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Incentives for Solar Energy in Industry

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INCENTIVES FOR SOLAR ENERGY IN INDUSTRY

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ABSTRACT

This study analyzes several issues on the effects that government subsidies and other incentives have on the use of solar energy in industry, as well as on other capital-intensive alternative energy supplies. Three major topics are addressed:

- Discounted cash flow analysis is used to compare tax deductions for fuel expenses with tax credits for capital investments for energy. The result is a simple expression for "tax equity."
- The effects that market penetration of solar energy has on conventional energy prices are analyzed with a free market model. It is shown that net costs of a subsidy program to the society can be significantly reduced by price elasticity effects.
- Several government loan guarantee concepts are evaluated as incentives that may not require direct outlays of government funds; their relative effectiveness in achieving loan leverage through project financing, and their cost and practicality, are discussed.

ACKNOWLEDGMENT

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CONTENTS

ILLUSTRATIONS

TABLES

INCENTIVES FOR SOLAR ENERGY IN INDUSTRY

I. Introduction

The United States government, through its tax and regulatory policies, influences the relative costs of energy from different sources. This is accepted, in principle, by most people because it is the only practical means by which many external, or societal, costs can be reflected in the prices paid for energy. On the other hand, it is also widely perceived that market distortions caused by some policies are not in the best interests of the society. Much of the national debate about energy concerns the question of which policies provide beneficial adjustments and which cause undesirable distortions.

Without federal incentives for solar energy, the present tax policies would artificially favor conventional fuels for industrial use, since operating costs are tax deductible. This is one of the reasons for introducing industrial solar investment tax credits. As the prospect of significant penetration of the market by solar energy grows, the importance of understanding the nature and effects of different incentive programs also increases. The purpose of this study is to provide a framework in the context of solar energy use in the industrial sector for such an understanding.

No attempt will be made in this paper to determine a desirable level of incentives for solar or other energy sources. This is a decision which, presumably, should involve the political process. The goal of this analysis is, instead, to help ensure that, once a decision has been made for a certain level of marketplace support, programs designed to implement the decision will be effective.

Much of this analysis is directly applicable to other capital-intensive domestic energy alternatives, such as wind and geothermal energy. It can also be applied to nonindustrial commercial applications. However, to simplify the discussion, industrial solar energy will be the focus of attention as the prototype energy alternative.

This paper addresses several separate but related questions. Section II analyzes the relationship between the incentive resulting from the tax deductibility of fuel charges as business operating expenses and the effect of investment tax credits combined with deductions for depreciating solar energy equipment. It is essential to use discounted cash flow calculations in this analysis, and the result is a formula which defines the "tax equity" level of the solar investment tax credit. At this level, the subsidization of solar energy is exactly equal to the subsidization of fossil energy.

In Section III, a simple market equilibrium model is used to determine the net cost of an incentive program when price elasticity effects are taken into account. An important result is the specification of the conditions under which an incentive program would have "zero subsidy cost," i.e., when the price effect fully offsets the cost of the subsidy program.

Section IV is a discussion of a different kind of government incentive--federal guaranteed loans for solar energy equipment. This analysis is considerably less quantitative than the previous two, in part because the cost and effectiveness of such a program depend on quantities that are difficult to predict. Nonetheless, it is worthwhile to discuss this concept at some length; such a program, though more complicated from a legislative viewpoint, may cost the government considerably less than the direct subsidy approach for the same level of market stimulation.

II. Tax Equity for Industrial Solar Energy

It is often said that solar energy for industry is put at a disadvantage by US tax laws, because fuel is deductible as an expense in the year the expense is incurred, whereas deductions for depreciation of capital equipment are spread out over a number of years. During periods of high inflation, the delay in tax benefits can represent a substantial loss to the solar energy user. On the other hand, the solar investment tax credit (ITC), when added to the conventional investment tax credit, is often perceived as a manipulation of energy economics for the sake of national energy self-sufficiency. Clearly, it is desirable to be able to compare quantitatively the effects of these different tax treatments, and to determine whether the tax laws favor conventional fuels or solar energy, or neither.

Since the time sequences of tax payments are different for conventional fuels than for solar energy, direct comparison of the tax effects can be achieved only with discounted cash flow (DCF) analysis.[1-4] A convenient way to analyze the relative effects of tax policies for fossil and solar energy is to imagine two factories producing identical goods at the same rate and price. One uses solar energy, the other conventional fossil fuels. The taxing process is then pictured as two flows. One consists of taxes equal to revenue times the tax rate flowing from the factory to the government; a reverse flow consisting of tax credits of various types (including the tax on deductions) goes from government to factory. Since the revenues for the two factories are equal, the only difference is in the flow of tax credits.

It is possible to define "tax equity" for solar energy as the following two conditions:

- The costs of the solar collectors and of the fuel for the conventional plant are such that the after-tax levelized energy cost is the same for both plants.

- The tax benefits to solar users (ITC and depreciation deductions) are such that the net present value (NPV) of all tax credits over the life of the solar energy system are equal for the two factories.

With these two conditions, it is possible to derive a simple formula for the level of ITC at which tax equity occurs (Appendix A):

$$\alpha_e = \tau(1 - D) \tag{1.1}$$

where α_e is the tax equity level of ITC, τ is the tax rate, and D is the NPV (per dollar invested) of the deduction for depreciation of capital equipment. (Formulas for D are given in Appendix A.)

