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THE ECONOMICS OF PHOTOVOLTAICS IN THE
COMMERCIAL, INSTITUTIONAL AND INDUSTRIAL SECTORS

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ABSTRACT

This paper describes the application of a model which computes system break-even capital costs, array break-even capital costs and profits from photovoltaic investments in the industrial, commercial and institutional sectors. Several tax and accounting combinations are described and utilized in this paper. Results indicate that, at rates of return usually found in the industrial and commercial sectors, photovoltaic investments will not be attractive when the costs of those investments are based on the Department of Energy's cost goals for 1986.

INTRODUCTION

The Department of Energy's Division of Solar Technology has set, as one of its objectives, the investigation of the competitiveness of investments in photovoltaic power systems by firms in the commercial and industrial sectors. These objectives are set out in (1), a preliminary multi-year plan, which describes the commercial and industrial sector as consisting of "intermediate load centers." System readiness goals of $1.60 a peak watt (Wp), in 1980 dollars, are established and deemed to be competitive in this sector.[1]

In addition to achieving certain engineering goals, that report also suggests investigations in nontechnological areas that are likely to have

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[1]This figure excludes considerations of operating and maintenance costs.

an impact on the degree and rapidity of penetration into the commercial and industrial sectors; specifically it mentions "legislative, regulatory and inancial incentives." Tabors et al., in (2), describe some preliminary analysis of legislative and regulatory issues, while this paper will describe the M.I.T. Energy Laboratory's approach to analyzing financial impacts on photovoltaic investment for intermediate load centers. The purpose of this paper is to describe the manner in which we model a firm's evaluation of a photovoltaic investment and to present results from an example commercial establishment.

This paper forms part of a series that will explore different issues arising out of attempts to market photovoltaic systems in the commercial and industrial sectors. "Evaluating Photovoltaic Investments in the Commercial, Industrial, and Institutional Sectors" (8) will examine the economic viability of photovoltaic investments for twenty example firms located in New England, Phoenix, and Madison. In addition to location-specific results, that report will describe the effects of different electric-utility rate structures, mandated or implied by the Public Utility Regulatory Policies Act (PURPA) of 1978. A localized solar-electricity supply function will also be generated in that paper.

"The Economics and Public Policy of Declining-Cost Energy Sources: The Case of Photovoltaics" (9) describes the time-dependent nature of the photovoltaic investments. This time dependence will hinge on the relationship between the potential investor's required rate of return and the relative rates of change in the cost of photovoltaic arrays and the cost of purchased electricity. That paper also discusses policy tools to overcome reluctance to invest due to inappropriate pricing of electricity.

Our approach and modeling effort are fully described and documented

in "A Modeling Method for Assessing Transition Energy Technologies" (10).

The plan for this paper is, first, to describe the inancial

considerations that are to be investigated, including rates of return,

investment tax credits, and depreciation rules. The model with which

this analysis is performed is described in the section which follows,

with additional considerations for a comprehensive modeling effort being

described. These include the use of both hourly, time-series insolation

data and hourly, time-series profiles of electricity consumption for

individual firms. In the final section, results of this investigation

for a single example firm, at a single location, are described.

FINANCIAL CONSIDERATIONS

Two approaches towards gaining an understanding of the likely impact

of photovoltaics in intermediate load centers are discussed here. The

first is to estimate the costs that photovoltaics will have to achieve in

order to be competitive with electricity purchased from the utility.

This cost is generally described as the "breakeven capital cost" (BECC)

and is frequently referred to throughout the photovoltaic literature

(see, for instance (3)).

The BECC can be of two types. The first is the system BECC, which is

the cost that the complete power system, including support structures,

installation costs, and power conditioning costs, will have to be reduced

to in order to compete with utility-purchased electricity. The second

type is the estimate of the BECC for the photovoltaic array itself, with

assumed costs for all other inputs. The estimation of the BECC here is

levelized; that is, the total net benefits for each year are discounted

to the first year of the investment and summed in a manner described algebraically below.

However, our modeling capability is by no means limited to estimating commercial and industrial BECC. We also present, below, the calculated profitability given estimated initial capital costs. The model also has the capability of altering demand for electricity in response to the relative prices of electricity from the utility at different hours of the day and in response to the implied cost of electricity from the photovoltaic array. Results of those estimations will be presented elsewhere. It seems worthwhile now, while cost goals are still being set, to determine whether those cost goals can reasonably be expected to match our estimate of the BECC.

