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526C-10
Photovoltaics Program
Technology Development and Applications
Lead Center

DOE/JPL-1012-45
Distribution Category UC-63

Federal Policies to Promote the Widespread Utilization of Photovoltaic Systems

Supplement: Review and Critique

J.L. Smith (Principal Investigator)

(NASA-CR-163148)	FEDERAL POLICIES TO	N80-24754
PROMOTE THE WIDESPREAD UTILIZATION OF	PHOTOVOLTAIC SYSTEMS. SUPPLEMENT: REVIEW	
AND CRITIQUE (Jet Propulsion Lab.)	115 p	Unclas
HC A06/MF A01	CSCS 10A G3/44	20946



April 15, 1980

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

(JPL PUBLICATION 80-32)

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

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ABSTRACT

This document is intended as a supplement to the two-volume report entitled Federal Policies to Promote the Widespread Utilization of Photovoltaic Systems that was submitted to Congress by the Department of Energy in February and April of 1980. This supplement contains review comments prepared by knowledgeable experts who reviewed early drafts of the Congressional report. Responses to the review comments by the Jet Propulsion Laboratory, preparer of the Congressional report, are also included in this supplement.

The Congressional report, mandated in the Solar Photovoltaic Energy Research, Development, and Demonstration Act of 1978 (P.L. 95-590), discusses various issues related to promoting the deployment of photovoltaic systems through the Federal Photovoltaic Program. Various Program strategies and funding levels are examined.

PREFACE

This document contains unedited review comments of the two-volume Congressional report entitled Federal Policies to Promote the Widespread Utilization of Photovoltaic Systems. A preliminary draft of the Congressional report was sent for review to 55 organizations representing industry, government, labor, consumers, academia, electric utilities, banking, and other interests. This supplement contains the comments of those organizations who submitted written reviews within specified time constraints. The response of the Jet Propulsion Laboratory (JPL) follows each review.

JPL prepared the report for the Department of Energy (DOE). The first volume of the report (Executive Summary and Findings) was submitted to Congress by DOE on February 29, 1980. The second volume (Technical Document) was submitted in April 1980.

The report responds to the Congressional mandate, set forth in Subsection 10(c), P.L. 95-590 (the Act); the Solar Photovoltaic Energy Research, Development, and Demonstration Act of 1978, directing the Secretary of Energy "to make recommendations to the President and to the Congress for Federal policies relating to barriers to the early and widespread utilization of photovoltaic systems in order to realize the goals set forth in Section 2" of the Act. Six specific sets of topics for which recommendations were requested were delineated by Congress. The purpose of the document was to fulfill that mandate.

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In addition, Congress required that in the preparation of the report, "the Secretary shall consult with the appropriate government agencies, industry representatives, and members of the scientific and technical community having expertise and interest in this area." This requirement was partially fulfilled through the formal reviews contained in this document.

Many changes have been made to the document since the preliminary draft, with many of the ideas in these written comments incorporated therein.

JPL recognizes that substantive disagreement will inevitably exist over some elements and approaches of the National Photovoltaic Program. Each viewpoint deserves full consideration in the Department of Energy's attempt to chart a course of photovoltaic development beneficial to the nation. While most of the review comments have already been fully incorporated, several comments required additional research beyond available time and scope limitations. In all such cases, additional in-depth analyses have been planned.

Many thanks are due to the various individuals involved in preparation of this report, especially Lowell Orren, the Task Manager, and principal authors, Rosalyn Barbieri, Robert Danziger, Patrick Caples, Amy Walton, Paul Carpenter, Tom Hamilton, Robert Chamberlain, Donna Pivrotto, and Richard Davis of JPL, and Richard Tabors, Drew Bottaro, and Phillip Ellis of the MIT/Energy Laboratory.

Jeffrey L. Smith

Principal Investigator

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Review

"Federal Policies to Promote Widespread Utilization of Photovoltaic Systems"

H. Ehrenreich
Division of Applied Sciences
Harvard University

In general this report appears to be fully responsive to the legislative mandate. It provides a thoughtful discussion of the status and prospects of the nontechnical aspects of the present DOE photovoltaics program. We fully agree with the conclusion that a PV program funded at the level of Options 1-3 will not meet the objectives of P.L. 95-590.

The events of 1979 have dramatically underscored the importance to the national interest of new energy sources. It is therefore certainly appropriate, even urgent, to reconsider the possible advantages of major increments in funding of the PV program.

On the other hand, the projections of Options 1-7 should be regarded as rather speculative. Even the warning in the Executive Summary that they "must be viewed with much caution" seems insufficient given the uncertainties of the input parameters and the "considerable controversy [that] still exists over modeling approaches." The cost analysis used to establish the breakeven of residential and some other systems at the 1986 price goal of \$1.60/W_p is labeled "preliminary". In fact, the lifecycle cost analysis approach has been criticized as over-optimistic as a predictor of marketplace acceptance (see Section 5.4, and the article by Bezdek et al. in Science, 3/23/79).

The logistic model of Chapter 7 also seems to possess several weaknesses. First, rapid market penetration and high market share are incompatible with the use of goals based on breakeven costs, since only large comparative

advantages can conceivably drive the dramatic market penetration rate assumed. Second, even given a large advantage, readers of Chapter 8 or the classic paper by Fisher and Pry will regard the assumed takeover time of 8.8 years as unlikely. Takeover times of 20-40 years ($\alpha = .11-.22$) are much more probable on the basis of past experience. While government intervention may act to shorten these times, the record of past commercialization efforts is mixed (see the Charpie Task Force Report).

The emphasis on the high-purity shortage is well placed. Because IC uses are much less price-sensitive than photovoltaic uses, and the increasing demand for LSI will upgrade the purity requirements of "semiconductor-grade" silicon, DOE should aim at stimulation of a separate industry producing "solar-grade" silicon to assure a predictable supply to the cell industry.

The remarks in Section ES.3 and elsewhere concerning large penetrations of PV systems into electric grids are too definite, since little experience in these areas exists.

This review has been prepared in collaboration with John H. Martin, Harvard University.

November 1979



JET PROPULSION LABORATORY California Institute of Technology • 4800 Oak Grove Drive, Pasadena, California 91103

December 18, 1979

Refer to: JLS/amc

Henry Ehrenreich
Division of Applied Sciences
Pierce Hall
Harvard University
Cambridge, MA .02138

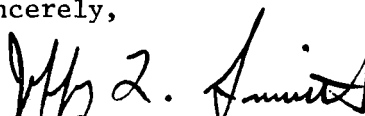
Dear Professor Ehrenreich:

Thank you very much for your timely and insightful review of the document "Federal Policies to Promote the Widespread Utilization of Photovoltaic Systems". Your comments will prove useful in the deliberations of the Department of Energy and Congress over the future of the Photovoltaics Program.

I would also like to thank you for supporting the report's contention that the impacts and costs of program options 1 through 7 "must be viewed with much caution." We support your belief that these projections are highly speculative and we appreciate your elevating that proviso to a high level of visibility. We also share your reservations over the proper assumption as to the value of the parameter alpha, and welcome any suggestions you may have as to how we should modify our thinking in this regard. In particular, does the Charpie Task Force Report give us any reason for optimism? Can a properly designed program meet the penetration rates we have assumed?, and what is a properly designed commercialization program? These are all questions to which we feel we need better answers.

We take no exception with any of the comments you make, and find yours to have been an extremely perceptive review. Thank you very much; your comments will be included in the review section of the final document.

Sincerely,


Dr. Jeffrey L. Smith

HARVARD UNIVERSITY

DIVISION OF APPLIED SCIENCES

PIERCE HALL, CAMBRIDGE, MASSACHUSETTS 02138

November 30, 1979

Lowell Orren
Jet Propulsion Lab
Bldg. 506, Room 316
4800 Oak Grove Drive
Pasadena, CA 91103

Dear Mr. Orren:

I am enclosing the detailed comments to aid revisions which I mentioned to you when we discussed the deadline for comments to be printed in the "Federal Policies" document. If I understood you correctly, there will be further revisions to the document before its final printing, although the draft being circulated to Congress has already been prepared. If that is incorrect and I have missed the boat, I apologize. The list of items enclosed is not intended as a balanced review but as a guide to parts of the document which in my view need correction or disambiguation. Anyone wishing to discuss any of the questions I've raised is invited to call (FTS 830-2875 or 617-495-2875) or write -- I'll be happy to explain what I meant, provide documentation, or retract my comment as the situation warrants.

Yours sincerely,


John Martin

Enclosure
JM/mc

Remarks on "Federal Policies to Promote Widespread Utilization
of Photovoltaic Systems"

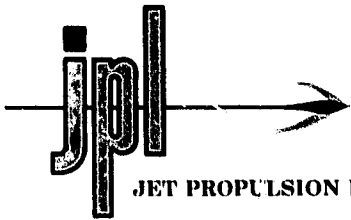
1. Problems with Tables C-1 through C-5:
 - a. In C-1 and C-2 flat replacement rates for residential and industrial users do not differ by a factor of two as posited. The industrial flat replacement rate is below both TOD rates. And should the two rate tables really be identical?
 - b. In tables 1-4 the TOD averages weighted by peak hour data do not match the flat rates. This is quite possibly correct, since higher demand during peaks increases peak weighting and corrections for seasonal or weekend factors can decrease it, but no explanation is given. It also seems to me that distribution would be better treated as an adder rather than a multiplier in the TOD rates.
 - c. There is no obvious resemblance between the peak timing information at the bottom of the tables and Tables 2-4 of Carpenter and Taylor, the cited source in Chapter 3.
 - d. Table C-5 needs revision: The BOS costs quoted (which are spurious numbers from the Carpenter & Taylor paper) fortunately play no part in the calculation. There is no Appendix 3 C, and presumably the fuel escalation rate is 3%.
2. The remarks at the top of 4-31 about the possibility of optimizing system size are misleading. Under the assumptions, the value of a PV system per unit rating must necessarily be a monotonically nonincreasing function of system size. Only models of system cost which include the relation of cost per watt to system size can lead to realistic calculations of optimum system size.
3. The Program Goals are often unclearly labeled as "system cost", but the Sandia calculations on which they are based use $\$1.60/W_p$ as a direct capital cost. A telephone conversation with R.B. Davis of JPL leads me to understand that the calculations of Ch. 4 were done using the $\$1.60/W_p$ figure as the owner's cost rather than the direct capital cost. An O&M charge was added separately, however. The calculations would be more in line with the 1986 Goals if done with a cost of about $\$1.80/W_p$. This does not greatly affect the shape of the curves in Figures 4-8 through 4-12, but would lead to a significant shift in the vertical axis of these graphs. Note also the misleading labels in Figures 4-9 and 4-11, which should have the word "system" substituted for "array".
4. A table of S_{i0} for the various options would be a useful addition to Chapter 7.
5. It is somewhat grandiose to dignify the ultimate market penetration numbers used in Ch. 7 with the phrase "estimate". They are guesses pure and simple. My own feeling is that large market penetrations, at least in nonutility markets, require quite a bit more than lifecycle breakeven. It is hard to imagine that 60% of new homes will be sold with 10-20 k\$ (1980) systems

which merely promise the owner that he will most likely be no worse off after 30 years than if he had not bought the system (if, of course, the system works properly for 30 years).

6. On p. ES-16, the statement that "PV generates power during high marginal cost periods, i.e., the daily peaks." is somewhat misleading. PV output peaks may or may not correlate with utility demand peaks. (It is this fact that makes PV capacity credit very small in some utilities.) A more accurate statement would be: "PV generates power during shoulder and sometimes peak demand periods, when marginal variable generation costs are relatively high."
7. On ES-17, the statement that distributed PV has "little effect on utility distribution systems costs" is too strong. The Aerospace Corp. work reported at Gatlinburg this spring found a distribution cost penalty of 20-30% under what seemed reasonable conditions.
8. Remarks concerning ultimate levels of penetration (Section ES,3) are more definite than permitted by the present state of experience. Every electricity supply option decreases in marginal worth as it increases in penetration, and problems of such large penetrations from PV have received little attention. Capacity penetrations of 30% have been examined in some model utilities (see Fig. 3-1), but the energy penetration percentage is about a factor of 2 less because of the low capacity factor of PV. Systems questions of seasonal storage, reserve requirements, etc. will require resolution at such high penetrations. The essential points are that penetration of a few percent is agreed by consensus to be possible, and that that is enough to justify a substantial government effort. The remark about PV's environmental preferability is also too strong. During normal operation PV systems only pollute with heat, a tremendous advantage, but questions have been raised (most recently by CONAES) concerning the real ecological cost of materials-intensive and large-area systems, and not all PV materials are entirely benign (e.g., cadmium). The major advantages of PV in operating pollution should not preclude careful scientific study of lifecycle environmental effects when large-scale deployment becomes imminent.
9. On page F-3, I would change "under realistic assumptions" to read "even under very optimistic assumptions."
10. On F-4, the statement that "their production is not limited by the availability of raw materials" is misleading. Silicon has no resource problem, but other cell materials such as CdS and GaAs do, and PV systems might lead to major demands on such mundane resources as iron ore at very high deployments.
11. On F-5, "DOE's plan to begin large-scale production..." implies that DOE plans to be a manufacturer. Perhaps "DOE's expectation that... deployment will begin in the..."
12. The AR&D element primarily addresses questions other than "basic device physics" (ES-4) as physicists understand that term. A possible improvement would be "Advanced research (in the AR&D element) on new materials, materials properties, cell design, and device physics may lead to devices which promise higher efficiency or lower cost than crystal silicon when fully developed."

13. I would add to the unfavorable features of Option 2 (F-14) the bullet "Program success dependent on highly successful commercialization-high risk", since government experiences in such efforts have been mixed (see Charpie Task Force Report).
14. Unless the model parameters are revised, the statements about probability on p. F-28 deserve qualification, at least to something like "... (less than 5%) even under the optimistic assumptions of the model." and "Thus, goals which might prove consistent..."
15. On F-29, "Figure F-1" should read "Figure F-2".
16. Also on F-29, I again dispute the wide-reaching claims about possible impacts. The PV penetration is a result of largely arbitrary assumptions in Section 7.4.3.1; there is no demonstration that these assumptions are justified or indeed possible. The impact for PV will depend on eventual PV costs, competitive energy costs, electricity demand, and a variety of technical issues regarding storage, grid design, regional power pooling, and so on. All these are to a considerable extent unknown. I share the belief that PV could become a major power source in the U.S. and the world, but quantitative statements of possible impact are misleading in the present state of ignorance. (See bottom paragraph, p. 7-18).

John H. Martin



JET PROPULSION LABORATORY *California Institute of Technology • 4800 Oak Grove Drive, Pasadena, California 91103*

March 17, 1980

Refer to: 311-JLS:amc

John Martin
Division of Applied Sciences
Harvard University, Pierce Hall
Cambridge, Massachusetts 02138

Dear John:

Thank you very much for your latest critique of the Congressional document "Federal Policies to Promote the Widespread Utilization of Photovoltaic Systems." Once again we have found your comments insightful and useful in document revision. Please accept my apology for not replying to your comments sooner.

Responses to your detailed comments follow:

1. Problems with Tables C-1 to C-5.
 - a. Each of these problems has been cleared up in a revised set of tables.
 - b. These comments have been forwarded to MIT Energy Lab (preparer of tables) for their consideration.
 - c. I cannot explain this, and have forwarded to MIT/EL for their consideration. Reference to Carpenter/Taylor has been deleted.
 - d. Modifications made per your suggestions.
2. I do not agree with this comment. Since the model referred to calculates net present value (that is, present value of benefits minus present value of costs), it can in principle be used to optimize system size. Of course, this is not its primary function, nor is the data of high enough quality to draw useful conclusions at this time. The confusion appears to arise because the relevant parameter to maximize is not "the value of a PV system per unit rating" as you state, but rather, net value of the PV system.
3. Your information on the formulation of the \$1.60/Wp system cost goal is faulty. The \$1.60/Wp includes all of the initial costs that an owner incurs to purchase a PV system--it's the total invoice price of an installed system to the system purchaser. Operating and maintenance costs are not included. This formulation was arrived at by a group at JPL (the Goals Working Group) early last year during our preparation of the Photovoltaic Multi-Year Program Plan for DOE; I chaired that group. Sandia was an active member and helped prepare cost estimates. The goal is used properly in the Congressional report.



John Martin

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March 17, 1980

Figures 4-9 and 4-11 have been revised per your suggestion.

4. I have requested that such a table be prepared.
5. I agree with your distinction between "estimates" and "guesses." We were very reluctant to prepare these "guesses" and only did so under clear direction from DOE, after having first submitted a draft that did not include them and after having raised precisely your objections as to the possibility of actually creating believable "estimates." Needless-to-say, our reticence did not prevail.

Please note, however, that your interpretation of our price goals is incorrect. If our price goals are attained, we do not "merely promise the owner that he will most likely be no worse off after 30 years than if he had not bought the system." This will only obtain if there is no real escalation (above inflation) in conventional energy costs over that 30 years. Our goals are predicated on the contention that in order for such systems to become attractive, they must breakeven in their first year of operation. That is, the first year's pro rata share of total PV system costs must be no greater than the cost of the energy displaced by the system in its first year of operation. This implies that future real escalation in electricity prices would lead to substantial savings on the part of the PV system owner. A closer look at the MYPP may prove helpful.

6. I have modified this statement in a manner similar to what you suggest, and to the same effect.
7. I have spoken directly with the people at Aerospace who prepared the report you refer to, and they confirmed our position, which is, while large numbers of retro-fit PV systems on the same distribution network (with power feedback) will necessitate definite changes in that network (e.g., larger transformers), the absolute size of the costs involved is "modest."

The current state of knowledge allows little more than a general characterization of the types of changes in the distribution system necessitated by large deployments of PV systems. Detailed investigations of necessary changes and their costs have yet to be completed. Most people working in the field believe that no large, costly surprises are likely to appear, and that those changes that are necessary do not cost a great deal (some of the changes may actually involve credits, such as deferring redundant line installation, or line downsizing). Furthermore, the opportunities to avoid these costs have obviously not been explored. Finally, new distribution nets serving new PV subdivisions have not been explored and should involve even less additional costs than for retrofitted systems.

P.S. 20-30% of what?



John Martin

-3-

March 17, 1980

8. In general, I agree with these remarks. 30% penetration (energy) is, indeed, a bold assertion that cannot be fully supported at this time. However, it is felt that the National Program must take the lead in examination and explication of the full possibilities of PV generation. We have suggested the 30% level primarily as an appropriate, ultimate target to guide R&D efforts, even though it could prove too high in future investigations. At this time, however, we do not anticipate that intractable problems will arise which preclude such large penetrations.

Also, we felt a strong statement of the environmental benefits of PV was appropriate. While we admit that PV is not entirely benign, and have an ongoing, well-funded, PV environmental research effort to anticipate and mitigate any potential problems, the environmental advantages of PV are quite substantial. We do not apologize for emphasizing those advantages. I might add that our environmental research effort includes investigation of health and safety issues, development of appropriate production process control technology, preparation of environmental statements, and investigation of materials supply and availability.

9. I made this change, omitting the modifier "very."
10. I do not believe your qualifications to this statement are particularly important. Both CdS and GaAs show less promise and are receiving less emphasis in the Program than was the case a year ago. Furthermore, both sets of materials are sufficiently available to support large quantities of production even if they make more rapid advancement than we anticipate. And remember that the primary application of GaAs is likely to be concentrators (minimizing material use) if used at all. We consider the supply of mundane materials (such as iron, glass, wood, plastic) to be very elastic within the conceivable ranges of production (30% ultimate penetration!), although this issue could benefit from further investigation.

11,12,15 Changes made as you suggest. Thanks

13. Change made as suggested with slight modification.

14. First suggestion incorporated. However, the goals are consistent with the President's 20% goal, even if their probability for attainment is low.

16. Once again, we find no basic disagreements with these qualifications.

Thanks again, John, for your time, interest, and effort. We shall send you a copy of the complete report when it becomes available.

Sincerely,


Dr. Jeffrey L. Smith

Muller and Company

25 Broad Street, New York, N. Y. 10004 • (212) 952-9400

Cable Address: Ocrellum • Telex: Muller 422506

MEMBERS OF THE NEW YORK STOCK EXCHANGE, INC.

Solar Services

Division

Anthony W. Adler

Director

November 15, 1979

Mr. Lowell Orren
Jet Propulsion Lab.
Building 506
Room 316
4800 Oak Grove Drive
Pasadena, CA 91103

RE: 720-RGF:mb "FEDERAL POLICIES TO PROMOTE THE WIDESPREAD
UTILIZATION OF PHOTOVOLTAIC SYSTEMS"

Dear Mr. Orren:

Here follows my comments as a "reviewer" of the above captioned document. My general overall impression of the document is that it was well thought out and well presented. I particularly support your conclusions found on page ES6 that ... "the specific quantity of output goal suggested in section 2(b) (1) of the Act is difficult to attain within the statues 1.5 billion dollar multi-year budget projection." Further your approach to the overall problem of analysis of the photovoltaic program by using a seven option format is both interesting and revealing. Further I support your specifying all goals on the basis of 1980 dollars:

Your findings regarding standards and warranties are well thought out and take into account full appreciation of the problems of developing industry consensus standards in the light of a rapidly changing technology.