Note that this equation does *not* contain several parameters which affect solar economics in other ways, e.g., fuel prices, operation and maintenance (O&M) costs, insolation, and collector efficiency. As a result, it provides a simple baseline against which to measure the extent of government support for different types of energy use. If, for example, the investment tax credit, α, is less than α_e, the net effect of tax policy is to favor fossil fuel use; if $\alpha > \alpha_e$, then solar energy is being preferentially subsidized. Figure 1 shows the value of α_e as a function of the discount rate and depreciation lifetime (assuming sum-of-the-years-digits depreciation).[3] For example, for a discount rate of 0.20 (which is a typical value for after-tax rate of return) and a 20-year depreciation schedule, we find that an ITC of 32% is needed to offset the deductibility of fuel. However, it is likely that the Internal Revenue Service will allow depreciation lifetimes of less than 20 years for solar energy systems although a definitive policy has not yet been established. At the present time, the ITC for industrial solar energy systems is 25% (including the conventional 10%). This would require a depreciation life of about 12 years for tax equity.

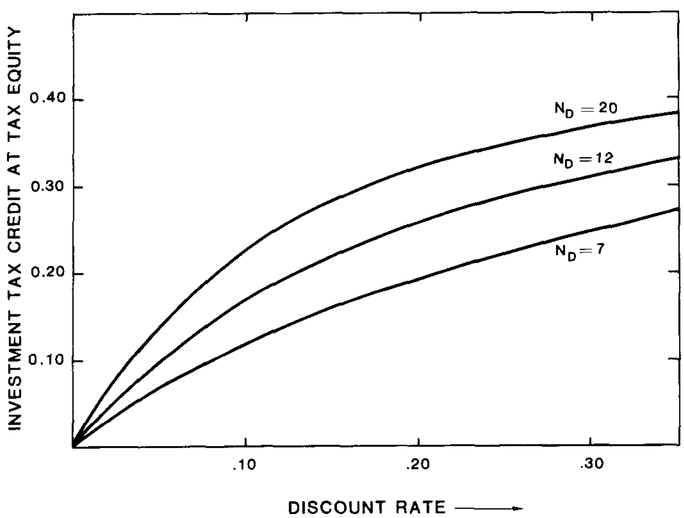

Figure 1. Tax Equity Level of Investment Tax Credit

There are three other important points concerning tax equity:

- If $\alpha = \alpha_e$, the choice between solar and conventional energy sources will be unaffected by whether or not the economic analysis includes taxes.
- If $\alpha = \alpha_e$, the net tax "charged" to solar energy is zero, just as the net tax charged to fossil energy would be zero, since it is fully deductible (Appendix A).[2]
- This analysis does not take into account the inhibitive effects of state and local property taxes on the use of solar energy. Since no such taxes are imposed on fuel use, tax equity at this level could consist simply of exempting solar installations from property taxes.

III. Direct Subsidies and Price Effects

Societal Costs and Subsidies

More than half of the petroleum presently consumed in the US is imported. One consequence of our increasing dependence on imported fuel has been a dramatic (18-fold) rise in price over the past 8 years.[5] As a result, a significant fraction of the production of the US economy has been diverted to pay the increased fuel bill, but the costs of dependency go beyond direct payments to exporters. There are also indirect costs to society such as energy-induced inflation, trade deficits, and the adverse effects of potential oil supply interruptions.

Because these societal costs are not reflected in the purchase price of imported oil, the operation of the free market results in energy usage patterns which may not be in the best interests of the nation. One mechanism which is often proposed to make the energy marketplace better reflect society's overall welfare is to "internalize" these social costs through subsidies or selective taxes. However, in order to determine how large a subsidy is appropriate, a dollar value must be attributed to each societal cost. These dollar values are called "import premiums," and numerous attempts have been made to calculate them on the basis of models of the economy and society.[5 6 7]

It is not the purpose of the present analysis to attempt such calculations or to comment on the results of calculations made by others. Instead, a distinct category of social costs will be studied which do not require subtle judgements of societal values or complex models of the economy. These are price effects, which result from the elasticity of supply and demand.

It will be shown in the following analysis that the actual cost of a solar subsidy program can be considerably less than its apparent cost, because the reduction in conventional energy price is a benefit to society which directly offsets the costs of the subsidy to the taxpayer. A simple method for expressing this effect, utilizing a "subsidy cost reduction factor," will then be presented.

This approach provides a baseline from which to measure the level of actual subsidization. In this sense, the goal is similar to the analysis of the previous section, which made it possible to measure the level of subsidization after the tax credits of solar have been adjusted to be equivalent to the tax benefits for conventional fuel use.

Subsidy Cost Reduction Due to Price Effects

There are several forms of direct government subsidies for solar energy, ranging from grants to manufacturers, to accelerated depreciation schedules, or tax credits for energy users. All have the feature that the price of energy to the user is reduced by an amount which comes directly from the government.

There would be numerous effects of such programs, many of which are difficult to quantify. We will consider two categories: direct market effects and indirect effects as listed in Table 1.

TABLE 1

Effects of Direct Subsidy Programs

Direct Market Effects
• Decrease in price of solar energy to the end user.
• Increase in the quantity of solar energy consumed.
• Decrease in the quantity of conventional energy consumed.
• Decrease in the price of conventional energy.
Indirect Effects
• Redistribution of the domestic energy market share between conventional energy suppliers and solar energy equipment manufacturers and installers.
• Reduction in petroleum imports.
• Changes in employment patterns.
• Changes in the tax base structure.
• Changes in defense spending due to reduced threat of war.
• Changes in environmental problems.
• Delay in exhaustion of petroleum supplies.
• Etc.

The term "conventional energy" in this context refers to all forms of energy that are not subsidized by the solar incentive program, including imported and domestic fossil fuels, nuclear and hydroelectricity, etc.

The important consideration, for the purpose of analysis, is that the direct market effects can be quantified in terms of price elasticities. It is simple and natural, therefore, to treat these direct effects as being actual reductions in the cost of subsidy programs. By contrast, indirect effects are much more difficult to quantify, requiring judgments of societal values and/or complex models of the economy. A possible mechanism for treating these effects is the import premiums discussed above.

