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COO/4094-2

The Economics of Adopting
Solar Photovoltaic Energy Systems in Irrigation

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11 July 1977

Prepared For

The U.S. Energy Research and Development Administration
Under Contract No. EY-76-C-02-4094

Page 5 - Last sentence of fourth paragraph should read:

"The results summarized in Table IV, show that irrigation remains viable utilizing conventional power systems for as long as 18-89 years at low rates of fuel increases; 9-45 years, under high rates of fuel increases."

Page 25 - Change to:

TABLE IV. Years in Future when Rising Fuel Costs Make Irrigation Unviable

STATE	PRODUCING REGION	ASSUMED REAL ANNUAL GROWTH RATE OF FUEL COSTS		
		0	2	4
Nebraska	55	∞	87	44
Texas	79	∞	33	17
Arizona	87	∞	18	9
California	101	∞	89	45

1 December 1977

DISCLAIMER

THE ECONOMICS OF ADOPTING SOLAR PHOTOVOLTAIC ENERGY SYSTEMS IN IRRIGATION

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ABSTRACT

An economic analysis concerning the adoption of solar photovoltaic energy systems in irrigation has been made compared to conventional fossil fuel energy sources. The basis for this analysis is presented along with a discussion as to the time of initial profitability, the time of optimal investment, the effects of the tax system, the cost per acre that would make irrigation unviable, and possible governmental incentives that would promote the deployment of photovoltaic irrigation systems between the time of initial profitability and the time of optimal investment.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

SUMMARY AND CONCLUSIONS

In the United States, over 35 million acres are irrigated with the aid of energy-using pumps on farms and ranches. This represented in 1974 an expenditure of 260 trillion BTU's of energy at an estimated cost of $520 million. Price increases in fossil fuels and potential shortages of natural gas have aroused interest in alternate energy sources for irrigation. In the United States, the majority of the energy for pumping water is used over extremely large areas (160 acre quarter sections), requiring large pumping units (100-300 kW peak power*). This large scale crop irrigation represents one of the most promising areas for photovoltaic power systems to penetrate a large market during the mid 1980's.

The economic analysis comparing conventional fossil fuel energy sources with solar photovoltaic energy systems for irrigation undertaken here shows that solar systems will become profitable in the early to middle 1980's if the cost of the solar modules follows ERDA's projections. These results are remarkably robust and insensitive to reasonable variations in discount rates, fuel escalation rates, and support system costs (exclusive of the photovoltaic modules). The basis for this analysis is presented along with a discussion as to the time of initial profitability, the time of optimal investment, the effects of the tax system, the cost per acre that would make irrigation unviable, and possible governmental incentives that would promote the deployment of photovoltaic irrigation systems between the time of initial profitability and the time of optimal investment.

The use of the photovoltaic power during the non-irrigating portions of the year would add to the economic attractiveness of the system, as well as providing relief for other farm operations that will be increasingly affected by the growing fossil fuel shortage and/or cost escalations. The analysis includes these off-season uses in the form of crop drying where appropriate, heating, owner residential supply and possible feedback to the utility.

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*Peak power is defined as the output power of a solar photovoltaic array when illuminated by a solar intensity of 0.1 watts/cm - approximately equivalent to noon on a sunny summer day.

I. INTRODUCTION

From the point of view of the farmer, the adoption of solar photovoltaic power sources, primarily for irrigation and crop drying, is a choice of technique, as well as an investment decision. Unlike more familiar choices of technique - whether or not to use a new seed - or investment decisions - whether or not to purchase a more powerful tractor - the adoption of solar photovoltaic energy sources is subject to enormous technological and economic uncertainties. Solar photovoltaic technology requires a relatively large front-end investment whose benefits are reaped in the form of fuel savings for a somewhat indeterminate time in the future. The technological uncertainties refer to performance characteristics of the arrays - how long will they last, what is their likely efficiency in converting solar energy into electrical energy, what maintenance costs are required. The economic uncertainties refer to future costs and prices: What is the likely cost of an array, if adoption is postponed one year, two years, n years; what are the likely costs of alternative fuels in the future; is Federal policy likely to equalize the costs of alternative fuels on a BTU basis; what is the price structure of electric utilities likely to be regarding peak load use or the purchase of excess electricity generated by the array at the farm site; what are the likely conditions for financing the arrays, regarding loan-value ratios, interest rates, term of loan, or tax treatment?