Transition markets, discussed in volume I page 10, namely the international markets, should be expanded on further in the document. I realize that it was not your responsibility to develop the international photovoltaic plan, however, as this is indeed a highly critical transition market for the photovoltaic industry I believe it deserves more coverage in this document.

Muller and Company

Mr. Lowell Orren
Page 2

November 15, 1979

The issue of the availability of poly-silicon deserves, perhaps, even more coverage as this appears to be a critical factor in the very near time frame with regard to market growth.

Some specific comments referring to Table F-3 page F-17 looking at the program options 4, 5, 6, & 7 I have the following comments:

1. The funding levels for market analysis are probably high enough at .026 level and should not be elevated for options 6 and 7. We tend to study things too much. Industry will do much of its own market analysis.
2. Education and training - the funding level is probably high enough at the level established for option 4. Again, Industry will do most of its own training.
3. Legislative and Institutional studies in Liaison at the .045 funding level should be more than adequate. Again, we tend to study things too much.
4. For levels 1 - 7 the funding for the entire International Plan is too low and should be funded at a level of at least twice the proposed level across the board. The sooner we take advantage of the opportunities offered in developing in lesser developed countries, the sooner we will create a volume market thereby bringing down the intermediate cost of silicon arrays. A \$110 million program through 1988 at that level, is insufficient to have any quantitative or qualitative impact.

Regarding paragraph 2 page F-20 Volume I, I totally disagree. Should there be large government purchases, the highly sophisticated electrical supply industry is more than competent to pick up the slack that exists in the present system.

Muller and Company

Mr. Lowell Orren
Page 3

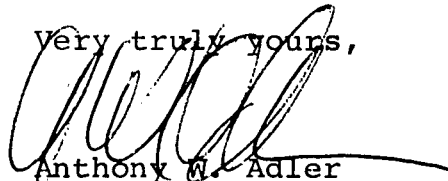
November 15, 1979

With regard to the findings F.4.1 Page F 40 Volume 1 new PV ventures are not entering at the rate of several per year. We find old ventures under new names. Further with regard to those findings the availability of capital as found in those large corporations gives them a distinct advantage of being able to buy a technological advantage. Capital is the name of the game. It can buy the technology. Yes, capital requirements are relatively small, visa the other major industries, however, the cost of entering the photovoltaic market continues to escalate as the technology improves. It is easier to enter as a systems integrator than at the level of cell manufacturer or array manufacturer. From Wall Street's point of view, we fund both technology and management expertise - not one or the other.

Again in findings in F.6.2 DOE Actions: there is not at the present time a continuous dissemination of accurate information to bankers, underwriters, stock brokers and insurance companies concerning the current state and expected development of photovoltaic technology, markets and industrial segment structure. If somebody in my community wants that information, they must go search it out.

With the exception of the above comments, I fully support your report.

Very truly yours,



Anthony W. Adler
Director

AWA/lr



JET PROPULSION LABORATORY *California Institute of Technology • 4800 Oak Grove Drive, Pasadena, California 91103*

December 18, 1979

Anthony W. Adler, Director
Muller and Company
25 Broad Street
New York, NY 10004

Dear Mr. Adler:

Thank you very much for your insightful, helpful, and comprehensive review of the Congressional document "Federal Policies to Promote the Utilization of Photovoltaic Systems." Your comments have proved useful in revising the final document and should aid the Department of Energy and Congress in their deliberations over the future of the Photovoltaic Program.

You requested that more information on the international markets and on the polysilicon problem be included in this document. As you know, a companion document to this, entitled "International Photovoltaics Program Plan" will be submitted to Congress simultaneous with the submission of this document. Thus, we felt any elaboration within this document would be redundant. We have highlighted the polysilicon problem to some extent, but more information on this problem is available in a separate publication from the Jet Propulsion Laboratory's Photovoltaic Lead Center. I have included a copy of the most recent edition of the document entitled "Silicon Materials Outlook Study for 1980-85 Calendar Years."

Your comments on funding details should prove helpful to the Department and Congress in formulating future plans for the Photovoltaic Program.

With respect to your disagreement with our contention that system-supplier bottlenecks might arise, you comment that "the highly sophisticated electrical supply industry is more than competent to pick up the slack that exists in the present system." I presume you mean by this that bottlenecks in the module supply industry can be met by the electrical supply industry, as opposed to bottlenecks in the system supplier industry. Thus, I have added a qualifier to the report which makes this distinction, and I hope this satisfies your objection. We have also reworded the statement concerning the rate at which new photovoltaic businesses are entering the module supply industry, per your suggestions. Your comments on capital availability are well taken but do not seem inconsistent with our own analysis.

Finally, with respect to your contention that information is not disseminated properly by the Program, the Department intends to improve information dissemination, and this report can itself be regarded as an early installment in that effort.



JET PROPULSION LABORATORY California Institute of Technology • 4800 Oak Grove Drive, Pasadena, California 91103

Anthony W. Adler, Director

2

December 18, 1979

Thanks again for your time and your useful comments, which will be included in the review section of the final document.

Sincerely,

A handwritten signature in black ink, appearing to read 'J.L. Smith', with a stylized flourish at the end.

Dr. Jeffrey L. Smith

Enclosure



IBEW

1125-15th St. N.W.
Washington, D.C.
20005

November 9, 1979

Lowell Orren
Jet Propulsion Laboratory
Bldg. 506, Room 316
4800 Oak Grove Drive
Pasadena, CA 91103

Dear Sir and Brother:

Volume 1 and 2 of "Federal Policies to Promote the Widespread Utilization of Photovoltaic Systems" have been reviewed.

Of particular interest was Chapter 8, The Construction Industry Infrastructure.

Of the three construction submarkets listed the first two are of prime concern to the PV program. The second two are of prime concern to organized labor. These are the two submarkets in which most of the seventeen construction unions mentioned are employed.

As a result the training received by organized labor is oriented toward these two submarkets.

IBEW members possess the requisite skills necessary for PV. An example of this is our involvement in high technology projects such as the aerospace program and nuclear power.

The most serious labor constraint is the potential rapid expansion of all energy projects to assure domestic control of our energy supplies. If the expansion is rapid, many more craftsmen will need to be trained to assure a well trained labor pool for all energy projects.

For the initial phase of PV demonstration the IBEW prefers Option 1 which tends to emphasize the central station system.

Sincerely,

A handwritten signature in cursive script that reads "Paul R. Shoop".

Paul R. Shoop
International Representative



JET PROPULSION LABORATORY *California Institute of Technology • 4800 Oak Grove Drive, Pasadena, California 91103*

December 18, 1979

Paul R. Shoop
International Representative
International Brotherhood of Electrical Workers
1125 15th Street, NW
Washington, D. C. 20005

Dear Mr. Shoop:

Thank you very much for your prompt response in review of the Congressional document "Federal Policies to Promote the Widespread Utilization of Photovoltaic Systems." The perspective of your organization should prove useful in the deliberations of the Department of Energy and Congress over the future of the Photovoltaic Program.

Your comments on the necessity to ensure an adequate labor pool for all energy projects, both solar and others, is well founded. The Photovoltaic Program is developing plans to assure adequate labor expertise for the installation of photovoltaic systems according to the Department's schedule.

Thanks again for your time and effort. Your comments will be included in the review section of the final document.

Sincerely,


Dr. Jeffrey L. Smith

FEDERAL TRADE COMMISSION
WASHINGTON, D. C. 20580

BUREAU OF COMPETITION

November 13, 1979

Mr. Robert G. Forney
Manager, Photovoltaics Technology
Development & Applications
Lead Center
Jet Propulsion Laboratory
4800 Oak Grove Drive
Pasadena, California 91103

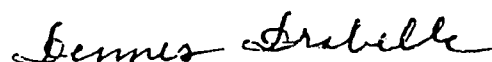
Dear Mr. Forney:

Thank you for the opportunity to review the preliminary draft of "Federal Policies to Promote the Widespread Utilization of Photovoltaic Systems". Please note that the views expressed in this letter are my own and are not necessarily those of the Federal Trade Commission or of any individual Commissioner.

I am disturbed by the draft's treatment of small-business opportunities in photovoltaics. In one place (volume II, pp. 6 - 20-21), the draft states that "[t]he photovoltaics business is, today, very competitive. New manufacturers are entering at the rate of several per year... Entry will not require large amounts of capital..." In another place (volume II, pp. 5 - 17-18) the draft states that there is a consensus among "subsidiary" solar producers that only large, capital-rich firms will survive as manufacturers of solar collectors. The draft goes on to state that other producers believe that small firms will survive as producers. The draft comes down on the side of the optimists, concluding, "Given the relatively small capital requirements, there is no inherent reason that small producers... could not survive and prosper." But since the capital requirements referred to are start-up costs, it is unclear why their "relative" smallness bodes well for firms' long-term survivorship. Meanwhile, another report prepared for the Department of Energy (Analysis of Small Business Participation in the Photovoltaic Area of Solar Technology, by Techmatics Corporation, April 1978) takes a dimmer view of ease of entry into photovoltaic manufacture: "Financial constraints are especially true [sic] for the entry level company particularly if it does not have established lines of business in other areas."

It seems to me that, at a minimum, this draft needs to be buttressed with a detailed justification for its optimistic conclusion that small business should thrive in the manufacture of photovoltaic cells: the conclusion does not seem to be borne out by the draft itself, appears inconsistent with the Techmatics report, and is certainly not shared by solar activists.¹

Sincerely yours,



Dennis Drabelle
Attorney
Bureau of Competition

¹(Editor's Note: The report states that small business will have much opportunity within the Photovoltaic Program and within industry as a whole, not necessarily in the manufacture of "photovoltaic cells." There is much apparent opportunity for small business in PV system design, integration, marketing, distribution, installation and service. However, the issue raised here (and by several other reviewers) of small business entry and survival in module manufacture is considered by the Department of serious enough import to require further in-depth study. Thus, a report directed specifically at the status and future prospects of small business in all aspects of photovoltaic system production and deployment is planned and scheduled.)



JET PROPULSION LABORATORY *California Institute of Technology • 4800 Oak Grove Drive, Pasadena, California 91103*

March 17, 1980

Refer to: 311-JLS:amc

Dennis Drabelle
Bureau of Competition
Federal Trade Commission
Washington, D.C. 20580

Dear Mr. Drabelle:

Thank you very much for your comments on the document, "Federal Policies to Promote the Widespread Utilization of Photovoltaic Systems." Your criticism of the report's position on small business opportunities in the photovoltaic industry is of concern to us, and has been supported by comments from other reviewers. In response to these comments, the Photovoltaic Program plans to undertake a more detailed and comprehensive review of the position of small business in the photovoltaic industry, the opportunities for the same, and a detailed look at the plans of the Department to aid small business in its attempt to succeed in the production of photovoltaic systems. A schedule for the development of this analysis is under consideration.

Let me point out, however, that the report does not contend that small business will succeed in every aspect of photovoltaic system production and supply. Rather, the report states that there appears to be ample opportunities for small business in the Photovoltaic Program and the photovoltaic industry as a whole. System design, integration, installation, marketing, distribution and service, especially for distributed residential systems, are clearly prime activities in which small businesses can thrive. While the report never asserts that small businesses will succeed in the production of "photovoltaic cells," module production for specialty markets may be an attractive small business opportunity. (The dominant photovoltaic module supplier today is a small business). Nevertheless, we agree that a more complete analysis of small business opportunity in every aspect of the photovoltaic industry is needed.

Thanks again for your time and effort. Your comments should prove useful in Department of Energy and Congressional review of the future of the Photovoltaic Program, and will be included in a supplemental document containing reviews of the Congressional document. When the study referred to above becomes available, we shall include you on its review and mailing list. Please accept my apology for the long lag we found necessary to properly respond to your comments. When the full document becomes final, we shall send you a copy.

Sincerely,

Dr. Jeffrey L. Smith

Solar Energy Research Institute
1617 Cole Boulevard
Golden, Colorado 80401
(303) 231-1000



November 14, 1979

Dr. Jeffrey L. Smith
Jet Propulsion Laboratory
California Institute of Technology
4800 Oak Grove Drive
Pasadena, CA 91103

Dear Dr. Smith:

Thank you for the opportunity to review your preliminary draft, "Federal Policies to Promote the Widespread Utilization of Photovoltaic Systems," dated November, 1979. As you indicated in your November 1, 1979 letter, comments are needed by November 14, 1979, therefore due to the short review period I have only reviewed Chapter 10, "Standards and Warranties."

In the text of Chapter 10 you indicate general support of the consensus standards process and at the same time recommend support for the FTC rule concerning standards and certification. I agree that standards, written by the consensus standards groups, is the proper approach to ultimate PV Commercialization. The SERI Performance Criteria and Test Standards Project supports and is implementing that philosophy. However, in regard to the FTC rule, there maybe and in some cases is opposition to this rule, in part, by the consensus groups. I cannot give you the details within the time frame permitted for review with regard to this opposition, however I would recommend that you contact the American National Standards Institute (ANSI) to obtain their position papers in regard to the FTC rule. A good contact for information at ANSI is Mr. Alvin Lai, 1430 Broadway, New York, N.Y. 10010 (Phone Number 212-354-3300). Their opposition may not be germane to what you discuss in Chapter 10, however your recommendation on page 10-19 Item 2, "Support adoption of the proposed FTC rule concerning standards and certification," implies a blanket endorsement of the FTC rule in total. This recommendation may be contradicting to your support of the consensus process.

I believe it is important that your findings be clear in this case since the PV Program is being supported, through standards writing activities, by ANSI, ASTM and IEEE.

If I can be of any further assistance please feel free to contact me.

Sincerely,

A handwritten signature in cursive script that reads "Richard DeBlasio".
Richard DeBlasio

RDB/cma

cc: Tom Hamilton, JPL
Gary Nuss



California Institute of Technology • 4800 Oak Grove Drive, Pasadena, California 91103

March 17, 1980

Refer to: 311-JLS:amc

Richard De Blasio
Solar Energy Research Institute
1617 Cole Blvd.
Golden, CO 80401

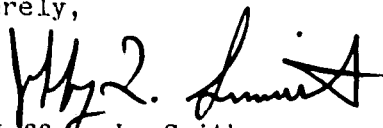
Dear Dick:

Thank you very much for your prompt review of the Congressional document "Federal Policies to Promote the Widespread Utilization of Photovoltaic Systems." Please accept my apology for not replying to you sooner.

Your warning concerning the controversy surrounding the FTC rule on standards and certification was appreciated. We immediately established contact with Alvin Lai at ANSI as you suggested and have received material from them concerning their opposition to the FTC rule. In response to this we have weakened our support for the rule--we no longer advocate adoption of the rule, and have leaned much more heavily on OMB Circular No. A-119 for administration policy with respect to standards.

Thanks again for your help, which has proved useful to us in revising the document. I have enclosed a copy of the final revision of the chapter for your information, as well as a copy of Circular No. A-119, in case you have not already seen it. When the entire document becomes final, we will mail you a copy.

Sincerely,



Dr. Jeffrey L. Smith

Enclosures

NEW YORK STATE ENERGY RESEARCH AND DEVELOPMENT AUTHORITY

MEMORANDUM

TO: Robert G. Forney, Manager: Photovoltaics TD&A Lead Center

DATE: 11/16/79

FROM: W. James Cole, Program Director *WJC*

SUBJECT: Comments on "Federal Policies to Promote Widespread Utilization of Photovoltaic Systems"

1. Introduction

The objective of the JPL draft report is to "make recommendations to the President and Congress for Federal policies relating to barriers to the early and widespread utilization of photovoltaic systems in order to realize the goals set forth in Section 2. (PV RD&D Act Subsection 10(2).)" The report is apparently the result of a comprehensive study effort investigating the technical, economic, market and institutional barriers to PV acceptance, assessing the accomplishments and future direction of DOE Photovoltaics program relative to overcoming these barriers, and setting forth potential funding options to attain alternative program goals.

The report concludes that DOE is undertaking all steps necessary to promote widespread deployment of PV systems and indicate that recommendations for Congressional action will be made on an as-needed basis. As a result, the following comments by the ERDA staff primarily emphasize concerns about the elements of the DOE Commercialization (COM) program as it relates to overcoming institutional barriers. Additional comments relate to the need for additional information about the ability of current AR&D and TD&A activities to attain the breakdown system cost goals cited in the report.

2. PV Economics, Technology Development and Production Costs

The current scope of the DOE PV program consists of a comprehensive AR&D and TD&A program to address high production costs as most important current barrier to PV acceptance.

Utilizing the break-even cost analysis under optimal utility rate conditions, the report establishes cost goals for residential and utility applications for different regions and representative utilities. These results, while useful as guidelines, cannot be generalized since they are dependent on highly location-specific conditions. For example:

- The cost of grid backup power for residential PV systems depends critically on whether it reduces peak demand on a specific utility. If a winter peak is slightly less than a summer peak, the after dark nature of the winter peak suggests less favorable economics for PV's. Current New York tariffs suggest this and the transition to PV-favorable tariffs is not addressed.
- Replacement by PV electricity of high cost capacity through economic dispatch is another aspect of favorable economics for PV's. Again, economic dispatch is highly system specific and depends on the plants, fuel mixes and load following characteristics of a utility.

New York ERDA in cooperation with the Public Service Commission (PSC) has

developed an Electrical Supply Alternatives Model (ESAM) which has been applied to analyzing the impact of WECS on the utility system. The ESAM model will soon be used to examine the impact of small-hydropower and could be employed to consider PV's both in isolation and conjunction with other renewables.

The JPL report attempts to build a convincing argument that technologies currently in the TD&A program can reach the \$1.60/Wp system break-even cost by 1986. This discussion, which relies on "learning curve" and competition arguments, is not persuasive in its present form. While ERDA's anticipated sponsorship of silicon ribbon R&D activities with IBM is based on our assessment that this goal can be attained, insufficient information on JPL production cost budgets and industry progress in achieving these cost goals is provided in the report to establish reader confidence. Furthermore, the reader is asked to believe that advanced PV technologies will attain the central station goal of \$1.10-1.30/Wp by 1990. Insufficient discussion is devoted to an interpretation of current AR&D projects relative to potential future production costs.

3. Institutional Barriers and PV Commercialization

Assuming that the near-term TD&A production cost cost goals for residential systems can be attained, PV systems will not penetrate the market unless the institutional barriers discussed in the report are comprehensively addressed. While the report indicates that DOE will pursue these issues as part of the commercialization effort, a specific plan or even a broad outline of such a plan is not specified.

Since the majority of these institutional barriers are highly location, utility, and state-specific (in terms of city, county and state laws and administrative procedures), their elimination in the near-term to meet DOE program goals will be enhanced through the planning and conduct of commercialization activities in cooperation with state-level organizations such as New York ERDA, the State Energy Office (SEO) and the Public Service Commission (PSC).

The elements of such a cooperative program might include:

- Residential PV system installations in several utility areas.
- Performance monitoring and assessment of utility interconnection problems.
- Utility Rate Design based on performance monitoring and modeling of electrical supply alternatives (ESAM).
- Equipment and System Standards and Warranties.
- Information Dissemination to Consumers, Builders and Financial Community.
- Development of Solar Access Zoning Guidelines.

At the present time, New York ERDA is involved in a number of cooperative pilot projects with DOE, JPL, SEO, PSC, and NYS utilities addressing each of these activities as they relate to solar domestic hot water systems, passive solar, wind and small-hydropower.

WJC/res



JET PROPULSION LABORATORY *California Institute of Technology • 4800 Oak Grove Drive, Pasadena, California 91103*

December 18, 1979

W. James Cole
New York State Energy Research and Development Authority
Rockefeller Plaza
Albany, NY 12223

Dear Mr. Cole:

Thank you very much for your prompt and insightful review of the Congressional document "Federal Policies to Promote the Widespread Utilization of Photovoltaic Systems." Your comments are well founded and will aid the Department of Energy and Congress in deliberations over the future of the Photovoltaic Program.

We fully agree with your comments on the highly location and utility specific aspects of PV system economics. You are right in your contention that the numbers presented can only be used as guidelines. The Program will extend these results to other locations and other utilities in the future. Development of appropriate rate structures for photovoltaic systems is a high priority of the PV Program. Unfortunately, detailed information on appropriate PV system rate structures is not available for inclusion in this report.

We were somewhat disappointed by your comments on the cost reduction techniques employed by the Program. In particular, we do not rely only on "learning curve and competition arguments." I refer you to Section 4.1.3 of Volume II which discusses in some detail the cost reduction techniques employed by the Program. Supporting documents are available which detail the technical aspects lying behind the cost reduction activities. I have included one such document for your information entitled "Price Allocation Guidelines," employed by the Low Cost Solar Array Project in their cost reduction efforts. Finally, you are correct in your contention that the cost reduction potential of AR&D concepts is much more uncertain than those of TD&A concepts.

Your criticism that the Commercialization Program Plan is not well defined, detailed, or comprehensive, is accepted. A plan is currently being developed by the Department of Energy and is not yet available for public release. Your suggestion that this plan must be implemented through cooperation with state level organizations is well taken, and all of the specific elements which you



W. James Cole

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December 18, 1979

suggest for incorporation into that plan are under consideration. We hope that when the plan is completed and released it will meet with your approval.

