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Effects of Expiration of the Federal Energy Tax Credit on the National Photovoltaics Program

May 1984

Prepared for
U.S. Department of Energy
Through an Agreement with
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by
Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

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16. Abstract

The Federal energy tax credit is scheduled to expire at the end of 1985. This study concludes that the U.S. photovoltaic (PV) manufacturing industry will be hurt by the expiration. Projected 1986 sales are significantly reduced as a direct result of system price increases following from expiration of the credits. The character of the industry will probably change, with greatly reduced emphasis on domestic electric utility applications. Indirect effects arising from unrealized economies of scale and reduced private investment in PV research and development (R&D) and in production facilities could have a very large cumulative adverse impact on the U.S. PV industry. The industry is forecasting as much as a fourfold reduction in 1990 sales if tax credits expire, compared with what sales would be with the credits. Because the National Photovoltaics Program is explicitly structured as a government-industry partnership, large changes in the motivation or funding of either partner can affect Program success profoundly. In particular, reduced industry participation implies that such industry tasks as industrialization and new-product development will be slowed or even halted. In addition, those PV research areas receiving heavy R&D support from private PV manufacturers, such as collector research, module reliability, and some balance-of-system development and large-system experiments, will be adversely affected due to reduced private participation and funding. Finally, the curtailment of electric utility applications will delay realization of photovoltaics as an important U.S. bulk power option.

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ABSTRACT

The Federal energy tax credit is scheduled to expire at the end of 1985. This study concludes that the U.S. photovoltaic (PV) manufacturing industry will be hurt by the expiration. Projected 1986 sales are significantly reduced as a direct result of system price increases following from expiration of the credits. The character of the industry will probably change, with greatly reduced emphasis on domestic electric utility applications. Indirect effects arising from unrealized economies of scale and reduced private investment in PV research and development (R&D) and in production facilities could have a very large cumulative adverse impact on the U.S. PV industry. The industry is forecasting as much as a fourfold reduction in 1990 sales if tax credits expire, compared with what sales would be with the credits. Because the National Photovoltaics Program is explicitly structured as a government-industry partnership, large changes in the motivation or funding of either partner can affect Program success profoundly. In particular, reduced industry participation implies that such industry tasks as industrialization and new-product development will be slowed or even halted. In addition, those PV research areas receiving heavy R&D support from private PV manufacturers, such as collector research, module reliability, and some balance-of-system development and large-system experiments, will be adversely affected due to reduced private participation and funding. Finally, the curtailment of electric utility applications will delay realization of photovoltaics as an important U.S. bulk power option.

FOREWORD

This report was prepared by the staff of the Photovoltaic Program Analysis and Integration (PA&I) Center of the Jet Propulsion Laboratory (JPL) during the fall and winter of 1983. The purpose of the report is to anticipate, for the benefit of National Photovoltaics Program management, the probable effects of Federal energy tax credit expiration on the research and development activities of the Program.

Projections of future PV sales volumes contained in this report represent JPL's summary of the results of a series of discussions between PA&I staff members and many knowledgeable members of the PV industry, senior employees of PV manufacturing companies, and industry consultants.

CONTENTS

EXECUTIVE SUMMARY

In 1980, Congress included within the Crude Oil Windfall Profits Tax Act a 15% solar-energy tax credit for businesses and a 40% credit for individuals. This provides indirect benefits to photovoltaics (PV) manufacturers by lowering the effective U.S. sales price (net, after tax) of qualifying sales. Under current legislation, these energy tax credits will expire at the end of 1985. Legislation that would extend the expiration date to the end of 1988 and increase the level of the credits is pending in Congress.

The purpose of this study is to assess likely effects of that tax credit expiration on the PV industry and on research activities of the U.S. Department of Energy (DOE) National Photovoltaics Program. As the latter activities are explicitly designed as a government-industry partnership and are jointly funded with industry, important changes in the PV industry must affect DOE research decisions.

The energy tax credits affect the PV producer, through a reduced effective price to the buyer; the seller receives no direct subsidy. Furthermore, an international buyer* does not receive the subsidy at all. And it must be remembered that important trends and influences, such as changes in perceptions of the nation's energy predicament, may exacerbate the effects of credit expiration.

In addition to thwarting the direct effects of tax credits in reducing PV system prices, tax credit expiration is likely to precipitate large indirect effects on PV sales growth resulting from reduced economies of scale and altered expectations. Economies of scale are very important to the young and small PV industry, with larger producers able to outperform smaller ones significantly, due to the strong cost advantages of larger integrated plants. New large plants will be delayed or never built if sales projections fall. Reduced expectations will reduce private funding of PV R&D, private photovoltaic plant and equipment investment, and pressure for extension of state tax credits and incentives. These effects are cumulative; they reduce the annual rate of PV technological advance, cost and price reduction, and sales growth.

Effects on Prices

Due to provisions in the tax code, the effective business energy tax credit is about 30%, and the effective credit for homeowners falls between 10% and 40%. Loss of the credits will directly increase effective prices (net, after tax) to the purchasers by these percentages. However, this does not consider the indirect effects described above. These indirect effects reduce the rate of technological progress and the resulting rate of cost and price reduction. It is impossible to gauge accurately the magnitude of these indirect effects.

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*In this document, an international buyer (in this context) is defined as a foreign purchaser who pays no income taxes in the United States.

An examination of the effect of tax credit expiration on market prices does not completely capture the incentives arising from the tax credit to investors in large PV systems. In particular, when large PV systems are funded with both equity and debt, the tax credit benefit appears to be large to the equity holders who receive it. It is often these equity investors who provide the entrepreneurial drive behind photovoltaic energy investment projects. And most important, third-party investors, considered herein as being included in the "utility sector" of the PV market, may be disproportionately discouraged by tax credit expiration, thereby killing the motivation behind large photovoltaic-system investments.

Effects on Sales

Attempts to predict industry sales are fraught with difficulty and uncertainty. Nevertheless, to gauge the effect of tax credit expiration on the PV industry and the PV Program, it is essential that some estimate of the likely reduction in sales volume, by class of PV technology, be made. Rather than attempt an independent estimate of the various factors and trends important to future PV sales, this study solicited the aid and the opinions of the PV industry. Interviews were conducted with 11 U.S. PV manufacturers and four PV industry market consultants. Each was asked to estimate 1983 sales in each of several market sectors. Each was then asked for forecasts of sales by market sector during 1986 and 1990. Two forecasts were elicited for each year, one assuming the expiration of the Federal energy tax credit at the end of 1985 and the other assuming its extension through 1990. Opinions varied widely, although the consensus was clearly that PV sales and the U.S. PV industry would be hurt significantly.

PV Manufacturers' Projections

In general, the 11 PV manufacturing companies surveyed believed that, in 1986, systems built by third parties for electricity sales to the utility sector would be damaged severely by the expiration of tax credits, with sales decreasing to half of what they would be with extended tax credits. Grid-connected residential systems and water-pumping systems would also be hurt, with sales reduced 30% to 50%. They thought that expiration would have no direct effect on the international market sector and only a small effect on domestic communication markets, although the concomitant loss in economies of scale as a result of losses of electric utility, residential and water-pumping sales could jeopardize the position of U.S. companies in the international market.

Consultant Projections

All four of the consultants generally agreed with the manufacturing firms about the effects of tax credit expiration in all market sectors except the electric utility sector. There was agreement that the residential and water-pumping markets would be hard hit, with other remote markets being virtually unaffected.

Three of the four thought that the electric utility sector would be profoundly stimulated by tax credits if they were extended to 1990. According to their projections, utility-sector sales in 1990 would be from five to 10 times greater with tax credits than without. Clearly, such large impacts must arise

partially from the indirect effects of tax credits on economies of scale and on photovoltaic investments rather than from direct price effects of tax credits.

1983 PV Sales by Sector

Based on discussions with the manufacturers and industry consultants, projections of the PV market were consolidated by sector, leading to the following conclusions if the Federal energy tax credits expire:

(1) The domestic residential markets, which depend heavily on tax credits, will be reduced 30% to 50% in 1986 in the non-grid-connected sector and 50% to 80% in the grid-connected sector.

(2) The electric utility sector, with more than 80% of the total market, will be severely reduced, by 35% to 85%, in 1986.

(3) The water-pumping and other industrial sectors will also be severely affected, with a decrease of 30% to 60% in 1986.

(4) The indirect effect of tax expiration on the competitive position of the U.S. PV industry in a worldwide market in which some foreign manufacturers receive subsidies from their governments could be profoundly damaging.

Due to very large uncertainties regarding sales in 1990, projections of total domestic PV shipments only were provided by respondents. On average, the respondents estimated that about 400 MW will be shipped by domestic companies in 1990 if tax credits are extended until then; if not, shipments in 1990 will only be about 100 MW. The bulk of this 75% reduction in PV markets will be in the electric utility sector, and clearly must arise from the compounded indirect effects of tax credit expiration.

Effects on the PV Manufacturing Industry

Utility-oriented PV companies will suffer a drastic reduction in projected sales in 1986 and 1990 as a result of tax credit expiration; some may cease operations. To small, independent companies, the PV utility business may no longer appear to be potentially profitable. For those that are owned by larger companies, the parent company may decide that there are more lucrative fields in which to invest capital. Alternatively, these companies may elect to shift their marketing strategy away from utility markets to pursue smaller, more specialized markets; thus they would compete more strongly with existing specialty companies. In addition, the loss of projected economies of scale from large utility-sector sales will raise projected manufacturing costs, making it more difficult for these companies to compete in all markets, including the international sector.