ERDA's Photovoltaic Field Tests and Applications Project can reduce some of these uncertainties, and thus accelerate the adoption of solar photovoltaic technology. Initial field tests in agriculture can resolve some of the technological questions of conversion efficiency and maintenance requirements. Other issues cannot be so easily resolved by experiment, such as, likely Federal regulatory policy or pricing structures of local utilities. In any projections of the viability of solar photovoltaics, these uncertainties have to be dealt with by judicious assumption. Finally, the viability of solar photovoltaic technology is subject to enormous micro-regional variation. For all uses of solar photovoltaics, interregional differences in insolation (both mean and variance) translate into cost differences per average kilowatt, taking storage into account. In agricultural uses, further account must be taken of interregional differences in the availability of surface and ground water, particularly in current and future expected depth.

II. THE MODE OF ANALYSIS

Five states account for about 70% of all the energy utilized in irrigation in the country (see Figure 1 and Table I and II). These states differ greatly in their relative dependence upon irrigation in agriculture, in the availability of surface water and depth of ground water, in the costs of alternative fuels, and hence in the typical energy source utilized. Texas, where 32% of the acreage is irrigated, depends greatly upon natural gas, as does New Mexico. Arizona and California, where nearly all the acreage is irrigated, depend almost entirely upon electricity. Nebraska, where 20% is irrigated, has a more diversified energy base.[1,6]

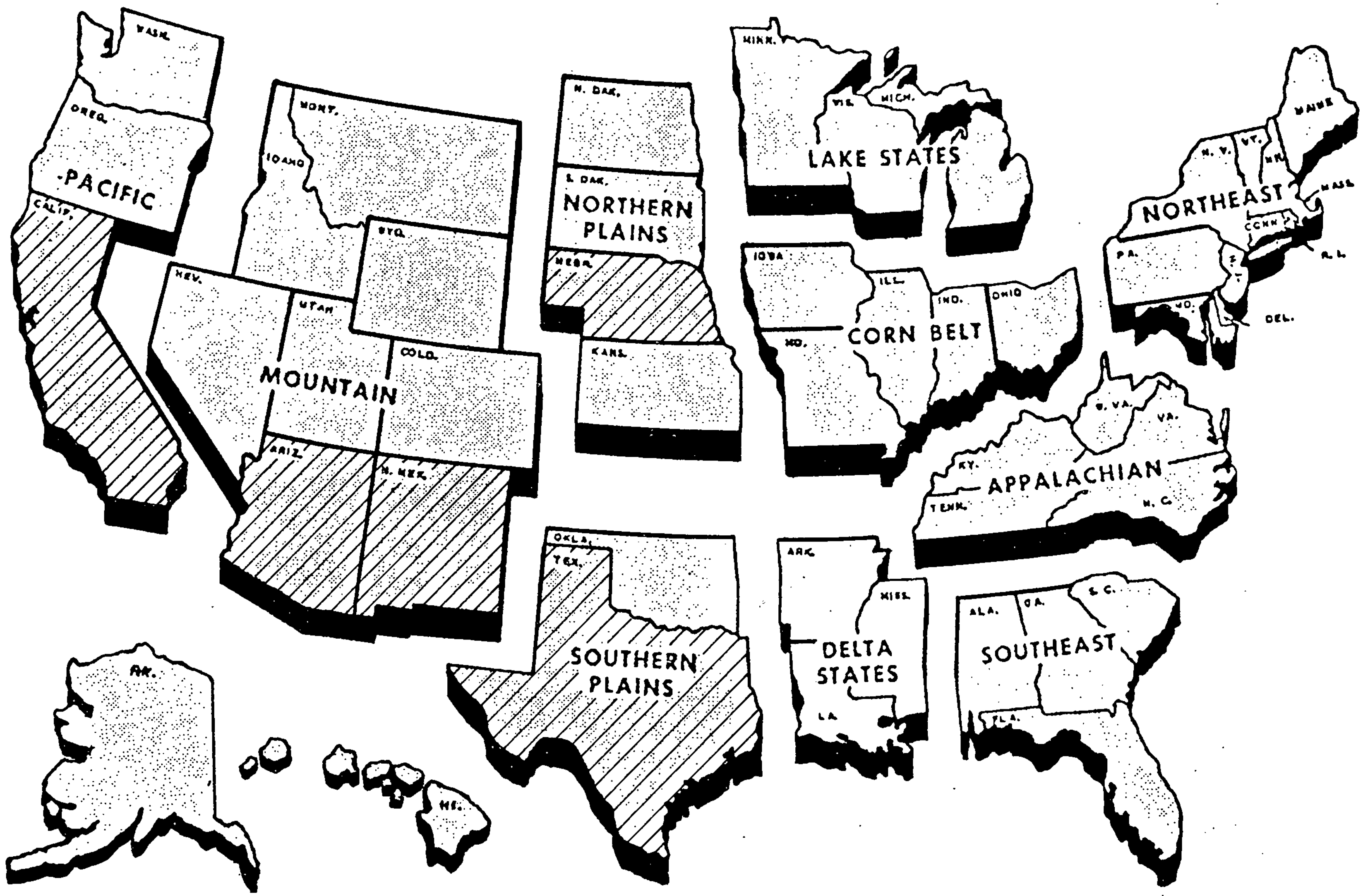
Because of these interregional differences, a separate analysis is performed for four typical producing areas, based upon subareas defined by the Water Resources Council.[1] For each subarea, the profitability of adopting solar photovoltaics could be analyzed for five alternative fuel sources and four alternative irrigation systems. To the extent that one assumes that Federal energy policy encourages the convergence of prices of all fuels toward a common value based upon their BTU content, and that farmers select the cheapest irrigation system, such a breakdown is unnecessary.