FORMULATION OF A FIRM'S BECC

Users of intermediate load center photovoltaic arrays can be characterized as having well-defined investment criteria. These investment criteria are established through standardized accounting practice and are used for reporting of income for tax purposes. The annual capital cost of an investment is the amount that the investment has been deemed to depreciate in that year, plus the cost of holding that capital stock (rather than selling it and investing the money elsewhere).[2] The profits from any investment, net of the depreciation and holding costs, are taxed at the corporate income tax rate, a factor which must also be accounted for.

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[2]This is generally referred to in the economics literature as the opportunity cost of holding capital.

These standardized cost-accounting techniques make evaluating the perceived benefits of an energy-saving investment relatively straightforward compared to the complexities of determining consumer's preferences for energy-saving devices in the residential sector, difficulties that are amply demonstrated in (3) and in (4). However, while cost-accounting methods are clearly defined, there are a variety of methods. Furthermore, the sorts of financial incentives that are likely to be provided for photovoltaic investments will probably include large investment tax credits and provisions for the rapid depreciation of these energy-saving investments. In addition, these tax incentives will vary from state to state. For all these reasons, it is necessary to maintain a high degree of flexibility in modeling a firm's cash flow.

There are three predominant methods of estimating annual depreciation of an investment allowed in the U.S. Internal Revenue Code and a fourth, experimental method which is used in this paper. The depreciation for a given year is the amount the firm deducts from its revenue to cover wear and tear of its capital stock. The depreciation methodologies currently practiced include

     i)   sum-of-the-year's digits,

    ii)   double-declining balance,

  iii)   straight line,

   iv)   accelerated straight line.

A further complication in the use of these accounting methodologies is the use of one of them for a firm's own use, while using another to report income for tax purposes. For instance, a firm may take an accelerated-straight-line depreciation for tax purposes, but estimate depreciation costs for its own records as a straight line over the life of the investment project.

An additional financial incentive to be investigated includes the use of investment tax credits (ITCs). ITCs are some proportion of the initial capital investment that is deducted from the firm's income tax bill in the year that the investment's construction is completed. For the purposes of a firm's internal accounting this tax benefit may be taken in the year it was received or, again, spread over the life of the project.[3]

A far more difficult problem is in deciding upon a reasonable rate of return that a firm may apply against its investment. A reasonable starting point in solving this problem might be to use some average of returns on investment for firms in various SIC codes.[4] There are several objections to this approach, the most serious being that such a rate of return would not capture the higher potential return expected of such a high risk investment.[5] At the very least, any examination of photovoltaic investment should provide a capability to alter the after-tax rate of return.

Additional tax benefits to be computed must include the deduction from taxable income of interest paid on bonds. We take the simple expedient of assuming that a firm finances a photovoltaics project by the

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[3]Depreciation schedules and investment tax credits will be more fully described in a forthcoming paper, (8).

[4]Standard Industrial Classification (SIC) codes are used to classify firms by type of product or service.

[5]These risks would not be limited to those associated with the technological uncertainty of photovoltaics. Additional concerns would include uncertainty over the future price of electricity, or of the price at which the firm's utility would be willing to purchase surplus production from the photovoltaic array. These points are discussed more fully in the final section of this paper.

same proportion of bond financing and equity financing found to have financed the rest of its capital investments to date.

A final consideration in estimating the BECC of any type of potential purchaser is to separate out of the formulation any costs that can be determined with a reasonable amount of certainty. For photovoltaic investments we can make reasonable estimates of the costs of support structures, wiring, power conditioning, and land. Specifying these known costs allow us to concentrate the analysis on the costs of the photovoltaic modules themselves. The formulation presented below separates the "known" costs from the "unknown" costs.