There is some diversity of opinion about the effects of tax credit expiration on concentrator companies, but the prevailing view is that they will be adversely affected and may elect to cease operations. The three concentrator manufacturers are small companies whose plans are heavily dependent on the extension of Federal energy tax credits until 1990. Their primary market in the near future is in third-party-financed systems, where electricity is sold to a utility from a third-party-owned generation system.

It is this class of equity investors, typically limited partnerships, that is most discouraged by the pending loss of the energy investment tax credits, thereby discouraging in turn the growth of this relatively new but important form of electric generation financing and ownership.

Effects on the Federal Photovoltaics Program

For the past decade the U.S. Government has led the world in advocating and funding research and development of PV power systems. The general effect of tax credit expiration on the National Photovoltaics Program will be to reduce the contribution of industry to the government-industry partnership, which has been very effective in the development of photovoltaics. The reduction in projected sales resulting from credit expiration will significantly reduce the incentive for industry to participate in Government R&D programs using their own funds. In addition, the partnership will suffer if industry does not carry out its assigned tasks of industrialization, commercialization and product development. The adverse implications for utility applications of photovoltaics arising from tax credit expiration will significantly delay the time at which photovoltaic power systems can be expected to contribute significantly to the U.S. domestic electric energy mix.

It is necessary to examine the Program's research tasks to identify those with higher fractions of government support and less vulnerability, versus those with more industry cost sharing and thus more vulnerability, to tax credit expiration.

The Five-Year Research Plan identifies 10 research tasks, grouped into three research classes: materials research, collector research and systems research. In general, materials research is of higher risk and longer term than are collector and systems research and, therefore, is less affected by fluctuations in industry funding.

Materials Research

The five materials research tasks are Single-Junction Thin Films, High-Efficiency Multijunction Concepts, Innovative Concepts, Silicon Materials, and Advanced Silicon Sheet. Work on three of these tasks (High-Efficiency Multijunction Concepts, Innovative Concepts and Silicon Materials) probably will not be affected drastically by the expiration of the Federal energy tax credit. These tasks are done at government laboratories, or at universities or research-oriented companies under contract to government laboratories.

Two materials research tasks would suffer significant losses as a result of reduced industry interest and funding: Single-Junction Thin Films and Advanced Silicon Sheet. A new program in Single-Junction Thin Films, launched last year, depends significantly on private industry interest and cost-sharing support. Because of the mature status of the Advanced Silicon Sheet task, many of the R&D activities have already been handed off to industry for further development. Should that private development cease, continuing Silicon Sheet generic research would be seriously threatened.

Collector Research

The next two research tasks, Flat-Plate Collectors and Concentrator Collectors, will be affected by the expiration of tax credits and the changing character of the PV industry that will result. A number of limiting characteristics of flat-plate modules have been identified and are being addressed by government laboratories and by industry (using their own resources as well as under government contract). It is likely that the industry will reduce its support of longer-term and riskier collector research as a result of tax credit expiration.

Further, industry may move away from or delay product development activities focussed on collectors suitable for the bulk utility market, e.g., 400 Vdc modules. Instead, interest might shift to lower voltage modules suitable to the off-grid export market. Hence, government R&D funding might be left as the only means to fill the technology gap.

Inasmuch as the very existence of the three concentrator manufacturing companies is threatened, research tasks involving concentrator design will be severely affected if tax credits expire. Concentrator cell research may survive, although testing of cell improvements in an industrial setting may be impossible if concentrator manufacturers cease operations.

Systems Research

The three systems research tasks are Module Reliability, Array and Balance-of-System (BOS) Development, and System Experiments. All three will be adversely affected by the expiration of the Federal energy tax credit.

Module Reliability research is performed and funded both by government laboratories and by private companies to identify appropriate test methods and to identify materials and processes that can withstand those tests. The reduction in projected sales will discourage PV manufacturers from conducting this research and from fabricating modules for testing. For the most part, power-conditioner work will be minimally affected by tax credit expiration. However, industry technology support for large-scale power conditioners (1 to 5 MW) might be seriously curtailed or cut back, again leaving Federal R&D support as one of the few means of taking up the slack. Work on fixed flat-plate structures will be minimally affected, since the effort is being performed by government laboratories and contractors that are generally not in the PV manufacturing business. However, work on tracking flat-plate and concentrator building-block concepts will be affected significantly by tax credit expiration. Companies participating in this effort tend to fall into the utility-oriented or concentrator types, whose projected sales are highly sensitive to Federal tax credits.

Large residential PV experiments will be discouraged, as they are profoundly affected by costs. The sharp reduction in projected PV sales will delay projected price reductions, thereby increasing the projected costs of large experiments. Unfortunately, the modest plans of the Program for direct funding of system experiments exacerbate the impact of tax credit expiration on this task, because the Program depends directly on privately funded system experiments for technology verification. Without tax credits or direct funding, the crucial step of system technology verification may not occur.

Conclusion

The PV industry will be seriously hurt by Federal energy tax credit expiration. The character of the industry will change, with a trend away from the utility sector and toward the international arena and, to a lesser extent, toward the smaller domestic communications market. Loss of the potential utility market may severely discourage further investment, leaving photovoltaics as a small industry supplying specialty products. Third-party financing arrangements will be delayed and possibly eliminated. Other trends or actions, such as altered perceptions of the national energy predicament, changing costs of alternative fuels, or increased foreign participation, may exacerbate the effects of tax credit expiration. The PV Program will require adjustment in its research plan to adapt to the effects of tax credit expiration.

The time at which photovoltaic power systems can be expected to contribute significantly to the U.S. bulk electrical energy mix will be markedly delayed. Equally significant, PV industry technology will be directed away from products intended for the utility sector, and perhaps toward products for the export market in stand-alone applications. This refocusing will impede the development, for example, of high-voltage modules, large-sized, cost-effective inverters, and reliable systems based on large-scale testing and field experience.

SECTION I

INTRODUCTION

In 1980, Congress included within the Crude Oil Windfall Profits Tax Act (PL 96-223) a 15% solar-energy tax credit for businesses and a 40% credit for individuals. In simple terms, this meant that a business that purchased a solar-energy system could reduce its Federal tax liability by an amount equal to 15% of the solar system's purchase price. Likewise, an individual's Federal tax liability could be reduced by 40% of the purchase price. This Federal tax subsidy of some photovoltaic (PV) system purchases provides indirect benefits to both foreign and domestic PV manufacturers by lowering the effective sales price of qualifying sales. However, since additional Federal tax benefits are available to business solar investments (as well as to other business investments), the energy tax credit represents a significantly larger fraction of the actual effective after-tax price of photovoltaic systems to business than the 15% nominal credit contained in the legislation.

Under current legislation, the solar-energy tax credits will expire at the end of 1985. Legislation is pending in Congress that would extend the expiration date to the end of 1988 and increase the level of the credits. Photovoltaic suppliers and manufacturers report that they already feel the impact of the expected tax credit expiration on sales of larger and longer-lead-time systems.

The purpose of this study is to assess probable effects of the energy tax credit expiration on the photovoltaic industry and on research activities of the national PV Program. Since these research activities are explicitly designed as a government-industry partnership and are jointly funded with industry, important changes in the PV industry necessarily affect government research decisions.

Note that the energy tax credits affect the PV producer only indirectly through a reduced effective price (or cost) to the buyer; the seller receives no direct subsidy. Furthermore, a very significant class of PV customer -- the international buyer* -- does not receive the subsidy at all, because he does not pay U.S. taxes. And although expiration of the energy tax credit is likely to have a significant adverse effect on the PV industry, other trends and influences on the industry may be of as much or more importance. For example, changes in perceptions of the national energy predicament (and associated projections of rates of real fuel-price escalation), rapid technological advances leading to system cost reductions, changes in state tax credits (especially in California), and rapid PV market growth are exerting important influences on the characteristics of world and U.S. PV markets and industry. These trends and influences may work to mask or to compound and exacerbate the credit expiration effects.

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*In this document, an international buyer (in this context) is defined as a foreign purchaser who pays no income taxes in the United States.

In addition to negating the direct effects of tax credits on PV system effective prices if tax credits expire, several indirect effects resulting from tax credit expiration loom large in importance. In particular, indirect effects on PV sales growth resulting from reduced economies of scale and altered expectations may be more important than the initial direct effects of increased system effective prices. To the extent that sales growth is directly reduced in 1986 and beyond by increased effective prices, cost reduction attributable to economies of scale will be reduced. These economies are very important to the young, small PV industry, with larger producers able to outperform smaller operations significantly due to the strong cost efficiencies of larger integrated plants. Several analyses have shown that such economies are available in plants up to 10 to 20 times the size of today's largest facilities. (See Reference 7, 4-15). New large plants will be delayed if sales projections fall. In addition, the pending tax credit expiration affects expectations concerning the future of photovoltaics (and other renewable energy sources). Reduced expectations will manifest themselves in reduced private funding of PV research and development, reduced private photovoltaic plant and equipment investment, and reduced pressure for extension of complementary state tax credits.* These indirect effects resulting from altered expectations and reduced economies of scale are cumulative; they reduce the annual rates of technological advance, cost (and market price) reduction and sales growth. Thus, the absolute and relative effects on projected sales is much worse in 1990 than in 1986 as a result of these indirect effects, whereas the direct effects of higher system effective prices have the same relative impact in 1986 and in 1990.

