufacturers, especially those producing "turnkey" systems or engineering, sub-systems and components, the research problems have been solved. For those firms working on long-term developments, on the other hand, research solutions were still a problem. However, there were only slight differences among the different production types.

Underlying these responses were comments concerning the economic viability of solar-thermal. As one respondent put it, "The problem is not solutions to R&D, but that you can't get investment (risk) capital to do development work. Even the best solar mousetrap in the world wouldn't get risk capital." Another respondent stated, "When looking at other alternative technologies, solar-thermal does not come out on top of the list in terms of economic viability. We would rank wind energy systems as being closer to economic viability."

STES UNCERTAINTIES

	YES	NO
SOLUTIONS TO R&D	23	30
COST OF COMPETING ENERGY	40	13
GENERAL ECONOMY	42	11

FUTURE MARKETING PLANS

The majority of firms surveyed had future marketing plans. When asked what types of products would be produced, the most frequent responses were items related to distributed system products: troughs, dishes, industrial process heat systems, and collectors. A few firms mentioned central receivers, but most of the responses were a variety of components and sub-systems that could be used for all the technologies: control systems, gas turbines, rankine engines, solar fuels, positioning systems, Brayton power systems, power conditioners, and thermal storage. The best near-term markets from the firms' point of view were industrial process heat, and electric utilities, followed by government and remote applications. The best long-term markets were very similar to these.

FUTURE MARKETING PLANS

YES	45	(83%)
NO	9	(17%)

STES COMMITMENT FOR DIFFERENT PRODUCTION TYPOLOGIES

When asked whether the firm would continue STES development if the Department of Energy STT program was discontinued next year, 53% said yes. "Pure" R&D firms were more likely to drop out than "turnkey" systems and engineering, sub-systems and components firms. But even the most committed of the production types - "turnkey" distributed systems, Type 1, 45% of the firms indicated they would drop out. The development of STES technology is still very dependent on Department of Energy funding, both for component and research development, as well as for demonstration prototypes and testing facilities. Without government support, the STES technologies are very vulnerable. As one respondent stated, "There is a fragile industrial infrastructure presently existing in the solar thermal market and any public policy (budgetary or other) that indicates a reduction of support would be tantamount to the unraveling of this fragile infrastructure. The only alternative would be to seek foreign sources of these vital raw materials and finished products."

In terms of which firms would continue or discontinue STES development, a higher proportion of the medium-size firms would drop out than either the large or small firms. Thus, one of the unplanned consequences of discontinuing the STT program is a more skewed production distribution comprising a handful of large firms and many small firms, with only a few medium-size firms in between.

STES COMMITMENT FOR DIFFERENT PRODUCTION TYPOLOGIES

PERCENT WHO WILL DROP OUT IF STES PROGRAM DISCONTINUED NEXT YEAR

	DISTRIBUTED SYSTEMS	BOWLS	CENTRAL RECEIVERS
"TURNKEY" SYSTEMS	45% TYPE 1	100% TYPE 4	67% TYPE 7
ENGINEERING AND SUBSYSTEMS COMPONENTS	50% TYPE 2	50% TYPE 5	48% TYPE 8
"PURE" R AND D	71% TYPE 3	50% TYPE 6	67% TYPE 9

TYPES OF FEDERAL R&D SUPPORT NEEDED

When asked what types of Federal R&D support was needed, the highest priorities were the testing of prototypes and the development of sub-systems and components. Nearly as important were full-scale system tests, followed by conceptual designs; less than half the firms thought basic research on fundamental phenomena is required.

TYPES OF FEDERAL R&D SUPPORT NEEDED

	% YES
TESTING PROTOTYPES	92%
DEVELOPMENT SUBSYSTEMS AND COMPONENTS	89%
FULL-SCALE SYSTEM TESTS	83%
DEVELOPMENT OF CONCEPTUAL DESIGNS	62%
BASIC RESEARCH	44%

OTHER FEDERAL SUPPORT NEEDED AND POLICY PRIORITIES

In addition to R&D support, other Federal support needed, as indicated by nearly all firms, was in the form of investment tax credits; three fourths also favored demonstration projects. Only about half the firms favored deregulation; the most frequently mentioned form being the deregulation of natural gas.