The approach taken here is that a subsidy reduction factor can be calculated that takes account of the direct or "price" effects. The product of the nominal subsidy and the subsidy reduction factor is termed the "net subsidy." If it is desirable to provide additional subsidies in order to internalize the indirect effects, it would be appropriate to adjust the subsidy level until the net subsidy equals the import premium that is estimated to represent the indirect effects.

The sequence of direct market effects, listed in Table 1, exhibits the logic of our analysis. The decrease in the price of solar energy stimulates market penetration. Conventional fuel is displaced and, with nonzero price elasticities, the price of fossil fuel is reduced, resulting in a benefit to the consumer. Figure 2 illustrates this effect with a simple market equilibrium model that uses constant elasticities. A more detailed mathematical analysis is presented in Appendix B, but the essential idea is clear in the figure.

The terms "cost" and "price" refer to values levelized over the lifetime of the solar energy system. Because of fuel price escalation, the levelized price of conventional energy can be expected to be two to three times current price, assuming a 20-year lifetime. (Reference 3 provides an example of a procedure for calculating levelized energy costs for industrial energy users.)

Without a subsidy, the demand curve intersects the supply curve for conventional fuel at a price, P_0, which is too low to allow solar market penetration. With the subsidy (g dollars per MBtu), a new market price, P_2, results, and solar energy penetrates to the extent of the quantity, Q_s. The total amount of subsidy is $g \cdot Q_s$ (hatched area in Figure 2).

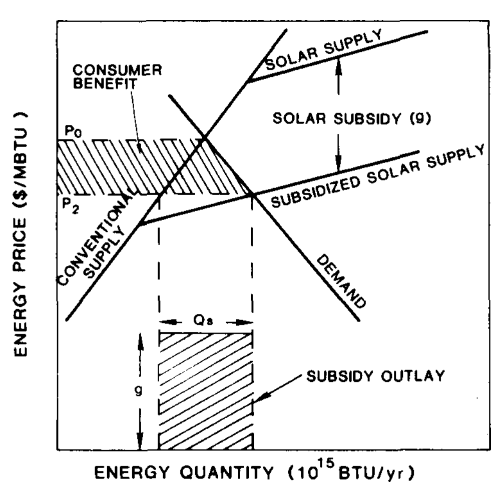

Figure 2. Equilibrium Market Model of Direct Effects of Subsidy Program

The shaded area between the two price levels, P_0 and P_2, is the increase in the "consumer surplus," that is, the difference between the value of the energy and its cost to the consumer.[4] We designate this area the consumer benefit (CB).

To obtain the net cost of the subsidy program to society, we subtract CB from subsidy outlays. The rationale is quite simple: the taxpayer must pay increased taxes for subsidy outlays, but this is directly offset by reduced costs of both conventional and solar energy.

A convenient way to express these results is to introduce a subsidy reduction factor:

$$SRF = 1 - \frac{CB}{g \cdot Q_s} \quad . \qquad (3.1)$$

The net subsidy, g', is obtained by multiplying the nominal subsidy, g, by the subsidy reduction factor (SRF):

$$g' = g \cdot SRF \quad . \qquad (3.2)$$

When a certain level of subsidization is desired to offset the numerous additional societal costs of importing fuel, it is the effective subsidy g', not g, that should be adjusted to this level.

Figure 2 shows that as g is increased, CB also increases, but so does the subsidy outlay. The difference between these two quantities is not a linear function of g, so that SRF depends not only on the various elasticities, but also on g itself. It is shown in Appendix B that:

$$SRF = 1 - \frac{Q_0}{\beta g} + \frac{\alpha}{2\beta M_D}\left(\frac{g - g_0}{g}\right) \quad , \qquad (3.3)$$

where Q_0 is the quantity of energy consumed without the subsidy, g_0 is the solar subsidy needed to initiate market penetration, and α and β are functions of the price elasticities.

One of the more interesting properties of Equation (3.3) is the fact that SRF can be zero for $g > g_0$ (see Figure 3). We define this as the "zero subsidy cost" (ZSC) condition, and it occurs when the price effect fully offsets the subsidy outlay. However, setting SRF equal to zero does not always result in a meaningful solution (for example, $g < g_0$ is not meaningful). There is a simple condition which determines whether ZSC can be achieved (see Appendix B):

$$g_0 < \frac{Q_0}{\beta} \quad . \qquad (3.4)$$

An interesting interpretation can be applied to this result if we define P_1 as the unsubsidized cost of solar energy (intersection of "Solar Supply" and

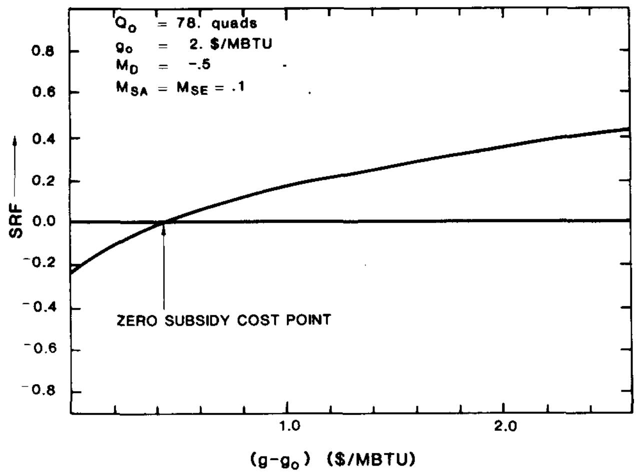

Figure 3. Subsidy Reduction Factor

"Conventional Supply" in Figure 2). We then obtain as the ZSC criterion:

$$P_1 < P_0 + \frac{Q_0}{\beta} \equiv P_{sm} \quad , \tag{3.5}$$

which defines P_{sm}, the maximum unsubsidized solar energy cost for which the ZSC condition is possible. This relationship is interesting in that the left side of the inequality refers only to the unsubsidized cost of solar equipment, and the right side depends only on the properties of the energy market before subsidies are imposed and before there is any solar market penetration.