Thanks again for your time. Your comments will be included in the review section of the final report.

Sincerely,

A handwritten signature in black ink, appearing to read 'Jeffrey L. Smith', written in a cursive style.

Jeffrey L. Smith

Enclosure

Solar Business Office

State of California
Edmund G. Brown Jr.,
Governor



November 9, 1979

Mr. Paul Maycock, Chief
Photovoltaics Program
U.S. Department of Energy
Washington, D.C. 20545

Dear Paul:

I am sorry I missed you in North Carolina, but I understand that affairs of state had to take precedence over playing in the piney woods. Nevertheless, the Program Review Meeting was well organized and well run, and I congratulate you again on having a well run and progressive program.

I wanted to give you my reactions to JPL's draft report to the Congress, "Federal Policies to Promote the Widespread Utilization of Photovoltaic Systems, Volume I," November 1979. On the whole, it is an excellent document. However, I believe that there are several erroneous conclusion and one fundamental methodological error.

First, as to method, I want to make the point that the proper economic comparisons to use in considering the "breakeven" costs of photovoltaics, for the purposes of national policy, are not the consumer's cost of alternative power supplies, but the macroeconomic costs and benefits, which includes the following quantifiable elements:

- a. Utilities' cost of new capacity (short-run marginal cost), which is much higher than average cost.
- b. Unsubsidized utility prices (tax subsidies might be as much as 55% of consumers' cost).
- c. Benefits of reducing air pollution from electric power production (might be as much as 1¢/Kw-hr in critical air basins).
- d. Real economic costs of imported oil supplies, which the Harvard Business School study suggests might be 200% or more of market price.
- e. The benefit to a utility of receiving revenues from PV as the central station plant is being built.

The Solar Business Office
Business and Transportation Agency
921 Tenth Street
Sacramento, CA 95814
(916) 445-0970

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Mr. Paul Maycock
November 9, 1979
Page Two

These are all additive benefits for photovoltaics. It may be that the real economic breakeven is \$4/Wp, installed, instead of \$1.40, and that the goal for "commercial readiness" should be 1983 or 1984.

This confusion of consumers' economics with national economics has led the DOE solar thermal program to consistently understate the economic benefits of solar energy, to the detriment of program funding, sufficient tax credit, and the national economy.

The divergence of national benefits from first-order consumer benefits argues for very substantial tax credits, low-cost loans, etc., to narrow the gap between the consumer's perceived cost of PV and its marketplace cost.

To the extent that this approach renders your program goals too conservative, it significantly affects the timing, scope and magnitude of federal commercialization efforts (I like Option 6, by the way), leads you to look for technology breakthroughs where none may be needed, and hinders the efforts of solar advocates to force utilities to consider PV in their post-1985 supply resource planning. So, it is important to re-do these economic comparisons from a national viewpoint and to include several scenarios for the costs of imported oil, synfuels (DOE's great Cheshire Cat) nuclear and other electric power alternatives.

Second, here are the things I flatly disagree with, as they appear in the report:

1. The report should make recommendations for immediate legislation. There are three clear needs:
 - . Include PV in the residential and commercial solar tax credits, up to \$10,000 installed system cost, including the costs of solar easements.
 - . Include PV in the Solar Development Bank, as there are many homeowners who would use PV today, with tax credits and low-interest loans.
 - . A 15% to 25% small minority business set-aside for prime contracts in all phases of the PV program. (See discussion below.)
2. 90% private market (p. ES-15) -- Government buys should include PV's external economic benefits, as discussed above. Government is not analogous to private decision-makers; it has broader goals.

Mr. Paul Maycock
November 9, 1979
Page Three

3. Based on the economic discussion above, the breakeven costs for distributed applications is too low and should be raised, probably by 100% (p. ES-16).
4. "Ample opportunities for small business and minority business participation are expected and will be actively encouraged by the Department." "Current laws are adequate . . ." (pp. ES 20, 21), Malarkey! This statement does not accord with DOE's miserable record in both R&D and procurement of funding small/minority businesses, especially as prime contractors.

The great bulk (90%+) of DOE's money goes to building up the solar capabilities of the Fortune 500 (or 1000), despite the fact that small businesses virtually created the electronics industry and contribute about 45% of the GNP and considerable innovation to the economy. All of these statements are well documented facts, as you are aware, not just one man's opinion.

The auto industry may be competitive, but there are not very many companies producing cars. The DOE-PV Program must pursue other goals than just producing power at \$1.50 - \$1.60/Wp. It must actively build up the capability of small/minority businesses (just as it built up the PV capability of GE, Westinghouse, Exxon, etc.), through a systematic pattern of targeted procurements. Also, note that the vertical integration you seem to be pushing could easily become very anticompetitive.

5. On solar access (p. ES-21), I disagree that zoning ordinances for solar orientation should not be enacted; it is now State law in California. It is very appropriate, for "economic, technical and aesthetic" reasons to require all new homes to have southerly ($\pm 45^\circ$) exposure for passive solar gain and a large enough south-facing roof area* (of any pitch) to accommodate future PV and solar water heater retrofits. In-house connections should also be required, to the degree that they do not freeze technology too early. These costs are very minor.

Why should we build 15-20 million residential units by 1990 which cannot be easily retrofitted? South-facing windows and roof area will become aesthetically acceptable quickly as the "energy crisis" worsens and as every new home has them (my trickle-down theory of aesthetic change).

* We should also be looking at 3-5 Kw as the appropriate design size (using maximum conservation), to cut needed roof area to 300-500 sq. ft.

Mr. Paul Maycock
November 9, 1979
Page Four

6. On capital availability (p. ES-21), your report should make a strong case for mandating utility financing of consumer solar systems (which we will have in California by next Spring), in combination with the Solar Energy Development Bank, which should right now finance residential PV systems.
7. On warranties (p. F-12), California now requires a full one-year installer's warranty and a full (parts and labor) manufacturer's warranty (3 year) for PV systems to qualify for the 55% tax credit. DOE's cost-sharing and future large-scale buys should adhere to this standard. In addition, we expect our utilities to offer installation inspections, service contracts and "warranties of last resort." But the initial onus should be on the installer and manufacturer.
8. The Report to the Congress should also stress:
 - a. Maximum efforts to conserve electricity through BEPS, mandatory appliance and lighting efficiency standards, time-of-day and marginal-cost pricing, and other load management techniques.
 - b. PV can conceivably be an excellent way to charge batteries for electric cars (either at the peak or via localized storage).
 - c. To get 0.5 million barrels/day (oil equivalent) from PV (i.e., 1 Quad/year) by 1998 does not require an Energy Mobilization Board or tearing up the West for coal, shale oil, etc. Also, there is no CO₂ production or additional local/global heat buildings. -4p.

Here are some program suggestions:


1. Initial public information efforts should use the highly successful format of HUD's "Solar Status" series.
2. DOE should accelerate the regulatory process for cost-sharing with privately funded projects. This area is a potential gold mine of commercialization information.
3. Utility interface issues need to be viewed from the consumer's as well as the utility's perspective. We have no obligation to keep utilities in business forever as power generators.
4. DOE should be prepared now to mediate conflicts with local building and planning officials, either via its own experts or via state solar or housing offices. Our experience is that mediation is very successful, if you use people well known to, and respected by local code and zoning officials.

Mr. Paul Maycock
November 9, 1979
Page Five

5. I would like to see calculations made as to the net energy of every commercial PV production process, including all steps through installation. This is an important and often overlooked parameter.

I hope you will be able to integrate these comments into the final report. I would appreciate receiving a copy of that report as soon as it is ready.

Best regards,


JERRY YUDELSON
Director

cc: Robert Forney (JPL)
Jeffrey Smith (JPL)
Joan Shorey (Solar Lobby)
Jon Veigel (SERI)
Henry Kelly (SERI)
Keith Haggard (SERI)



JET PROPULSION LABORATORY California Institute of Technology • 4800 Oak Grove Drive, Pasadena, California 91103

December 18, 1979

Jerry Yudelson
Director of the Solar Business Office
Business and Transportation Agency
921 10th Street
Sacramento, CA 95814

Dear Mr. Yudelson:

Thank you very much for your detailed and timely critique of the Congressional document "Federal Policies to Promote the Utilization of Photovoltaic Systems." Your comments should prove useful in Department of Energy and Congressional deliberations over the future of the Photovoltaic Program. I would like, however, to respond to several of your criticisms.

You take issue with our methodology for calculation of system breakeven goals, suggesting that we have omitted five specific items which, if included, would bring the breakeven photovoltaic system price from \$1.60 in 1986 as calculated in the report, to \$4.00/Wp in 1983 or 1984 as suggested in your letter. The first and last of these five items, namely, the utilities' cost of new capacity and the benefit to utilities of receiving revenues from central station installations incrementally as the PV capacity comes on-line, are included in the methodology of the report, and are reflected in the goals as stated in the report. The remaining three items are either external costs, such as pollution or national security, or subsidization of generation sources competitive with photovoltaic systems. You are correct in stating that these are omitted from our methodology. However, they were omitted intentionally.

In part, this intention stems from the directive of Congress found in the RD&D Act which requested this report, to "have as an objective, the production of electricity from photovoltaic systems, cost competitive (emphasis added) with utility generated electricity from conventional sources." While admitting the phrase "cost competitive" is ambiguous in its definition, it could be interpreted as ruling out correction for subsidies in utility prices.

More important in our decision to omit these three items, however are the benefits arising from setting goals competitive with conventional sources on a strict cost basis, as done by the Photovoltaic Program. We are somewhat perplexed by your desire to see a higher cost goal. If the Photovoltaic Program is successful in accomplishing the \$1.60/Wp goal, the benefits to solar energy and the nation as a whole will be much larger than if performance were only to match \$4.00/Wp, as you recommend. First, the incentives to



Jerry Yudelson

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December 18, 1979

purchase and own photovoltaic systems would be much stronger under our scenario, making it much easier to convince people to install photovoltaic systems without having to resort to mandatory and coercive programs. Secondly, the total cost of the production of the systems will be lower, resulting in increased economic efficiency and benefits to the nation as a whole. The fact that subsidies could lower the price below \$4.00/Wp to the consumer, under your scenario, does not negate the fact that either taxpayers or utility stockholders would have to pick up the cost of the subsidy. If a \$1.60/Wp is feasible without an overwhelming increase in PV Program cost, and without an insufferable delay in the initial introduction of photovoltaic systems, the benefits to the nation would appear overwhelming. Furthermore, the progress to \$1.60/Wp does not necessarily imply that we would not meet the \$4.00/Wp as soon as or earlier than a program directed exclusively at the \$4.00/Wp goal. With a \$4.00/Wp goal, expenditures on research and development would be much less, because the extent of the development effort would be much less. Given lesser expenditures, the rate of progress might be less. Therefore the \$4.00/Wp goal may be reached later than under a program that has to stretch to reach \$1.60/Wp.

Appropriate, technically-sound, and proven system designs for residential photovoltaic systems do not yet exist. Installation, maintenance, instrumentation, and power conditioning are among the major system design and engineering problems that remain to be adequately resolved. Any system constructed prior to the necessary system development work is likely to be severely disappointing (the existing solar programs have provided ample evidence of this phenomenon). Thus, during the time necessary to complete the system design and engineering development, component and system cost reduction activities can be vigorously pursued, thereby delaying the introduction of viable PV systems very little.

Also, if we are able to attain \$1.60/Wp, then the subsidies that you correctly suggest photovoltaic systems deserve because of their benefits in the reduction of external costs, such as pollution (your item three), and national security (your item four), can still be enacted and will result in massive deployment of photovoltaic systems. The benefits from those subsidies will not be lessened if the Program reaches \$1.60/Wp instead of \$4.00/Wp. On the contrary, the benefits will be compounded because of the extreme attractiveness of photovoltaic systems, not only to the nation but to each private citizen.

You imply in an analogy between the Photovoltaic Program and the solar thermal program that our report understates the benefits to the nation of photovoltaic systems. No where in this report have we tried to calculate the benefits of photovoltaic systems. (I refer you to the Solar Energy Research Institute



Jerry Yudelson

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December 18, 1979

Report entitled "Photovoltaic Venture Analysis" which has made calculations of this sort.) The closest we come to a statement of benefits is in the conclusion section on page ES-25: "The promise of photovoltaic systems is very bright. Given successful completion of the National Photovoltaic Program, photovoltaics can substantially increase the security of our electricity supply at no increase in cost, while reducing the harmful side effects of conventional electricity production." Our goals are chosen to provide precisely these benefits.

Your next set of comments deal with recommendations you feel we should have included in the report. We accept the first two items as appropriate, but wonder why you stress that 15 to 25% of prime contracts, with prime emphasized, must go to small, minority businesses. We do not know the source of your objection to subcontracts. The Photovoltaic Low Cost Solar Array Project contracts with small business for close to 20 percent of total project funding. (Recent analysis has shown that, when subcontracts are included, DOE's record is not as bad in this regard as you contend.) Finally, I might note that the report does not encourage vertical integration. Although we do think that there are specific instances where vertical integration may be helpful, we certainly do not encourage anti-competitive behavior.

Your discussion in paragraph five of solar access and the need to prepare homes to be retrofitted with solar systems is stimulating. We agree that this issues deserves more attention and analysis. You suggest that "these costs are very minor." We would welcome a demonstration of that fact. Some of the alterations and additions to the current Program that you suggest must certainly be considered, including incentives to prefit homes with the internal connections and to guarantee solar access and sufficient solar roof space. We would appreciate any further information you have with respect to these aspects of solar energy development. We do not currently favor mandating utility financing of consumer solar systems. Nor do we think the residential market is ready for solar energy development bank loans because appropriate residential photovoltaic system designs do not yet exist, nor are residential photovoltaic systems even remotely competitive. This money is better spent financing other types of solar investments.

Your suggestion that utilities should offer installation inspections, service contracts, and "warranties of last resort" would seem to conflict somewhat with the statement that "we have no obligation to keep utilities in business forever as power generators." Although we certainly agree with the latter, we are not convinced of the benefits of forcing a natural competitor of distributed photovoltaic systems (the utilities) to service and warrant those



Jerry Yudelson

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December 18, 1979

systems. This may create a serious conflict of interest. Furthermore, it is not an onus that utilities should necessarily be expected to bear.

We appreciate your suggested program alterations, especially those suggesting how the program should be implemented. Thank you once again for your comments; we have found them most stimulating. A truncated version (per your telephone conversation with Lowell Orren) shall be included in the review section of the final document.

Sincerely,

A handwritten signature in black ink, appearing to read 'Jeffrey L. Smith', written over the typed name.

Dr. Jeffrey L. Smith

Southern California Edison Company



P. O. BOX 800
2244 WALNUT GROVE AVENUE
ROSEMEAD, CALIFORNIA 91770

F. A. MC CRACKIN
ACTING DIRECTOR
RESEARCH AND DEVELOPMENT

November 19, 1979

TELEPHONE
(213) 572-1097

Jet Propulsion Laboratory
Building 506, Room 316
4800 Oak Grove Drive
Pasadena, CA 91103

Gentlemen:

Southern California Edison welcomed the opportunity to review the draft of the "Federal Policies to Promote the Widespread Utilization of Photovoltaic Systems". Because of your time constraints, only the Executive Summary Findings and the Utility Systems and Economic Issues were examined in any detail. Though the document does not draw conclusions on the extent to which photovoltaics should be funded, it very clearly states the possible paths to achieving the goals and should provide valuable assistance to Congress and DOE.

After reviewing the document, Southern California Edison maintains its contention that rapid, massive commercialization of today's ingot technology is premature because of its potential technological obsolescence and ephemeral economic attraction. A more prudent course is to reduce R&D priority on materials having displayed little progress and vigorously pursue those that have shown potential to meet long-term goals. A moderate commercialization effort will maintain the existing photovoltaics industry and expand the industry infrastructure without the threat of misdirecting valuable time and resources on soon to be obsolete technology.

Southern California Edison's review of the draft document has found that the portions dealing with utility systems were inconsistent in depth of understanding and displayed a less than clear picture of utility operations. For example, the report correctly states that large power plants are rising in cost and are facing increased environmental regulations. The report also states that system reliability generally improves with larger numbers of smaller plants. However, the report incorrectly concludes that there are no advantages to the larger sized power plants. Not mentioned is that power plants in the range of 500-1000 MW typically

November 19, 1979

have a definite place in large interconnected networks, such as SCE's 15000 MW system, where economies of scale can be realized and overall system reliability not be jeopardized. The draft report also appears to have a "small is beautiful" bias which lessens its credibility.

Mention should also be made that individuals deciding to install photovoltaic systems must assume the social responsibility to produce reliable electric power. The utility will be depending upon the dispersed photovoltaic systems to justify constructing fewer new power plants to minimize the overall cost of electricity to the consumer. Should certain neighborhoods become net exporters of energy, as the report contends, this responsibility will further expand. Additionally, if multiple quads of energy are to be produced by dispersed systems, then correspondingly large numbers of individual users will have to assume this social responsibility to maintain reliable power output.

Thank you for the opportunity to review this document. Should you have any questions on the points we have made, feel free to contact Mr. Nick W. Patapoff at (213) 572-2961.

Yours truly,

A handwritten signature in cursive script, appearing to read "Alvin T. ...".



JET PROPULSION LABORATORY California Institute of Technology • 4800 Oak Grove Drive, Pasadena, California 91107

December 18, 1979

F. A. McCrackin, Acting Director
Research and Development
Southern California Edison Company
P. O. 800
2244 Walnut Grove Avenue
Rosemead, California 91770

Dear Mr. McCrackin:

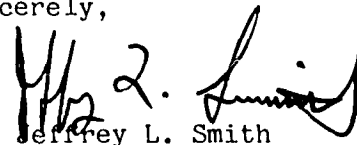
Thank you very much for your prompt and insightful review of the document "Federal Policies to Promote the Widespread Utilization of Photovoltaic Systems." Your comments will aid both the Department of Energy and Congress in deliberations over the future of the Photovoltaic Program.

Your comment that the report "incorrectly concludes that there are no advantages to the larger size power plants" has caused us some concern. We did not intend nor can we find such a conclusion. We support your contention that in the foreseeable future large scale power generation sources will be necessary in most utility grids. Even if distributed photovoltaic systems made up as much as 30% of grid generation, 70% must still be generated by other sources. It would be helpful to us if you could pinpoint where the confusion arises.

Finally, we agree with your suggestion that individuals deciding to install photovoltaic systems should assume a social responsibility for generating that power in a reliable fashion. However, we also believe that if economic incentives are set up properly it will be in the homeowners best interest to generate power reliably. In particular, if rate structures are set correctly, we believe this economic incentive can be very powerful.

Thank you again for your time and interest. Your comments will be included in the review section of the final document.

Sincerely,


Dr. Jeffrey L. Smith

SPECTROLAB

a subsidiary of Hughes Aircraft Co.

12500 Gladstone Avenue · Sylmar, California 91342 · Tel. (213) 365-4611 · TWX: 910-496-1488

November 15, 1979

Mr. Lowell Orren
Jet Propulsion Laboratory
Bldg. 506 Room 316
4800 Oak Grove Drive
Pasadena, California 91103

Dear Mr. Orren:

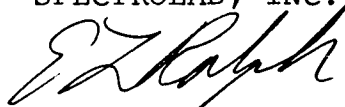
I have reviewed the draft document "Federal Policies to Promote the Widespread Utilization of Photovoltaic Systems", although it was quite limited due to the time factor. I find the document is well organized and generally sound. In respect to specific weaknesses I have the following comments to make.

Although the document does attempt to highlight the problems associated with the potential shortage of silicon materials (which would be equally true for any alternate material), the problem of getting the industry to make investment decisions, and the concerns of obsolescence of plants and equipment, I don't believe these concerns are still properly addressed. My feeling is that the build-up of the PV industry must meet all the normal economic criteria that any other business meets. Therefore, the primary concern must be to establish a reasonable assurance of a market and at the same time be confident that the return on investment is satisfactory. This point does not seem to be adequately addressed in the various options. Without a proper ROI incentive, I believe it will be very difficult to get businesses to make the large commitments at the rates desired.

I hope this reply is useful to you, and I want to offer my help in any further discussions you might desire regarding the above.

Very truly yours,

SPECTROLAB, INC.



E. L. Ralph
Vice President
Product Planning

ELR:sg

cc: Robert Forney - JPL

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JET PROPULSION LABORATORY California Institute of Technology • 4800 Oak Grove Drive, Pasadena, California 91103

December 18, 1979

E. L. Ralph
Vice President for Product Planning
SPECTROLAB
12500 Gladstone Avenue
Sylmar, California 91342


Dear Mr. Ralph:

Thank you very much for your prompt review of the Congressional document "Federal Policies to Promote the Widespread Utilization of Photovoltaic Systems."

The concerns you express over an adequate market for photovoltaic systems and an adequate return to investment in photovoltaic production facilities are well founded. The four program options discussed in the report which include a large commercialization effort were designed specifically to provide a market for the industry. Of course, it is not the intention of the Program to guarantee to any specific firm an adequate return on investment, although it is hoped that the Program can provide industry, as a whole, with the opportunity to earn an adequate profit. Ultimately, success of the Photovoltaic Program with respect to its long range goals should aid the photovoltaic industry to become large, growing, and profitable.