OTHER FEDERAL SUPPORT NEEDED AND POLICY PRIORITIES

	% YES
INVESTMENT TAX CREDITS	88%
DEMONSTRATION PROJECTS	75%
DEREGULATION	52%

POLICY PRIORITIES FOR DIFFERENT PRODUCTION TYPOLOGIES

There does not seem to be a major difference of opinion among the different production types regarding other Federal support needed. Almost all were agreed on the need for tax credits, prototypes, system tests, and component developments. Possibly even more interesting is that "turnkey" distributed systems - Type 1 firms, have a slightly stronger need for Federal support than the other types. The Type 1 firms are, of course, those firms who were closest to marketing. But their ability to compete successfully is dependent, to some extent, on government support. It is also apparent from other analysis, that these firms have actually taken greater risks in terms of investment commitment because of Federal support. Thus, the Federal government, rather than preventing them from risking their own resources, has actually provided a slight cushion upon which they could build.

POLICY PRIORITIES FOR DIFFERENT PRODUCTION TYPOLOGIES

TOP 3 PRIORITIES

	DISTRIBUTED SYSTEMS	BOWLS	CENTRAL RECEIVERS
"TURNKEY" SYSTEMS	PROTOTYPES SYSTEM TESTS 100% COMPONENT DEVELOPMENT TAX CREDITS 91% TYPE 1	COMPONENT DEVELOPMENT CONCEPTUAL DESIGN PROTOTYPES 100% SYSTEM TESTS TAX CREDITS TYPE 4	COMPONENT DEVELOPMENT PROTOTYPES 100% TYPE 7
ENGINEERING AND SUBSYSTEMS COMPONENTS	COMPONENT DEVELOPMENT 100% PROTOTYPES 95% SYSTEMS TESTS TAX CREDITS 89% TYPE 2	COMPONENT DEVELOPMENT PROTOTYPES TAX CREDITS 100% TYPE 5	PROTOTYPES 96% COMPONENT DEVELOPMENT 88% SYSTEM TEST TAX CREDITS 83% TYPE 8
"PURE" R AND D	COMPONENT DEVELOPMENT SYSTEM TESTS 100% PROTOTYPES TAX CREDITS 86% TYPE 3	COMPONENT DEVELOPMENT SYSTEM TEST, TAX CREDITS DEREGULATION 100% TYPE 6	COMPONENT DEVELOPMENT 100% SYSTEM TESTS TAX CREDITS 83% TYPE 9

SUMMARY

A model of the current STES industry can now be postulated.

1. Firm size is a major factor in the emerging organization of the STES industry. Large firms can handle large-scale projects, whereas medium-size firms can handle only smaller-scale projects. Small firms tend to be specialized and are sub-contractors to large firms.

2. The type of technology on which a firm works is partially dependent on the size of the related project. Central receiver systems are large and, therefore, attract the largest firms. Since small firms usually sub-contract from large firms, small firms also tend to work on central receiver systems. Medium-size firms, on the other hand, work on smaller-scale systems, such as troughs or dishes.

3. The smaller-scale systems are the closest to marketing. Thus, the medium-size firms are more likely to be currently marketing or are closer to marketing. On the other hand, the large firms, who are working generally on central receivers, are farthest from marketing. The longest-term, however, are the "pure" R&D firms (Types 3 and 9), which are generally small firms.