It is simple to predict the effects of Federal tax credit expiration on the effective price of a PV system relative to what the effective price would have been with the credit; it is much more difficult to predict absolute prices in 1986 or 1990 or market sizes with or without tax credits. Photovoltaic technology is expected to show continued rapid advances over the next decade, and system market prices are expected to fall as this technology is adopted and as production volumes rise. Without the credits, PV systems costs are expected to continue to decline and sales volumes are expected to grow, but not nearly as rapidly as if credits are extended. Tax credit expiration must be viewed in the context provided by these rapidly moving forces within the young and dynamic photovoltaic industry.

Section II of the study begins with a discussion of the direct effect of the tax credits on the effective market prices of PV systems by market sector. Section III contains a summary of the results of a set of telephone and direct interviews with PV experts concerning U.S. PV industry sales in 1983 and projected 1986 and 1990 sales with and without tax credits. The results of these two steps are used next to assess the effects of tax credit expiration on the PV industry. Although this analysis was conducted on a

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*California is by far the most important domestic market for photovoltaics (e.g., all PV systems dedicated to supplying domestic electric utilities have been located in California) due to its favorable climate, high electricity prices, and state energy tax credits, which provide approximately the same magnitude of after-tax benefits as do the Federal credits. If both California and Federal tax credits expire, the PV industry will be dealt a much more serious blow than it will if only one set of credits expire.

company-by-company basis, the effects are summarized for three classes of PV manufacturers: utility-oriented companies, specialty flat-plate companies and concentrator companies. The effects of tax credit expiration on the National Photovoltaics Program are assessed by examining the effects of expiration on those PV companies pursuing R&D whose work is complementary to the goals of the Federal PV program. The U.S. Department of Energy Five-Year Research Plan identifies 10 research tasks designed to accomplish Program goals. The effects of the tax credit expiration on each of these research tasks is assessed. Appendix A reviews and summarizes relevant Federal legislation and pending legislation.

SECTION II

DIRECT EFFECTS ON THE EFFECTIVE PRICES OF PHOTOVOLTAIC SYSTEMS

This section discusses how the Federal energy tax credit directly affects the actual after-tax prices or costs of PV systems to their purchasers. Because different market sectors are affected in different ways, each sector is considered separately. For this analysis, five sectors are considered: (1) International (2) Grid-Connected Residential (3) Remote Residential (4) Domestic Electric Utility and (5) Domestic Water Pumping, Communication, and Other.

Since the tax credit is not available to international buyers, there will be no direct effect on these markets should the credit expire. All domestic markets will be directly affected, however, as described below. Both domestic and international prices and sales suffer the important indirect effects, resulting from reduced economies of scale and reduced investment incentives.

Grid-Connected Residential Systems

The present market price of residential grid-connected PV systems is about $15/W. Very few residential grid-connected systems have been installed in the United States. By 1986, these systems are likely to range in power from 2 kW to 5 kW each and to cost between $5 and $10 (1983 $) per watt of generating capacity.

Table 1 shows the amounts that a household would have to spend for a PV system in the price and size ranges expected by 1986.

Currently the Federal residential energy tax credit (for solar systems installed at one's principal residence) is 40% of the solar-energy system market price, with a limit of $4,000. Table 2 shows the percentage of savings for various combinations of PV system sizes and price levels. Only the smallest system size at the lowest price qualifies for the full 40% credit. All other combinations in this table are limited by the $4000 maximum credit.

Thus, the costs of increases in system size beyond that size which yields the full credit (2kW or less) jump dramatically. This powerful effect of the tax credits may artifically constrain the size of residential systems. Homeowners who size their systems to match the credit will suffer a full 40% increase in effective price if the tax credit expires.

On the other hand, some buyers may find the very small system sizes that qualify for the 40% credit to be overly constraining. These homeowners may choose to buy larger systems that do not qualify for the full 40% credit. For these homeowners, as Table 2 indicates, the percentage of savings from the Federal energy tax credit increases as system market price drops and decreases as system size increases. Furthermore, due to important system economies of scale and to buyer preference, it is reasonable to assume that system market price and size are not independent. That is, smaller systems are likely to have higher per-unit production and installation costs (and prices) than are larger systems. In addition, if lower prices are available, these buyers will

Table 1. Total 1986 Expenditure Per Residential Grid-Connected PV System, 1983 $

Price	2 kW	3 kW	4 kW	5 kW
$5/W	$10,000	15,000	20,000	25,000
$8/W	16,000	24,000	32,000	40,000
$10/W	20,000	30,000	40,000	50,000

Table 2. Savings by a Household From the Energy Tax Credit, %

Price	2 kW	3 kW	4 kW	5 kW
$5/W	40.0	26.7	20.0	16.0
$8/W	25.0	16.7	12.5	10.0
$10/W	20.0	13.3	10.0	8.0

tend to choose larger systems. Thus, large systems tend to be associated with low prices and vice versa. These effects imply that the effective price of grid-connected residential PV systems for these homeowners is likely to be increased directly in 1986 by 10% to 30% should tax credits expire. Indirect effects will become important in later years, as the rate of market price decline is decreased and the rate of sales growth is slowed.

Remote Residential Systems (Non-Grid-Connected)

The typical remote residential system is much smaller than a grid-connected system, currently averaging less than 1/2 kW, and selling for $12/W to $15/W without storage. System size is expected to increase as the system price drops. For remote residential systems, system size is expected to range between 0.5 kW and 2 kW, and to cost somewhere between $5/W and $10/W by 1986 (in 1983 dollars). Furthermore, typical remote systems are expected to have a 5-8 kWh storage capability to provide power during low insolation periods. Storage currently sells for about $50/kWh. Thus, the total cost for 8 kWh storage capacity would be about $400. Table 3 shows the total installed cost (or market price) for a remote residential system with storage as system sizes and prices vary.

As with grid-connected systems, the allowable Federal energy tax credit for remote residential systems is $4,000 for expenditures greater than or equal to $10,000 and 40% of the total cost for expenditures less than $10,000. Table 4 shows the percentage savings in expenditures due to the Federal energy tax credit for each price and size combination in Table 3. Since these are the size and price ranges expected in 1986, these savings will be realized if the Federal energy tax credit is extended beyond 1986.

Table 3. Total 1986 Expenditure Per Remote Residential System Including 8 kWh of Storage, 1983 $

Price	0.5 kW	1 kW	2 kW
$5/W	2,900	5,400	10,400
$8/W	4,400	9,400	16,400
$10/W	5,400	10,400	20,400

Table 4. Savings for Remote Residential Systems, %

Price	0.5 kW	1 kW	2 kW
$5/W	40%	40	36
$8/W	40	40	24
$10/W	40	36	19

Again, system size and price can be assumed to be inversely related. If the price drops as low as $8/W in 1986, then the system size may increase to 2 kW, resulting in a 24% saving from the Federal energy tax credit. At a price of $10/W, a typical system size might be 1 kW, yielding savings of 38%. In this scenario, the total savings from the Federal energy tax credit would range between 24% and 40%.

Domestic Utility, Water Pumping, Communications and Others

There is no maximum credit limit included in the business energy tax credit, which applies to other domestic applications, including third-party-owned PV systems selling exclusively to electric utilities, water pumping and communications. Congress set this credit at 15% of the total system cost rather than 40% as with residential applications.. However, the credit represents a much higher fraction of the actual after-tax cost to the purchasers of a business PV system than this nominal 15%, because of existence of other tax benefits that substantially reduce the after-tax cost of all business investments, thereby increasing the importance of the energy tax credit relative to this significantly reduced actual investor cost.

In particular, the 10% investment tax credit, depreciation deductions and state tax credits (if any) reduce the actual cost of PV (and other) investments to approximately 50% of their market cost. The effect of federal tax credit expiration is to increase the effective PV price by 30%.

Table 5 shows the 15% Federal energy tax credit as a percentage of actual after-tax cost of PV systems for two classes of business investors (partner-

Table 5. The Impact of the Federal Energy Tax Credit on Actual PV System Costs for Utility, Water Pumping and Communication Applications, %

	With California State Tax Credit of 25%	With No State Tax Credit
Third-Party Utility (limited partnership)	35.7	26.8
Water Pumping, Communication, Other (corporate)	35.0	26.0

ships and corporations) in (1) California and (2) states with no state investment tax credit. The derivation of these percentages is included in Appendix B.

As Table 5 shows, the business energy tax credit looms much larger as a percentage of an investor's actual after-tax cost (effective price) of a PV system then the nominal 15% credit would imply. Loss of this credit would represent substantial increase in the effective price of business PV systems. In sum, loss of the Federal energy tax credits will substantially increase the effective prices of PV systems and can be expected to significantly reduce PV system sales relative to what they would be with tax credits available.

In addition, these direct effects do not include the indirect effects mentioned above that arise from reduced economies of scale and reduced incentives for investment in R&D, plants and equipment. These indirect effects will reduce the rate of technological progress and the resulting rate of cost and price reduction. Although we believe that these effects will be significant, it is impracticable to provide a precise quantitative assessment of them.

Finally, it is noted that varying incentives arise from the tax credit between different types of investors in large PV systems. The financial structure of the project is important. For example, when large PV systems are funded with both equity and debt, the tax credit benefit appears to the equity holders who receive it to be large. It is often these equity investors who provide the entrepreneurial drive behind photovoltaic-energy investment projects. Of course, the long-term debt holders will consider all costs and benefits in their negotiations with potential equity investors, thereby spreading tax benefits and other benefits and costs among all participants. Nevertheless, third-party investors may be disproportionately discouraged by tax credit expiration, thereby vitiating the motivation behind large PV system investments.