The breakeven capital cost is achieved when the electricity savings due to the photovoltaic investment minus the operating costs of the array are just equal to the stream of capital costs, both discounted. In real terms[6] this can be written

$$(1 - CT) \cdot \sum_{t=0}^{T} \frac{S_t - OP_t}{(1. + R_i)^t}$$

$$= \sum_{t=0}^{T} \frac{D_t^{u,f} \cdot Y + K_t^{u,f} \cdot Y \cdot R_i - CT \cdot (D_t^{u,g} \cdot Y + K_t^{u,g} \cdot Y \cdot R_b \cdot DEBT)}{(1. + R_i)^t}$$

$$+ \sum_{t=0}^{T} \frac{D_t^{k,f} \cdot Z + K_t^{k,f} \cdot Z \cdot R_i - CT \cdot (D_t^{u,g} Z + K_t^{u,g} \cdot Z \cdot R_b \cdot DEBT)}{(1. + R_i)^t}$$

where:

CT   is the corporate tax rate.

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[6]I.e., taking no account of inflation.

$D_t^{k,f}$, $D_t^{k,g}$

are the depreciation in year t of the investment whose costs are known (for the firm's own books and for tax purposes, respectively), as a proportion of the known, initial capital investment.

$D_t^{u,f}$, $D_t^{u,g}$

are the depreciation in year t of the investment whose costs are unknown (for the firm's own books and for tax purposes, respectively), as a proportion of the unknown, initial capital investment.

DEBT

is the proportion of the project that is financed through loans and bonds.

$K_t^{k,f}$, $K_t^{k,g}$

are the undepreciated stocks of capital of the known investment (support structures, etc.) as a proportion of the known, initial, capital investment, (for the firm's own books and for tax purposes, respectively).

$K_t^{u,f}$, $K_t^{u,g}$

are the undepreciated stocks of the capital of the unknown investment (support structures, etc.) as a proportion of the unknown, initial, capital investment, (for the firm's own books and for tax purposes, respectively).

OP_t

is the operating cost in year t.

R_i

is the firm's after-tax rate of return.

R_b

is the bond interest rate for the portion of the investment costs raised through loans.

S_t

are the electricity savings in year t.

t

is the time index.

T

is the final year of the project's life.

Y

is the dollar value of the unknown portion of the initial capital investment.

Z

is the dollar value of the known portion of the initial capital investment.

Solving for the BECC of the unknown portion of the initial investment we get

$$Y = \frac{\sum_{t=0}^{T} [(1 - CT) \cdot (S_t - OP_t) - D_t^{k,f} \cdot Z - K_t^{k,f} \cdot Z \cdot R_i + CT \cdot (D_t^{k,g} \cdot Z + K_t^{k,g} \cdot Z \cdot R_b \cdot DEBT)]/(1 + R_i)^t}{\sum_{t=0}^{T} [D_t^{u,f} + K^{u,f} \cdot R_i - CT_t \cdot (D_t^{u,g} + K_t^{u,g} \cdot R_b \ DEBT)]/(1 + R_i)^t}$$

This equation can also be used to take the investment tax credit into account by multiplying the known and unknown capital stock variables by one minus the ITC wherever those variables appear. For institutional investments in photovoltaics the equation must be altered to take account of tax arrangements for that sector, and internal rates of return may need to be set to some lower level. For government facilities all tax-related terms should be removed.

THE MODEL

The economic evaluation of photovoltaics in the industrial and commercial sectors depends on a far more complicated model than the previous section implies. It will not be described in its entirety here. Figure 1 is a schematic of the model used in this paper. The complete model (SOLIPS)[7] reads weather tapes for a location and converts the insolation data on those tapes into electricity production from a photovoltaic array of a size specified exogenously. The electricity production for a given hour for a given day, suitably adjusted for losses due to power conditioning, is matched against electricity consumption figures for a firm in the same general location

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[7]Developed largely by Thomas Dinwoodie of the Energy Laboratory's Utility System Program.