In order to give examples of the use of these results, choices must be made for the free parameters. Consider a case in which the levelized cost of conventional energy is $10/MBtu, corresponding to an initial oil price of $23/bbl.* Suppose the solar incentive needed to equal this price is $4/MBtu (this is g_0). For demand elasticity, we choose $M_D = -0.044$ in units of $/MBtu per annual quad ($10^{15}$ Btu/year), which is a commonly used assumption.[5] The highest level of uncertainty is in the elasticity of the conventional energy price. We will use, as an example, the value suggested by Stobaugh and Yergin:[6] $M_{SC} = 0.052$. For the solar energy supply elasticity, M_{SS}, we will arbitrarily assume the same value. Finally, we will take the quantity Q_0 to be 78 quads, the current annual US consumption rate. If the subsidy g is $6/MBtu, then substituting into these formulas results in a subsidy reduction factor of:

$$SRF = 0.66 \quad ,$$

and a net subsidy of:

---

*This is the levelized conventional energy cost over a 20-year period; this might correspond to an initial price of $4.17/MBtu which escalates at 13% for 20 years and is discounted at 15%.

$$g' = \$4.00/\text{MBtu} \quad .$$

Thus the outlay of $6/MBtu results in a net cost of $4/MBtu. The zero subsidy cost condition is not possible since $\beta = 42$, hence $Q_0/\beta = 1.86$, which is less than g. In fact, this establishes the cost threshold for the ZSC condition from Equation (3.5):

$$P_{SM} = \$11.86/\text{MBtu} \quad .$$

When unsubsidized solar energy costs reach this point, it would be possible to introduce a subsidy which would have no net cost to the society.

Limitations of the Model

A simple market equilibrium model has been used in the foregoing analysis. The limitations and usefulness of such models for describing the real-world behavior of economic systems have been discussed extensively in the microeconomics literature.[4] Several specific assumptions are of particular importance:

- All energy forms are perfectly substitutable.
- There is a single energy price at any given time, and it changes instantaneously in response to changes in supply or demand.
- Consumers and producers act independently in such a way as to maximize their individual wealths.

These assumptions do not strictly apply to the complex reality of the international and domestic energy markets. Nevertheless, the model can be valuable for providing insights concerning the underlying interrelationships of more complex economic systems. The purpose of this section is to discuss the best way to interpret the quantities appearing in the analysis in light of the limitations identified above.

For example, it would probably be incorrect to attempt to deduce the supply elasticity for conventional fuel by analyzing the rapid, small-scale fluctuations of this market. Because of monopolistic control and other constraints, these fluctuations would probably not correlate well with price movements over the long times and large quantity changes that were the focus of attention in the preceding analysis.

As an example of a standard monopolistic market strategy, it is possible that OPEC would restrict oil production in order to maintain the price level (Reference 4, p 252). The effect would be to reduce, abnormally, the OPEC share of the energy market. There are, however, limits to the amount of control that could be exerted in this way, and after a time delay, a new market equilibrium would probably be reached.

Similar delays might occur, independent of monopolistic effects, because of the "stickiness" of energy prices, i.e., the reluctance of producers to accept price reductions in an inflationary economy. The reduction in real price could then occur only by currency inflation, which takes time. In either case, the best choice for supply elasticity would be the value associated with the final, stable, equilibrium price.

Another important limitation of the analysis concerns the substitutability of solar for conventional energy. It was assumed that arbitrary substitution was possible at the same energy price when, in fact, the cost of substituting solar in some applications may be extremely high compared with its cost in other applications. The proper interpretation of the free market analysis is then to restrict its application to cases when the solar market penetration is small enough that the solar energy cost used is a reasonably representative value.

IV. Project Financing and Government-Guaranteed Loans

In the previous sections, the discussion of incentives was restricted to various types of direct subsidies. These include subsidies to the manufacturer, purchase credits, tax credits, and tax deductions. For all these incentives, the present value of the cost of energy to the user is reduced directly by a transfer of government funds. This type of incentive was analyzed because it is presently the principal vehicle for government stimulation of solar energy market penetration, and because it is amenable to quantitative treatment. However, there are other ways the government can foster solar energy development; the costs and benefits of these alternatives may be more difficult to quantify, but they may, in fact, represent more efficient uses of tax dollars.

In this section, we will discuss ways in which the cost of solar energy to the industrial user can be reduced by government-supported loan programs. It is not an exhaustive treatment, nor does it represent advocacy of any particular program. The intent is instead to clarify a number of important issues concerning loan leverage, project financing, and government-guaranteed loans.

Loan Leverage

In order to compare the cost of solar energy to that of fossil energy, we must assume a discount rate, d, to account for the time value of money. If

$$d > (1 - \tau)i \quad , \tag{4.1}$$

where i is the loan interest rate and τ is the tax rate, then the after-tax cost of money is less than the user's time value of money, so that it is advantageous to finance with loans. In other words, the net present value (NPV) of the stream of loan payments will be less than the dollar amount of the loan. For the 50% income tax bracket of most firms, and the high discount rates often demanded of energy investments, the effect of loan financing can be dramatic. Figure 4 shows the ratio of the levelized solar energy cost with and without loan financing as a