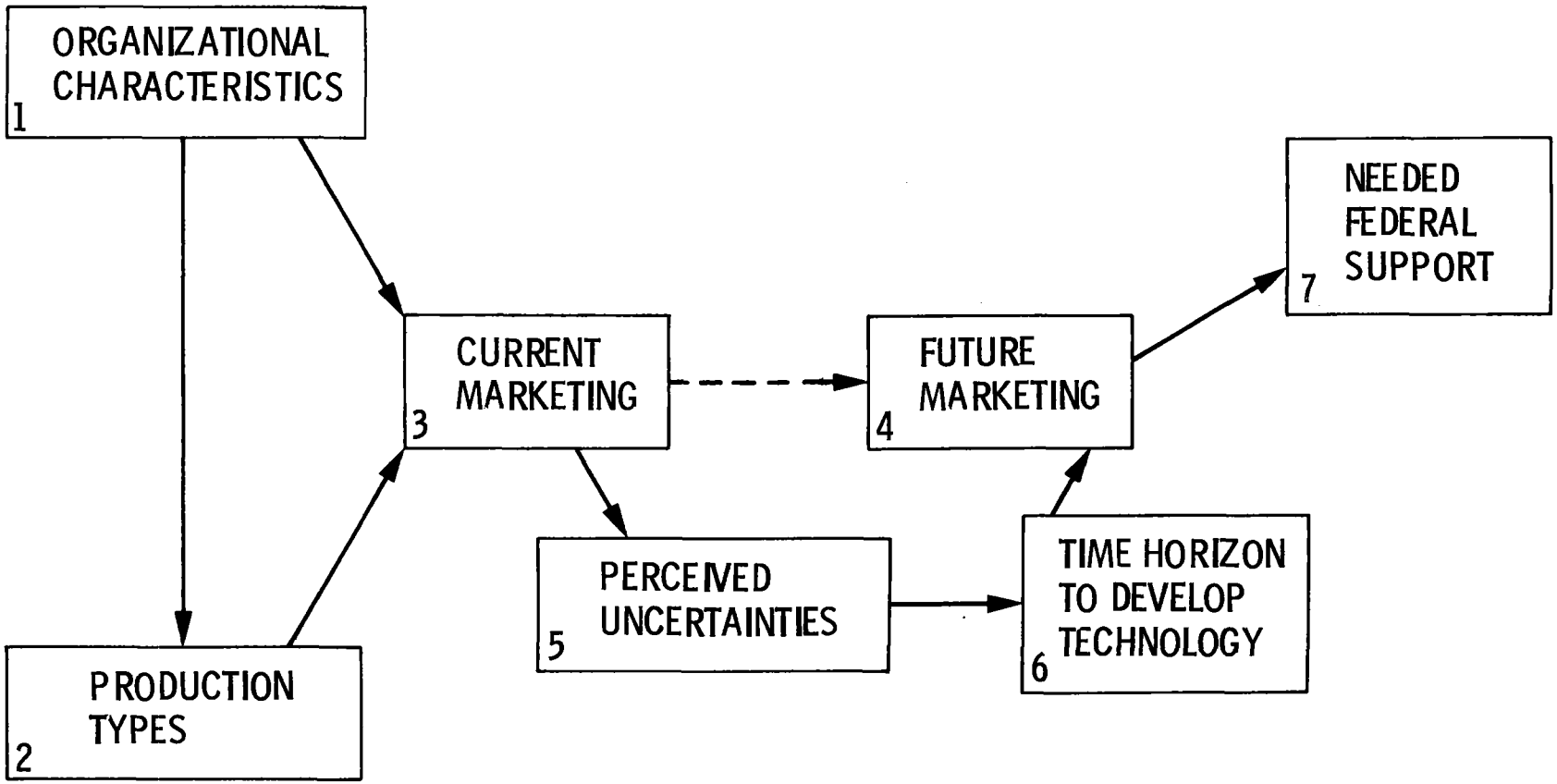
4. Firms that were currently marketing are more likely to have marketing plans in the future, though most firms do have future plans. Because the "turnkey" distributed systems are nearest-to-market, those firms are more likely to have plans for the future.

5. There are a number of uncertainties that affect future marketing plans. For those firms that were currently marketing, the uncertainties of competing energy sources were a problem. On the other hand, those firms working on long-term technologies considered R&D problems to be a major uncertainty.

6. For most firms, continued Federal funding of STES development is a major uncertainty. Almost half of all the firms would discontinue development if the program was discontinued. Among those firms with a longer time horizon that are, therefore, more vulnerable without government support, more than half would discontinue. But even the nearest-term production types - Types 1, 4, and 7, which are all "turnkey" system suppliers, are dependent on Federal support; for these types, more than half the firms would drop out if the program was discontinued.

7. Finally, there is a strong need for continued Federal support of STES. The strongest priorities are more demonstrations, full-scale system tests, continued component development, and tax credits for investments. Almost all firms saw a continued need for Federal funding of STES for at least the next decade in order to make STES competitive with other energy sources.

POSTULATED STES INDUSTRY MODEL



FINAL FREQUENCIES

ID#: ___ (1-3)

CARD#: 1 (4)

FIRM
I.D.#:_____

STES MANUFACTURERS SURVEY

FIRM NAME:_____ CITY/STATE:_____

CONTACT PERSON:_____

TELEPHONE #:_____/_____
AREA CODE

TIME BEGINNING:_____ AM PM TIME ENDING:_____ AM PM TOTAL # OF MINUTES:_____

#MINUTES: 39 (5-6)

OF MINUTES INTERRUPTION:_____

RECORD OF CONTACT ATTEMPTS

	DATE	DAY OF WK	TIME	RESULT	INTERVIEWER I.D.#.	COMMENTS
1.			AM PM			
2.			AM PM			
3.			AM PM			
4.			AM PM			

#CALLS: 3 (7)

IF CONTACT CANNOT BE REACHED ON THIRD ATTEMPT, USE A PROXY CONTACT - A PERSON WHO IS KNOWLEDGEABLE ABOUT THE STES PROGRAM IN FIRM.