Thank you again for your comments. They will aid the Department of Energy and Congress in deliberations over the future of the Photovoltaic Program. Your comments will be included in the review section of the final document.

Sincerely,



Dr. Jeffrey L. Smith

SOLENERGY CORPORATION
23 NORTH AVENUE · WAKEFIELD, MASSACHUSETTS 01880
TELEPHONE (617) 246-1855 · TELEX 94 9399

November 13, 1979

Mr. Robert Forney
Photovoltaic Lead Center
Jet Propulsion Laboratory
CA Institute of Technology
4800 Oak Grove Drive
Pasadena, California 91103

Dear Bob,

The attached comments on the preliminary draft of "Federal Policies to Promote the Widespread Utilization of Photovoltaic Systems" dated November, 1979, should be taken in the light they were made, constructive, I hope.

The documents are detailed and it is impossible for me to review it completely. If I can contribute an additional word or sentence which either clarifies or explains or perhaps corrects, I will feel I have contributed something toward your effort.

Basically, there must be a government commercialization program spread over the years. The folly not to have demonstration programs in the 1980 budget should not be repeated in subsequent years. The price force cannot be tolerated except but for the cash-rich manufacturers. As single crystal prices remain constant due to high poly costs, an independent manufacturer cannot be expected to deliver or promise to deliver goods below cost or without profit. It is essential that small manufacturers make a profit to exist.

I am sure you and DOE realize it is also essential to keep a balanced industry consisting of both small and large businesses.

Thank you for the opportunity to comment.

Regards,



Robert W. Willis
President

RWW/ck

Enclosure

Comments from SOLENERGY CORPORATION

General

I am not addressing the actual total dollar expenditure. This is far too complicated for a DOE outsider to make substantive judgments. I would also point out that this document is extremely detailed and rapid comments are impossible.

Generally, I should point out that it is imperative that cost numbers, \$1.60/Wp for example, be defined as 19XX dollars installed (not installed) with (without) profit for the manufacturers. There is much confusion as to what these dollar numbers include. I would suggest an addition to the preface clarifying this point.

ES 2.2

"The willingness of the PV industry to accept risks involved in early investments in advanced automated, low-cost production processes."

This assumption makes another assumption which I am not comfortable with. It assumes that all PV companies have unlimited capital with which to invest in risk situations. This is not at all true. In the case of the major oil and electronic firms which have capital to risk, DOE can ask the risk to be taken. In the case of Solenergy Corporation which is not capital rich, it is unfair to assume it should risk capital. After all, the biggest risk is using one's own capital. It seems to me DOE should be willing to fund high-risk situations, otherwise we will be completely dependent on the more affluent companies.

ES-3 Utility and Photovoltaic System Interaction

ES-18 "In general PV systems displace capacity from peaking, intermediate and baseload categories with capacity credit ranging from 0 - 50% of name plate rating."

One problem is with peak loads which may occur while PV systems are inactive 4 - 6PM. It would appear that peaks are the largest problem and better study of peak times is necessary before making a general assumption that displacement of peaks is possible. I agree that daytime peaks would be served, but a better understanding of utility rate structure and peak service is necessary.

ES-4

It would appear that the statement, "The PV industry is, today, quite competitive. Entry into PV module and system production appears relatively easy, and several new firms have recently entered the industry" is inaccurate. The entry into cell production, the base of the industry, is not easy, and "several" (page F40) is not equal to one or two. This statement should be modified. You are justifying the fact that anyone can enter and, therefore, small business participation is not a problem. In fact, this is the theme throughout pages F40 - F46. This should be looked at competitively as on page 6-3. This list does not reflect commercial cell manufacturing capabilities as at least seven on the list do not manufacture cells from base silicon. I would, therefore, respectfully point out that involvement of new, small companies as well as opportunities are, at least difficult, if not impossible. I cannot generally accept F4 Findings as these pages are not consistent with actual fact as they relate to small business versus large business.

ES-5

I would point out that some zoning restrictions would prohibit the use of photovoltaics, and where such restrictions such as "Historical District Commissions" are in force, it will be necessary to educate both townspeople and zoning officials in its merits. Perhaps a minor modification in Finding 2 on page ES20 where the word education is inserted appropriately would be of value.

ES-6

Capital availability for PV producers is a substantial problem. This occurs, primarily, for small companies as potential investors cannot recognize a clear government program and, therefore, are unwilling to venture. (I would be happy to relate personal experiences on a private basis to the author of this paragraph as he really has no experience and, therefore, no right to make such a statement.)

Option 7

The problem of doubling PV production per year is complicated by the availability of raw material (poly crystalline silicon.) In addition, only capital rich companies could afford these investments.



JET PROPULSION LABORATORY *California Institute of Technology • 4800 Oak Grove Drive, Pasadena, California 91103*

December 18, 1979

Robert W. Willis, President
Solenergy Corporation
23 North Avenue
Wakefield, Massachusetts 01880

Dear Mr. Willis:

Thank you very much for your timely and detailed review of the Congressional document "Federal Policies to Promote the Utilization of Photovoltaic Systems." Your comments should prove useful in the deliberations of the Department of Energy and Congress over the future of the Photovoltaic Program.

Your suggestion that it be explicitly stated whether or not profits are included in the cost goals of the Program is well taken. The report has been modified in several places to reflect the fact that competitive rates of return are included in all of the price goals in this report. We also agree with your comments on the importance of the correlation between utility system load peaks and the output peaks of the photovoltaic system, and the need for better understanding of utility rate structures for photovoltaic systems.

Your primary objection centers around capital availability and small business opportunity in the manufacture of photovoltaic modules. This same issue has been raised by several other reviewers. We agree that this is a significant matter of concern, and the PV Program plans to conduct a more detailed and comprehensive review of the status of small business in the Program, as well as the plans of the Program to promote small business entry and prosperity in the photovoltaic industry. I might point out, however, that the existing report does not contend that small business will succeed in every aspect of photovoltaic system supply. Small business should prosper in the manufacture of modules for specialty markets as well as in other aspects of photovoltaic system supply, such as installation, maintenance, and system integration. Also, the question as to whether sufficient capital is available for investment in module production is separate from the question of whether or not small business will succeed in the production of photovoltaic modules.

Finally, let me point out that the Department does have plans to fund innovative, unsolicited proposals for various photovoltaic systems arising from innovators, whether they be large or small. The Program intends to make every effort to ensure a healthy, competitive photovoltaic industry, and to ensure small business opportunity to the extent feasible within that industry.



Robert W. Willis

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December 18, 1979

Thank you again for your useful comments, which we have used to modify the document in several places. Your comments will be included in the review section of the final document. When the analysis mentioned above is complete we will include you on the review and public distribution lists. The sincerity of your concerns is clear. They shall be taken into account in the development of the Department of Energy's Photovoltaic Program.

Sincerely,

A handwritten signature in black ink, appearing to read 'J.L. Smith', written over the printed name.

Jeffrey L. Smith

SOLAR POWER CORPORATION'S COMMENTS

ON

"FEDERAL POLICIES TO PROMOTE THE WIDESPREAD
UTILIZATION OF PHOTOVOLTAIC SYSTEMS"

We are of the opinion that the goals established by Congress in PL-95-590 cannot be achieved with the funding set by Congress in 1978. We also believe that unless there are early scientific breakthroughs, it is unlikely that the ultimate cost reduction goals of the photovoltaic program can be met on schedule.

There are several points in the study that are particularly noteworthy:

- There will be a severe problem in the near term due to the limited availability to the photovoltaic industry of highly refined silicon and there will be a mid-term problem for the industry in obtaining lower cost solar-grade silicon.
- If the total costs of photovoltaic systems are to be significantly reduced, technology breakthroughs are required in storage systems as well as photovoltaic technology.
- A high level of government funding and stimulation (as identified in Option 6) will have its obviously positive aspects limited by some negative effects such as raw material and product supply bottlenecks, higher prices due to shortages, and inferior quality systems installed by less than competent suppliers, who are in the market on a temporary basis.

We think that the following points are not adequately addressed in the study:

- The various Options do not really take into account the relatively large and economically attractive international markets which are opening up for U.S. photovoltaic manufacturers in the 1980's.
- The study continues to envision a program under which "photovoltaic system prices could realistically be forced down" toward the price of conventional grid electricity. We think that prices should be set through the mechanisms of free-market competition. Continued

government pressure to reduce prices down to or below manufacturing costs will undoubtedly eliminate current and potential photovoltaic suppliers.



JET PROPULSION LABORATORY *California Institute of Technology • 4800 Oak Grove Drive, Pasadena, California 91103*

December 18, 1979

Mr. Sylvester L. Farrell
Solar Power Corporation
500 E. Poplar Road
Sterling, VA 22170

Dear Mr. Farrell:

Thank you very much for your review of the Congressional document "Federal Policies to Promote the Widespread Utilization of Photovoltaic Systems." Your comments should serve to highlight several of the important points made in this document, and should prove useful to the Department of Energy and Congress in deliberations over the future of the Photovoltaic Program.

In particular, thank you for your support in our contention that problems may arise in the supply of polysilicon materials, or in system supplier or other bottlenecks if the Program is stimulated at too rapid a rate. We do not agree, however, with your second comment. You assert that our document contends that storage systems will have to be reduced greatly in price in order to reduce the installed cost of photovoltaic systems. In fact, we make no such contention. On the contrary, the report states that storage is not necessary in photovoltaic systems to make them economically competitive in grid connected applications. Also, you suggest that "early scientific breakthroughs" are necessary in order to achieve the cost goals of the Program. We are interested in the precise meaning of "early scientific breakthroughs." We agree that significant progress in the technology is necessary and that some of that progress could be called breakthroughs, but others use the term "breakthroughs" to imply a more significant step function in technological change than we think is necessary to make the price goals. If you have further thoughts along these lines, feel free to contact us.

The report did not discuss the international markets because the document is being accompanied to Congress by a companion document entitled "International Photovoltaic Program Plan" which addresses these markets in detail.

Your final comment implies that the strategy of the Program to "force system prices down" is inconsistent with the use of free market mechanisms to set prices. We don't share that view. The Program intends to allow the free



Mr. Sylvester L. Farrell

-2-

December 18, 1979

market to set the prices for photovoltaic components and systems, but we still believe that we can bring about significant cost reduction through the techniques discussed. We welcome further clarification of the perceived inconsistency between these two tactics.

Thanks again for your useful comments, which will be included in the review section of the final document.

Sincerely,

Dr. Jeffrey L. Smith


13 November 1979

Lowell Orren
Jet Propulsion Laboratory
Bldg. 506, Room 316
4800 Oak Grove Drive
Pasadena, California 91103

Dear Mr. Orren:

I have asked Norman Milleron, a physicist, to review this study on Federal Policies to Promote the Widespread Utilization of Photo-voltaic Systems and am submitting his comments in response to your request of 1 November 1979 (720-RGF:hsb).

Sincerely yours,


Ralph Nader

Enclosure

Comments on Federal Policies to Promote the Widespread Utilization of Photovoltaic Systems - Prepared by Norman Milleron, 13 November 1979

Volume I (the executive summary) seems to mirror faithfully Volume II (technical document), except that the figures, including the crucial figure 2-1 (page 2-4, II) are omitted. I comment, therefore, only on Volume II.

There are a number of praiseworthy statements and discussions in Volume II. However, these can only be discussed by first resolving the contradiction between the stated purpose of the study and Figure 2-1, page 2-4, if this figure is taken seriously.

The central purpose is stated in paragraph 1, page 1-1 "...to report...on various potential barriers to widespread photovoltaic system development." Unfortunately, the lack of discussion of the implications of figure 2-1 compromises this laudable purpose as follows.

The figure shows that photovoltaic arrays cover roof tops and other areas adjacent to and on individual residences in order to serve the needs of people using and owning these residences. Note that photovoltaics cover all or almost all of the roof area directly facing the sun at some time during the day. How, then, are the people's needs for hot water and space heating and cooling to be met? The report neither poses nor comments on this question as far as I can see. Are their combined needs for heating, cooling and electrical to be satisfied by 8 to 10 kilowatts of photovoltaic generating capacity?

This problem is not mentioned and seems to be an omission of prime importance to the stated purpose of this report. All of a given roof facing the sun must be covered by photovoltaics because only 5 to 10% of the sun's energy hitting this occupied area can be converted to electric power. What happens to the other 95 to 90% of the incident solar energy? Apparently, this energy is dissipated, without utilization, into the ambient environment or radiated through the atmosphere.

In other words, this document does not mention so-called hybrid flat plate-PV collectors that would provide not only practical amounts of electric power but also energy for hot water and space heating from the area available. Part of the reason for this omission may be that the Department of Energy does not request a discussion of hybrid PV-thermal collectors because such hybrids do not fall neatly into the DOE's categories of work.

The economic arguments, market penetration rates, questions of acceptance etc. would be markedly different if the hybrid PV-thermal option were discussed. For example, how are the residences in figure 2-1, page 2-4 to be heated if all of the sun facing surface is used for electrical power, such amount of power being

Comments on Federal Policies to Promote the Widespread Utilization of Photovoltaic Systems - Milleron, page 2

too little for practical use in heating requirements ?

The Study mentions only silicon PV and the other materials that lose their efficiency as their temperature is increased. On the other hand, gallium arsenide, for example, does not lose efficiency at temperatures necessary for hot water and space heating. Such hybrids would win economically over materials that would not serve in thermal-PV hybrids.

end



JET PROPULSION LABORATORY California Institute of Technology • 4800 Oak Grove Drive, Pasadena, California 91103

December 18, 1979

Norman Milleron
c/o Ralph Nader
P. O. Box 19367
Washington, D. C. 20036

Dear Mr. Milleron:

Thank you very much for your comments on the Congressional document "Federal Policies to Promote the Widespread Utilization of Photovoltaic Systems." I apologize for the confusion which has apparently arisen over the interpretation of Figure 2.1, Volume II, which shows a photovoltaic system neighborhood. This figure was never intended to be highly accurate with respect to photovoltaic system configuration, but rather was meant to portray the general direction of the Photovoltaic Program (i.e., distributed residential systems).

Your contention that serving the electrical needs of a household is not the only consideration is certainly valid. The proper integration of photovoltaic system design with general energy conservation, as well as space and water heating needs of the household, is a primary concern of the system design activities of the Photovoltaic Program. However, this report was not intended to provide, nor did Congress ask for, detailed information on the various system configurations under investigation by the Department of Energy.

Various options for meeting the space and water heating needs of households are under active investigation in the system design engineering elements of the Program. Electric heat pumps, solar assisted electric heat pumps, combined PV/thermal collectors, and side-by-side PV and thermal collectors are all under active consideration by the Department. More information on the promise of such collectors is available from the Department of Energy or from the Photovoltaic Lead Center at the Jet Propulsion Laboratory. To reiterate, the Department of Energy believes that the development of proper PV system designs requires consideration of the entire energy needs of the residence.

Once again, I am sorry for the confusion that has arisen over the somewhat inaccurate Figure 2.1. Thanks again for your comments; they will be included in the review section of the final document.

Sincerely


Dr. Jeffrey L. Smith

(Retype)

UNITED STATES DEPARTMENT OF JUSTICE

WASHINGTON, D.C. 20530

February 1, 1980

Mr. Thomas Stelson
Assistant Secretary for
Conservation & Solar Energy
Washington, D.C. 20580

Dear Mr. Stelson:

Pursuant to the Solar Photovoltaic Energy Research, Development and Demonstration Act of 1978, 43 U.S.C. Sec. 5581, the Department of Energy ("DOE") intends to submit a report to Congress entitled, "Federal Policies to Promote the Widespread Utilization of Photovoltaic Systems," DOE/CS-0114. Section 10 of that Act requires DOE to consult with "appropriate" Federal agencies regarding the adequacy and conclusions of the report. 42 U.S.C. Sec. 5589. In accordance with that provision you recently submitted a December, 1979 draft of the report to the Department of Justice ("Department") for review. The purpose of this letter is to advise you of areas in the draft report which the Department believes require further analysis so that, as required by the Act, Congress is adequately advised of the expected state of competition in photovoltaic (PV) markets and of the competitive effect of planned or proposed government activities in those markets.

The principal conclusions in the draft report regarding competition are that the PV industry is highly competitive, and that the "industry is expected to remain highly competitive."* Executive Summary at 20. These conclusions are based upon the premise that "the availability of raw materials, the opportunities for vertical integration, and the capital requirements preclude any possibility of monopolization or restriction to entry." Technical Document at 6-21. Our review of the draft report indicates that the factors relied upon in describing and predicting the competitive situation in the PV industry have not been adequately evaluated. In particular, the Department believes that additional information and analysis is needed regarding the silicon refining sector of the PV industry.

PV cells, also known as solar cells, are solid-state devices which directly convert the sun's energy to electricity. The most popular current technology employed for this purpose consists of thin sheets of highly-refined silicon, arranged in single-crystal configurations, through which the sun's

* Editor's Note: This review was conducted on an earlier draft of this document. Many of the conclusions and quotes referred to have been revised or dropped in response to this review and others.

energy causes electrons to move towards electrical conductors attached to the cell. Production of this version of the technology requires highly sophisticated refinement of silicon into a single-crystalline form. Silicon, thus refined, is cut into one of a variety of physical configurations and attached to electrical conductors. Generally, cells are arranged together in whatever array the manufacturer deems useful for the market it serves. The cells are then incorporated into various modules adapted for particular end-uses.

The PV industry is naturally divided into at least two vertical levels: silicon refining and cell manufacturing. Although some PV cell manufacturers are vertically integrated backward into silicon refining, as highly refined silicon is also used in semiconductors, most silicon refining is done by the electronics industry.

An assessment of the nature and extent of competition in the silicon refining industry would indicate whether refiners have market power, and whether PV manufacturers which are vertically integrated possess a significant share of the upstream market. Such an analysis should consider the types of contractual arrangements between refiners and silicon purchasers, economies of scale in refinery processes, the size and number of firms in the refining industry, and the cost and availability of substitutes for refined silicon in the electronics and PV industries.

As noted above, the draft report indicates that at least three factors, the lack of "restrictions to entry" and the "availability of raw materials (and) the opportunities for vertical integration...." (p. 6-21) will preclude anticompetitive developments in the PV industry. These conclusions, however, seem to conflict with a study prepared for DOE,^{1/} referred to in the draft report, which warns that a shortage may occur in 1982 or 1983 of the refined silicon necessary for the production of single-crystal silicon-based photovoltaic cells (p. 6-15).^{2/} Moreover, it appears that a contributive cause for the expected shortage would be recent DOE breakthroughs in the technology for refining silicon, which are expected to reduce the cost of such refining by a factor of six. (p. 6-16). Immediate application of the DOE-developed process cannot be expected, however, absent action by DOE to accelerate dissemination of this new technology since, as noted in the report, "most successful entrants (to PV markets) will adopt proprietary production processes different from those developed by government." (p. 6-13).^{3/} The draft report does not expect private use of current technologies to make up

^{1/} JPL's Silicon Material Availability Study (Phase 1, August, 1979).

^{2/} The report also indicates that refined silicon shortage may occur in 1983-1984. See p. 6-18.

^{3/} Should refined silicon become unavailable due to the predicted shortage, refining would become a necessary part of a new entrant's PV production process.

the expected shortage, because, "given the likely advent of new, cheaper technology on the horizon, producers are understandably reluctant to add capital and energy intensive capacity that will probably be obsolete before or soon after it becomes operational." (p. 6-17)

The report goes on to note that, although DOE "is giving high priority to solving the problem," (p. 6-17), it has not settled upon a solution. The report should assess the competitive significance of this shortage in the PV market and evaluate the likely competitive effects of the alternatives which DOE is considering to alleviate the shortage.

The draft report identifies a "Multi-Year Purchase Strategy" which contemplates significant government purchases of PV equipment to stimulate commercialization of PV technologies. The report notes, however, that the "exact timing, scale, duration, technologies and markets associated with the purchase strategy have yet to be determined by DOE" (p. 6-25). At no point, however, does the report discuss either the relationship between the government purchase strategy and the expected shortage of refined silicon, or the likely competitive consequences of the purchase strategy. For example, the report should determine whether government purchases will exacerbate the shortage or affect some firms more harshly than others, thereby adversely affecting competition in the PV industry. After these questions have been analyzed, the report should also indicate how DOE may design the purchase strategy to minimize possible anticompetitive effects.

The draft report identifies several potential government responses designed to deal directly with the shortage. These responses are grouped under two broad approaches: proposed increases in silicon refining capacity by a variety of measures, and movement of PV production away from use of highly refined silicon as a basic material. Each of these general approaches could have significant effects on the structure of the PV industry. Under the first approach--increasing refining capacity--the method by which additional refining is obtained is crucial to the competitive viability of existing PV manufacturers that do not have refining capacity. For example, if some silicon refiners have market power, government incentives for the expansion only of existing refining capacity might have the effect of either leaving that market power intact or increasing it. If, on the other hand, the government were to build or contract for the construction of new refining capacity with government control over its output, the availability of such new sources of supply might limit the exercise of any existing market power.