SECTION III

INDUSTRY MARKET FORECAST

It is straightforward to calculate the relative effective prices of PV systems with and without tax credits, but it is much more difficult to predict actual prices in 1986 or beyond. Photovoltaic system prices have fallen rapidly over the last decade. Collector prices, which constitute more than half of the cost of most systems, have fallen from more than $100/W to less than $10/W. Further significant price reductions are expected through economies of scale and adoption of new technology. The photovoltaic industry, in conjunction with governments worldwide, is spending heavily on photovoltaic R&D, with significantly less costly products and production methods widely expected as a result. Photovoltaic production capacity, output and shipments have grown very rapidly (see Table 6). Continuation of such growth will give rise to significant cost savings through economies of scale. However, tax credit expiration is likely to reduce this technological progress and retard the realization of economies of scale.

It is equally difficult to predict the effects of tax credit expiration on PV industry sales. Expiration clearly will reduce sales relative to what they would have been with the credit, but the magnitude of this reduction is uncertain.

In addition to the direct and indirect effects of tax credit expiration, several independent factors or trends are exerting profound influences on PV industry sales. These independent factors and trends include changes in general perceptions of the national energy prediament, which manifest themselves in changes in predictions of real energy price escalation rates; changes in the perceived capital costs of alternative electric power sources, especially nuclear and coal; and changes in the organizational and institutional relationships that govern the supply of electric generation, including changes in state tax credits and foreign PV investment incentives. These trends are themselves working in opposite directions, and their strengths and durations are unknown. Thus, attempts to predict industry sales analytically are difficult.

Nevertheless, to gauge the effect of tax credit expiration on the PV industry and the National PV Program, it is essential that some estimate of the likely reduction in sales volume by class of PV technology be made. Rather than attempt an independent estimate of the various factors and trends important to future PV sales, this study has solicited the aid and judgment of the photovoltaic industry. Informal interviews were conducted with 11 U.S. PV manufacturing firms and four photovoltaic industry market consultants. Each respondent was asked to estimate 1983 sales in each market sector discussed in Section II. He was then asked for forecasts of sales by market sector during 1986 and 1990. Two forecasts were elicited for each year, one assuming the expiration of the Federal energy tax credit at the end of 1985 and the other assuming an extension of the tax credit through 1990.

Table 6. Regional Photovoltaic Shipments and Manufacturing Capacity (Source: Photovoltaics: Strategy Development, Vol. V, Department of Energy Internal Working Document Draft, March 1984)

	Shipments, MW (Total for Year, %)				Production Capacity, MW			
Country	1980	1981	1982	1983	1980	1981	1982	1983
United States	2.5 (73)	3.5 (64)	4.9 (59)	12.5 (58)	4.4	8.2	13.1	15
Japan	0.5 (15)	1.1 (20)	1.7 (20)	5.3 (25)	1.0	2.6	5.6	8
Europe	0.4 (12)	0.9 (16)	1.7 (20)	3.3 (15)	0.8	1.3	2.1	5
Other	0.1 (0)	Negl. (0)	0.1 (1)	0.4 (02)	Negl.	0.1	0.5	1
Totals	3.4 (100)	5.5 (100)	8.4 (100)	21.5 (100)	6.2	12.2	21.3	29

Source: Shipment: R.L. Watts, 1983 PV Industry Developments, DOE Semiannual Presentation, March 1984. Production Capacity: 1980-1982 data from R.L. Watts et al., Photovoltaic Technology Assessment, prepared for the DOE Photovoltaics Division, March 1983, Table 3.1; 1983 production capacity data estimated by A. Krantz, DOE Photovoltaics Division, January 1984.

Assessments of the effects of tax credit expiration varied widely, although the consensus was clearly that PV sales and the U.S. PV industry would be hurt significantly. This is consistent with the clear support voiced by the industry for continuation of the tax credits.

Valid objections can be raised to the use of expert assessments in forecasts of the type described above. As a rough check, we can appeal to the body of empirical knowledge of demand-curve elasticities. A region of a demand curve is said to be elastic if a change in the price of a product leads to an even greater percentage of change in the sales of that product. Conversely, a product exhibits inelastic demand if the change in price results in a smaller percentage of change in sales. A surprisingly large number of products exhibit elasticities close to an absolute value of 1 (a 10% price reduction leads to a 10% sales increase) through large ranges of their demand functions. Very large elasticities (say, greater than 5 in absolute value) or small elasticities (close to zero) may be suspect. Since we know from Section II that the direct and instantaneous percentage increase in effective prices as a result of tax credit expiration is in the range of 30% to 40%, we can expect percentage reductions in sales of the same rough magnitude in 1986 (compared with what they would otherwise have been) if the demand for photovoltaic systems exhibits typical characteristics.

On the other hand, expert judgment is, in this case, of value separate from that of the accuracy or objectivity of its forecasts, because expectations about the effects of tax credit expiration already appear to be affecting the actions of PV suppliers and manufacturers. If sales growth is expected to diminish, the pace of R&D can be expected to slow, thereby reducing the rate of technological progress. Futhermore, belief that the Federal government is losing interest in solar energy may discourage the extension of complementary state tax benefits. Put differently, the indirect effects of expected tax credit expiration may already be manifest: expectation of expected tax credit expiration may trigger reduced technological progress, lessened interest in alternative energy sources, fewer state tax incentives, etc. Thus, if the industry expects large effects from the tax credit expiration, the prophecy may be self-fulfilling.

PV Manufacturing Company Projections

In general, the 11 PV manufacturing companies surveyed thought that, in 1986, systems built by third parties for electricity sales to the utility sector would be severely affected by the expiration of tax credits, with sales decreasing to about 50% of what they would have been with extended tax credits. Grid-connected residential systems and water-pumping systems would also be affected, with sales reduced about 30% to 50%. They thought that expiration would have no direct effect on the international market sector and only a small effect on domestic communication markets, although the concomitant loss in economies of scale as a result of losses of electric utility, residential and water-pumping sales could indirectly jeopardize the market position of U.S. firms in the international area, especially in view of the subsidies received by some foreign PV manufacturers from their own governments.

Three of the companies believed that they would be virtually unaffected by the expiration of tax credits, because nearly all of their sales are in market sectors that are virtually immune. Those companies that are, or aspire to be, primarily in the electric utility market thought that expiration would be a serious blow. Among the concentrator manufacturers there was a significant difference of opinion. Two of the companies thought that expiration of the tax credit at the end of 1985 would put them out of business and, in fact, they report feeling adverse effects of potential customers anticipating the expiration already. A third concentrator company thought that it would be hurt, but that its survival was not in doubt. The fourth concentrator company believed that its concentrator systems will be cheaper than flat-plate systems by the end of 1985, and that extension of the tax credit would help keep their flat-plate competition alive. They also believe that the impending expiration is encouraging their customers to make near-term purchases, which will assist in bringing their prices down.

One company expressed the opinion that the Federal energy tax credit was too low, and offered as evidence the fact that third-party-financed sales are insignificant and are limited to California, with its large state credits. Furthermore, this company believes that foreign manufacturers are seriously threatening U.S. manufacturers and that expiration of the credits will accelerate foreign penetration of international and domestic markets.

Consultant Projections

All of the consultants generally agreed with the manufacturing firms about the effects of tax credit expiration in all market sectors except the electric utility sector. There was agreement that the residential and water-pumping markets would be hard hit.

In the domestic electric utility sector, there was some disparity of opinion. One consultant thought that the electric utility market would not develop significantly by 1990, even with tax credits. The other three believed that the electric utility sector would be profoundly stimulated by tax credits if they were extended to 1990. According to them, by that year utility sector sales would be from five to 10 times greater with tax credits than without. Clearly, such large effects must partially arise from the indirect effects of tax credits on economies of scale and investment rather than solely from the direct price effects of tax credits.

Based on discussions with these 11 PV manufacturing firms and four industry consultants, JPL constructed tables that contain its consolidated projections of the PV market by sector. Table 7 shows estimates of 1983 shipments by domestic manufacturers. Because these numbers are predominantly historical, there was no wide disparity among the respondents.

It is important to note that more than 80% of the market is contained in the electric utility and international sectors. The international sector is only indirectly affected by the expiration of Federal energy tax credits. The electric utility sector exhibits the greatest uncertainty about how it will be affected, although there is agreement that the effects will be serious.

Table 7. 1983 PV Shipments by Domestic Manufacturers (Source: JPL Estimate Based on Survey of the Industry)*

Market Sector	Shipments, MW	Share of Market, %
Residential, Non-Grid-Connected	0.642	6.0
Residential, Grid-Connected	0.060	0.6
Electric Utility (third party)	6.030	56.5
Water Pumping	0.202	1.9
Communications	0.801	7.5
Other Industrial (includes government experiments)	0.360	3.4
International	2.580	24.1
Totals:	10.675	100.0

Table 8 contains a consolidated forecast of shipments by domestic PV manufacturers in 1986 if the tax credits are allowed to expire at the end of 1985.

Table 9 is a similar estimate for 1986 based on the assumption that Federal tax credits are extended to 1990, with no change from the current levels.

Table 8. Projected 1986 PV Shipments by Domestic Manufacturers With Tax Credit Expiration (Source: JPL Estimate Based on Survey of the Industry)

Market Sector	Shipments, MW	Share of Market, %
Residential, Non-Grid-Connected	5	12.5 - 7.7
Residential, Grid-Connected	1	2.5 - 1.5
Electric Utility (third party)	10 - 25	25.0 - 38.5
Water Pumping	2 - 3	5.0 - 4.6
Communications	7 - 9	17.5 - 13.8
Other Industrial (includes government experiments)	5 - 7	12.5 - 10.8
International	10 - 15	25.0 - 23.1
Totals:	40 - 65	100 - 100

*Tables 6 & 7 are taken from different sources and thus contain slightly different 1983 total U.S. shipments data.