RESULT

R NOT AVAILABLE	SPECIFY ABOVE...	01
CALL BACK ARRANGED..	SPECIFY ABOVE...	02
R REFUSED.....	SPECIFY ABOVE...	03
TERMINATED.....	SPECIFY ABOVE...	04
INCAPABLE.....	SPECIFY ABOVE...	05
COMPLETED WITH R.....		06
COMPLETED WITH PROXY.....		07
INCOMPLETE.....		08
OTHER.....	SPECIFY ABOVE...	09

	DATE	INITIAL
LOGGED OUT		
LOGGED IN		
EDITING COMPLETE		

	DATE	INITIAL
CODING COMPLETE		
KEYPUNCHED		
KEYPUNCHED VERIFIED		

ASK TO INITIAL CONTACT PERSON

(Good morning/afternoon/evening). I'm _____ from the Jet Propulsion Laboratory in Pasadena, California. We are conducting a survey for the U.S. Department of Energy of firms who have or have had contracts with the Department of Energy for the development of solar-thermal energy systems (STES). These are the technologies which concentrate sunlight.

Your name has been provided as a person who is knowledgeable about solar-thermal energy development within your firm (division). We need to interview the highest-ranking technical or marketing person responsible for solar-thermal energy systems within your firm (division).

Who would that person be?

IF MORE THAN ONE PERSON MENTIONED, ASK: Which one of these persons would know the most about solar-thermal energy systems within your firm and would be able to present your firm's position with respect to solar-thermal energy systems?

NAME: _____

TITLE: _____

TELEPHONE #: _____/_____
AREA CODE

IF CONTACT PERSON IS R, CONTINUE WITH INTERVIEW AND READ INFORMED CONSENT.

FIRM
I.D. #:_____

CONFIDENTIAL

I would like to read an informed consent statement to you.

We would like to obtain information about your current program with solar-thermal energy systems and about your development plans for the future. The information we obtain from this study will be used for a general evaluation of the Department of Energy solar-thermal program. The interview will take approximately 30 minutes. All information that is obtained will be held in the strictest confidence.

1. No information about individual firms will be released. Only group results for the entire sample will be released.

2. Even though the Department of Energy will receive a report from the survey, they will not receive any data on individual firms.

3. None of the information you provide will be shown to any person at the Jet Propulsion Laboratory who is now or will be, in the foreseeable future, involved in the selection of contractors for future solar-thermal energy systems procurements.

4. After the information has been recorded numerically in the computer, the individual identity of questionnaires will be destroyed.

We have to make this guarantee of strict confidentiality in order to protect the rights of individual firms.

Your participation in this survey is entirely voluntary and you may refuse to answer any question or terminate the interview at any time. However, your cooperation is very important because your firm is one of a select number who are central to the development of solar-thermal energy systems. The information you provide will help in understanding the impact of the solar-thermal energy systems program.

Again, you may be assured that your answers are strictly confidential. They will not be used for other than statistical purposes.

INTERVIEWER ACKNOWLEDGES READING INFORMED CONSENT STATEMENT.

_____ _____

INTERVIEWER SIGNATURE DATE

FIRM
I.D.#_____

To start with, I'd like to ask you some questions about your firm's involvement with solar-thermal energy systems. These are the technologies which concentrate sunlight.

1. Is your firm currently working with any solar-thermal concentrating technology? (developing or marketing a solar-thermal concentrating product or service)

YES.....SKIP TO Q2.....100 — 1: (8)

NO.....ASK A.....0

A. Does this mean that your firm is no longer working with a solar-thermal concentrating technology? — 1A: (9)

YES.....1

NO.....2

→ CLARIFY DISCREPANCY:_____ — DS: ____ (10)

_____

B. In what year did your firm stop working with solar-thermal technologies? RECORD YEAR. — 1B:

YEAR
STOPPED
STES
DEVELOPMENT:_____ — (11-14)

SKIP TO S2 on
SPECIAL FORM, p. 20

2. What types of solar-thermal concentrating technologies is your firm working on? Are they working on: READ a-e. CIRCLE ALL THAT APPLY.