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┌──────────────┐                                              ┌──────────────┐
│  SOLMET      │   Hourly Insolation                          │ Financial and│
│  TAPES       │ ────────────────────►                        │    Cost      │
│              │                                              │ Assumptions  │
└──────────────┘                                              └──────┬───────┘
                                      ┌───────────────────┐          │
                                      │   SOLIPS          │          ▼
┌──────────────┐                      │ ─ Match Hourly    │   ┌──────────────┐
│  UTILITY     │   Rate for that Hour │   Data            │   │    PVEC      │
│  MODEL       │ ────────────────────►│ ─ Estimate Flows  │──►│              │
│              │                      │   of Electricity  │   └──────┬───────┘
└──────────────┘                      │   to Load,        │          │
                                      │   to Storage and  │          ▼
                                      │   from Storage    │   ─ Photovoltaic BECC
┌──────────────┐   Hourly Electric    │   to Load         │   ─ System BECC
│  FIRM'S      │   Consumption        │                   │   ─ Profits
│  ELECTRIC    │ ────────────────────►│                   │
│  LOAD TAPE   │                      │                   │
└──────────────┘                      └───────────────────┘
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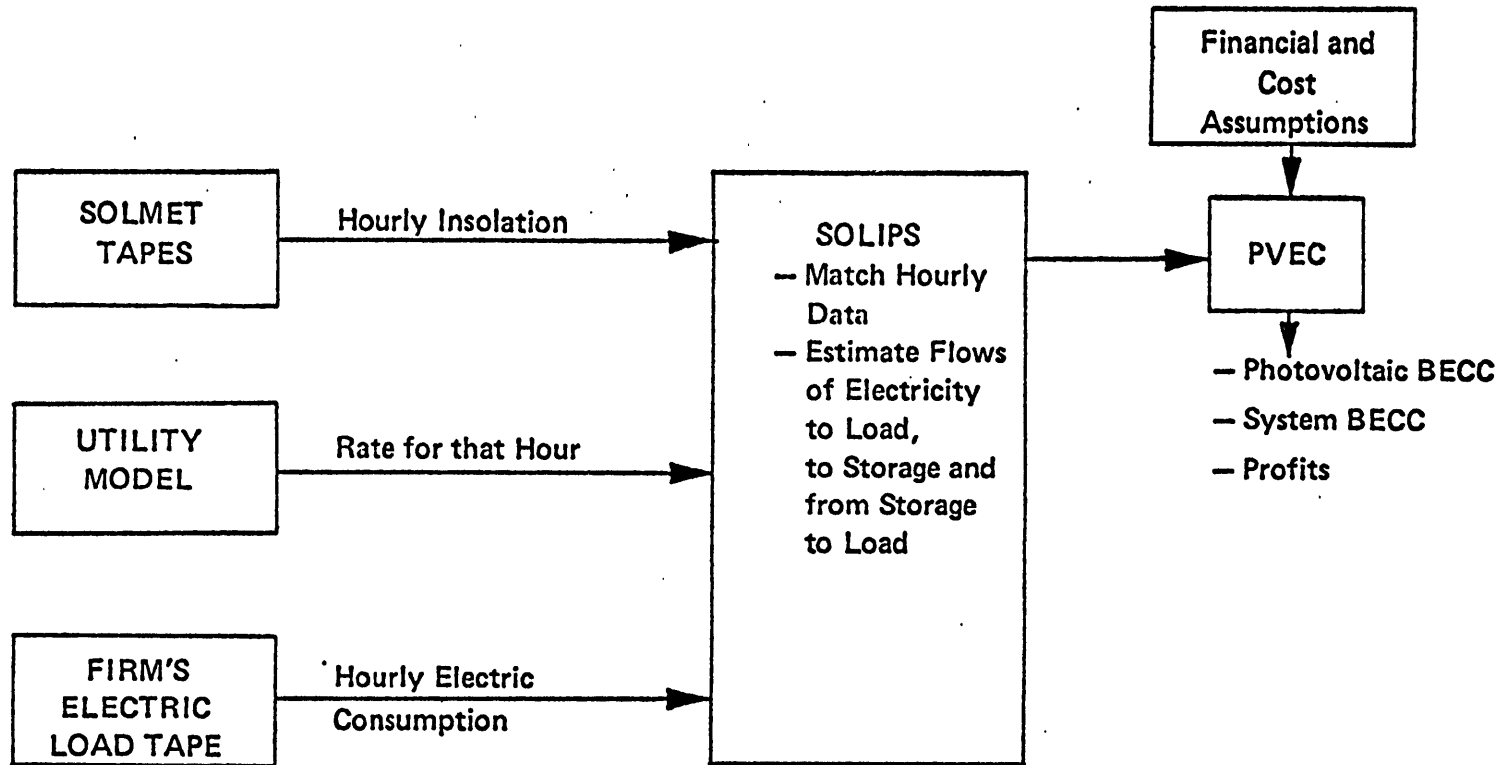
Figure 1
Schematic of Modelling System

at exactly the same time. The electricity is then routed to meet the
firm's demand for that hour. If the array provides electricity in excess
of the plant's demand and if the utility will accept that excess, it is
fed back into the grid at a price set at some proportion of the utility's
selling price. The model is also capable of handling a storage
capability to take up excess supplies and feed them back to meet load
levels higher than those capable of being met by the array. No storage
capability is discussed in this paper.