Similarly, the manner in which the government might choose to stimulate a shift away from use of refined silicon as the basic material for PV production could have different competitive impacts on existing and future competitors in the PV industry. The report makes only a partial listing of companies which utilize other manufacturing processes (p. 6-14) and does not determine whether any undue competitive advantage might be given to one or more companies by the

government's decision to use any particular technology. Given the array of alternative technologies from which the government might choose--semi-crystalline silicon, amorphous silicon, cadmium sulfide, gallium arsenide, etc.--it is important to identify which companies would gain or lose from the options available to the government.

The report, while indicating DOE uncertainty as to these two alternatives, recommends a third alternative, closely related to the first: encouragement of new refining capacity in firms which currently lack it. (p. 6-18). This alternative is described in the report as "vertical integration." The report, however, contains no competitive analysis of vertical integration on PV manufacturing. The effect of such integration depends crucially on the state of competition and the capacity configuration in the silicon refining market, issues which were not adequately presented in the draft report. Since the report makes no recommendations with respect to the first two possible government responses to the predicted refined silicon shortage, the basis upon which the third alternative was recommended is unclear, especially in the absence of competitive analysis with respect to any of the alternatives.

The report also presents an inadequate basis for concluding that capital requirements will not restrict entry into the PV manufacturing market. The only discussion in the report of capital requirements for entry into this market appears in Chapter 5 of the Technical Document, which expresses the conclusion that "capital requirements between now and 1986 are of the same magnitude as those required for the mature technology." (p. 5-6). The report estimates that these requirements are in the range of \$10 to \$15 million per production line. This estimate is for construction of a plant to assemble single-crystal silicon solar cells. However, if there are no independent sources of refined silicon supply and vertically integrated firms do not have excess refining capacity, it would be necessary to include the cost of acquiring refinery facilities as well in the capital costs for a potential entrant. Moreover, no mention is made of the costs of facilities to produce semi-crystalline or amorphous silicon-based cells, or to produce non-silicon cadmium sulfide or gallium arsenide cells which are possible substitute technologies for single-crystal silicon. In light of the assumption in the draft report that the government might respond to the predicted shortage of silicon refining capacity by steering development efforts away from single-crystal silicon-based cells into one of the above-listed alternatives, an informed conclusion regarding the significance of capital requirements as a potential entry barrier cannot be made in the absence of cost estimates for these alternative technologies.

Further, the report's assessment of the significance of capital requirements as a potential entry barrier--listing the capital required for a single production line for a currently-popular PV technology--overlooks another conclusion of the report, that "the technology is anticipated to change very rapidly..." (p. 6-21). If this proves true (and recent experience in the PV industry confirms its accuracy), new entrants may have to rely on

very short amortization periods for production lines built today. Indeed, depending on the rapidity of technological development (accelerated by government research & development expenditures), a new entrant may need to plan for the construction of two or more entirely new production lines in the first five to ten years of existence. If this proves to be true, the report would have understated capital requirements, even for the single technology assessed. These capital requirements could constitute a significant entry barrier which potential entrants could not meet through financing. Since the cost of financing is, in any event, generally higher for new entrants than for existing firms in a market, this might constitute a considerable absolute cost barrier to entry.

Although the report states that capital markets are "among the more 'perfect' markets in existence," (p. 5-2), the discussion in the report of experiences of four independent PV manufacturers in raising capital does not bear out this observation as applied to high-technology ventures in the throes of accelerated development. (p. 5-9 - 5-12). One major independent manufacturer offered the opinion that it was impossible to obtain debt financing since "lenders do not believe independents are good risks for their money." (p. 5-10). Another major independent manufacturer had trouble finding a bank which would even read its proposal. This latter producer succeeded in obtaining bank financing only when it pledged to produce customized products for specialty markets. (p. 5-11; see also p. 5-12). This suggests that financing not only affects the ability of new entrants to begin PV manufacturing, but also could determine the nature and extent of the manufacturing and marketing activities which new entrants can undertake.^{4/}

The report also suggests that despite government efforts, there is inadequate and, perhaps, misleading information in the financial community regarding the commercial viability of PV manufacturing. Because the technology and the market itself is changing rapidly it is not clear whether new entrants, other than capital-rich enterprises in related fields, will be able to obtain necessary financing. As the report notes, these factors have

"given some impetus to the acquisition of photovoltaic producers by large oil companies or semi-conductor manufacturers. The ability of these companies to supply ample capital over long periods of time while absorbing substantial losses is a strong inducement for the independent to sell out. Thus, almost all current photovoltaic system manufacturers are at least partially held by oil companies or some other large manufacturer." (p. 5-7).

^{4/} One independent manufacturer has made a public stock offering, but the results of the offering apparently were not known at the time the report was written. (p. 5-10).

On the other hand, the report notes that "the technology is anticipated to change very rapidly, giving a distinct advantage to those firms that have foresight and flexibility, thereby neutralizing the advantages of large, powerful corporations." (p. 6-21). Further analyses of the relative strengths of small and large firms is necessary in order to draw reasonable conclusions regarding the competitive significance of capital requirements in the PV industry.

The apparent advantages that large corporations, such as oil companies, may possess for successful entry into the PV market raises a series of additional questions regarding competition not addressed in the report. What is the level of concentration in the PV industry? Have firms entering the PV market from other industries displayed different competitive behavior than independents? Are oil and electronics firms entering the market primarily by acquisition or by the establishment of new subsidiaries? Has the choice between those two modes of entry affected concentration and competitive behavior in the industry? The Justice Department has obtained information which suggests that in 1977 and 1978 the industry was relatively concentrated (a 4-firm concentration ratio above 60% and an 8-firm ratio in excess of 90%). Both the historical effect of the methods by which large firms have entered PV markets and the expected competitive effects of large-firm entry through acquisition of new companies are factors which the report ignores.

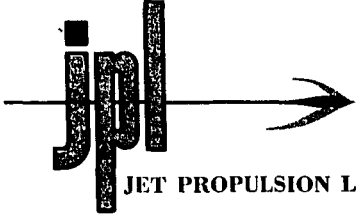
Absent such analyses, statements in the report that the industry is "highly competitive" and is expected to remain so are not adequately supported. In light of this and of the report's stated commitment to "encourage the entry, growth and survival of small, independent producers," (p. 5-18), further analysis and discussion of the competitive consequences of large firm participation in PV markets should be undertaken before the final report is submitted to Congress.

The Department of Justice, thus, concludes that the draft report gives an incomplete picture of present and future competition in PV markets. It is recommended that additional inquiry be made into the effects of the predicted shortage of refined silicon and of capital requirements on future competition and that particular attention be paid to the competitive effect of government responses to the various market problems identified in this letter.

We remain available to work with you and your staff in this matter.

Sincerely,

Donald L. Plexner
Deputy Assistant Attorney General
Antitrust Division



JET PROPULSION LABORATORY *California Institute of Technology • 4800 Oak Grove Drive, Pasadena, California 91103*

3 April 1980

Refer to: 311/JLS:amc

Glen Stover
Department of Justice, Anti-Trust Division
1101 Pennsylvania Ave., N.W. Room 6312
Washington, D.C. 20530

Dear Glen:

Thank you very much for the comprehensive and insightful Justice Department review you helped prepare of selected sections of the Department of Energy report to Congress entitled "Federal Policies to Promote the Widespread Utilization of Photovoltaic Systems." As you know, your review has stimulated considerable revision of the document, including substantial and important changes to our predictions of the likely competitive state of the future photovoltaic industry. In addition, as a result of your review we have concluded there is a pressing need to begin a more comprehensive investigation of the likely evolution of the PV industry and the competitive implications of planned or proposed Photovoltaic Program actions on that evolution. When plans for this study are formulated, I will contact you to determine your interest and appropriate role in carrying that study to a successful completion. Needless-to-say, revisions were made to the Congressional report without benefit of the planned study, and thus, we could do nothing more than reflect our current knowledge. Accordingly, we have substantially increased the emphasis placed on uncertainties concerning the competitive evolution of the industry.

Thanks again, Glen, for an important contribution to our work. The remainder of this letter will delineate in detail our approach or reaction to each of the specific issues the Justice Department raised in its review.

A. Your first major criticism challenges our general conclusions on the future competitive state of the photovoltaic industry:

The principal conclusions in the draft report regarding competition are that the PV industry is highly competitive, and that the "industry is expected to remain highly competitive." Executive Summary at 20. These conclusions are based upon the premise that "the availability of raw materials, the opportunities for vertical integration, and the capital requirements preclude any possibility of monopolization or restriction to entry." Technical Document at 6-21. Our review of the



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draft report indicates that the factors relied upon in describing and predicting the competitive situation in the PV industry have not been adequately evaluated. (Justice Department Review).

Our response to this was to (1) explicitly state all our reasons for concluding that the current industry can be described as competitive and (2) retract our conclusion that the "industry is expected to remain highly competitive," substituting the conclusion that the future competitive state is uncertain. While these corrections were made at several places, a quote or two from the revised version should suffice to illustrate our approach:

Currently, the photovoltaic business seems quite competitive. The terrestrial industry is very new (less than 5 years old) and very small (approximately \$20 million in total commercial sales in 1979). Nevertheless, there are 14-15 U.S. firms currently producing flat-plate silicon modules (see Volume II, Table 6-1). U.S. firms compete with those of Europe (especially France) and firms in Japan. Price competition and competition for markets appears intense. Many firms are currently sustaining losses in hope of eventual success. Several new PV ventures have recently entered or are preparing to enter the industry. Three new technologies are on the verge of commercial production. Existing firms range from very small independent businesses to subsidiaries of the largest corporations in the world. Thus, module production appears to be competitive currently (Federal Policies ..., p. F-44,)

Given the early state of PV production technology, markets, industry, and the rapidity and extent of expected change, a clear picture of the industry most likely to successfully supply photovoltaic systems to mass, grid-connected markets has not yet emerged. In particular, the efficient scale of manufacturing operations is not well defined, government decisions affecting industry structure remain to be settled, and the relative attractiveness of photovoltaic manufacture, marketing, sales and service industries to various private producers have yet to be determined. Furthermore, the eventual role of electric utilities as well as the applications classes which become most attractive (e.g., residential, commercial, industrial, agricultural, international or central station), will affect the structure and character of this emerging industry. The DOE has recently initiated plans to investigate these issues in even more detail, in order to



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guide DOE efforts to promote a healthy, competitive, self-sustaining, private PV industry. In summary, while the current PV industry appears to be growing, healthy and competitive, there are significant uncertainties and possibly adverse trends (e.g., silicon material shortage) that cloud its future. Clearly, the DOE must choose its policies to promote and encourage a competitive evolution of the industry (Federal Policies, pp. F-46 - F-48).

Finally, the quote you took from our report, p. 6-21, has been deleted.

- B. A significant portion of Justice's comments were directed at more fully exploring the effect of the potential silicon material shortage and the government's likely response to that shortage. To that end, the revised report draws substantially upon the Silicon Material Outlook Study prepared last fall by JPL:

In particular, the Department (of Justice) believes that additional information and analysis is needed regarding the silicon refining sector of the PV industry. (Justice Department Review)

An assessment of the nature and extent of competition in the silicon refining industry would indicate whether refiners have market power, and whether PV manufacturers which are vertically integrated possess a significant share of the upstream market. Such an analysis should consider the types of contractual arrangements between refiners and silicon purchasers, economies of scale in refinery processes, the size and number of firms in the refining industry, and the cost and availability of substitutes for refined silicon in the electronics and PV industries. (Justice Dept. Review).

There are no good substitutes for silicon in the electronics industry. A loss of silicon would effectively set back the electronics industry by many years. To a lesser extent, the same is true for photovoltaic devices. The best substitute for silicon in PV devices is concentrators. However, concentrators are less technically proven, are more complicated, and are not suited for many current applications. Furthermore, their future costs remain uncertain. Other materials (e.g., cadmium sulfide, gallium arsenide) are not yet considered technically feasible by DOE and have not been demonstrated to be feasible by any private firms. Thus, silicon material is very important for both photovoltaics and the electronics industry.

A new Table 6-6 has been added to the report (taken from the Silicon Materials Outlook Study) which gives existing and predicted silicon material refining



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capacities for each manufacturer in the free world for each year 1977 through 1985. As that table indicates, only one current producer of PV modules is also a producer of polysilicon (Motorola). And Motorola only produces 100 MT of silicon out of an existing annual world supply of 2700 MT.

Most PV manufacturers do not even purchase silicon material directly. Rather, they buy wafers from wafer producers, a very competitive industry (discussed at length in the report). Only two PV manufacturers other than Motorola (Solarex and ARCO Solar) have the capability to produce wafers, and therefore the need to buy polysilicon on the open market. The remaining twelve PV firms listed in Table 6-1 do not deal directly with polysilicon manufacturers. Both wafers and polysilicon material are purchased through long-term supply contracts as well as on the open market.

Economies of scale differ substantially among the various silicon refinement processes. The existing conventional Siemens process does not have significant economies above 200 MT/year. (Some people claim it has little economies above the size of a single reactor of 10 MT/year.) Advanced Siemens may have economies ranging up above 500 MT/year, as indicated in Table 5-1(b) of the report. The new processes under development will likely have significant scale economies ranging as high as 3000-4000 MT/year. Furthermore, these scale economies differ substantially among the various processes, with Westinghouse felt to have the largest economies (4000 MT), Union Carbide next (1000 MT), and Battelle the least economies of scale. Of course, any significant expansion of the silicon PV industry will require very large quantities of polysilicon (approximately 1000-1200 MT per 100 MWp).

As discussed in the report, the world-wide silicon material industry appears to be quite competitive. Prices have been depressed, and several major firms (e.g., DuPont) have exited the industry as a result of intense competition and low profits. The desertion of the industry by many U.S. firms has concentrated U.S. output in the hands of Dow Corning. However, Dow faces significant foreign competition. The future competitive state of this industry is very difficult to foresee, however. The variety of possible technical approaches, government policies, industry reactions, and market demands (e.g., for PV applications) make it difficult to predict the evolution of this industry.

Immediate application of the DOE-developed process cannot be expected, however, absent action by DOE to accelerate dissemination of this new technology since, as noted in the report, "most successful entrants (to PV markets) will adopt proprietary production processes different from those developed by government." (Justice Department Review)

This statement indicates some misunderstanding of the status of silicon refinement technologies. The 3 or 4 primary refinement processes under



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development by DOE cannot be immediately adopted because the technologies are not yet ready for commercial production. The most advanced process will not become ready for at least several years. The proprietary production processes referred to in the passage you quote are module production steps. The quote was intended to convey the message that, of the multiple production steps between wafers and modules, many firms will attempt to improve on the government process in one step or another. Nevertheless, most firms are and will continue to draw heavily on government developments. We do not expect all firms to use processes entirely taken from government developments. The report has been modified to clarify this expectation.

The draft report identifies several potential government responses designed to deal directly with the shortage. These responses are grouped under two broad approaches: proposed increases in silicon refining capacity by a variety of measures, and movement of PV production away from use of highly refined silicon as a basic material. Each of these general approaches could have significant effects on the structure of the PV industry. Under the first approach--increasing refining capacity--the method by which additional refining is obtained is crucial to the competitive viability of existing PV manufacturers that do not have refining capacity. For example, if some silicon refiners have market power, government incentives for the expansion only of existing refining capacity might have the effect of either leaving that market power intact or increasing it. If, on the other hand, the government were to build or contract for the construction of new refining capacity with government control over its output, the availability of such new sources of supply might limit the exercise of any existing market power. (Justice Department Review)

Similarly, the manner in which the government might choose to stimulate a shift away from use of refined silicon as the basic material for PV production could have different competitive impacts on existing and future competitors in the PV industry. The report makes only a partial listing of companies which utilize other manufacturing processes (p. 6-14) and does not determine whether any undue competitive advantage might be given to one or more companies by the government's decision to use any particular technology. Given the array of alternative technologies from which the government might choose--semi-crystalline silicon, amorphous silicon, cadmium sulfide, gallium arsenide, etc.--it is important



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to identify which companies would gain or lose from the options available to the government. (Justice Department Review)

The report has been modified to clearly indicate that a shift away from silicon toward other PV materials is not one of the options currently being considered to deal with the silicon shortage:

Finally, redirection of the Program toward technologies other than silicon (e.g., concentrators) is considered a longer-term option, not now under active consideration. (Federal Policies ..., p. F-52).

The Program does not consider any non-silicon materials to be technically feasible at this time, and therefore would not consider a major reorientation of the Program toward them to be wise. I might also note that the listing on p. 6-14 of companies involved in advanced materials production is complete, to the best of my knowledge. None of these attempts at production has had any significant impact on the marketplace (i.e., total quantities of output have been miniscule). Single-crystal silicon flat-plate modules remain the only technology produced in significant quantities.

We have also modified the report to explicitly indicate that expansions of silicon refinement capacity must be encouraged in a manner that does not adversely affect the competitive state of either silicon refining or PV production. Thus, given that availability of silicon materials is crucial to PV success, capacity expansion from new producers (including PV module makers) as well as from existing producers is desired. Expansion from existing producers alone is not desirable:

Installation of new refinement capacity by new industry entrants is a preferred alternative, employing both conventional and new refinement technologies. (Federal Policies ..., p. F-52)

Thus, even though we do not believe current silicon producers have significant market power (see discussion above) we definitely wish to encourage new entrants for the purpose of promoting as much competition as possible.

The report, while indicating DOE uncertainty as to these two alternatives, recommends a third alternative, closely related to the first: encouragement of new refining capacity in firms which currently lack it (p. 6-18). This alternative is described in the report as "vertical integration." The report, however, contains no competitive analysis of vertical integration on PV



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manufacturing. The effect of such integration depends crucially on the state of competition and the capacity configuration in the silicon refining market, issues which were not adequately presented in the draft report. Since the report makes no recommendations with respect to the first two possible government responses to the predicted refined silicon shortage, the basis upon which the third alternative was recommended is unclear, especially in the absence of competitive analysis with respect to any of the alternatives. (Justice Department Review)

Encouragement of new refining capacity by existing PV firms has never been considered a preferred or stand-alone alternative for dealing with the silicon material shortage. While new sources of silicon must be welcomed whatever their source, the Program does not intend to emphasize one source to the exclusion of others. On the contrary, the more sources (especially new sources) made available, the more likely we are to prevent the shortage from arising, and the more likely silicon material production will be competitive. Thus, the report now states:

Several categories of solutions are under investigation. In the near term, increasing the available quantity of semiconductor grade polysilicon is the preferred approach through options such as modifying existing silicon reactors to accept different feedstocks, thus increasing their capacity, pilot plant production or procurement. Included in this would be actions to encourage the installation of refinement capacity by existing or new module manufacturers, installation of prototype production facilities of new refinement technologies by new industry participants, and new entrants into conventional silicon production. Clearly, the establishment of new sources of supply for the open market is a primary objective both to increase the supply directly and to aid in the growth of a healthy, competitive PV industry. (Federal Policies ..., p. 6-21)

While we are prevented from becoming more explicit about details of the solutions under consideration due to their preliminary status, we can say unequivocally that the competitive effects of the various options is expressly considered in judging their value.

The final Justice Department comment on the silicon material shortage dealt with the relationship between the shortage and the Multi-Year Purchase Strategy:



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At no point, however, does the report discuss either the relationship between the government purchase strategy and the expected shortage of refined silicon, or the likely competitive consequences of the purchase strategy. For example, the report should determine whether government purchases will exacerbate the shortage or affect some firms more harshly than others, thereby adversely affecting competition in the PV industry. (Justice Department Review)

It is clear that the potential silicon shortage jeopardizes the future of both the photovoltaic industry and the Federal Photovoltaic Program. If a severe shortage materializes, the effects on the existing industry would be profound. While the emphasis placed on non-silicon materials and concentrators would undoubtedly increase, it is not obvious that any of these concepts have sufficient promise to prevent the effective demise of the current PV industry, should silicon become unavailable. The national PV Program would also be very seriously impacted, depending on the severity and length of the shortage and its effect on silicon module prices. Accordingly, we have added the following footnote to the report:

If solutions to the potential silicon material shortage fail, the purchase program would be significantly impacted. Its costs would increase and its likelihood of attaining price goals would decrease. In this event, the purchase program would probably be redesigned toward non-silicon technologies, smaller scales, and later implementation schedules. (Federal Policies, p. 6-33)

Thus, it is of utmost importance that a silicon material shortage not arise.