		YES	NO	
a.	Point-focus central receivers?.....	33	21	2a: (15)
b.	Parabolic troughs?.....	24	30	2b: (16)
c.	Hemispherical bowls?.....	8	46	2c: (17)
d.	Point-focus distributed receivers, such as the parabolic dish? or.....	32	22	2d: (18)
e.	Something else?.....	14	38	2e: (19)

→SPECIFY: SOLAR PONDS - 2
FRESNEL LENS - 1
EVACUATED TUBES - 3
CONVERSION EQUIP - 1
SOLAR FUELS - 1

I: ___ (20)

II: ___ (21)

3. Currently, is your firm: READ a-f CIRCLE ALL THAT APPLY.

		YES	NO	
a.	Supplying research and development to the government?.....	43	11	3a: (22)
b.	Supplying "turnkey" systems to users?.....	14	40	3b: (23)
c.	Manufacturing sub-systems or components?	24	30	3c: (24)
d.	Supplying engineering services to solar-thermal energy users?.....	40	14	3d: (25)
e.	Using energy produced by solar-thermal systems?.....	8	46	3e: (26)
f.	Doing anything else with solar-thermal technology?.....	7	47	3f: (27)

→ SPECIFY: COMPUTER DESIGN - 1
ECONOMIC STUDY - 1
MATERIALS - 1
MARKET ANALYSIS - 1
DOE CONTRACT MGMT - 1
PLANNING - 1

I: ___ (28-29)

II: ___ (30-31)

4. How many years has your firm or its predecessor been involved with solar-thermal energy systems development? RECORD YEARS.

4: __ __ (32-33)

NUMBER OF YEARS WITH STES: $\bar{x} = 6.3$ MED = 5.5

5. Last year what was the average number of persons in your firm working on solar-thermal systems? (full-time equivalent) RECORD NUMBER.

IN UNSURE, ASK: Approximately, how many people on average worked on solar-thermal systems?

5: __ __ __ __ (34-37)

NUMBER OF PEOPLE WORKING ON STES: $\bar{x} = 16.9$ MED = 9.5

6. Do you currently market any solar-thermal product or service to commercial users? (other than for Department of Energy-sponsored projects)

NO, R AND D ONLY.....SKIP TO Q12, p. 9.....26

YES, ALSO MARKET PRODUCT OR SERVICE.....ASK Q7.....28

6: (38)

FOR FIRMS WHICH ARE CURRENTLY MARKETING PRODUCTS OR SERVICES

7. What type of solar-thermal energy product or service does your firm currently market? (or intend to market in the very near future)? LIST IN ORDER OF MENTION UP TO 3 PRODUCTS OR SERVICES. EXCLUDE SOLAR WATER HEATERS AND FLAT PLATE COLLECTORS.

7:

PRODUCT #1: AEEC 6 — I: (39-40)

PRODUCT #2: TROUGH 4 — II: (41-42)

PRODUCT #3: CON REC 4 — III: (43-44)

COLLECTORS 3

8. Last year, 1980, what was the total volume of sales, in dollars, of your firm's solar-thermal energy products or services? (Other than for Department of Energy-sponsored projects.)? RECORD AMOUNT.

8:

IF UNSURE, ASK: What would be your best guess?

(45-49)

TOTAL DOLLARS OF STES PRODUCTS IN 1980: $ $\bar{X}$ = 1763 MED = 60 THOUSAND

9. Are the solar-thermal products or services expected to make a profit this year?

9: (50)

YES.....SKIP TO Q10..... 12

NO.....ASK A..... 16

A. By which year are they expected to make a profit? RECORD YEAR

YEAR IN WHICH SOLAR-THERMAL PRODUCTS EXPECTED TO MAKE PROFIT: $\bar{X}$ = 1983 MED = 1981

9A: (51-54)

FOR FIRMS WHICH ARE CURRENTLY MARKETING PRODUCTS OR SERVICES (CONTINUED)

10. Would you say that the marketing channels for distributing your firm's solar-thermal products are:

Very adequate,.....3

Quite adequate,.....5

Moderately adequate,.....7

Not very adequate, or.....8

Not at all adequate?.....3

10: (55)

A. .What are the major distribution problems for your solar-thermal products or services? LIST IN ORDER OF MENTION UP TO 3.

10A:

PROBLEM #1: LACK OF AWARENESS 5

PROBLEM #2: LACK OF DEMAND 5

PROBLEM #3: LACK OF PEOPLE 4
CUSTOMER INFO 3

I: __ __ (56-57)

II: __ __ (58-59)

III: __ __ (60-61)

11. Has support from the Department of Energy led to a reduction of your costs in developing solar-thermal products or services? (the start-up costs of developing the product or service)

YES.....ASK A.....23

NO.....SKIP TO Q12.....6

11: (62)

A. Would you have introduced solar-thermal products or services on the market without Department of Energy support for their development?

YES.....7

NO.....18

11A: (63)

B. Without Department of Energy support, how much in additional funds would it have cost your firm to develop the technology? RECORD AMOUNT.