Table 9. Projected 1986 PV Shipments by Domestic Manufacturers With Extended Tax Credits (Source: JPL Estimate Based on Survey of the Industry)

Market Sector	Shipments, MW	Share of Market, %
Residential, Non-Grid-Connected	8 - 10	10.0 - 8.3
Residential, Grid-Connected	2 - 5	2.5 - 4.2
Electric Utility (third party)	40 - 60	50.0
Water Pumping	3 - 7	3.8 - 5.8
Communications	9 - 11	11.2 - 9.2
Other Industrial (includes government experiments)	8 - 12	10.0
International	10 - 15	12.5
Totals:	80 - 120	100 - 100

Comparison of Tables 8 and 9 leads to the following conclusions if the Federal energy tax credits are allowed to expire:

(1) The domestic residential markets, which are heavily dependent on tax credits, will be reduced by 30% to 50% in 1986 in the non-grid-connected sector and 50% to 80% in the grid-connected sector, compared with what they otherwise would be.

(2) The electric utility sector is the most uncertain, but will be severely reduced, by 35% to 85%, in 1986.

(3) The water-pumping and other industrial sectors will also be severely affected, with a decrease of 30% to 60% in 1986.

(4) The indirect effect of tax expiration on the competitive position of the U.S. PV industry in a worldwide market in which some foreign manufacturers receive subsidies from their governments could be profoundly damaging.

Due to very large uncertainties regarding sales in 1990, projections of total domestic PV shipments only were provided by respondents. The respondents estimated that about 400 MW will be shipped by domestic companies in 1990 if tax credits are extended until then, but if tax credits are allowed to expire at the end of 1985 shipments in 1990 will only be about 100 MW. The bulk of this 75% reduction in PV markets will undoubtedly be in the electric utility sector, and clearly must arise from the compounded indirect effects of tax credit expiration.

The sales forecasts of Tables 8 and 9 can be combined with the percentage changes in effective system prices resulting from credit expiration calculated in Section II to yield estimates of demand elasticities. Table 10 provides

Table 10. Elasticities of Demand Implied By Industry 1986 Sales Forecasts (Source: JPL Estimate, See Appendix C)

Market Sector	At Sales Means	Range at Sales Forecast Extremes
Residential, Non-Grid-Connected	1.6	0.9 - 3.0
Residential, Grid-Connected	4.1	1.3 - 16.7
Electric Utility (third party)	3.0	1.3 - 5.3
Water Pumping	2.2	0.0 - 4.3
Communications	0.7	0.0 - 1.7
Other Industrial	1.6	0.4 - 3.2
International	NA	NA

the results of such an exercise, which is included as Appendix C. These elasticity estimates are based on the assumptions that the sales forecasts of Tables 8 and 9 differ solely as a result of the presence or absence of Federal tax credit; i.e, that the forecasts were made on the assumption that tax credit extension or expiration is independent of any other event or action that may affect PV system sales and that all other such events or actions do not differ between the two Tables (in economic terms, ceterus paribus). In addition, we must assume that the indirect effects of tax credit expiration (reduced R&D, changes in state tax incentives, less economies of scale) in 1986 are negligible (zero). With this assumption, the percentage change in price is solely a result of the direct price effects calculated in Section II. To the extent that this assumption is false (indirect price effects are non-negligible), the elasticity estimates of Table 10 are biased upwards.

The elasticity estimates of Table 10 appear fairly reasonable. Those market sectors in which PV is already quite competitive and for which there are attractive alternative power sources (i.e. communications and remote residential) exhibit elasticities close to 1. The higher elasticity for grid-connected residential accords with the observation that a very good substitute source of power is readily available.

Finally, high elasticities in the electric utility sector can be accepted when one considers that the transition from remote and specialty PV markets to utility bulk-power markets involves a change in standard units of power measurement from thousands of watts to thousands of megawatts, a six-order-of-magnitude growth. Clearly, reaching the bulk-power market puts photovoltaics in an entirely new arena. Thus, high demand elasticities in this range of the PV demand curve are not unreasonable.

SECTION IV

EFFECTS ON THE PHOTOVOLTAICS MANUFACTURING INDUSTRY

This section discusses likely effects on photovoltaic manufacturers of expiration of Federal energy tax credits. The discussion is restricted to manufacturing companies, excluding system integrators and consultants.

Three types of manufacturing companies are addressed: utility-oriented companies, specialty companies and concentrator manufacturers.

The primary marketing thrust of electric-utility-oriented companies is supplying PV hardware that generates electricity for the utility grid. These companies are aiming primarily at third-party financed systems, as electric utilities are not eligible for the tax credits. Specialty PV companies are primarily in the business of serving one or more of the smaller market sectors, such as residential, water pumping, communications or segments of the international market. Concentrator companies' primary interest is the manufacture and sale of concentrating PV systems. Some companies fall into more than one of these groups, but the interests of all PV manufacturers are represented.

Utility-Oriented Companies

Utility-oriented companies suffer a drastic reduction in projected sales in 1986 and 1990 as a result of tax credit expiration. This may cause some companies to cease operations. For small, independent companies, the PV utility business may no longer appear to be potentially profitable. For those companies that are owned by larger companies, the parent company may decide that there are more lucrative fields in which to invest their capital. Alternatively, these companies may elect to shift their marketing strategy away from utility markets to pursue the smaller, more specialized markets. They would then compete more strongly with existing specialty companies. In addition, the loss of projected economies of scale from large utility-sector sales will raise projected manufacturing costs, making it more difficult for these companies to compete in all markets, especially in the international sector.

Specialty Companies

The direct effects of the expiration of Federal energy tax credits on specialty companies, ignoring the secondary effects that may arise from intensified competition, will range from little to moderate. The degree to which a specialty company will be affected depends upon the portion of its sales that lies in those specialty markets most sensitive to tax credits, such as domestic residential, water-pumping and other industrial markets. Those companies that are primarily in the domestic communications and international sectors will be least severely affected.

It is even possible to argue that specialty PV companies would be helped by the expiration of the tax credit: if larger, utility-oriented companies lose the cost advantages of large-scale production, the competition that

specialty companies face may be somewhat less. But the more likely effect is that at least some utility-oriented companies will market more aggressively in the specialty markets, if tax credits are allowed to expire.

Concentrator Companies

There is considerable diversity of opinion about the effects of tax credit expiration on concentrator companies, but the prevailing view is that these companies will be affected adversely and may elect to cease operations.

Three of the four concentrator manufacturers are small companies whose business plans are heavily dependent on the extension of Federal energy tax credits until 1990. Their primary market in the near future is third-party-financed systems in which electricity is sold to a utility from a third-party-owned generation system. It is precisely this class of equity investor, typically limited partnerships, that is most discouraged by the pending loss of the energy investment tax credits, discouraging in turn the growth of this relatively new and important form of electric generation financing and ownership.

Overall Effects

What effect will the impending expiration of Federal energy tax credits have on the PV manufacturing industry as a whole? It can certainly be said that the industry will suffer some strongly negative effects. Projected sales for 1986 are reduced by about half, and it is likely that some companies will not survive. Sales projections for 1990 show large effects from tax credit expiration, with total sales as much as four to six times greater with credits than without. It also appears that some companies will not be seriously affected and others, though strongly affected, will be able to survive.

The character of the PV industry will change. To the extent that costs are driven by production levels, they will not decline as rapidly as they would have in the presence of tax credits. The indirect effects of expiration on state tax incentive extensions and private R&D funding may work to reduce technological progress, price declines and market sales further . Companies will be forced to turn to carving out niches for themselves in one or more market sectors that are less sensitive to shifts in Federal policy. A strong trend toward marketing in the international arena, where foreign competitors are already gearing up for a major battle, will probably emerge. Subsidies by foreign governments to their domestic manufacturers could further worsen the competitive position of U.S. companies. Third-party-financing arrangements will certainly be greatly delayed and possibly eliminated. The photovoltaic industry will lose some of its diversity and dynamic character if the energy tax credit expires. Some firms will be forced out or consolidated, while others will choose to withdraw.

SECTION V

EFFECTS ON THE NATIONAL PHOTOVOLTAICS PROGRAM

For the past decade the U.S. government has led the world in advocating and funding research and development of photovoltaic power systems. This Federal program, an important part of the worldwide PV development process, is now funded at approximately $50 million per year, and has recently implemented a Five-Year Research Plan to continue subsidizing promising photovoltaic research and development through a mutually beneficial government-industry partnership. The Program emphasizes cost sharing of photovoltaic research with private firms.

Because of this close association between the Program and the U.S. photovoltaic industry, any event of profound importance to the industry is also of importance to the Program. As this report has shown, tax credit expiration is viewed with consternation by the industry, and is likely to have profoundly adverse effects on many industry members.

This section assesses likely consequences for the Federal PV program if tax credits expire. It begins with a brief review of several adverse implications that would follow tax credit expiration that bear on the overall success of photovoltaics but that do not directly affect the Federal PV research program. The section then looks in more detail at potential consequences for the research and development plans of the Program.