Estimates of the flows of electricity are transmitted to PVEC, the
economic subroutine. The flows of electricity for the one year in which
the array outputs are matched are assumed to be the same for every year
of a project's life, with a suitable adjustment for degradation.[8]
These annual figures are then multiplied by the projected price of
electricity in each year of the project's life. For this paper the
project is assumed to have a 20-year life with an additional year to
design and construct the project. Construction takes place in 1985 with
electricity production starting in 1986.

The financial and, if specified, the balance of systems cost
parameters are also fed into PVEC. For each year of the project the
stocks of capital and the amount of depreciation for the array and system
are computed and applied in the equation specified above. No
depreciation takes place during the construction year of the project. In
the final year of the project all the remaining value of the capital
stock is depreciated to zero.

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[8]For the results presented below, the assumed degradation rate
results in an average peaking output, over the life of the array, that is
86 percent of the array's rated peak.

Weather data are read from SOLMET tapes (5). Hour-by-hour electricity consumption for 400 individual plants has been obtained by the MIT Energy Laboratory's Utility Systems Program from four utilities in Florida, New England, Arizona, and Wisconsin.

RESULTS

System Break-Even Capital Costs

The first problem raised in the introduction was to determine whether the Department of Energy's cost goals are low enough to make photovoltaic investments competitive with purchased electricity under conventional tax and accounting regimes. If they are not, it becomes necessary to analyze a variety of tax incentives and financing arrangements that may allow a significant enough return to the potential investor.

Results of such an analysis are presented in Table 2. The potential investor is a branch of a commercial bank in Phoenix, one of the plants for which we have hourly electricity consumption figues. The base case financial and price assumptions are listed on Table 1, which also indicates the bank's electric energy and capacity requirements. The electricity prices used are from (1, p. xii), which is the price that the Department of Energy forecasts will be set for industrial and commercial customers in Phoenix by 1986.[9] The investment tax credit allowed is 10%, in common with the investment tax credits allowed for "Section 38" property under the Internal Revenue Code. In all cases presented on Table 2 it is deducted from the initial cost of the investment in the

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[9]Our price is slightly higher because we set the price at 6.4 mills in 1980 and inflate it by 3% a year from 1980 to the end of the project's life.

TABLE 1

FINANCIAL BASE CASE ASSUMPTIONS

Internal rate of return = 7.5% (real)
Interest on Bonds   = 5.0% (real)
Investment tax credit   = 10.0%
Depreciation: sum-of-the-years digits.
Rate of increase of electricity rates =
                              -3% (real)
Electricity rates : $0.064/kwh (1980$)
Project life   : 20 years
Buy-back rate   : $0.032/kwh (1980$)
0 and M costs   : $1.50/m^2/yr

CHARACTERISTICS OF BANK BRANCH.
Location   : Phoenix
Annual Electric Consumption :
                    142,000kwh/yr.

TABLE 2

SYSTEM BECC FOR COMMERCIAL USER OF PV UNDER DIFFERING FINANCIAL ASSUMPTIONS (1980 dollars per peak watt)

300 m^2 array

ASSUMPTION	BECC
1. BASE	0.87
2. ITC = 20%	0.98
3. R_i = 5%	1.36
4. Accelerated Depreciation	1.65
5. R_i = 7.5%, ITC = 30%	1.12
6. R_i = 5.0%, ITC = 30%	1.56

year construction is completed. All depreciation deductions are then a proportion of the initial investment multiplied by one minus the ITC.

Table 2 is set up so that, for the first four rows, we change our financial assumptions one by one from the base case. Rows 5 and 6 consider different combinations of financial accounting.

The cost objectives of the Department of Energy are listed on Table 3. For comparison with Table 2, the relevant goal is to have intermediate load systems available by 1986 for $1.60 a peak Watt. Row 1 of Table 2 indicates that, under conventional accounting practices, and using the typical financial parameters listed on Table 1, the system BECC will be about half of this goal.