11B:

ADDITIONAL FUNDS TO DEVELOP TECHNOLOGY WITHOUT DOE: $ $\bar{X}$=13488 MED=1037.5 THOUSAND

__ __ __ __ __ (64-68)

END CARD 1

START CARD 2

ID#:

(1-3)

CARD#: 2

4

FOR ALL FIRMS

Now I'd like to ask you some questions about your research and development program for solar-thermal energy systems.

12. Are you currently under contract with the Department of Energy for the development of solar-thermal energy technology?

12: (5)

YES.....39

NO.....13

A. Approximately how much is the total cumulative dollar amount of your Department of Energy contracts for the development of solar-thermal products or services? (the total value for all years you've had contracts). RECORD AMOUNT.

IF UNSURE, ASK: What would be your best guess? An approximate amount is all that we need.

12A:

DOLLAR VALUE OF TOTAL DOE CONTRACT: $\bar{X}=5805$ $MED=1455$ THOUSAND

(6-10)

13. To date, has your firm been able to invest any of its own private funds for the development of solar-thermal technology? (including borrowed funds).

13: (11)

YES.....ASK A.....44

NO.....SKIP TO Q14.....10

A. Approximately what is the total dollar amount of your own private funding in solar-thermal technology; for example, investment in equipment and facilities, labor and materials? (with your own firm's funds) RECORD AMOUNT.

13A:

IF UNSURE, ASK: What would be your best guess?

DOLLAR VALUE OF FIRM'S OWN FUNDS IN STES R AND D: $\bar{X}=1408$ $MED=200$ THOUSAND

(12-16)

DON'T KNOW.....99999

ASK B

B. Of your <u>research and development</u> budget, approximately what <u>percentage</u> goes to solar-thermal energy development? (that is, of the total amount of your firm's own funds which are invested in R and D). Would you say:

Greater than 75%,.....8

Between 50% and 75%,.....2 13B: (17)

Between 25% and 50%,.....3

Between 10% and 25%, or.....7

Less than 10%?.....21

NONE 10

REFUSED TO ANS 2

14. <u>Before</u> your first Federal contract for the development of solar-thermal technology, was your firm involved in its development?

YES.....29 14: (18)

NO.....23

(2)

15. Where do the greatest uncertainties lie in making commercially-viable solar-thermal products? Would you say that (...) is an uncertainty? READ a-c. CIRCLE APPROPRIATE ANSWER IN COLUMN A.

FOR EACH "YES", ASK: How uncertain is (...)? Would you say it was Very uncertain, Quite uncertain, Moderately uncertain or Slightly uncertain? CIRCLE APPROPRIATE ANSWER IN COLUMN B.

Would you say that (...) is an uncertainty?	A. YES	A. NO	B. VERY UNCERTAIN	B. QUITE UNCERTAIN	B. MODERATELY UNCERTAIN	B. SLIGHTLY UNCERTAIN	
a. Solutions to research and development problems	23	30	4	4	13	2	15a: (19)
b. The cost of competing energy sources	40	13	17	9	9	5	15b: (20)
c. The general economic climate	42	11	16	11	13	2	15c: (21)

A. Is there anything else which is a major uncertainty in making solar-thermal products commercially-viable?

YES..... 46 — 15A: (22)

NO..... 7

SPECIFY: NOT ECONOMICAL - 8
CAPITAL COST - 6
LOW PUBLIC INFO - 5
CONSISTENCY, POLICY 4
WILL PGM CONTINUE 4

I: __ __ (23-24)

II: __ __ (25-26)

III: __ __ (27-28)

Now I'd like to ask you about your firms' future plans for the production and marketing of solar-thermal products or services.

16. Is your firm planning to market solar-thermal products or services in the future?

YES.....ASK A..... 45

NO.....SKIP TO Q17..... 9

16: (29)

A. In the future, is your firm planning to: READ a-f. CIRCLE ALL THAT APPLY.

16A:

	YES	NO	
a. Supply research and development to the government?.....	40	14	a: (30)
b. Supply "turnkey" systems to users?.....	32	21	b: (31)
c. Manufacture sub-systems or components?.....	32	21	c: (32)
d. Supply engineering services to solar-thermal energy users?.....	39	15	d: (33)
e. Use energy produced by solar-thermal systems?.....	20	33	e: (34)
f. Do anything else with solar-thermal technology?.....	5	48	f: (35)

→SPECIFY: SUPPLIERS - 1
PLANNING - 1
ECONOMIC STUDY - 1
NEW APPLICATIONS - 1
DOE CONTRACTMGMT - 1

I: (36-37)

II: (38-39)

B. What solar-thermal products or services will your firm eventually market? LIST IN ORDER OF MENTION UP TO 3 PRODUCTS.

16B:

PRODUCT #1: TROUGHS 6
IPH SYSTEMS 5

I: (40-41)

PRODUCT #2: DISHES 5
UNSPECIFIED COMP 4

II: (42-43)

PRODUCT #3: CEN REC 3
COLLECTORS 3

III: (44-45)

C. In which year will your firm market its first solar-thermal product or service without government subsidy? RECORD YEAR.