The general effect of tax credit expiration on the National Photovoltaics Program will be to reduce the contribution of industry to the government-industry partnership, which has been highly effective in the development of photovoltaics. The reduction in projected sales resulting from credit expiration will significantly reduce the incentive for industry to participate in government R&D programs using their own funds. In addition, the partnership will suffer if the industry does not carry through with its assigned roles of industrialization, commercialization and product development, as discussed below.

Industrialization*

The National Photovoltaics Program has no goals specifically related to the industrialization of photovoltaics or directly promoting the industrialization process. Thus, none of the goals of the Program are directly threatened by a weakening of incentives to invest in photovoltaic manufacturing facilities. However, the weakened investment incentives indirectly threaten overall Program success because they reduce the likelihood that industry will persevere in the government-industry partnership. The Program can hardly be judged a success if the U.S. PV industry fails to adopt new technology and expand its production facilities, even if the technical goals of the Program are achieved.

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*Industrialization is defined here as "a process of planning and investing in the establishment of private, profit-making manufacturing ventures."

Market Growth (Commercialization)

Similarly, the Program has no specific goals related to commercialization of photovoltaics or the rate of photovoltaic market growth. Thus, no Program goals are directly threatened by a reduction in the expected size of future PV market sales.

Nevertheless, the severely adverse implications discussed above of tax credit expiration on electric utility applications of photovoltaics bear significantly on the larger national objectives behind photovoltaics and other Federal renewable energy R&D. While the direct loss of several hundred megawatts of PV capacity in 1990 is not in itself severely damaging to the nation's energy situation, the resulting delay in development and deployment of bulk power PV systems may reasonably be presumed to postpone the time when PV systems will make truly important contributions to the United States electricity energy supply.

Photovoltaic Product Development

The Program also has no direct goals for the development of new photovoltaic products or for developmental improvements in existing products. Existing work in the Program that has been aimed at such goals is scheduled for termination. Thus, a reduction in investment incentives for PV product development and improvement will not directly affect any of the goals of the Program. Once again, however, a failure by industry to maintain its investments in product development and improvement would threaten the government-industry partnership as currently structured.

Photovoltaic Research and Development

As set forth in the Five-Year Research Plan, the purpose of the Program is to:

> ". . .sponsor high-risk, potentially high payoff research and development in photovoltaic energy technology which will result in a technology base from which private enterprise can choose options for further development and application. . ."

Implementation of this research:

> ". . .is based on the continual existence of an informal, mutually beneficial government/industry partnership."

This research partnership is threatened by expiration of the tax credits, as one of the two partners (industry) will be hurt significantly. In particular, if industry partially or wholly withdraws from PV research and development, the effects on the R&D activities of the Program will be serious.

Obviously, those areas of the Program that are fully funded by government contract will not be as affected as areas supported by significant industry cost sharing. According to the Five-Year Research Plan:

> "The Federal role in this partnership varies from subtask to subtask. The Federal government assumes a leadership role,

sponsoring nearly all related research, in the longer term higher risk areas such as advanced thin film materials, high efficiency multi-junction concepts, and innovative ideas. A lesser Federal role is maintained as technologies progress through the development phase."

Thus it is necessary to examine the research tasks in detail to discover which are of longer term, with larger fractions of government support and with less vulnerability, and which are those with more industry cost sharing and, thus, greater vulnerability to tax credit expiration.

The Five-Year Research Plan identifies 10 research tasks, grouped in three research categories: materials research, collector research and systems research. In general, materials research is of higher risk and longer term than collector and systems research, and therefore is less affected by fluctuations in industry funding. Each of the 10 research tasks is examined below.

Materials Research

The five materials research tasks are: Single-Junction Thin Films, High-Efficiency Multijunction Concepts, Innovative Concepts, Silicon Materials, and Advanced Silicon Sheet. Work on three of these tasks (High-Efficiency Multijunction Concepts, Innovative Concepts and Silicon Materials) probably will not be strongly affected by the expiration of the Federal energy tax credit. These tasks are supported either at government laboratories or at universities or research-oriented companies under contract to government laboratories. Fewer Innovative Concept proposals may be made by industry if tax credits expire; they are speculative and have little relationship to near-term PV markets and are often generated with university or science-foundation support. Even though private support to Silicon Materials research is very substantial, it is driven by the very large silicon-materials markets that are not closely connected with photovoltaics.

Two materials research tasks may suffer significant losses as a result of reduced industry interest and funding: Single-Junction Thin Films and Advanced Silicon Sheet. A new cost-shared, three-year competitive research program in Single-Junction Thin Films was launched last year. This program depends significantly on industry interest and support and would be jeopardized by a lessening of that interest and support. Because of the mature status of the Advanced Silicon Sheet Task, most of its R&D activities have already been handed off to industry for further development. Should that private development cease, continuing government Silicon Sheet generic research would be seriously threatened.

Collector Research

The next two research tasks, Flat-Plate Collectors and Concentrator Collectors, are grouped under collector research. It is likely that both of these tasks will be strongly affected by the expiration of tax credits and the changing character of the PV industry that would result.

In the Flat-Plate Collector Task, the objective is to establish the technology for high-efficiency, low-cost flat-plate modules. A number of limiting characteristics of flat-plate modules have been identified, and these

are being addressed by both government laboratories and by industry, using their own resources, as well as under government contract. It is likely that the industry will reduce its support of longer-term and riskier collector research as a result of tax credit expiration, requiring an examination of the adequacy of government plans for this task in the absence of that support. The drive by industry toward low-cost, high voltage collectors suitable for the bulk energy market would be severely slowed.

In the Concentrator Collector Task, the situation is unusual because, in general, companies that manufacture concentrator modules are not the same companies that manufacture concentrator cells (many flat-plate manufacturers produce their own cells). All four concentrator-module manufacturers buy cells from someone else. Since the very existence of three of these four companies is threatened by tax credit expiration, research tasks involving concentrator module and array design will be severely affected if tax credits expire. Concentrator cell research will survive, however, since it is carried out mainly by government laboratories or research-oriented firms under contract to government laboratories. On the other hand, practical testing of cell improvements in an industrial setting may become impossible if concentrator module manufacturers cease operations. Thus, the plans of this Task are threatened and, at least, are likely to require adjustment if tax credits expire.

Systems Research

The last three research tasks are included under systems research: Module Reliability, Array and Balance-of-System (BOS) Development and System Experiments. All three of these tasks will be damaged by the expiration of the Federal energy tax credit.

The goal of the Module Reliability Task is to verify the performance of flat-plate modules and to develop methods to increase their lifetimes. The current focus is on crystalline silicon, with amorphous silicon modules being addressed as they become available. Research is performed and funded both by government laboratories and by private companies to identify appropriate test methods and to identify materials and processes that can withstand those tests. The reduction in projected PV sales will tend to discourage PV manufacturers from conducting this research and from fabricating modules for testing.

The Array and BOS Development Task is directed toward reducing the costs and improving the efficiency of power conditioners and reducing the costs of structures, wiring and tracking mechanisms. Power-conditioner work in the small and intermediate size range will be little affected by tax credit expiration. However, industry-supported product development of large (1 to 5 MW) power conditioners suitable for bulk energy installations would surely be diminished, if not halted. Work on fixed flat-plate structures will also be unaffected, since the effort is being made by government laboratories and contractors that generally are not in the PV manufacturing business. However, work on tracking flat-plate and concentrator building-block concepts will be significantly affected by tax credit expiration. Companies participating in this effort tend to fall into the utility-oriented or concentrator types discussed in Section IV, whose projected sales are quite sensitive to Federal tax credits.

The Residential Experiment Stations will not be immediately affected by tax credit expiration although plans to seek more private support of these stations in the future may be disrupted. Larger system experiments will be discouraged, since they are profoundly affected by costs. The sharp reduction in projected PV sales will delay projected price reductions, thereby increasing the projected costs of large experiments. For example, the Sacramento Municipal Utility District experiment includes 10 phases whose projected costs will be affected by the expiration of tax credits. In fact, it is reasonable to assume that, were it not for the Federal energy tax credit and the resulting economies of scale for the PV industry, the cost of the first phase of the SMUD project would have been significantly larger. Unfortunately, the modest plans of the Program for direct funding of system experiments exacerbates the effects of tax credit expiration on this task, since the Program is depending directly on privately funded PV system experiments for technology verification. Without tax credits or direct funding, the crucial step of system technology verification based on thorough going field testing may not occur.

Table 11 summarizes the effects of the expiration of the Federal energy tax credit on the PV Program research tasks. The first two columns are reproduced from the Five-Year Research Plan and the "Effects of Federal Energy Tax Credit Expiration" column was added to summarize the comments contained in this Section.