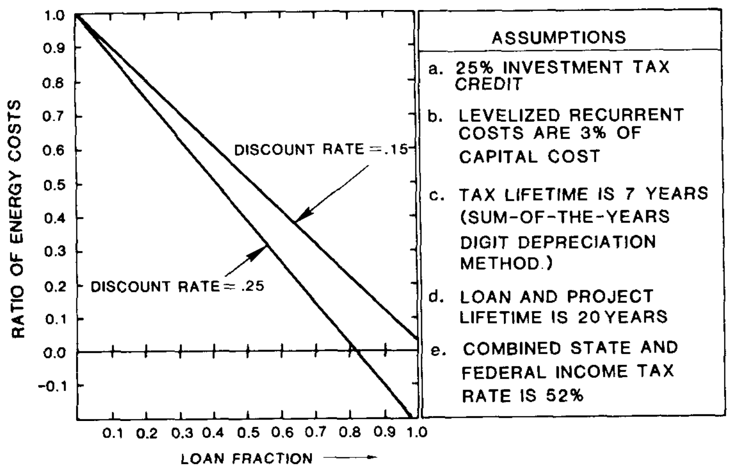

Figure 4. Ratio of Levelized Solar Energy Costs With and Without Loan Financing

function of the discount rate for a typical set of system parameters. (The economic methodology used to obtain these results is described in Reference 3.) For example, for the typical discount rate of 15%, Figure 4 shows that the annual cost of solar energy is reduced by a factor of 1.23 when an 80% loan is used to finance the system.

Unfortunately, there may be a subtle fallacy in using these results to compare the cost of solar and conventional energy. The error is neglecting the fact that there is a coupling between the level of debt and the discount rate; increasing the debt fraction can have the effect of increasing the discount rate.

There are a number of mechanisms by which this coupling can take place, depending on the type of organization sponsoring the project. Generally, as one increases the debt/equity ratio of a firm, a point is reached at which the adverse effects of increased debt (e.g., increased interest rates, reduced stock prices) cancel the beneficial effects of loan leverage. These adverse effects are reflected in an increased discount rate. In fact, one widely held view of corporate financial structure,[8] due to Modigliani and Miller, maintains that exact cancellation occurs at all debt levels so that there is no loan-leveraging effect for conventional debt financing.

Whether the Modigliani-Miller theory is accepted or not, what is important is that for a corporation, there is usually a debt/equity level established by management which applies to the entire pool of investment funds. If a higher debt fraction were applied to a particular project, this would require a lower debt fraction for some other project, thereby reducing its rate of return. Therefore, to be consistent it is customary to treat all projects as if they had the same debt level. One common way of doing this is to include the effect of leveraging in the discount rate itself, and then to evaluate all projects as being equity financed. For utilities, it is possible to include this effect explicitly, since the discount rate is specified by regulation to be the after-tax cost of capital. Thus according to one widely followed procedure, for a utility with a debt fraction of D, the discount rate is:

$$d = (1 - D)d_s + D(1 - \tau)i \quad , \tag{4.2}$$

where d_s is the return paid on common stocks, and i is the interest paid on bonds (debt).[9]

We conclude from this analysis that as long as conventional debt financing is employed, and it is the credit of the firm as a whole which supports the debt, a real reduction in the cost of solar energy cannot be achieved by loan leveraging. However, if it were possible to break the link between the debt and the discount rate, the leveraging effect seen in Figure 4 could actually occur. This is the goal of a wide variety of financing mechanisms which come under the heading of "project financing."

Project Financing

The goal of project financing is to financially isolate a "project" from the rest of the firm. An example would be a project sponsored by a corporation but financed by a loan that is not backed by the credit of the corporation. (The debt might be supported by the collateral of the project or by a third party.) This "off-balance sheet" financing allows the sponsoring firm to profit from the loan leverage without suffering the adverse consequences associated with conventional debt.

There are many mechanisms for achieving project financing, ranging from joint ventures to various types of leasing arrangements.[10] Most of these are, at present, not applicable to the financing of solar energy systems because of the risks and uncertainties associated with solar technology. Under these circumstances, the only feasible way to achieve project financing involves some form of third-party guarantee. In particular, the approach to be discussed here is a federally guaranteed loan program.

Guaranteed Loans and Solar Energy

Historically, government-guaranteed loan programs have been an important way for the government to support or stimulate specific sectors of the economy for some perceived societal benefit. There are currently more than 100 different federal loan guarantee programs, ranging from farm ownership and pollution control to railroad maintenance and improvement.[11]

However, it is important to point out that the goal of almost all of these programs is not to achieve project financing, but to overcome credit limitations for a specific group. Thus the government typically assures the bank that if the borrower defaults, the government will pay the outstanding principal.

This type of guarantee is not sufficient to accomplish project financing, because the first recourse is to the borrower, so that the loan contributes to his overall indebtedness; that is, it appears on his balance sheet. Undoubtedly, such a program could stimulate development of solar energy to some extent by allowing a slightly reduced interest rate and by overcoming the credit limitations of some potential buyers. However, the most important markets for industrial solar use are among those companies that are well enough established to have planning horizons of 10 years or more and whose decisions can be based on the life-cycle costs of the various energy alternatives. The firms which could benefit by the extension of their credit limitations (high credit risks) are just those that would least likely be interested in making a large capital investment for long-term energy supplies. Conversely, the firms most likely to be interested in solar energy do not need the government's guarantee to obtain financing. They would benefit to the extent that loans at slightly lower interest rates might become available, but they would not see the substantial reduction in levelized energy cost predicted in Figure 4. It will be assumed for this analysis that the intended targets for a loan guarantee program are businesses which are good credit risks. For this market, what is needed for project financing is a program which does not require a default on the part of the purchaser in order for the guarantee to be exercised. Such guarantees are commonly designated "nonrecourse."

Structures for Loan Guarantee Programs

There are several ways that such a program could be designed. It is useful to characterize the guarantee as a promise by the federal government in the following form:

"If A (conditions), then B (actions)"

and to consider the different types of programs defined by different combinations of A and B. Table 2 lists various conditions (A) for exercising the guarantee and actions (B) taken when these conditions occur.