IF UNSURE, ASK: Approximately in which year?

YEAR FOR FIRST SOLAR-THERMAL PRODUCT SALE: $\bar{X}$ = 1983
MED = 1983

16C: (46-4

D. Approximately how much capital, in dollars, is needed to bring your solar-thermal products or services to the point where they will be commercially-viable without government subsidy? RECORD AMOUNT.

IF UNSURE, ASK: What would be your best guess? An approximate amount is all that is needed? 16D:

CAPITAL REQUIRED TO MAKE STES COMPETITIVE: $\bar{X}$ = 133,090 $MED = 2025 THOUSAND

(50-54)

E. What do you see as the nearest-term market for your firm's solar-thermal products or services; that is, which customer would first be most interested in your technology and for what purpose? LIST IN ORDER OF MENTION UP TO 3. 16E:

MARKET #1: IPH 23 I: (55-56)

MARKET #2: ELEC UTIL 19 II: (57-58)

MARKET #3: GOVT PRODUCTS 5 III: (59-60)

REMOTE SITES 9

F. What do you see as the ultimate best market for your firm's solar-thermal products or services; that is, the customer and purpose you would most like to make a product for? LIST IN ORDER OF MENTION UP TO 3. 16F:

BEST MARKET #1: IPH 22 I: (61-62)

BEST MARKET #2: ELEC UTIL 21 II: (63-64)

BEST MARKET #3: 3RD WORLD-REMOTE 6 III: (65-66)

GOVT PRODUCTS 3

17. If Department of Energy funding of solar-thermal technology development were discontinued in your technology area next year (1982), would your firm increase your own level of funding to make up the slack, maintain your own level of funding at approximately what it has been, or decrease your own level of funding?

INCREASE LEVEL OF FUNDING..... 1

MAINTAIN SAME LEVEL OF FUNDING..... 19 17: (67)

DECREASE LEVEL OF FUNDING..... 33

A. If Department of Energy funding were discontinued in your technology next year, would your firm continue to develop the current solar-thermal technology that you are working on, change to another solar-thermal technology, or discontinue work in solar-thermal technology altogether?

CONTINUE SAME TECHNOLOGY.....ASK B.....26

CHANGE TO ANOTHER STES.....SKIP TO D.....1

DISCONTINUE STES ALTOGETHER...SKIP TO Q18.....22

17A: (68)

B. How many additional years would it take before your firm could complete development of the technology without Department of Energy support? (so that it would be commercially-viable) RECORD YEARS.

NUMBER OF YEARS BEFORE DEVELOPMENT COMPLETE WITHOUT DOE: $\bar{X} = 6$ MED = 5

17B: __ __ (69-70)

C. Without Department of Energy support, would you try to be first to enter the solar-thermal market, would you wait for competitors to open up the market initially, or would you wait until the market was fully developed before entering?

WOULD ENTER FIRST.....17

WOULD WAIT FOR COMPETITORS.....8

WAIT FOR DEVELOPED MARKET.....7

17C: (71)

SKIP TO Q18

D. Would this change be dependent on the existence of Department of Energy funding in this new area?

YES.....1

NO.....DNA

17D: (72)

END CARD 2

START CARD 3

ID#: ___ (1-3)

CARD#: 3 (4)

Now I'd like to ask you some final questions about the role of government in general in the development of solar-thermal technology.

18. From your firm's point of view, how would you evaluate the Department of Energy solar-thermal program to date? Would you say it has been:

Very good,.....3

Good,.....14

Fair,.....21

Poor, or.....10

Very poor?.....4

18: (5)

19. What have been the most significant accomplishments of the Federal solar-thermal program to date? LIST IN ORDER OF MENTION UP TO 3.