In all analyses, solar photovoltaics are assumed to meet peak irrigation demands. Off-peak use of the arrays for crop drying, for domestic use, and for sale to the central power facility are also considered separately.

III. WHEN WILL FUEL COSTS MAKE IRRIGATION UNECONOMICAL?

Irrigated lands in the United States absorb 10% of the acreage, but produce 20% of the crop output. Currently, approximately 12% of the U.S. per capita energy is devoted to the production, processing, transportation, sales

Figure 1. MAJOR U.S. IRRIGATION STATES



TOP FIVE ENERGY CONSUMERS IN IRRIGATION (~70% Of Total)

SOURCE (6)

and consumption of food, one fifth of which is consumed in production and production related activities on the farm. Irrigation is a major element in this category accounting for approximately 0.5% of all the energy consumed in the nation.[6,8]

Rising fuel costs threaten the viability of commercial agriculture on irrigated lands, at least under conventional energy systems. For some lands, particularly those in the arid zones of the Southwest, unirrigated land has practically no agricultural value. For other irrigated lands, there are alternative, lower yielding agricultural uses, particularly for grazing. The consequence of rising fuel prices will be to make irrigated agriculture unviable in many areas, and to redistribute agricultural production to more humid zones within a few decades. The ultimate consequence to the consumer is higher costs of food and fiber.

The time at which conventional irrigation becomes unviable can be computed by making some simple assumptions about agricultural land values and rents. According to conventional theory, rent equals the difference between operating revenues and operating costs, including returns to reproducible capital and entrepreneurship, at a particular site. Land is worth the present discounted value of rents in its most productive use. The relationship between agricultural rents and land values implies that farmers utilize approximately a 3% discount rate.[3]

Assume that average revenues (Q) and operating costs (M) are stable over time, but that fuel costs increase at the compound rate r. Next suppose that the values of irrigated (I) and unirrigated (U) lands prior to the energy crisis are known and the farmer's discount rate is assumed to equal i = 3%. Irrigated agriculture will become unviable when the increment in fuel costs, above the pre-crisis level (F_0), equals the difference between irrigated-unirrigated land rents:

$(I-U)i = \left(F_0 e^{rt} - F_0\right)$, where e is the base of the natural logs or

$$rt = \log (F_0 + Ii - Ui) - \log F_0$$

Taking a typical region, assume that prior to the energy crisis land values are \$1000 per acre under irrigation and \$300 without irrigation, rents \$30 per acre, and fuel costs approximately \$16 per acre. After the crisis, fuel costs rise at 2% per annum. Then: $.02\, t = \log (\$16 + \$30 - \$9) - \log (\$16)$ and $t = 42$. In other words, under conventional energy systems, with no improvements in irrigation efficiency, agriculture becomes unviable in this particular region in 42 years. Doubling the discount rate cuts the critical period in half. Doomsday could be postponed by more efficient scheduling procedures. In Nebraska, for example, energy costs could be cut in half by better scheduling.[5]

The present value of the land under irrigation is now:

$$I' = \int_{t=0}^{42} \left(Q - M - F_0\right) e^{-it} - \left(F_0 e^{rt} - F_0\right) e^{-it} = \$700$$

In 42 years the land is worth \$300 for unirrigated uses, which discounted at three percent to the present equals \$87. The total value of land is thus (\$700 + \$87=) \$787.