One likely tax incentive for photovoltaics will be an investment tax credit of 20 percent. In row 2 we have increased the ITC to this level. The additional 11 cents per peak Watt that the firm could pay under our electricity pricing assumptions still falls well below DOE's goals.

In row 3 we reduce the firm's required return on investment (in real terms), from 7.5 percent to 5.0 percent. Our results indicate that the reduction results in an increase in system BECC of almost 40 percent. Applicability of photovoltaics to the commercial and residential markets is obviously very sensitive to the internal rate of return.

It is unlikely that intermediate load center photovoltaic investments will enjoy evaluations based on so favorable a rate of return. Golden states, in (6), that after-tax "hurdle rates" applied by a firm against cogeneration investments is higher than for that firm's competing conventional investments. Factors causing this adjustment include the perceived higher risk of cogeneration and the general unwillingness for firms to expand their operations to include the production and occasional

TABLE 3

DOE PHOTOVOLTAIC
COST GOALS

	COST (1980$/Wp)	DATE
SYSTEM READINESS	$1.60	1986
COMMERCIAL READINESS: (array module)	$0.70	1986
COMMERCIAL READINESS: (array module)	$0.50	1989
ADVANCED TECHNOLOGIES TECHNOLOGICAL READINESS: (array module)	$0.15- $0.40	1986

sale of electricity. Both these points obviously apply to intermediate load center photovoltaic investments.

Row 4 indicates the effect of another common tax incentive used to encourage investments: accelerated depreciation. The firm is presumed to be allowed to claim, against its taxable income, 50 percent of the original investment cost (minus the ITC) in each of the two years immediately following construction of the facility, rather than more gradually over the life of the project. For the purposes of the firm's own books, the investment is still depreciated by the more gradual sum-of-the-year's rates. Our simulation indicates that only with the entire package of tax incentives and with the lower rate of return does the system break-even capital cost rise to a level greater than the $1.60 price goal set by the Department of Energy.

Rows 5 and 6 list results for another tax option that is frequently discussed, that of raising the investment tax credit to 30%. In row 5 we return to the base-case assumptions. The 30% investment tax credit does not, by itself, raise the BECC to targeted price level unless, as indicated in row 6, the firm's internal rate of return is only 5 percent.

Photovoltaic Module Break-Even Capital Cost

The DOE cost objective of $1.60 per peak Watt can be broken down to two parts, that of the conventional support structures and that of the more uncertain photovoltaic array itself. The formulation of the BECC presented above allows us to separate costs for which we have reasonable estimates from the more uncertain photovoltaic array costs and then to assess the cost that must be achieved for the photovoltaic array in order for the total system to be a competitive investment, again varying the financial parameters.

This is done in Table 5. The assumptions for the structural supports, generally referred to as balance of systems costs (BOS costs) are taken from (7) and are listed on Table 4. These cost assumptions result in an average cost for the support structures of $1.04 a peak Watt. Referring again to Table 3 it can be seen that the cost goal for the photovoltaic array itself is to achieve a status of technological readiness of $0.70 a peak Watt by 1986.

The results on Table 5 indicate that for a 300 square meter array, the array size for which the average photovoltaic BECC is highest, the BECC is negative under both the base case assumptions and with a 20% investment tax credit. Lowering the internal rate of return (row 3) and also allowing for accelerated depreciation (row 4) pushes the photovoltaic BECC close to DOE photovoltaic cost goals. Only in the cases of rows 4 and 6 do we achieve costs of over $0.50 a peak Watt. DOE does not plan to achieve commercial readiness status at this cost until 1989. (See Table 3.)

Our model also generates total discounted profits given assumed costs for both the photovoltaic array and for the balance of systems. Table 6 lists these results for three different array sizes in order to demonstrate the o timizing capability of the model. Only if a low internal rate of return is used to evaluate the project in combination with a 30 percent tax credit do we achieve positive profits, and then only if we can additionally assume low costs for the array itself. The bottom row of Table 3 indicates that the Division of Solar Technology plans only to achieve technological readiness for arrays in the low range of costs by 1986.