COMPONENT DEV (ALL INCL TECH) 16

ACCOMPLISHMENT #1: BRING TECH TO MATURITY 8

BARSTOW 7

ACCOMPLISHMENT #2: PUBLIC INFO 7

CEN REC TECH DEV 5

ACCOMPLISHMENT #3: CRTF 5

19: I: ___ (6-7) II: ___ (8-9) III: ___ (10-11)

20. What have been the most significant deficiencies of the Federal solar-thermal program to date? LIST IN ORDER OF MENTION UP TO 3.

LACK OF FUNDS/COMMITMENT 12

DEFICIENCY #1: LACK OF CONSISTENCY 7

LACK OF LONG TERM RNG 7

DEFICIENCY #2: LACK OF CONTINUITY 4

LACK OF LONG TERM GOALS 4

DEFICIENCY #3: POOR ADMINISTR. 4

20: I: ___ (12-13) II: ___ (14-15) III: ___ (16-17)

21. In considering the types of Federal research and development that are needed, from your own firm's viewpoint, is there the need for: READ a-e. CIRCLE APPROPRIATE ANSWER IN COLUMN A.

FOR EACH "YES", ASK: How important is Federal support for (...)? Would you say Very Important, Quite Important, Moderately Important, or Not Very Important? CIRCLE APPROPRIATE ANSWER IN COLUMN B.

Is there the need for (...) :	A. YES	A. NO	B. VERY IMPORTANT	B. QUITE IMPORTANT	B. MODERATELY IMPORTANT	B. NOT VERY IMPORTANT	
a. Basic research on fundamental phenomena?	24	30	11	7	5	1	21a: (18)
b. Development of components and sub-systems?	48	6	31	13	4	0	21b: (19)
c. Development of conceptual designs?	33	20	12	9	10	2	21c: (20)
d. Testing of prototypes at the system level?	49	4	36	9	3	1	21d: (21)
e. Full-scale system tests and user applications?	44	9	25	12	6	1	21e: (22)

FOR ANY "YES", OBTAIN SPECIFICS AND RECORD BELOW.

a. BASIC RESEARCH: MATERIALS 5

b. COMPONENTS/SUB-SYSTEMS: DISH COMPONENTS - 8; CONTROL SYS 3 ; SURFACE COATINGS 3

c. CONCEPTUAL DESIGN: DISH DESIGNS - 2

d. PROTOTYPES: RELIABILITY 6 ; DISH PROTOTYPES - 3 ; C-R PROTOTYPES - 2

e. SYSTEM TESTS: FULL SYS DEMO 3 ; IPH 3; RELIABILITY 2; DISH 2

SPECIFICS:

	I	II
a:	23 24	33 34
b:	25 26	35 36
c:	27 28	37 38
d:	29 30	39 40
e:	31 32	41 42

22. Other than research and development, is there the need for any Federal support for the development of solar-thermal technology?

YES.....ASK A..... 48

NO.....SKIP TO Q23..... 4

22: (43)

A. Is there the need for Federal support through: READ a-e.

	YES	NO
a. Increased or extended investment tax credits?.....	46	6
b. Demonstration projects?.....	39	13
c. Specific deregulatory actions?.....	23	21
→ SPECIFY: NATURAL GAS - 6 REPEAL PURPA - 2 MAINTAIN PURPA - 2		
d. Anything else?.....	30	23
→ SPECIFY: USER TAX INCEN - 5 LOAN GUARANTEES - 4 UTIL TAX INCEN - 3 INFO DISSEMIN - 3		

22A:

a: (44)

b: (45)

c: (46)

I: __ (47-48)

II: __ (49-50)

d: (51)

I: __ (52-53)

II: __ (54-55)

23. How many years longer should Federal research and development funding of solar-thermal continue? RECORD YEARS.

YEARS FOR FEDERAL STES PROGRAM: $\bar{X} = 10.8$ MED = 9.5

INDETERMINATE/ INDEFINITE PERIOD.....99

23: __ (56-57)

24. Last year, the Federal budget for solar-thermal energy systems was $140 million. This year, the requested Reagan-budget was $44 million. What do you feel is the appropriate yearly level of Federal spending for the development of solar-thermal technology? RECORD AMOUNT.

APPROPRIATE LEVEL OF FEDERAL STES BUDGET: $\bar{X} = 171.3$ MED = 140 $\_\_\_\_$ MILLION A YEAR

24: __ (58-60)

25. That ends the questions. If I need to ask any more questions, is it alright to telephone you back?

YES.....53

NO.....DNA

25: (61)

On behalf of the Jet Propulsion Laboratory and the Department of Energy, I would like to thank you for giving us some very valuable information. I would like to repeat our guarantee of complete confidentiality for your information and that only group results will be published.

END CARD 3