C. The third (and last) major set of Justice Department criticisms centered around the availability of adequate capital to finance the production of PV systems:

The report also presents an inadequate basis for concluding that capital requirements will not restrict entry into the PV manufacturing market. The report estimates that these requirements are in the range of \$10 to \$15 million per production line. This estimate is for construction of a plant to assemble single-crystal silicon solar cells. However, if there are no independent sources of refined silicon supply and vertically integrated firms do not have excess refining capacity, it would be necessary to include the cost of acquiring refinery facilities as well in the capital costs for a potential entrant. Moreover, no mention is made of the costs of facilities to produce semi-crystalline or amorphous silicon-based cells,



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or to produce non-silicon cadmium sulfide or gallium arsenide cells which are possible substitute technologies for single-crystal silicon. (Justice Department Review)

Further, the report's assessment of the significance of capital requirements as a potential entry barrier--listing the capital required for a single production line for a currently popular PV technology--overlooks another conclusion of the report, that "the technology is anticipated to change very rapidly..." (p. 6-21). If this proves true (and recent experience in the PV industry confirms its accuracy), new entrants may have to rely on very short amortization periods for production lines built today. Indeed, depending on the rapidity of technological development (accelerated by government research & development expenditures), a new entrant may need to plan for the construction of two or more entirely new production lines in the first five to ten years of existence. If this proves to be true, the report would have understated capital requirements, even for the single technology assessed. These capital requirements could constitute a significant entry barrier which potential entrants could not meet through financing. Since the cost of financing is, in any event, generally higher for new entrants than for existing firms in a market, this might constitute a considerable absolute cost barrier to entry. (Justice Department Review)

As a result of these comments, the capital cost estimates of the report have been significantly expanded. Nevertheless, it is important to emphasize the considerable uncertainty surrounding capital requirements to produce for the grid-connected markets of the late 1980's:

Nevertheless, there is considerable uncertainty surrounding estimates of the capital requirements that will become necessary for production at efficient scales to supply mass electricity markets at cost effective prices. Different photovoltaic technologies and production processes are likely to require different scales of production to produce efficiently and at lowest cost. Thus, capital requirements for the various production steps depend upon the technologies and production processes which become dominant. (Federal Policies, p. 5-5)

Secondly, the program does not devote significant effort to the design of production facilities for non-technically feasible concepts (materials other



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than silicon or concentrators). Until the concepts are proven feasible, major work on them will be devoted to advanced research on device efficiency, etc. Thus, capital cost estimates are not available for mature facilities employing non-technically feasible concepts. Even though several small facilities employing these concepts have been built by private firms, these facilities are not representative of facilities capable of meeting the goals of the Program and, therefore, the capital costs of these facilities bear little relationship to the capital requirements for entry into production for grid-connected markets.

A new Table 5-1(b) has been added to the report which presents capital requirements for state-of-the-art silicon material refinement facilities. As discussed above, scale economies and, thus, capital requirements for the DOE-developed new refinement technologies are still ill-defined. Nevertheless, it appears that an additional \$10 million will be required to enter PV module production at efficient scales for the grid-connected markets if silicon material refinement capacity is desired. Thus, the total requirement is approximately \$25 million (\$15 million for module production, \$10 million for silicon). Finally, if one assumes the initial investment will quickly become obsolete, so that an entirely new investment must be made within the planning horizon, these requirements could easily double. Thus, as a very rough estimate, \$50 million should be adequate capitalization to effectively and efficiently enter the PV module production business and periodically update production techniques to remain competitive:

Thus, \$50 million represents an approximate upper bound on total capital required for early entry into silicon array manufacturing including silicon material production, even with technology evolution and obsolescence, at competitive scales and prices over the foreseeable horizon. As emphasized above, these conclusions depend strongly on the technologies and production processes which become dominant. (Federal Policies, p. 5-10)

Finally, Justice challenges the report's contention that capital markets appear to be functioning efficiently, supplying PV manufacturers with adequate capital. Justice quotes some of the troubles experienced by various PV entrepreneurs and the adjustments they found necessary to obtain financing. Justice concludes:

This suggests that financing not only affects the ability of new entrants to begin PV manufacturing, but also could determine the nature and extent of the manufacturing and marketing activities which new entrants can undertake. (Justice Department Review)



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I believe Justice has misinterpreted the characteristics of a well-functioning capital market. It is certainly not true that such a market would supply capital to everyone, or that obtaining financing may not require substantial reorientation of investment plans. A "perfect" capital market would supply capital to all "worthy" or potentially profitable investments. Thus, difficulty in obtaining financing experienced by one individual or another may simply reflect inadequate, unprofitable, or otherwise poor investment proposals.

A more relevant consideration is the overall supply of capital to PV investments. In general, the supply of capital to photovoltaics appears quite ample. Oil companies and electronic firms have made substantial venture capital investments. Many small firms have obtained financing from various other sources, including a successful stock offering (report has been revised to reflect this) as well as from individual private investors.

D. Justice concluded its comments with several less comprehensive criticisms. The first of these dealt with the relative position of small vs large firms in PV manufacturing and the access small firms have to capital:

Further analyses of the relative strengths of small and large firms is necessary in order to draw reasonable conclusions regarding the competitive significance of capital requirements to the PV industry. (Justice Department Review)

Several other reviewers have raised significant questions concerning the opportunities for small businesses in the photovoltaic industry and the policies of DOE and the Program aimed at promoting small business opportunities. We believe that small business will have many opportunities in PV manufacture, supply and sale. This does not mean, however, that all aspects of PV system supply will be suitable for small business. Silicon refining and automated module production for mass markets may be more efficient in medium or large businesses. Small business should be able to thrive in distributed system supply, sales, installation, and service as well as in module production for specialty markets. Nevertheless, we have acknowledged significant uncertainties concerning the status and prospects of small business in the Program and have promised Dennis Drabelle of the Federal Trade Commission that we would undertake a review of small business opportunities in the near future.

The apparent advantages that large corporations, such as oil companies, may possess for successful entry into the PV market raises a series of additional questions regarding competition not addressed in the report. What is the level of concentration in the PV industry? Have firms entering



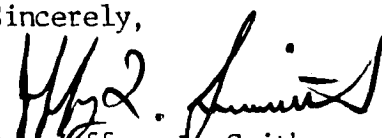
the PV market from other industries displayed different competitive behavior than independents? Are oil and electronics firms entering the market primarily by acquisition or by the establishment of new subsidiaries? Has the choice between those two modes of entry affected concentration and competitive behavior in the industry? The Justice Department has obtained information which suggests that in 1977 and 1978 the industry was relatively concentrated (a 4-firm concentration ratio above 60% and an 8-firm ratio in excess of 90%). Both the historical effect of the methods by which large firms have entered PV markets and the expected competitive effects of large-firm entry through acquisition of new companies are factors which the report ignores. (Justice Department Review)

This set of questions constitute Justice's final comments. The information quoted on concentration ratios is approximately correct (similar information has been added to the report). However, let me point out that in an industry with only \$15-20 million in total annual sales, the fact that eight firms exist at all is surprising! Given its tiny size, it is not unusual to have such "high" concentration ratios.

To the best of my knowledge, all oil company entry to photovoltaic production has been through acquisition. Motorola, an electronics firm, is developing its PV capability in-house. There have been complaints from some independents that oil companies are using their financial power to establish low prices and sell at a loss in order to capture a large market share. While those complaints may have some validity, the actions of the oil companies have not been so drastic as to dislodge Solarex from its dominant position in the industry. (Solarex is majority held by an independent businessman with minority oil company participation). Furthermore, some oil company subsidiaries claim that they do not get oil company support for their operating costs--they must earn enough through module sales to cover their expenses. Oil company participation appears to be limited to facility and R&D investments. Finally, the market prospects for PV have been attractive enough to encourage the entry of several new independents. Thus, it does not appear that large firm acquisitions have thus far adversely affected the photovoltaic industry.

This concludes my detailed response to your comments, Glen. I hope you have found my answers satisfying. Please do not hesitate to call or write at any time in the future if I may be of help. We shall send you a copy of the complete report when it becomes available. I have included copies of the revised Chapters 5 & 6. Thanks again for your assistance.

Sincerely,



Dr. Jeffrey B. Smith

Enclosure

THE AEROSPACE CORPORATION



Post Office Box 92957, Los Angeles, California 90009, Telephone: (213) 648-5000

4 December 1979

Dr. Jeffery L. Smith
Mail Stop 506/316
Jet Propulsion Laboratory
4800 Oak Grove Drive
Pasadena, California 91103

Dear Jeff:

I have reviewed the preliminary document, "Federal Policies to Promote the Widespread Utilization of Photovoltaic Systems," dated November, 1979 and would like to make several comments and suggestions. In general, I believe the document is excellent - well written, accurate and appropriately comprehensive. The principal areas where some changes seem warranted are in the areas of utility and photovoltaic system integration and in the sections that identify the potential for photovoltaics to be used in central station power plants. Utility integration issues are being examined by DOE within the Photovoltaic Program and also as part of the New Source Technology Integration Program. The document reflects the concerns and activities of the Photovoltaic Program but should also reflect those of the New Source Technology Integration Program. While no insurmountable integration problems are presently known for distributed PV systems, much work on integration must be done before such systems can achieve widespread utilization. It is important that this work proceed now so that, as the number of PV systems increases, major integration problems do not become serious impediments. Specific suggestions for changes in the text are included in the attachment.

Due to several economic peculiarities it is recognized that PV price goals for widespread central power applications should be slightly lower than the price goals for distributed applications. However, in some circumstances it is expected that PV systems with prices equal to those needed for distributed applications will also be economic for use in central power applications. This is particularly significant because PV central power applications offer the potential for reducing oil and gas consumption. Utilities have much greater engineering expertise and access to capital than most potential distributed system owners. The size of a PV central plant, the minimum institutional changes required to exploit this market, the centralized decision process for major projects within the utility industry, and the limited number of alternatives open to utilities also make PV power station applications attractive. Should the U. S. be required to initiate a crash program away from oil, these latter attributes of PV central power applications would be quite important. Only Option 1,

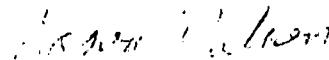
Dr. Jeffery L. Smith

4 December 1979

which appears to substantially reduce the near-term technology development efforts in favor of greater reliance on higher risk longer term developments in order to stay within the target budget, would preclude this contingency planning. Detailed comments and suggestions on this subject keyed to specific page numbers and paragraphs are included in the attachment for your consideration.

Sincerely,

THE AEROSPACE CORPORATION



Mason Watson
Principal Director
Energy Systems

MW/gj

Attachment

cc: Charlie Smith, DOE

ATTACHMENT: DETAILED COMMENTS AND SUGGESTIONS

Page ES-16 Second Bullet in Section ES.3

"The statement is made "To be competitive with conventional, utility generated power, PV systems must be reduced in price to \$1.60/W_p for distributed applications, and \$1.10 - \$1.30/W_p in central station applications". While several studies have supported the belief that wide-spread penetration of the central station market may require price reductions to the \$1.10 - \$1.30/W_p level, a meaningful central station market may exist beginning in the mid to late 1980's for those utilities in the sunbelt that are heavily dependent on oil. If oil prices continue to escalate even at rates much lower than experienced over the last 5 years, it will be possible to generate PV energy at a price equal to or less than the cost of oil consumed in producing an equivalent amount of electrical energy. To reflect this potential it is suggested that the sentence, "A limited but potentially significant application of PV systems in central station applications may also be possible at a price of \$1.60/W_p." be added at the end of this paragraph.

Page ES-17, 18 Last Bullet Page ES-17 Continuing to ES-18

It is stated that "...the presence of utility system-wide storage may reduce the value of photovoltaic power". This assertion is true for nearly any additional generation capacity including new coal plants since the presence of the utility system-wide storage permits a greater utilization of existing capacity, thereby reducing the value of new capacity. However, the use of utility system-wide storage can increase fuel consumption due to losses in putting energy into and withdrawing energy from storage and different fuel costs for peaking and baseload units. It is possible to save money but burn more fuel. In the sunbelt, where PV systems will be viable at the earliest date, the extra fuel consumed is likely to be oil or gas, since only a small or moderate nuclear or coal baseload capacity now exists or will exist in the 1990's. The requirement for utilities to reduce oil consumption by 50% by 1990 in accordance with the recent Presidential directive will dictate against the use of system-wide storage in oil-dependent utilities and favor renewable energy sources such as PV. The statement made may be true in an abstract sense but is not pertinent in a practical sense. It is suggested that the sentence beginning "Until PV system penetration..." be replaced by, "The presence of utility system-wide storage may reduce the value of PV systems with penetrations less than approximately 10% in utilities possessing large amounts of nuclear or coal capacity. For utilities highly dependent on oil and gas, system-wide storage may enhance rather than reduce the value of PV power."

Page ES-18 Next to Last Bullet in Section ES.3

Large penetrations of PV systems into electric grids (30% or more) are stated to be feasible with substantial benefits given the attainment of PV system price goals and the timely resolution of institutional issues. Such large penetrations will inevitably involve thousands or tens of thousands of individual PV units all interacting with the

utility grid and perhaps providing energy to the grid for consumption at other load points. The integration of such a large number of power generating units, which maybe 10's to 100's of times more power units than in present utility systems, presents a formidable challenge to efficient system control, stability, and other normal and emergency operations. These issues are being addressed by the DOE Division of Electric Energy Systems and should not preclude the effective utilization of PV systems. To reflect the need to continue this work the last line of this paragraph should be changed to read, "...price goals and timely resolution of operational and institutional issues."

Page ES-18 First Bullet Continuing onto Page ES-19

The highly competitive nature of the PV industry is cited. Increased competition in the form of new entrants into the industry is expected as markets increase in size. Not mentioned is the substantial and growing foreign competition to the domestic industry. Since a sizeable international market and industry is expected, the competitive posture and strength of the domestic industry should not be examined in isolation. A sentence such as, "Foreign competition, especially in international markets, is expected to be strong." should be added.

Pages F-3 and F-4, Section F.2.2, First Paragraph

This paragraph enumerates several of the advantages of PV systems. Unfortunately, the need for concise statements appears to have contributed to some minor over-generalizations. It is suggested that the phrases "no noise" be changed to "little noise", "no heat" be deleted (concentrator PV systems and hybrid panels may deliberately produce heat for productive use), and "and siting" be deleted (the need to support large arrays and provide access for the above may be an important siting issue, see Section F.5).

Page F-10

The discussion on this page delineates the markets for PV power systems. Not mentioned are potentially significant DOD applications such as in the MX Program noted in the footnote on page F-3. A sentence such as, "Special DOD applications may further stimulate current and intermediate markets." could be added to the next to last paragraph of page F-10.

Page F-33, Section F.3.1 Second Paragraph

Three factors are cited from a utility perspective pertinent to the attractiveness of interconnected distributed PV systems. A fourth factor should be added, specifically, "4) the ability to operate and control the grid in a safe, reliable, and economic manner". Also, in many utility systems the highest generation costs are associated with the evening peak when PV systems with little or no storage would not be effective. Nevertheless, any PV system is expected to provide energy during the mid-day peak where costs are high even though they may not be the highest. The word "highest" should be changed to "high" in the eighth line from the bottom.

Page F-34

The paragraph beginning, "Some utilities may employ discriminating or punitive rate structures..." should be modified to reflect the potential for government to preclude unreasonable rate structures. This first sentence should be altered by changing "employ" to "propose" and inserting as the second sentence, "Such proposals will normally require approval by governmental regulatory agencies. Furthermore, under authority granted..."

Page F-35, Subsection Titled Load Management

This paragraph is too simplistic and does not reflect an understanding of load management by means other than energy storage. Although PV systems can be expected to reduce daytime peaks, they will not necessarily impact evening peaks, especially during winter months. More importantly, the use of load management techniques such as time-of-use rates and cyclic shedding or remote control of some appliances (e.g., air conditioners or hot water heaters) will not be changed by the presence of PV systems. On the contrary, the existence of distributed PV systems may involve communication channels for control purposes that would permit implementation of such techniques with little cost impact.

The last sentence of this paragraph implies new units will have to be brought on-line during rapid weather changes. While this may ultimately be done, the implication is misleading and does not reflect an understanding of utility operations. Units are maintained on-line at all times to compensate for rapid changes in load and generating capacity as part of the spinning reserve. The need for, and importance of, increased spinning reserve in the operation of utility grids interconnected with solar or wind power units is not now fully understood, but is under active study by the DOE Division of Electric Energy Systems.

This section should be rewritten substantially or deleted. The latter is recommended.

Page F-36, First Sentence

Generation failure is one of several reliability concerns of utilities and should not be singled out as "primary". Delete the parenthetical phrase.

The statement that customer-generated photovoltaic power combined with energy storage will allow a customer to choose his own reliability level should be deleted. Although strictly speaking this is theoretically possible, it is economically unrealistic as is identified on page F-38 in the last sentence before "Conclusions". The viability of PV systems does not require such impractical arguments to be made and they detract from the credibility of the technology.

Page F-36, Second Paragraph

The second sentence of this paragraph should be changed to read, "Balanced against this is the additional complexity introduced by having to accommodate feedback power

from the end of distribution networks and yet to maintain control of the total grid during normal and abnormal conditions." In the next sentence change "reliability" to "operational", to include control, stability and spinning reserve integration issues.

Page F-38, Section Titled Storage Requirements

The comments made for pages ES-17 and 18 apply here as well. PV and storage systems may be economically competitive but are not necessarily substitutes for each other in the sunbelt. Storage may increase the consumption of oil and gas but PV will reduce consumption. Change this paragraph by inserting "economically" before "competitive" in the third sentence and deleting the parenthetical "(substitutes)". Add at the end of the paragraph, "For any level of penetration PV systems will reduce the consumption of fuels while storage will contribute to improved efficiency of operation of equipment with some possible increase in fuel consumption."

Page F-38, Section Titled Conclusions

Delete the first sentence. The interconnection of PV systems seems definitely desirable but it remains to be seen how simple it will be. Change the last sentence of this paragraph to read, "The major limitations are economic, e.g., the high initial cost of the PV systems, utility integration, and the necessity for appropriate rate design."

Page F-39, Section F.3.2, First Paragraph

The second sentence of this paragraph references DOE program activities only in the design of photovoltaic systems and adaptations to distribution systems. This is too restrictive. This sentence might be revised to read, "These programs address the specific design and development of photovoltaic systems to interconnect with the grid and the integration of such systems with the existing utility grid."



JET PROPULSION LABORATORY California Institute of Technology • 1800 Oak Grove Drive, Pasadena, California 91103

March 17, 1980

Refer to: 311-JLS:amc

Mason Watson, Principal Director, Energy Systems
The Aerospace Corporation
Post Office Box 92957
Los Angeles, California 90009

Dear Mason:

Thank you very much for your insightful and detailed critique of the Congressional document "Federal Policies to Promote the Widespread Utilization of Photovoltaic Systems." Your comments were among the most useful, and have been used to modify and improve the document in several places.

We have received reviews from F. F. Parry, DOE/EFS, and Jerry Pfeffer, DOE/ERA, both of whom made comments similar to your own with respect to the technical integration of PV systems into the electric grid. We agree with your contention that this issue deserves more attention, and have tried to modify the report to reflect this concern.

In response to your (Aerospace's) advocacy of the early central station market, we have added to the Executive Summary Findings on Utility Integration (p. ES-17) the sentence:

"A limited but potentially significant application of PV systems in central stations may also be possible at a price of \$1.60/Wp in those utilities heavily dependent on oil with limited alternatives for new, conventional generation sources".

This sentence immediately follows a discussion of the price goals of the Program. Aerospace's recent analysis (Central Station Applications Planning Activities and Supporting Studies, Aerospace Corp., January 1980) of this oil replacement market was quite convincing and very well done. You are to be commended for an important insight as well as for the supporting analysis. Nevertheless, I still believe we need updated evidence based on utility production cost and reliability simulations to more fully understand the implications for PV central power of recent, profound changes in the prices of oil and coal, as well as coal and nuclear capacity.

Thanks again for your thoughtful review. Detailed responses to your own detailed comments follow:

PAGE

ES-16 Modification made as suggested, (see above discussion).



Mason Watson

-2-

March 17, 1980

ES-17,

-18(a) I agree with this comment up to the point where you claim that the fact that the presence of utility-wide storage reduces the value of PV power "is not pertinent in a practical sense." The important point is that since dedicated storage is inferior to system-wide storage, and since system-wide storage is detrimental to PV, then advances in storage technology (and thus its deployment) are detrimental to PV deployment at low penetration levels. This has definite, important implications for the conduct of a PV/storage R&D program. Second, although I agree with your initial conclusions about storage in utilities with large oil/gas sources (that it is not very attractive), this does not justify the last sentence of your comment: "For utilities highly dependent on oil and gas, system-wide storage may enhance rather than reduce the value of PV power." On the contrary, this latter statement contradicts your earlier support for my contention.

Unless PV will be charging the storage during the daytime for discharge at another time, storage will not enhance PV. This will only occur when the penetration of PV is so large that the inherent inefficiencies of storage are offset by the gains of shifting PV output from its time of generation to some other time. In an oil/gas dependent utility, it would seem especially likely that high cost fuel can be immediately offset by PV without going through storage. Thus, it would seem highly unlikely that PV will be used to charge storage in such utilities, if storage is present, admitting that there is little incentive to install storage in the first place in such utilities.

ES-18(b) Modifications made as suggested by you and F.F. Parry. See comments above.

ES-18(c) Modification made as suggested.

F-3, F-4 Modifications made as suggested, except for the deletion of "and siting." We do believe PV has much greater siting flexibility than oil, nuclear, or coal. Consider all the options: residential rooftops, commercial buildings, industrial sites, and the lack of restrictions imposed by effluents, noise, danger, etc., that other technologies suffer from.

F-10 Modified as suggested.