TABLE 4

BALANCE OF SYSTEM
COST ASSUMPTIONS

(1980 dollars per m^2 of array)

Steel frame, materials	: 11.48
Steel frame, galvanizing	: 2.10
Steel frame, fabrication	: 4.76
Gaskets	: 0.98
Ground connection costs	: 1.68
Assembling costs	: 5.04
Shipping costs	: 0.98
Installation costs	: 2.80
Cost of structure to hold panel in place	: 13.72
Foundation concrete costs	: 28.00

TABLE 5

ARRAY BECC FOR COMMERCIAL USER
OF PV
UNDER DIFFERING FINANCIAL ASSUMPTIONS
(1980 dollars per peak Watt)

ASSUMPTION	$300\ m^2$ array
1. BASE	-0.14
2. ITC = 20%	-0.03
3. R_i = 5%	0.35
4. Accelerated Depreciation	0.51
5. R_i = 7.5%, ITC = 30%	0.11
6. R_i = 5.0%, ITC = 30%	0.55

TABLE 6

NET RETURNS ON PHOTOVOLTAIC
INVESTMENT
UNDER DIFFERING FINANCIAL ASSUMPTIONS
(1980 dollars per peak Watt)

FINANCIAL ASSUMPTIONS	COST ASSUMPTIONS	ARRAY SIZE (m^2)		
		200	300	400
BASE	1	-6,773.	-9,926.	-11,571.
	2	-14,116.	-20,851.	-27,778.
ITC = 20%	1	-4,801.	-7,035.	-9,460.
	2	-11,328.	-16,746.	-22,355.
R_i = 5%	1	-434.	-634.	-1,065.
	2	-6,252.	-9,289.	-12,557.
R_i = 7.5% ITC = 30%	1	-2,829.	-4,145.	-5,649.
	2	-8,540.	-12,642.	-16,933.
R_i = 5.0% ITC = 30%	1	1,322.	1,941.	2,330.
	2	-3,767.	-5,631.	-7,725.

COST ASSUMPTIONS:

    1: $0.28 per peak Watt (1980 Dollars)
       (Becomes $0.37 after 31% total mark-up by distributors and contractors)
    2: $0.70 per peak Watt (1980 Dollars)
       (Becomes $0.92 after distributor and contractor mark-ups)

Table 6 is useful in validating our specification of the break-even capital cost presented above. Our low-cost array (of Table 6's array cost assumptions) is priced at $0.37 per peak Watt, and the balance of system costs of (7) result in an average cost of $1.04 per peak Watt. The resulting $1.41 per peak Watt is slightly higher than the system BECC found on row 3 of Table 2. These cost assumptions, then, should result in a net profitability of just short of zero when applied to the same financial assumptions. These assumptions are found in the third row of Table 6. Table 2 assumes a 300m^2 array and, looking under the column on Table 6 for the same array size, gives us a loss in the investment of $634. This loss is entirely accounted for by the $0.05/Wp difference between the breakeven cost and the actual cost paid.

CONCLUSIONS

The primary purpose of this paper is to describe the application of a model which has several useful properties. The first of these is its ability to employ exact, hourly electricity consumption and production figures in the estimation of the profitability of a photovoltaic investment with either known or assumed costs.

The second useful capability of this model lies in its ability to focus on the costs of individual components (or a collection of several of the components) of the total photovoltaic power system to help determine the directions in which efforts at cost reductions should be focused. Our analysis indicates that the high costs for the non-array portions of the systems that have been estimated elsewhere are causing considerable damage to the profitability of photovoltaics as it is likely to be perceived in the commercial and industrial sector.

The model's results are also useful in targeting commercialization efforts of intermediate load centers since, in the shorter run, photovoltaics will only be an attractive investment opportunity to those firms and institutions with lower rates of return. Investigations of likely firms and many institutions may reveal organizations that have a sufficiently low rate of return to make initial commercialization efforts more fruitful.

Finally we have discussed packages of tax incentives that may overcome initial reluctance to invest in photovoltaics. Failure to adjust electricity prices to reflect long-run replacement costs rather than embedded rates (as discussed in (2)) may justify overcoming this pricing obstacle with these tax tools. On the other hand, these tools are costly, in terms of their reductions in tax revenues, and frequently cause investment decisions to be made that may be far from optimal from the point of view of the economy as a whole or energy policy more specifically.

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