Table 11. Effects of Tax Credit Expiration on PV Program Research Tasks

Research Phase or Task	Five-Year Goal	Effects of Federal Energy Tax Credit Expiration
Materials Research:		
1. Single-Junction Thin Films	Increase efficiency of large-area (>50 cm^2) single-junction thin film cells to 15% using polycrystalline materials and to 12% using amorphous material; extend cell-life expectancy to 30 years	Moderate effect
2. High-Efficiency Multijunction Concepts	Increase efficiency of small-area (≥1 cm^2) multijunction crystalline cells to 35% under concentrated sunlight and of multijunction thin film cells to 18%	Little effect

Table 11. Effects of Tax Credit Expiration on PV Program Research Tasks (Cont'd)

Research Phase or Task	Five-Year Goal	Effects of Federal Energy Tax Credit Expiration
Materials Research (Cont'd):		
3. Innovative Concepts	Conduct research on promising new cell materials, devices, and conversion concepts	Little effect
4. Silicon Materials	Determine feasibility of processes that can reduce the cost of semiconductor-grade silicon to $16/kg	Little effect
5. Advanced Silicon Sheet	Increase efficiency of small-area (≥1 cm^2) silicon ribbon cells to 20%; increase their growth rates to levels needed to be cost-competitive	Probable negative effects due to reduced industry research levels resulting from reduced projected sales volume
Collector Research:		
6. Flat-Plate Collectors	Establish the technology for $90/$m^2$ 15%-efficient crystalline silicon flat-plate module and $70/$m^2$ 12% thin-film module	Significant effects due to reduced participation by PV manufacturers in cooperative research program
Research Phase/Task Collector Research:		
7. Concentrator Collectors	Establish technology for $125/$m^2$ 22%-efficient concentrator module that has life expectancy of 30 years	Significant effects due to severe impact on concentrator module manufacturers; industrial base reduced or eliminated

Table 11. Effects of Tax Credit Expiration on PV Program Research Tasks (Cont'd)

Research Phase or Task	Five-Year Goal	Effects of Federal Energy Tax Credit Expiration
Systems Research		
8. Module Reliability	Increase lifetime of flat-plate collectors from 10 to 30 years; verify acceptable performance	Significant impact due to reduced participation by PV manufacturers
9. Array and Balance-of-System Development	Develop cost-effective array field designs ($50/m^2 fixed flat-plate, $75/m^2 tracking flat-plate, $150/m^2 concentrator) and power-conditioning units ($150-$300/kW, 95%-98% efficient, depending on size) and extend life expectancy of PCUs to 30 years	Little effect on small-scale power conditioning units and fixed flat-plate BOS. Moderate effect on large-scale power conditioning. Significant effect on tracking flat-plate and concentrator BOS due to relevant PV manufacturers experiencing reduced market growth
10. System Experiments	Provide necessary information to verify system performance and identify technical requirements for further materials, collector, and systems research	No immediate effect on RES experiments but future plans disrupted. Significant impact on larger experiments due to delay in cost reductions resulting from economies of scale and to loss of credits to private system experiment developers (e.g., ARCO Solar, Inc.)

SECTION VI

SUMMARY AND CONCLUSIONS

Unless legislation is enacted by Congress to prevent it, the Federal energy tax credit will expire at the end of 1985. If this happens, the following effects will be felt by the PV manufacturing industry and the Federal PV Program:

(1) Effective prices (net, after tax) for most domestic PV systems will increase instantaneously between 30% and 40%.

(2) Projected shipments by domestic PV manufacturers in 1986 are in the range of 40 to 65 MW, compared with 80 to 100 MW if tax credits are extended.

(3) In 1990, shipments may be as low as 100 MW if tax credits expire, compared with as much as 400 MW if tax credits are extended, due partially to indirect effects arising from reduced economies of scale, lessened investment incentives and reduced technical progress.

(4) The residential market is heavily dependent on tax credits; it will be reduced 30% to 50% in the non-grid-connected sector and 50% to 80% in the grid-connected sector in 1986. However, the latter market is extremely small in 1986.

(5) The utility sector, the most uncertain yet promising, will be severely reduced (by 35% to 85%) in 1986.

(6) The water-pumping and other industrial sectors will also be severely affected, in the range of 30% to 60%, in 1986.

(7) The communications sector will be adversely affected.

(8) The international sector will suffer because of the increased competitive edge given foreign producers and the increased costs to domestic manufacturers due to the indirect effects of credit expiration.

(9) The PV industry will be seriously hurt; its character will change, with a trend away from the utility sector and toward the international arena and, to a lesser extent, the smaller domestic communications market. Loss of the potential utility market may severely discourage further investment, leaving photovoltaics as a small industry supplying specialty products.

(10) To the extent that costs are driven by production levels, they will not decline as rapidly as they would have in the presence of tax credits.

(11) Third-party-financing arrangements will be delayed and possibly will perish.

(12) Three National Photovoltaics Program materials research tasks -- High-Efficiency Multijunction Concepts, Innovative Concepts, and Silicon Materials -- will probably suffer few serious consequences if tax credits expire.

(13) Two materials research tasks -- Single-Junction Thin Films and Advanced Silicon Sheet -- may lose significant cost sharing by industry of their research activities as a result of altered profitability expectations, if tax credits expire. Several promising Advanced Silicon ribbon projects, supported entirely by industry, may be completely lost.

(14) The Flat-Plate Collector and Concentrator Collector Research Tasks will probably lose significant participation by collector manufacturers if tax credits expire.

(15) Some of the research tasks associated with systems research will be adversely affected; others will be unaffected. There will be moderate effect on large scale power conditioning, little immediate effect on fixed flat-plate Balance-of-System Development or the Residential Experiment Stations. There is likely to be significant effect, however, on module reliability and tracking flat-plate and concentrator Balance-of-System development due to decreased industry participation. Significant delays or cancellations of large system experiments are likely, due to delays in cost reductions resulting from unrealized economies of scale.

(16) Tax credit expiration will occur in the context of a rapidly changing environment for photovoltaics. Other independent trends or actions, such as altered perceptions of the national energy predicament, changing costs of alternative fuels, or increased foreign participation, could exacerbate the effects of tax credit expiration.

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APPENDIX A

RELEVANT FEDERAL TAX LEGISLATION

This Appendix presents a brief summary of Federal tax legislation relevant to this study, which is concerned only with the effects of the expiration of the energy investment tax credit. Other relevant tax legislation is assumed to remain in effect, including state tax subsidies* and research and development tax credits.

Investment Tax Credit

The investment tax credit is established in Section 38**. The amount of this credit is established in Section 46 as 10% except for regulated utilities, which are limited to 3/7 of that amount. PL95-600, the Revenue Act of 1978, makes the investment tax credit permanent and increases the limitation on the credit from $25,000 plus 50% of tax liability in excess of $25,000 to $25,000 plus 90% of excess of $25,000. However, PL97-248, the Tax Equity and Fiscal Responsibility Act of 1982, reduced this limit to $25,000 plus 85% of the excess over $25,000. PL97-34, the Economic Recovery Tax Act of 1981, extends the period for which investment tax credits can be carried forward from seven to 15 years, leaving the period for which the credits can be carried backward at three years. In addition, this act changes the way property in different property life classes is treated so that property in the three-year class is eligible for a 6% investment credit and property in the five-year class or higher is eligible for the full 10%.

Energy Investment Tax Credit

PL96-223, the Crude Oil Windfall Profits Tax Act, amended Section 46 to provide a solar energy tax credit of 15% (over the regular investment tax credit). This credit has no limit but is scheduled to expire on December 31, 1985. Section 48 defines eligible energy property as including PV systems. This section was also amended by PL96-223 to exclude regulated utilities from claiming the energy tax credit on photovoltaic and other renewable energy systems, which gave impetus to third-party financing.

Section 44C, as amended by the Crude Oil Windfall Profits Tax Act, provides a 40% solar tax credit for individuals on renewable energy systems installed before to December 31, 1985. Cost limitation is $10,000. Excess credits (exceeding tax liability for that year) can be carried forward to succeeding years. Renewable energy source property includes property on a dwelling that uses solar energy for the purpose of providing electricity for use within the dwelling. The dwelling must be in the United States and must

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*State tax credits are highly variable. Morris (see Bibliography) contains an excellent summary.

**Section numbers are those of Sections of Title 26 (Internal Revenue Code) of The United States Code.

be the principal residence of the taxpayer. The entire credit is taken when the installation is completed (retrofit) or when use begins (new construction). If 20% or more of the use is for business purposes, only the residential portion counts for this energy credit.

Depreciation

Section 167 provides for depreciation deductions on property used in a trade or business or property held for the production of income.

The Economic Recovery Tax Act of 1981 establishes a new depreciation system, known as the Accelerated Cost Recovery System (ACRS), and provides specific depreciation schedules for investment properties of various classes (3-year, 5-year, 10-year, and 15-year) placed in service in 1980 through 1984. It also provides increased ACRS allowances for properties placed in service in 1985 and later, but these increases were subsequently repealed by Public Law 97-248, the Tax Equity and Fiscal Responsibility Act of 1982 (TEFRA). Under these laws, a photovoltaic system owned by a third-party venture would qualify as a 5-year class property for depreciation under Internal Revenue Code Section 167 and 168. For such a 5-year class property, the accelerated depreciation schedule is:

Ownership Year:	1	2	3	4	5
Depreciation, %:	15	22	21	21	21

A utility company, as owner of the same plant, would be allowed to depreciate it only over 10 or 15 years.

TEFRA lowers incentives for investing in capital equipment by reducing the depreciation basis and eliminating scheduled changes in the depreciation schedule. The basis reduction is 50% of the tax credits. Since solar investments qualify for a 25% tax credit, the depreciation basis for solar is reduced by 12.5%. Thus solar investments are penalized more than other investments by the basis reduction.

Interest

Section 163 provides a tax deduction for all interest paid or accrued.

Transfer of Credits and Depreciation

Recognizing that some businesses and utilities may not be able to use the abovementioned tax credits and depreciation allowances completely, the Economic Recovery Tax Act of 1981 provides for their transfer to corporations that can use them. To facilitate the transfer of these benefits, the Act establishes safe-harbor rules that, if met, characterize a transaction as a lease for allowing the various tax credits and deductions to the nominal lessor. For 1984 and subsequent years, TEFRA has repealed the safe-harbor leasing provisions and replaced them with provisions for an alternative procedure, finance leasing.