F-33 Modified as suggested.

F-34 This passage had previously been modified per comments of other reviewers.



Mason Watson

-3-

March 17, 1980

F-35 Load Management: Your criticisms of this section are not disputed by JPL and were echoed by several other reviewers. Since the legislation (P.L. 95-590) specifically calls for a discussion of the implications of PV for load management, I do not consider deleting this section acceptable. I have tried to modify the discussion in ways suggested by your comments. Unfortunately, neither you nor any other reviewer made detailed or extensive suggestions for modification. Hence, we still view this section to be less than adequate. I have enclosed a copy of our revised version, and would be delighted to receive a more detailed critique from you of our remaining omissions and errors.

F-36(a) First modification made as suggested. Your second suggested modification charges that enhanced customer reliability levels, due to PV systems combined with storage, are "economically unrealistic." How do you know this to be the case? A small storage device that could maintain basic electrical requirements (e.g., refrigerator, one or two lights) could be extremely valuable during blackouts, especially to rural and other customers at the end of long, unreliable distribution networks. Many such customers suffer loss of service 10 or more times per year. We do not assert that this enhanced reliability will be attractive, only that it may be attractive to certain customers. This does not refer to stand alone systems.

F-36(b) Modified as suggested

F-38(a) Comments above concerning system storage and PV apply. I did make a few changes in the direction you suggest.

F-38(b) I deleted the reference to the relative simplicity of interconnection.

F-39 Modified in a manner similar to that suggested, and to the same effect.

Thanks again, Mason, for your time and effort. If you have further comments, or would like to suggest further changes to the modified Load Management discussion (see enclosure), please let me know. We shall send you a copy of the complete document when it becomes final.

Sincerely,

Dr. Jeffrey L. Smith

Enclosure



Department of Energy
Washington, D.C. 20585

Jeffrey L. Smith
Jet Propulsion Laboratory
4800 Oak Grove Drive
Pasadena, CA 91103

COMMENTS CONCERNING "FEDERAL POLICY TO PROMOTE THE WIDESPREAD UTILIZATION OF PHOTOVOLTAIC SYSTEMS"

The Division of Electric Energy Systems (EES) (Resource Applications) has an active program for New Technology Integration. The program has both a near-term aspect and a long-term aspect. The near-term program is focused on modifying existing methods and tools to accommodate the near-term integration of a limited number of new technology devices on electric power systems. The long-term program is directed toward developing new planning and operating methods and support apparatus necessary to guide the development of the power systems of the future. This will insure that the understanding and support technology base necessary to provide for optimal integration of large penetrations of new technologies will be ready when required.

There are numerous, serious, integration issues which exist, with much work to resolve the issues remaining to be done. The Executive Summary of the subject report does not appear to be aware of the work of the EES Division in this area, nor does it adequately reflect the seriousness of the integration issues remaining to be resolved.

For example, p. ES-18, second bullet, could be adequately modified by adding the underline words: "Large penetrations of PV systems are feasible, ... given attainment of the PV system price goals and timely resolution of institutional and technology integration issues".

On p. F-33, the utility perspective deals only with institutional issues. Integration issues concerning acceptable power quality, system protection, communication and control, reverse power flow, and impact of spinning reserve requirements on PV capacity credit are of equal concern from the utility perspective.

On p. F-34, the statement that some utilities may employ discriminatory or punitive rate structures to discourage PV interconnection, is needlessly biased and inflammatory, and should be toned down or eliminated.

On p. F-35, the load management discussion fails to recognize that load management techniques, like system storage, can be used to provide a buffer between the instantaneous load and generation.

Jeffrey L. Smith

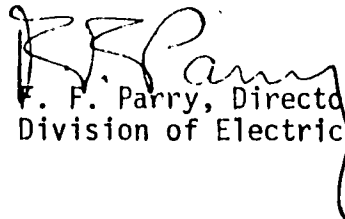
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On p. F-36, the reliability discussion is very superficial. The issues of reliability, cost of service, and worth of energy, are very complicated and interrelated. Recognition of these interrelationships should be made in future revisions.

On p. F-38, the conclusion that PV interconnection is relatively simple, with the major limitations being economic, is in itself overly simplistic. A significant new technology integration effort is underway by this division. A number of significant technical problems have been uncovered and are being addressed through programs now being formulated. While not intentionally misleading, the failure to recognize that technical problems do exist, in a report of this nature which is going to congress, will ultimately create a false impression and unjustified optimism on the part of its final audience. Granted that the problems are probably amenable to engineering solutions, the audience should at least be made aware of their existence. The report can still serve its purpose, with appropriate modifications.

We would appreciate the opportunity to review similar documents in the future.

Sincerely,


F. F. Parry, Director
Division of Electric Energy Systems

cc: Stanley Weiss - RA
Bennett Miller - CS
Robert San Martin - CS



JET PROPULSION LABORATORY California Institute of Technology • 4800 Oak Grove Drive, Pasadena, California 91103

March 17, 1980

Refer to: 311-JLS:amc

F. F. Parry, Director
Division of Electric Energy Systems
Department of Energy
Washington, D.C. 20585

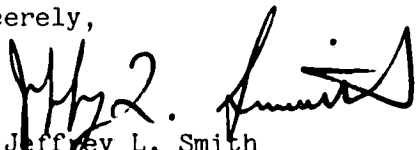
Dear Mr. Parry:

Thank you very much for your comments on the Congressional document "Federal Policies to Promote the Widespread Utilization of Photovoltaic Systems." Your suggestions concerning the proper emphasis to be placed on technical integration of dispersed PV systems with the electric grid were well taken and have been used to modify the document in several places.

We agree that our discussion was superficial in some aspects, especially with respect to reliability and load management. We feel a definite need to increase our own understanding of the effects of grid-connected PV systems on such issues as well as of the costs necessary to achieve satisfactory integration of PV systems into the electric grid. Any information you could provide on the magnitude of specific problems, the priorities, schedules and objectives of your research program, or appropriate contacts for discussion of specific issues would be much appreciated.

Thanks again for your comments. We will include you in the review process of any such document in the future.

Sincerely,



Dr. Jeffrey L. Smith

Alfred H. and Laura L. Canada
P.O. Box 70, 380136 Grindelwald Road
Mammoth Lakes, CA 93546

November 30, 1979

Dr. Jeffery L. Smith
Principal Investigator
Federal P-V Policies Study
Jet Propulsion Laboratory
4800 Oak Grove Drive
Pasadena, CA. 91103

Subject: Option Number Eight

Dear Jeff:

Thank you for the opportunity to read and comment on your two volume preliminary document, "Federal Policies to Promote the Widespread Utilization of Photovoltaic Systems. It needs an Option #8, a response that walks-the-second-mile, so to speak, with the Congress charge in P.L. 95-590. In a copy of notes for a Lions Club presentation given yesterday in Bishop are some of the ideas that I would recommend to you as Option #8.

You already have S.E.E.D. material and copies of the two Grindelwald Letters and notes for my talk at the Pinehurst meeting. To this now add the Nov. 29th note for the Lions. The Lions meeting yesterday was ladies' day with a total turn-out of about 80. As they say in Bishop, a town that still resents D.W.P.'s taking all of the water for Los Angeles, "the Rotarians own the town and the Lions run the town". The town gets its electric power from DWP while the outskirts are S.C.E. The thrust of the talk was of course the great opportunity that the DWP owned Owens Valley (once a great agricultural area) offers in huge power generation, via S.E.E.D., and the accompanying energy intensive industries with arid Jojoba and Guayule farming on leased land under the S.E.E.D. panels. The talk drew many questions, even from a County Supervisor, and much interest in the scale model.

Your two volume report is fine, a bit heavy reading, and reads fine if one thinks in terms of Amory Lovins' "soft technology" or, as I would characterize it "soft futures". I do suggest that the comparison of Goals from your report and P.L. 95-590 and SEED may find more lay appeal in my terms. Can most Congressmen and the public understand and find empathy with Quads, Megawatts of Production and Cost per kilowatt? I have converted both your numbers and mine to barrels of oil displaced. Now there is a measure that rings a bell.

If I read your report in terms of huge, near-term central station, then there are lots of places where the text needs to be changed. But then you or some of your staff can do that as well as I can. In reading the report I must ask, how much is your report and for that matter P.L. 95-590's 90% private buyers influenced by the Lovins-Shorey "again concern itself with simplicity and elegance and vast systems would become extinct"? I admire their Solar Lobby's industry in promotion of solar but their companion issue of going back to the old-homestead in electric power is ludicrous. Sell that to a pioneering developing nation but not to an industrialized nation.

I have had little feed-back from the ideas presented on S.E.E.D. at Pinehurst....and for that matter on SEED since its inception in 1977. However, the point of the pitch and the charts at Pinehurst was to question the D.O.E. pronouncement through their S.E.R.I. agent to the A.P.P.A. arm of the utilities. And your report while not as pesimistic doesn't go nearly far enough in painting the central station future for P-V. Do we really believe that P-V has no chance to replace declining nuclear or to even run in the same race? Please see the Nov. '79 issue of Electric Light and Power for numerous stories that in sum suggest that much of the remaining up-beat talk on nuclear is but the death rattle of the entrenched nuclear coterie that is about to go the way of the buggy-whip manufacturers.

Certainly in today's crisis of considering the prospects of a war on the behalf of a deposed petroleum bretheren we need to examine what it would take to move P-V into a major offset of our oil imports. I don't say study large sized P-V. A lot of people have done that in parametric analyses and system studies that evolve cross-over points that can be used either as a future hope or by others to support the EPRI "2020 myth" or SERI's "Gossamer Albatross" line.

In S.E.E.D., in the "Purposes" developed for a systems analysis for the Pinehurst pitch....and in the Lions Club material, the "Purposes" can be approached in a very specific engineering analysis and plant design. J.P.L. working with either DWP or BPA or both could help them do a plant design. If Al Canada, through the SEED study or even the Pinehurst paper, asks about the possible prices or budgetary estimates for such a plant, the answer is about the same that JPL gets from their small-buys-roulette program. It just doesn't get to the corporate interests that make new manufacturing industries. Some told you that at Pinehurst. As an aside, neither does Dennis Costello's international marketing planning in one aspect, replacement of diesel electric generation in the desert areas. See the recent ALCOA diesel electric prices used in the Pinehurst material; \$240/KW. At local 70¢ fuel that might be an attractive P-V objective except that even in Tijuana we hear prices of 18¢....and that doesn't suggest much of an international market.

But what if in doing a serious and quite specific central station plan either BPA or DWP asked for budgetary estimates on panels in the quantities envisioned in the Hydro-Solar-Bus or in S.E.E.D.? That is a whole new ball-game both in your response to The Congress and in projections of costs and quantities. You seem to avoid central station P-V with almost as much devotion as do E.P.R.I. and S.E.R.I.

In the Pinehurst material I tried to develop quite specifically the idea that balance-of-system costs could take on an entirely different aspect if considered in central station terms and perhaps against a very specific HVDC intertie. Also I tried to drive home the point that we are not stuck with the "later but not now Harvard syndrome" by simply designing an interface that separates the power extraction from the cells in the panel. We don't need to wait for the penultimate panels but let cell development be on-going with the producing plant. It can work.

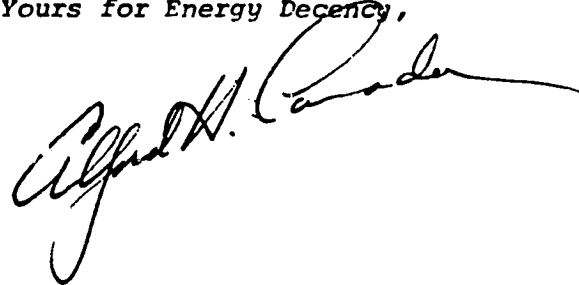
EPRI has just come out with their new strategy for the electric energy industry. "It re-emphasized that solar, wind, geothermal, biomass and other alternatives to conventional fuels may provide enough electric energy in the long-term, but just can't be counted on to do the job in the next two decades". Can JPL, who put a man on the moon in but a decade, possibly subscribe to this statement? Can you possibly believe that working with DWP and BPA you couldn't have 85,300 MW (nameplate) of P-V in place in less than a man-on-the-moon-decade? Can you possibly believe that there isn't an Option #8 in the response to P.L. 95-590 for a nation now ringing church bells?

in the travail of energy blackmail?

Yours for Energy Decency,

Alfred H. Canada

cc. Dr. Paul D. Maycock, DoE
Dr. Hector J. Durocher, BPA
Dr. Louis H. Winnard, DWP

A handwritten signature in black ink, reading "Alfred H. Canada". The signature is written in a cursive style with a large, sweeping initial "A".



JET PROPULSION LABORATORY California Institute of Technology • 4800 Oak Grove Drive, Pasadena, California 91103

March 17, 1980

Refer to: 311-JLS:amc

Alfred H. Canada
P. O. Box 70
380136 Grindelwald Road
Mammoth Lakes, CA 93546

Dear Al:

Thank you very much for your review of the Congressional document "Federal Policies to Promote the Widespread Utilization of Photovoltaic Systems." Your comments should prove useful in the Department of Energy's review of the future of the Photovoltaic Program.

Your consistent and outspoken support of the central station utility option for photovoltaics is much appreciated. As you know, the desire for small, decentralized "appropriate technology" is very strong and has increased the emphasis of the PV Program in distributed applications. Photovoltaics has been classified by DOE primarily as a distributed option intended for use on buildings. A balanced program in which both distributed and utility applications are pursued in parallel is desirable.

We do not, however, support your contention that the time is ripe for massive installation of central utility PV systems. It is not really a question of whether it could be done but whether or not its worth it. Even granting significant savings from true mass production, the cost of current PV systems is and would remain high indeed. The material costs alone would lead to electricity prices 4 to 5 times higher than today's prices; and capital amortization, labor, safety, taxes, etc. would add significantly to that. Whether paid through electricity rates or taxes, it is still the American public who must foot the bill. Even if one specifically targeted the deployment of utilities which burn a lot of oil, it is not clear that PV is the preferred (cheapest and easiest) alternative generation source at the current time. Other alternatives (coal, fluidized bed, geothermal, biomass, natural gas) may be easier and cheaper to implement now.

Furthermore, there are serious unresolved technical integration issues, such as system stability, reliability and source of backup, that arise when large amounts of PV are introduced.



Alfred H. Canada

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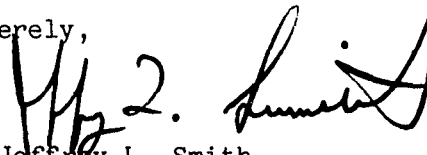
March 17, 1980

Finally, are we really ready to risk all on a one-shot deal? Suppose we attempted to implement your S.E.E.D. proposal. If technical difficulties and cost overruns occurred, the entire PV Program would be jeopardized.

Thus, we much prefer an accelerated development and cost reduction effort leading to rapidly falling PV system prices and increased understanding of technical integration issues. Coupled with an adequate testing and demonstration program, this effort will allow rapid deployment of PV systems beginning in the second half of this decade. At that point, your call for massive deployment is more likely to find sympathetic and eager listeners.

I hope this brief discussion has helped clarify our position on SEED. Thanks again for your comments, your interest and support. We shall send you a copy of the complete document when it becomes final.

Sincerely,



Dr. Jeffrey L. Smith

(Retype)

Department of Energy
Washington, D.C. 20461

MEMORANDUM FOR THOMAS E. STELSON
 ASSISTANT SECRETARY FOR CONSERVATION
 AND SOLAR ENERGY

FROM: HAZEL R. ROLLINS
 ADMINISTRATOR
 ECONOMIC REGULATORY ADMINISTRATION

SUBJECT: NONCONCURRENCE ON DOE/CS-0114/1,2, FEDERAL POLICIES TO
 PROMOTE THE WIDESPREAD UTILIZATION OF PHOTOVOLTAIC SYSTEMS

We have received the above-referenced report mandated by Section 10(a) of the Solar Photovoltaic Energy Research, Development and Demonstration Act of 1978, Public Law 95-590. For reasons outlined below, we cannot concur in public release of this document.

The basis of our nonconcurrence is the inconsistency between statements made in the Executive Summary and Findings sections of the report and the Technical Discussion related to the impact of solar photovoltaic technology (SPV) on electric power systems. A second general problem relates to the use of vague terminology to justify specific findings.

We have attached a list of specific comments for consideration by your staff. Jerry Pfeffer of my staff would be pleased to provide more details on any of our comments.

Attachment

Areas of Concern in SPV Report DOE-CS-0114/1,2

I. Executive Summary and Findings;

- o page ES-15 No intensive analysis indicated, referenced, or provided.
- o item ES-3
 - (1) the grid can provide backup, but cost of backup very much in question.
 - (2) agree in principle, but no analysis shown on derivation of \$/kw targets that includes utility system integration costs.
 - (3) agree rates are key, but FERC guidelines under PURPA 201, 210 are based on net avoided costs, not SPV commercialization needs.
 - (4) PURPA guidelines prohibit punitive actions by utilities and, therefore, no DOE action should be required.
 - (5) agree no "intractable technical problem," but cost very much in question, particularly since no analysis has been performed. Further impact on distribution (and transmission) may be quite large.
 - (6) agree storage may not be necessary, but no analysis shown.
 - (7) cost implications of 0-50% capacity credit for SPV quite large considering cost of conventional generation required for backup.
 - (8) statement appears to contradict one in second to last paragraph of section 2.4.
- o item ES-8 Unresolved issues must include definition of utility system integration costs which directly impact cost-effectiveness of SPV.
- o item ES-11 Agree SPV promise is bright, but statement that SPV will "substantially increase security of electricity supply at no increase in cost" is unsupported by analysis and to use the words of the Technical Discussion, "intuitively" incorrect.

- o item F2.8 Price goals for central and dispersed SPV unsupported by analysis which includes electric system integration costs.
- o item F3.1 (See comment ES.3(8)) Also last paragraph on page F36 is misleading.
- o item F3.1.2 Unsubstantiated.
- o item F3.1.3 Reliability impact statement is inadequate. Further, statement of large numbers of small units being better than converse is necessarily true only for firm, controllable generation (e.g., fuel cells).
- o item F3.1.7 Conclusions unsupported by analysis as F.3.2 points out.
- o item F3.2.2 Discussion insufficient, where is analysis?

II. Technical Discussion

- o item 2.3 (Second paragraph) Savings in transmission costs only if no backup required by SPV.
- o item 2.4 (Third paragraph) Correct Statement.
- o item 3.3.1 Please note the net result is to displace coal and nuclear power and increase oil and gas use. Is this national policy?
- o item 3.3.2.2 In the rate structure section, the analysis performed incorrectly assumes away the utility system integration costs which are the basis for our nonconcurrence. This analysis is both inappropriate and misleading.

MEMORANDUM

TO: Economic Regulatory Administration (ERA)

FROM: Jeffrey L. Smith, Jet Propulsion Laboratory

SUBJECT: Review of preliminary Congressional document "Federal Policies to Promote the Widespread Utilization of Photovoltaic Systems"

(The following memo was forwarded to ERA through the Photovoltaic Division of DOE)

The purpose of this memorandum is to respond to comments transmitted from Hazel Rollins, the Administrator of the Economic Regulatory Administration (ERA), to Thomas E. Stelson, Assistant Secretary for Conservation and Solar Energy, concerning the preliminary document "Federal Policies to Promote the Widespread Utilization of Photovoltaic Systems" (referred to here as the "Federal PV Policies" report). ERA has not concurred in the public release of this document based upon two general perceived deficiencies: (1) "...inconsistency between statements made in the Executive Summary and Findings Section of the report and the technical discussion related to the impact of Solar Photovoltaic technology (SPV) on electric power systems" and (2) "...the use of vague terminology to justify specific findings....". These general charges are supported by 21 detailed comments from ERA.

We wish to thank ERA, Hazel Rollins, and those individuals with ERA (Jerry Pfeffer, Dave Moore, Harry Derderian) for their time and effort spent in reviewing and critiquing this document. Their comments have been useful in revising and improving the report and have emphasized an important perspective on the likely interactions between existing electric grids and distributed, renewable electric generation technologies. We hope the revised document, along with the detailed explanations (found below) of our response to each of ERA's comments, will prove sufficient to win ERA's concurrence for public release.

Most of ERA's comments revolve around the meaning and interpretation of system price goals set by the PV Program to guide photovoltaic research and development, and the degree to which

various cost elements have or have not been adequately reflected in the selection of these goals. Two sets of costs have been especially emphasized by ERA: (1) the costs of backup power, and (2) the costs of modifications to utility transmission and distribution networks necessary to accommodate interconnected photovoltaic systems.

For example, the first specific ERA comment is:

- o "Page ES-15: No intensive analysis indicated, referenced, or provided."

The relevant passages from page ES-15 of the report are:

It is suggested that the price goals be refined by setting separate targets at \$1.60/Wp for distributed (grid-connected) systems to be achieved in 1986, and \$1.10 to \$1.30/Wp for central station systems to be achieved in 1990, both expressed in 1980 dollars....