TABLE 2

Loan Guarantees: Conditions and Actions

	A: Conditions for Exercising the Guarantee
A1.	Solar energy system fails to satisfy some specified performance criterion.
A2.	Conventional fuel prices are lower than expected.
A3.	Borrower chooses to exercise guarantee option.
A4.	Borrower defaults on loan payments.
	B: Actions Taken
B1.	Government pays the creditor the outstanding principal or a specified fraction thereof. Ownership of the system reverts to the government (loan guarantee).
B2.	Government pays the debtor the outstanding principal or a specified fraction thereof. Ownership reverts to the government (purchase option).
B3.	Periodic transfers of funds to the debtor are made by the government, either through tax credits or direct grants.

In assessing the different loan guarantee concepts, several critical questions can be identified.

- Is the guarantee effective? Does it stimulate solar energy usage at a minimum cost to the government?

- Is the program subject to abuse?

- Is the program practical in the existing institutional, political, and economic environment?

In the following analysis, the loan guarantee concepts identified in Table 2 will be evaluated with respect to these three questions.

Program Effectiveness -- An example of a program with limited effectiveness would be any concept requiring the borrower to default for the guarantee to become effective, as in option A3, Table 2. As discussed earlier, the value of such a guarantee to the potential user who is a good credit risk would be a slight reduction in interest rates, not the accomplishment of project financing.

Even if the assets which support the debt are limited to the project equipment alone, as in the Geothermal Loan Guaranty Program,[12] it is important to avoid the legal condition of default because of the impact it would have on credit ratings. For this reason, it may be valuable to substitute for the nonrecourse guarantee (identified in option B1, Table 2) a conventional loan guarantee combined with an option to purchase the system for the outstanding principal (option B2).

Another potential bar to the effectiveness of a government-guaranteed loan program would occur if unnecessary bureaucratic complexity discouraged participation by a business community which often perceives itself as already hampered by an excess of federal regulation. A recent study of industry opinion regarding the Geothermal Loan Guaranty Program concluded that this problem was a major reason for the reluctance of small businesses to become involved.[12] It is, therefore, essential that the program be simple and unambiguous. Simplicity of this type is one of the principal advantages of the investment tax credit as an incentive. It is also important that the cost of the bureaucracy required to administer the program be kept to a minimum.

Potential for Abuse -- Some care will be required in formulating a program that will not be susceptible to abuse, i.e., exploiting the guarantee program for purposes other than that of increasing use of solar energy. It is important, for example, to limit opportunities for making a gratuitous profit regardless of the cost or performance of the solar energy system. This can occur, for example, when the combined effects of the loan guarantee, depreciation deductions, and investment tax credits result in a net profit even if no energy is produced by the system.[13,14] One way to prevent this is to require a down payment which is large enough to maintain the incentive to purchase high-quality equipment at minimum prices and to operate and maintain the system in a responsible manner.

Another useful feature of a guaranteed loan program is coinsurance, which simply means that less than 100% of the loan is guaranteed by the government; the remainder is supported by the credit of the borrower and secured by his assets, as in a conventional loan. Typically, the level of coinsurance would be only 5% to 10%. Two important benefits result. First, poor credit risks will be screened out, significantly reducing the rate of default. Second, coinsurance will eliminate the need for the government to conduct full-scale, independent credit investigations of each loan applicant. The task of evaluating credit-worthiness is relegated to private financial institutions, which are better suited for it than the federal government. The result will be reduced governmental cost and reduced paperwork for the loan applicant. The importance and value of coinsurance for other guaranteed loan programs has been emphasized in References 12 and 14.

It may also be effective to require the borrower to post a bond, whose purpose would be to partially or fully defray the cost of salvaging the solar equipment. This would help insure that the equipment is operated and maintained properly and would discourage activation of the guaranty without good reason.

Institutional Compatibility -- Many program options identified in Table 2 make sense in theory, but would not work well in practice. For example, the options (A1, A2) that require the identification of a particular condition of the solar energy system or of the economy introduce the need for some kind of an arbitration process. In other words, a determination that the solar energy system performed below some minimal standard requires the monitoring and evaluation of the system according to some set of standard procedures, and a technical regulatory structure must be established to insure the authenticity of this evaluation. Experience has shown that this kind of requirement introduces unwieldy complexity and confusion. Similarly, the identification of particular economic conditions might require an arbitration process. The prospect of such adjudication mechanisms introduces the possibility of the legal system becoming involved, which will further discourage participation. Therefore, the activation of the guarantee should be based on clear and unambiguous conditions such as those identified in options A3 and A5.

The conclusion from this analysis is that it should be possible, in principle at least, to design an effective loan guarantee program based on the combination A3 and B1, or A3 and B2. Such a program should stimulate solar market penetration via project financing without the adverse effects identified with the other concepts. The challenge is to formulate such a program in detail, avoiding the problems of abuse and bureaucratic unwieldiness. No such attempt will be made here. However, a number of subsidiary issues related to loan guarantee programs will be discussed briefly.

Other Issues

Solar Leasing Companies -- Solar energy leasing companies could play an important role by allowing the benefits of a loan guarantee program to be reflected in low charges for delivered energy, without requiring each user to deal with the federal government or to become an expert in solar engineering.[15] There may be ways of explicitly providing legislative and regulatory mechanisms by which such energy leasing companies could be integrated into the guaranteed loan program.

Program Cost -- The direct costs of the program will be a combination of administrative costs (assumed to be small) and the costs of defaults. In comparing the cost of a guaranteed loan program with that of the direct subsidy approach, the critical insight is that, under normal circumstances, the guarantee would not be exercised, and hence there would be no cost to the government. By contrast, the normal event with a direct subsidy approach involves a substantial cost to the government for every solar energy system constructed. It is difficult, however, to predict the annual cost to the government because the rate of default is unknown.