APPENDIX B

DERIVATION OF THE FEDERAL ENERGY TAX CREDIT EXPRESSED AS A PERCENTAGE OF THE EFFECTIVE PRICE OF A PV SYSTEM

Define parameters as shown in Table B-1:

Table B-1. Definition of Parameters

Symbol	Parameter Description	Value
r	Annual discount rate	0.12
τ_s	State tax rate	0.105
τ_f	Federal tax rate	0.50 (partnership) 0.46 (corporate)
d_s	State depreciation factor	0.79
d_f	Federal depreciation factor	0.71
γ_s	State tax credit	0.25
γ_f	Federal tax credit ($\bar{\gamma}_f + \overset{\Lambda}{\gamma}_f$)	0.25 or 0.10
$\bar{\gamma}_f$	Federal investment tax credit	0.10
$\overset{\Lambda}{\gamma}_f$	Federal energy tax credit	0.15 or 0.00
P_{ew}	Effective price with Federal energy tax credit	
P_{eo}	Effective price without Federal energy tax credit	
P_m	Market price	--

d_f and d_s values are calculated from:

$$d_f = \sum_{t=1}^{5} d_t/(1 + r)^t \text{ where } d_t = 0.15,\ 0.22,\ 0.21,\ 0.21 \text{ and } 0.21 \text{ for } t = 1 \ldots 5 \text{ years respectively}$$

$$d_s = \sum_{t=1}^{3} d_t/(1 + r)^t \text{ where } d_t = 0.33,\ 0.33 \text{ and } 0.33 \text{ for } t = 1,\ 2,\ 3 \text{ years respectively}$$

as allowed by the Accelerated Cost Recovery Schedules for Federal and California taxes respectively.

By the Federal and California tax codes we may now define:

$$P_{eo} = P_m - P_m\tau_s(1 - \gamma_s)d_s - \gamma_s P_m - \tau_f(1 - \bar{\gamma}_f/2)d_f P_m - \bar{\gamma}_f P_m + \tau_f\gamma_s P_m + \tau_f\tau_s(1 - \gamma_s)d_s P_m \quad (1)$$

and

$$P_{ew} = P_m - P_m\tau_s(1 - \gamma_s)d_s - \gamma_s P_m - \tau_f(1 - \gamma_f/2)d_f P_m - \gamma_f P_m + \tau_f\gamma_s P_m + \tau_f\tau_s(1 - \gamma_s)d_s P_m \quad (2)$$

Equations 1 and 2 show that the effective price of a PV system with or without Federal energy tax credits is the market price (P_m) reduced by four factors and increased by two factors. The first two factors represent savings in state taxes due to depreciation and state tax credits respectively; the next two factors represent savings in Federal taxes from depreciation and Federal tax credits; and the last two factors represent the "recapture" of state tax benefits by Federal taxes.

We can now define the Federal energy tax credit as a percentage of effective market prices to be:

$$\Delta P/P \times 100 = \frac{P_{eo} - P_{ew}}{(P_{eo} + P_{ew})/2} \times 100$$

The impact of the Federal energy tax credit on effective market prices in third-party-owned electric utility applications where the third party is a partnership has been calculated for two cases:

Case No.1: No State Tax Credit

(a) To calculate the effective price to a partnership of a PV system purchase without the Federal energy tax credit (P_{eo}) and with no state tax credit available let

$$\bar{\gamma}_f = 0.0;\ \gamma_s = 0.0;\ \text{and}\ \tau_f = 0.50$$

Then from (1)

$$P_{eo} = P_m[1 - \tau_s d_s - \tau_f(1 - \bar{\gamma}_f/2)d_f - \bar{\gamma}_f + \tau_f\tau_s d_s] \quad (3)$$

$$= P_m[1 - (0.105)(0.79) - 0.50\ (1 - 0.05)(0.71) - 0.10 + 0.50(0.105)(0.79)]$$
$$= 0.5213P_m$$

(b) To calculate the effective price with the Federal energy tax credit, let

$$\overset{\Lambda}{\gamma}_f = 0.15;\ \gamma_f = 0.25;\ \gamma_s = 0.0;\ \tau_f = 0.50$$

In this case we use Equation 3 and replace $\bar{\gamma}_f$ with $\gamma_f = 0.25$,

or

$$P_{ew} = P_m\,[1 - (0.105)(0.79) - 0.50(1 - 0.125)(0.71) - 0.25 + 0.50(0.105)(0.79)]$$
$$= 0.3979P_m$$

For this case, the percentage change in effective price is $\Delta P/P \times 100$ where

$$\Delta P = P_{eo} - P_{ew} = (0.5213 - 0.3979)P_m = 0.1234P_m \text{ and}$$

$$\frac{\Delta P}{P} \times 100 = \frac{(\Delta P)100}{(P_{eo} + P_{ew})/2} = \frac{0.1234P_m}{0.4596P_m} \times 100 = 26.8\%$$

Case II: With 25% State Tax Credit

(a) To calculate the effective price without the Federal energy tax credit, let

$$\gamma_s = 0.25;\ \overset{\Lambda}{\gamma}_f = 0.0;\ \tau = 0.50$$

Then from (1)

$$P_{eo} = P_m[1 - 0.105(1 - 0.25)(0.79) - 0.25 - 0.50(1 - 0.05)(0.71) - 0.10$$
$$+ 0.50(0.25) + 0.50(0.105)(1 - 0.25)(0.79)]$$

$$P_{eo} = 0.4066P_m$$

(b) To calculate the effective price with energy tax credit, let

$$\gamma_s = 0.25;\ \overset{\Lambda}{\gamma}_f = 0.15;\ \gamma_f = 0.25;\ \tau = 0.50$$

Then from (1)

$$P_{ew} = P_m[1 - 0.105(1 - 0.25)(0.79) - 0.25 - 0.50(1 - 0.125)(0.71) - 0.25$$
$$+ 0.5(0.25) + 0.50(0.105)(1 - 0.25)(0.790)]$$

$$P_{ew} = 0.2833P_m$$

and

$$\frac{\Delta P}{P} \times 100 = \frac{P_e - P_{ew}}{(P_{eo} + P_{ew})/2 \times 100} = \frac{0.1233}{0.3450} \times 100 = 35.7\%$$

The impact of the Federal energy tax credit in water pumping and communication applications is similar to third - party electric utility partnership applications. The only difference is the Federal tax rate, which is assumed to be 46%, since the business purchaser is a corporation. Letting $\tau_f = 0.46$ and following the same procedure for calculating P_{ew} and P_{eo} as illustrated above, we obtain the following:

CASE I

In the case of no state tax credit, the percentage change in effective price due to energy tax credit is

$$\frac{\Delta P}{P} \times 100 = \frac{P_{ew} - P_{eo}}{(P_{ew} + P_{eo})/2} \times 100 = \frac{0.5449 - 0.4194}{0.4822} \times 100 = \frac{0.1255}{0.4822} \times 100 = 26.03\%$$

CASE II

In the case of 25% state tax credit, the impact of the Federal energy tax credit on the effective price is

$$\frac{\Delta P}{P} \times 100 = \frac{(0.4211 - 0.2956)}{0.3584 \times 100} = \frac{0.1255}{0.3584} \times 100 = 35.02\%$$

APPENDIX C

CALCULATION OF ELASTICITIES PRESENTED IN TABLE 10

The elasticities of Table 10 were calculated by dividing the percentage change in forecast sales quantity contained in Tables 8 and 9 by the percentage change in effective after-tax system prices directly resulting from the credit expiration as calculated in Tables 2, 4 and 5. Mean elasticities were calculated using the means of the forecast sales ranges in Tables 8 and 9 and the means of the extremes of the price changes of Tables 2, 4, and 5.

Table C-1 contains the forecast sales data used for these elasticity calculations and Table C-2 contains the percentage change in prices used for the calculations. Note that the data in Table C-2 are restatements of the estimates of Tables 2 and 4 to conform with the convention that changes be expressed as a percentage of the midpoint of the prices with and without credits. Thus, the 40% residential savings found in Tables 2 and 4 becomes a 50% price change in Table C-2:

$$\frac{100 - 60}{(100 + 60)/2} \times 100 = \frac{40}{80} \times 100 = 50\%$$

To illustrate a typical calculation, the first entry of Table 10 (Remote Residential mean elasticity) is found by:

$$\frac{9 - 5}{(9 + 5)/2} \times \frac{1}{0.35} = \frac{4}{7} \times \frac{1}{0.35} = 1.6$$

Table C-1. Forecast Data Used to Calculate Data in Table 10 (From Tables 8 and 9)

Market Sector	Tax Credit Status	Mean Sales	High Sales	Low Sales
Residential, Non-Grid-Connected	with credit	9.0	10	8
	without credit	5.0	5	5
Residential, Grid-Connected	with credit	3.5	5	2
	without credit	1.0	1	1
Electric Utility (Third Party)	with credit	50.0	60	40
	without credit	17.5	25	10
Water Pumping	with credit	5.0	7	3
	without credit	2.5	3	2
Communications	with credit	10.0	11	9
	without credit	8.0	9	7
Other Industrial	with credit	10.0	12	8
	without credit	6.0	7	5

Table C-2. Percentage Change in Effective After-Tax Prices Used to Calculate Data in Table 10

Market Sector	Mean Price Change, %	High Price Change, %	Low Price Change, %
Residential, Non-Grid-Connected	35	50	22
Residential, Grid-Connected	27	50	08
Electric Utility (Third Party)	32	36	27
Water Pumping	31	35	26
Communications	31	35	26
Other Industrial	31	35	26