These recommended goals were derived from an intensive analysis of both the required prices necessary to compete in conventional grid electricity markets, and the level to which PV system prices (including competitive rates of profit for manufacturers and system suppliers) could realistically be forced down through the various cost reduction techniques employed by the Program. DOE's Photovoltaic Multi-Year Program Plan discusses these analyses and results in detail. (italics added)

As indicated, the "intensive analysis" referred to was prepared for, and in conjunction with, the development of the draft Photovoltaic Multi-Year Program Plan (MYPP). The price goals were derived over a three month period (January-March 1979) in an investigation conducted by the Goals Working Group chaired by the Jet Propulsion Laboratory with representatives from all the major prime contractors within the DOE PV Program. The purpose of the Group was to establish PV system price targets to guide the cost reduction efforts of the PV Program. The group examined two sets of

constraints: (1) the level of PV system prices necessary to "compete" with conventional sources, and (2) the extent of PV system cost reduction believed to be possible through the various cost reduction techniques available to the Program. As illustrated in the referenced MYPP, goals were then selected which are believed to satisfy both these constraints simultaneously. The goals selected represent more than a 10-fold reduction in present PV system costs.

How were the "PV system prices required to compete with conventional sources" calculated? As indicated in the "Federal PV Policies" document, PV systems are envisioned to be fully grid interconnected, with energy feedback when the PV system is producing more electricity than is consumed at the PV site and drawing on the grid whenever consumption is greater than PV output (e.g., at night). The PV electricity can, thus, be viewed as displacing electricity that would otherwise have to be produced by other (presumably conventional) sources. The fact that the total energy required to be produced conventionally is reduced changes the total costs incurred by the utility system in generating electricity. The most obvious change is a reduction in total conventional fuel costs due to reduced fuel consumption. Other important changes in conventional costs are: (1) possible changes in the required conventional capacity on the grid (including changes in transmission system capacity due to these generation capacity changes), and (2) costs imposed on the utility due to necessary changes in the distribution network to accommodate power feedback from distributed PV systems and to maintain utility system stability and reliability in the face of random fluctuations in PV power output. In general,

interconnection of PV systems will always reduce conventional fuel consumption and, thus, conventional fuel costs; will sometimes reduce required conventional capacity but never increase it (see below); and may impose either positive or negative costs on the distribution network depending on the type of changes required, although it is generally felt that distribution network costs will increase modestly (see below). Maintenance of acceptable utility system stability and reliability may require significant expenditures once the penetration of PV systems becomes large (e.g., greater than 10% of energy generation). The net sum of these changes in conventional costs represents the total savings in conventional costs realized by the PV system, and therefore represents the maximum price at which the PV system could be sold and still remain cheaper than the conventional alternative--that is, it is the PV system price required to "compete." When the PV system is not owned by the utility, the owner does not directly realize these conventional cost savings, but rather sees only the effects on his electricity bill. If the electric rate structure the owner faces correctly "translates" these savings to him (note that only true time-of-use marginal replacement cost pricing would fully accomplish this), he faces the same incentives as would a prospective utility PV system buyer. Rate structures are thus very important to a determination of the competitiveness of non-utility owned systems, as emphasized throughout the "Federal PV Policies" document. Since ERA did not raise this as an issue, the rest of the discussion will assume either utility ownership or a rate structure which correctly translates the conventional cost savings to the non-utility owner.

How were the savings in conventional fuel and capital costs calculated? Unfortunately, there is no simple, accurate way to accomplish this. Complex simulations of utility production cost, dispatch and reliability are required. In these simulations, an entire utility system is modelled for each hour in the year. The total demand for electricity in each hour is input and the available plants are then dispatched to meet that load. The total fuel consumed is calculated as well as the number of hours in which the total capacity is not sufficient to supply the entire load. This latter concept--expected hours of capacity deficiency (EHCD)--is equivalent to the loss of load probability (LOLP), a widely used measure of utility system reliability. The utility system is first simulated with no PV systems in the available capacity. Total fuel costs are calculated, and the amount of conventional capacity required to be available to keep the EHCD below some arbitrarily prespecified level is calculated. Next, a specific quantity of PV systems is added to the available capacity. The output of these systems is calculated with detailed PV system performance models which take into account (for every hour in the year) the sunlight available (from actual weather tapes), temperature, windspeed, PV system efficiency, etc. The total yearly conventional fuel costs are then calculated and the EHCD added up. In general, fuel costs are always lower with PV than without, and the EHCD is sometimes lower (never higher since the addition of PV could never decrease EHCD below what it would have been without any PV). If EHCD are lower, the simulation is rerun with smaller and smaller quantities of conventional capacity available until the EHCD rises back to the

same level it was in the simulation with no PV capacity (that is, the prespecified reliability level). This conventional capacity (and its related transmission) is thus displaced or saved by the PV system and is often referred to as the capacity credit. It represents the conventional units that can be deferred if PV systems are installed while maintaining constant reliability of the utility system. It varies a great deal among utilities and regions of the country, and as pointed out in the "Federal PV Policies" document, generally falls in the range of 0 to 50% of the nameplate rating of the PV system.

It was the sum of values of these two savings--conventional fuel and capacity displaced--that were used to derive the "system prices necessary to compete." (Note that this represents the net avoided fuel and capital cost.) Since the utility system reliability is maintained at a prespecified level, the cost of backup to the PV system is automatically included. (An equivalent way to view it is that no "credit" is taken for conventional capacity that cannot be deferred because it must be built anyway in order to maintain utility system reliability even if PV systems are installed.)

How were costs incurred due to changes in the distribution network handled? In general, the changes in the distribution network required by interconnection and associated costs are poorly understood. Grid interconnection with power feedback for distributed PV systems is a relatively new concept. Technical investigations of grid interconnection of cogeneration and other distributed technologies have begun (see, for example, the work of DOE/Electric Energy Systems) and have yielded some very preliminary

results. We know, for example, that large amounts of power feedback may require increased transformer sizes, modifications to voltage regulators, and more sophisticated system protection. These changes are expected, by the investigators working on them, to incur only modest costs. It has been speculated, and some preliminary investigations have shown (see p. 2-15, "PV Federal Policies"), that some redundancies in subtransmission facilities may become unnecessary when PV generation is located at the load, resulting in minor cost savings. More complicated changes, such as requirements for new communication and control systems, are little more than speculation at this time. The necessity for these changes is poorly defined, the configuration of the changes not well-defined and cost estimates non-existent. This state of knowledge applies also to complications introduced by large PV penetrations such as alterations in the optimal grid generation mix and requirements for spinning reserves (system transients resulting from large PV penetrations have not been addressed, never mind the costs of mitigative measures.)

One must keep in mind, however, that the Photovoltaic Program is preponderantly one of research and development. That is, the Program is explicitly attempting to carry out research activities to produce hitherto unknown information. Thus, the lack of knowledge characterizing the technical integration issues is not unique. On the contrary, such issues are being addressed as an on-going part of the R&D effort of DOE and its distributed electric technologies. DOE/ERA, DOE/EES, Aerospace Corporation, JPL's Utility Systems Group, Sandia Corporation, EPRI (through a JBF Scientific investigation of distributed PV systems), and SERI are some of the

organizations actively pursuing this type of research. Inquiries of researchers in these organizations produces the following summary of existing knowledge:

- (1) Full interconnection of distributed systems with power feedback is technically feasible up to quite large penetration of those systems.
- (2) The problems and costs of such integration when the number of systems interconnected is small are minor and easily handled.
- (3) As penetration of distributed systems increases the required changes in the distribution networks and in system operation and control (e.g., spinning reserves) are not well-defined, and, thus, the costs have not been estimated.

In summary: for relatively small penetrations of distributed PV systems and without bunching too many such systems on any one distribution substation, interconnection is not anticipated to be a problem and is expected to result in only minor costs. As penetration increases, however, the technical fixes required, along with the associated costs, have yet to be determined, although the researchers do not anticipate large, currently unforeseen technical difficulties requiring large expenditures.

How did we take these interconnection costs into account in arriving at the price goals? In general, we omitted them. The purpose of the price goals is to give a concrete target for PV R&D efforts. The primary concern is to produce systems cheaply enough so that a sizable, sustainable, private market for distributed interconnected PV systems can thrive. There are minimum annual

rates of output considered necessary to achieve this goal. The annual rates imply only small penetrations of PV systems into the nation's electric grids, however. Thus, the price goals were selected to make the "first" PV systems competitive, not very large penetrations. (It is believed that further cost reductions will occur beyond the price goals if this market is created, due to learning effects and introductions of new PV concepts and materials, thereby spurring larger penetrations; or those penetrations could become justified through real increases in the prices of conventional sources.) For this reason, technical integration costs were omitted. (For the same reason, we also did not consider the effects of increasing PV penetrations on displaced fuel and capacity costs, which decrease as penetration increases.)

Furthermore, it is not clear what the technical integration costs are as penetration increases, nor what fraction of them should be "charged" to PV integration. We include in the PV system costs (and, thus, in the \$1.60/Wp goal) all costs associated with producing power of acceptable utility quality (power conditioning) and all other special changes required at the site by the PV system (additional metering). Costs associated with changes in the distribution network to accept this power are required equally for wind, small hydro, distributed fuel cells, small cogeneration, load management, etc. Should the PV Program accept sole responsibility for such modifications by reflecting them in its goals?

~~This completes the summary of our position on price goals and their relationship to "back-up" and "technical integration" costs.~~
The rest of the memo responds to the specific comments of ERA.

- o "item ES-3 (1) the grid can provide backup, but cost of backup very much in question."

As indicated above, backup costs are fully reflected in the Program's goals, and, if the goals are achieved, PV systems (including their backup) will be as cheap as the conventional sources they displace. (This applies to relatively low levels of PV penetration into the grid.)

- o "item ES-3 (2) agree in principle, but no analysis shown on derivation of \$/kW targets that includes utility system integration costs."

Utility system integration costs were omitted for the reasons discussed above.

- o "item ES-3 (3) agree rates are key, but FERC guidelines under PURPA 201, 210 are based on net avoided costs, not SPV commercialization needs."

Yes, but we have based SPV commercialization on net avoided costs! That is, our entire rate structure discussion is predicated upon, and explicitly recommends adoption of rate structures that are totally in consonance with the FERC guidelines. The PV Program has watched closely the preparation of FERC rules for small power producers and cogenerators, has submitted written and oral public comments, and has communicated personally with the relevant FERC staff. We have explicitly based both the price goals and our rate structure assumptions on the concept of net avoided costs, as discussed above and do not believe there is any conflict between our Program and FERC's guidelines or PURPA.

- o "item ES-3 (4) PURPA guidelines prohibit punitive actions by utilities and, therefore, no DOE action should be required."

Wouldn't attempts to enforce FERC rules involve DOE action?

Furthermore, the rules as currently constituted by FERC leave much leeway for state PUC implementation. Specific DOE action directed at facilitating state implementation could prove beneficial at some point.

- o "item ES-3 (5) agree no "intractable technical problem," but cost very much in question, particularly since no analysis has been performed. Further impact on distribution (and transmission) may be quite large."

As discussed above, we do not disagree with this comment. We have, therefore, made a new entry in that section of the report entitled "Unresolved Issues," as you suggest we should do (see below), to further emphasize the current need for more and better information with respect to technical integration issues.

- o "item ES-3 (6) agree storage may not be necessary, but no analysis shown."

We are not sure what "analysis" is referred to in this comment. The "Federal PV Policies" report discusses at some length why the current costs of electrical storage will probably make grid-interconnection with feedback an economically preferable option. Technically, storage is not required. Of course, as the report points out, for very large penetrations of PV the situation may change, so that storage becomes economically attractive.

- o "item ES-3 (7) cost implications of 0-50% capacity credit for SPV quite large considering cost of conventional generation required for backup."

Once again, back-up costs are fully reflected in PV system price goals. (See above discussion.)

- o "item ES-3 (8) statement appears to contradict one in second to last paragraph of Section 2.4."

The statements referred to are:

"(8) Large penetrations of PV systems into electric grids (30% or more of total consumption) are feasible, with substantial benefits to the environment (and an increase in the use of a non-depletable, secure solar fuel source), with no increase in cost, degradation in electricity supply reliability or quality, given attainment of the PV system price goals and timely resolution of institutional and technology integration issues." p. ES-19

and:

"Photovoltaic output is stochastic in that the availability of sunlight has a significant random component. At very large penetrations of photovoltaic systems this could impose significant problems for the utility in terms of reliability, spinning reserve, and dispatch control. Unfortunately, very little is known at this point concerning the effect of large penetrations of photovoltaic systems on these variables." p. 2-16

We see no contradiction in these statements. The benefits attributed to PV sources are predicated upon resolution of "technological integration" issues. Furthermore, we have not asserted that all of the U.S. electricity supply can or will come from photovoltaics (although this is not totally impossible). We chose the 30% penetration figure as a balance between the likely appearance of costly and/or uncontrollable integration problems and the ultimate promise of PV power. However, given that the actual promise of PV is very uncertain, we have weakened the parenthetical reference to 30% penetration so that it now reads: "possibly as much as 30% or more of total consumption)." As discussed at length above, all of our goals are based on net avoided costs, on systems that produce acceptable quality power, and on maintaining utility system reliability at current levels. Of course, ultimate

penetrations of PV power depend not just on making the goals, but also on how much the goals are bettered, on the increase in integration costs as penetration increases, on reductions in capacity credits as penetration increases, etc. To further reflect this uncertainty, a qualifying sentence has been added to the end of the paragraph found on p. ES-19. This sentence is: "The extent of ultimate deployment of PV systems depends upon the success of PV system cost reduction activities, the future costs and availability of all alternative electricity sources, and the success and costs involved in resolving institutional and technology integration issues."

- o "item ES-8 Unresolved issues must include definition of utility system integration costs which directly impact cost-effectiveness of SPV."

We fully support this suggestion, and have, accordingly, added utility system integration as the third unresolved issue in Section ES-8. The text of that addition is:

A final unresolved issue, which deserves additional attention, is the likely effect on electric utility systems of large penetrations of photovoltaic systems. As discussed at several places in this document (e.g., Section 2.4), large deployments of PV systems will impose unknown requirements on utilities with respect to technical system integration, spinning reserves, and utility system reliability and stability. The satisfaction of these requirements may involve significant costs. Until these issues have been more fully explored, the ultimate promise of photovoltaic systems cannot be determined. Thus, Departmental examinations of these issues must receive high priority.

- o "item ES-11 Agree SPV promise is bright, but statement that SPV will 'substantially increase security of electricity supply at no increase in cost' is unsupported by analysis and to use the words of the Technical Discussion, 'intuitively' incorrect."

We do not accept this comment. Since no reference to penetration is given in the statement, and since "significant" penetration of PV systems can occur without incurring unknown technical integration costs, we cannot discover any basis for claiming this statement is incorrect or misleading.

- o "item F2.8 Price goals for central and dispersed SPV unsupported by analysis which includes electric system integration costs."

As discussed above, the price goals do not include integration costs because these costs are minor at relatively low penetrations. Price goals are not chosen based upon penetration levels at which technical integration costs could become substantial.

- o "item F3.1 (See comment E3-3(8)) Also last paragraph on page F36 is misleading."

The last paragraph of p. F36 is:

"Both the physical utility systems and their ownership patterns will evolve in various, complex ways with the addition of PV systems. However, no degradation of quality or cost of the U.S. electrical supply is anticipated. PV systems have the potential to increase the security and reduce the harmful side effects of electricity production at no increase in total cost. Using the grid as backup allows pooling of stochastic loads, enhanced reliability, and centralized operations and dispatch. Potential for cost savings exist, especially in utility transmission costs."

We see nothing misleading about this paragraph. If the PV Program is successful in accomplishing its objectives, each of these claims will hold. Thus, PV has this potential -- although that potential may never be realized, of course. Nevertheless, we have eliminated the sentence concerning potential cost savings in transmission as this claim is unnecessary, possibly, confusing and of minor importance.

- o "item F3.1.2 Unsubstantiated."

Section F3.1.2 is a brief discussion of the implications of PV for utility load management (a topic of discussion explicitly requested by Congress.) Several reviewers objected to the inadequacy and oversimplification of this section. Therefore, we have rewritten the section. Any specific suggestions as to how this section may be further improved would be welcomed.

- o "item F3.1.3 Reliability impact statement is inadequate. Further, statement of large number of small units being better than converse is necessarily true only for firm, controllable generation (e.g., fuel cells)."

This section has also been substantially rewritten. The statement concerning larger numbers of smaller generators has been eliminated. We think the section is now more closely in line with the Technical Discussion and the discussion found above. Specific suggestions for improvements would be appreciated.

- o "item F.3.1.7 Conclusions unsupported by analysis as F.3.2 points out."

F3.1.7 reads:

"The interconnection of PV systems is not only relatively simple, it is highly desirable. Given successful completion of the planned PV Program, very large penetrations of photovoltaic systems (as high as 30% or more of total generation) into electric grids are feasible. The major limitations are economic, primarily the high initial cost of the PV systems, and secondarily, the necessity for appropriate utility rate design as well as resolution of technical integration issues."

This paragraph has now been modified as follows:

"The interconnection of PV systems with electric grids is highly desirable. Given successful completion of the planned PV Program, very large penetrations of photovoltaic systems (possibly as high as 30% or more of total generation) into electric grids may become feasible. The major limitations are economic, primarily the high initial cost of the PV systems, and secondarily, the necessity for

appropriate utility rate design as well as the resolution of technical integration issues without incurring unreasonable costs."

- o "item F3.2.2 Discussion insufficient, where is analysis?"

Section F3.2.2 reads:

"The adaption of capacity expansion planning models to incorporate photovoltaic systems will be an important step in the ability of the DOE/PV Program to develop information about the long-range implications of large penetrations of PV into utility grids, and to understand the impact of rate structures on the potential for such penetrations."

As pointed out in Section 2.5, no methodology for capacity expansion planning which incorporates photovoltaic (or other solar) technologies currently exists, therefore, no real analysis can be performed. The DOE/PV Program in conjunction with EPRI is currently funding an on-going effort to develop such a model at the MIT Energy Laboratory under a 2-year contract. Section 2.5 does contain approximately 2 pages of rather speculative discussion of likely grid generation evolution with PV systems as part of the generation mix.

- o "item 2.3 (Second paragraph) Savings in transmission costs only if no backup required by SPV."

As discussed above, the addition of PV systems to utility grids sometimes enhances the grid's reliability and, therefore, allows the deferral of conventional capacity. Clearly, the transmission facilities that would have served the deferred conventional capacity can also be deferred.

- o "item 2.4 (Third paragraph) Correct Statement."

2.4 is reproduced above (in this memo). Thank you for the endorsement.

- o "item 3.3.1 Please note the net result is to displace coal and nuclear power and increase oil and gas use. Is this national policy?"

The only reference in Section 3.3.1 to this subject is:

"As photovoltaic electricity is always dispatched when available (see Section 2.4), and as the highest cost conventional sources are backed out first, the first photovoltaic systems displace the most expensive of the generating plants first, most often intermediate oil plants or combustion turbines, depending on the configuration of a utility's load and capacity."

The only place in the entire document that implies any possibility of increased use of oil or gas from PV interconnection is found in the rather speculative Section 2.5 (discussed above). Here, the report states:

"The introduction of photovoltaic systems, especially at large photovoltaic penetrations (at least greater than 10%), implies the need to supply power from other sources during those days when the sun is hidden behind clouds. These sources will not need to be operated much of the time. That is, large photovoltaic penetrations could eventually increase the need for peaking and, possibly, intermediate capacities. (This conclusion does not hold for small penetrations of solar power, however. In general, the first units of photovoltaic systems will displace capacity from all three categories: peaking, intermediate, and base load.)

Stated another way, large penetrations of photovoltaic power in combination with peaking and intermediate sources (e.g., gas turbines) will substitute for baseload coal, nuclear, oil, and gas sources. Thus, to the extent that oil and gas are used for baseload generation, photovoltaic systems can displace them. But, to the extent oil and gas are used in peaking units, photovoltaic systems could eventually increase their use. It must be emphasized that these conclusions hold only when photovoltaic penetrations become large (at least greater than 10%).

The vast majority of oil burned by electric utilities is done in utilities with large quantities of base load and intermediate oil plants. PV will always displace oil in the utilities. Even if an eventual need for additional peaking units does arise because of very large PV penetrations, the capacity factors of all peaking units could drop, thereby reducing fuel use. Even if fuel use in

these peaking units increase, it will not involve significant amounts of oil. And, please keep in mind that this possibility does not arise until PV penetrations are very large (greater than 10% of total generation) which will not occur until long after 2000, if at all. By then, different peaking sources may be available (or substitutes for them, e.g., load management, storage). This section (2.5) was meant to be speculative. The possibility of increasing oil or gas use is quite remote, both in time and in probability.

- o "item 3.3.2.2 In the rate structure section, the analysis performed incorrectly assumes away the utility system integration costs which are the basis for our nonconcurrence. This analysis is both inappropriate and misleading."

As discussed above, the technical integration costs are believed to be minor at low PV penetrations and to only become significant as penetration grows very large. Thus, rates for early system deployment should, in fact, include only minor corrections for those costs. They were assumed away here to simplify the calculations, especially since reliable, quantitative estimates of these costs do not yet exist. There was no intention to imply that, conceptually, they should be omitted.