Indirect costs of a loan guarantee program are even more difficult to estimate. For example, an important indirect cost may be inflationary pressure introduced by increased demand on capital. Unfortunately, no reliable models of the US economy currently exist that could accurately predict this effect. However, direct and indirect costs would probably be less with a well-designed government-guaranteed loan program than with direct subsidies achieving the same level of market stimulation.

Solar Energy Equipment as Collateral -- The cost incurred by the government each time a loan guarantee is activated is strongly affected by the market value of the equipment after removal and reinstallation. This highlights the importance of designing collector systems which are "salvageable," i.e., easily removed and reinstalled. In other words, it is important that solar energy systems, like automobiles, ships, and buildings, be good collateral. The effect of loan leverage on life-cycle costs is so large that it may be justifiable to design salvageability into the equipment, even if it results in increased initial cost or somewhat degraded performance.

V. Summary and Conclusion

It is very difficult to determine rationally the relative level to which each available energy source should be supported in the marketplace by government tax and regulatory policies. Two distinct steps would be required:

- The value system which the policy is intended to reflect must be determined.
- The quantitative effect of different federal actions must be estimated.

Such an ambitious undertaking has not been attempted here. Some of the societal benefits of solar energy which a government incentive program might incorporate into the price structure have been mentioned. But it is also clear that there can be negative effects when government artificially supports solar energy. The purpose of this analysis has not been to assess the relative weights of the positive and negative effects of any particular program, but to discuss some general issues relevant to the industrial solar energy user and to identify some important effects that are often overlooked in discussions of energy tax policy.

The discussion of direct government incentives (which are equivalent to direct transfers of funds to the solar energy user) has focused on two issues. Both involved the cost of energy to the user, viewed in a context large enough to include tax policy as a system variable. First, it was shown that the effect of the tax deductibility of fuel costs as operating expenses can be quantitatively compared with the effect of investment tax credits and depreciation deductions for solar energy equipment, once a discount rate has been specified. The resulting expression for the "tax equity" level of investment tax credit indicates that the current level of 25% investment tax credit for industry is equitable if a depreciation lifetime of 12 years is assumed.

Second, it was shown that price effects (reduction in price as a result of the reduction in demand) can reduce the effective cost to society of any direct incentive program. An important result of this analysis was to specify the conditions under which a direct incentive program would have "zero social cost." However, this result cannot be used with a great deal of precision at present because of the large uncertainty in the supply price elasticity for conventional energy.

The effects, both direct and indirect, of federal credit support and loan financing are considerably more difficult to predict than those of direct subsidy incentive programs. As a result, the discussion of federal loan guarantees did not employ quantitative models to any significant extent. (For a quantitative analysis of the effect of project financing on risk, see Reference 16.) Nevertheless, the issues are so complex that it is valuable to have an abstract, qualitative framework for this analysis. One conclusion is that solar energy costs to the industrial user can be substantially reduced by project financing. Furthermore, a simple way to achieve such reductions involve a government-guaranteed purchase option for the borrower, combined with some form of security bond or coinsurance to protect the government. A carefully designed program based on such a concept may have the potential of stimulating a high level of solar energy market penetration at a relatively low cost to the government.

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APPENDIX A

Derivation of Tax Equity Formula

Let

A = System cost per MBtu/year delivered.

O = Levelized value of operation and maintenance (O&M) costs per unit initial investment.

N = System lifetime.

N_D = Depreciation lifetime.

τ = Effective combined state and federal corporate income tax rate.

α = Investment tax credit (conventional plus solar).

d = Discount rate.

$$CRF(d,N) = \text{Capital recovery factor} = \left(\frac{d}{1 - (1 + d)^{-N}}\right) \quad .$$

If C_f and C_s are the levelized required revenue for fossil and solar energy, respectively, and T_f and T_s are the corresponding levelized value of the stream of tax benefits per MBtu/year, then the tax equity conditions from Section II are:

$$C_f = C_s \quad , \qquad \text{(A.1)}$$

$$T_f = T_s \quad . \qquad \text{(A.2)}$$

Procedures for calculating these quantities have been discussed in detail in References 1 and 3. T_s can be written as the sum of three terms:

$$T_s = T_s^1 + T_s^2 + T_s^3 \quad .$$

<u>Investment Tax Credit</u>

$$T_s^1 = \alpha \cdot A \cdot CRF(d,N) \quad . \qquad \text{(A.3)}$$

Operation and Maintenance Expense Deductions

$$T_s^2 = \tau \cdot O \cdot A \quad . \tag{A.4}$$

Depreciation Deductions

$$T_s^3 = \tau \cdot A \cdot D \cdot CRF \quad . \tag{A.5}$$

D is the present value of depreciation deductions per unit of capital investment. For a sum-of-the-years-digits depreciation schedule,[3]

$$D = \frac{2}{N_D(N_D + 1)d} \left\{ N_D - \frac{1}{CRF(d,N_D)} \right\} \quad , \tag{A.6}$$

and for a straight line schedule:

$$D = \frac{1}{N_D - CRF(d,N_D)} \quad . \tag{A.7}$$

C_s can be similarly decomposed with the result:

$$C_s = \frac{CRF \cdot A}{(1 - \tau)} \{1 - \alpha - \tau \cdot D\} + OA \quad . \tag{A.8}$$

For fossil fuel, the only relationship needed is:

$$T_f = \tau C_f \quad , \tag{A.9}$$

which results from the deductibility of fuel expenses. Combining Equations (A.1), (A.2), and (A.3) results in:

$$T_s = \tau C_s \quad . \tag{A.10}$$

It is interesting at this point to give an alternative interpretation to the tax equity condition. Since C_s is the required revenue (as defined in Reference 3) for the solar energy, $\tau C_s - T_s$ would be the portion of taxes paid which can be charged to solar energy. Equation (A.10) shows that this is equal to zero.[2]

Substituting Equations (A.3)-(A.5) and (A.8) into (A.10) results in the tax equity condition:

$$\alpha_e = \tau(1 - D) \quad . \tag{A.11}$$

APPENDIX B

Derivation of Price Effect Formulas

Figure 5 is an elaboration of Figure 3 which will be used to define the terms used in analyzing the free market model. One energy demand curve, D, and several supply curves are shown. SS is the supply curve for solar or alternative energy. SC is the conventional energy supply curve, and when these are added horizontally, the result is the combined supply curve, S_0. Finally, when solar receives a subsidy of g, the solar curve is moved down resulting in the combined supply curve, S*. The slopes of all these curves are the price elasticities, and they are defined as follows:

M_D Demand elasticity.

M_{SC} Conventional supply elasticity.

M_{SS} Alternate or solar supply elasticity.

M^* Combined supply elasticity when some solar energy penetration has occurred.

The last quantity is related to the others by:

$$M^* = \frac{M_{SS} M_{SC}}{M_{SS} + M_{SC}} \quad . \tag{B.1}$$

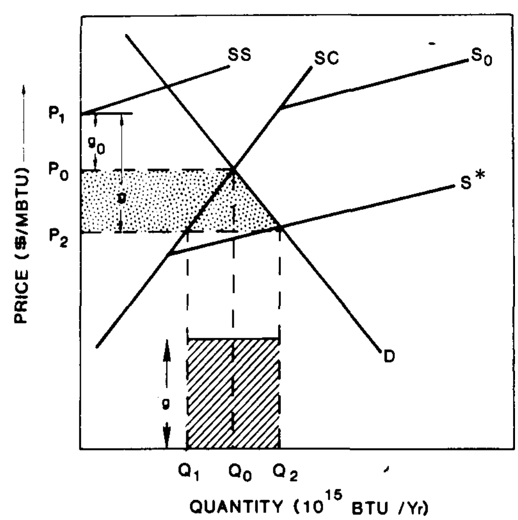

Figure 5. Equilibrium Market Model for Analysis of Price Effects

The market price without a subsidy is determined by the intersection of S_0 and D. This is P_0. The minimum subsidy, g_0, is defined as the difference between P_0 and the cost of solar energy at zero quantity, P_1. The new market price, after the solar subsidy is introduced, is denoted P_2. Q_0 is the quantity of energy purchased per year without the solar subsidy, and Q_2 is the quantity purchased after the subsidy. Of this, Q_1 is conventional energy and $Q_2 - Q_1$ is solar energy.

It is now a straightforward matter to calculate the price effect. The total outlay for the subsidy program is the area of the rectangle at the bottom of the figure. The benefit to the consumer is the change in the "consumer surplus,"[17] which is the area below the demand curve and above the market price. Thus the consumer benefit is the area of the trapezoidal region between P_0 and P_2. The net cost of the program is the difference in area of the two shaded regions. The trapezoidal region has an area of:

$$A_1 = (P_0 - P_2)\left(Q_0 + \frac{Q_2 - Q_0}{2}\right) \quad , \tag{B.2}$$

while the rectangle has an area of:

$$A_2 = g(Q_2 - Q_1) \quad . \tag{B.3}$$

Using point-slope equations for the supply and demand curves, it is possible to write everything in terms of Q_0, g, g_0, and the elasticities:

$$P_0 - P_2 = -\frac{M_D M_{SC}(g - g_0)}{M_{SS}M_{SC} - M_D(M_{SS} + M_{SC})} \quad , \tag{B.4}$$

$$Q_2 - Q_1 = \left(\frac{1}{M_{SC}} - \frac{1}{M_D}\right)(P_0 - P_2) \quad , \tag{B.5}$$

$$Q_2 - Q_0 = -\frac{1}{M_D}(P_0 - P_2) \quad . \tag{B.6}$$

To simplify notation, we introduce the elasticity functions:

$$\alpha = \frac{M_D M_{SC}}{M_D(M_{SS} + M_{SC}) - M_{SS}M_{SC}} \quad \text{and} \tag{B.7}$$

$$\beta = \frac{M_D - M_{SC}}{M_{SC}M_D} \quad , \tag{B.8}$$

both of which are positive, since M_D is negative. The net program cost is thus:

$$NPC = \alpha(g - g_0)\left[\left(\beta + \frac{\alpha}{2M_D}\right)(g - g_0) - Q_0 + \beta g_0\right] \quad . \tag{B.9}$$

The subsidy reduction factor (SRF) is obtained by dividing Equation (B.9) by the subsidy outlay, A_2, resulting in:

$$SRF = 1 - \frac{Q_0}{\beta g} + \frac{\alpha}{2\beta M_D}\left(1 - \frac{g_0}{g}\right) \quad . \tag{B.10}$$

The net subsidy is reduced to:

$$g_{net} = g \cdot SRF \quad . \tag{B.11}$$

If the trapezoid is divided into a rectangle and a triangle, the second term in Equation (B.10) comes from the rectangle, and the third term is due to the triangle.

The zero subsidy cost (ZSC) condition is obtained by setting SRF equal to zero. The result is:

$$g = \frac{\alpha g_0 + 2M_D Q_0}{(\alpha + 2\beta M_D)} \quad . \tag{B.12}$$

However, there is an additional criterion, since the equations are only valid for $g > g_0$. Imposing this on Equation (B.11) results in the simple criterion:

$$g_0 < \frac{Q_0}{\beta} \quad , \tag{B.13}$$

which is necessary and sufficient for the ZSC condition defined in Equation (B.11) to exist.

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