At what maximum cost per acre must solar photovoltaics be available in order to make irrigation feasible again? The introduction of solar photovoltaics not only eliminates the capital loss due to the fuel price increase (\$1000 - \$787 = \$213), but it also eliminates all fuel costs in perpetuity. The present value of the latter equals \$553. If arrays can be provided at the cost of less than (\$213 + \$533=) \$756 per acre, then they are a profitable investment. Further into the future as the price of fuel rises and the value of irrigated land drops, arrays become viable at an even higher cost. An analysis of this type was carried out for each of the four Water Resource producing areas considered in this report based on the data shown in Table III. The results summarized in Table IV, show that irrigation remains viable utilizing conventional power systems for as long as 42-78 years at low rates of fuel increases; 21-27 years, under high rates of fuel increases.

IV. THE COST-BENEFIT CALCULUS

A. Analytical Expressions Used

The profitability of adopting solar photovoltaics for irrigation is computed from formulas (1)-(3):

$$NET_{jk} = BENEFIT_{jk} - COST_{jk} \tag{1}$$

where j = 1 in 1977; k = region 1....4

$$COST_{jk} = \left\{\left[X + (15{,}000-X)e^{-j/\tau}\right] + Y\right\} * A_k/E_f \tag{2}$$

where the term in the brackets represents the cost per kilowatt of the arrays according to ERDA projections (see Table VIII), X being the target cost per peak kW; where the second term Y is the cost of supporting structures plus the difference in cost between conventional motor and generator and a solar-powered motor (operating only during sunlight hours), battery, and DC-AC inverter costs; where A_k is peak kilowattage required to meet irrigation demands of Tables III and V under insolation conditions listed in Table VI; and where E_f is the system electrical efficiency, including inverter and max power tracker losses (E_f taken to equal 0.9). An all-DC system, which utilizes more expensive motors but no inverter, was found to be somewhat less profitable than an AC system, if the AC surplus electricity could be sold to the central power facility or utilized in the home. Land costs of the arrays were ignored as they are trivial, i.e., an array generating one peak kilowatt utilizes only three-thousandths of an acre.

$$BENEFIT_{jk} = \sum_{t=j+1}^{j+T} \frac{\left(CFI_{ko} + CFD_{ko} + RP_{ko} + RS_{ko}\right) * e^{rt} + CM_{ko} - .01*COST_k}{(1+i)^{t-j}} \tag{3}$$

where T = 20, the presumed number of years in the lifetime of a solar energy system, where CFI_{ko} is the cost of meeting irrigation demands under conventional fuels, priced initially at \$3.00 per million BTU; where CFD_{ko} is the cost of meeting drying demands under conventional fuels @ 2¢ per kWH; where RP_{ko} equals savings in residential purchases, assuming 30 kWH/day off-season @ 5¢ per kWH; where RS_{ko} equals savings in residential purchases for heating or in sales or excess power to central @ 2¢ per kWH, which is equivalent to the current cost of home heating oil. Annual system maintenance costs (CM_{ko}) are assumed to equal 1¢ per kWH output for the conventional systems and one percent of capital cost at 1986 prices (j = 10) for the solar powered system.

Four sets of parameters are applied to the analysis. First, the escalation in real fuel costs are assumed to equal, alternatively, 2 and 4 percent.[2] Second, the discount rates are, alternatively, 3, 5, and 8 percent. Three percent represents the long-term, risk free, real rate of interest, such as that operative during the 1950s when prices were stable. Five percent represents the subsidized rate currently charged by the Farmer's Home Administration for 40-year real estate loans. Eight percent is the rate charged by that same agency for 12-year equipment loans and the unsubsidized rate charged by the Farm Credit System for 30-year mortgages. Third, the target array costs are $500/kilowatt (pk) in 1986 and bounded by $100 and $300 in the year 2000 (see Table VIII). Fourth, system support costs are $546 or $1052/kilowatt (pk), as described in Table VII.

It should be noted that the option of storing water off-season was considered. While this reduces on-season peak kilowatt requirements, it also requires additional expenses for excavating a pond, pumping water from the ponds (an average of nine feet), land-use loss, and additional pumping required to recoup evaporation losses. Preliminary calculations showed that storage may be cheaper than the no-storage option in the early 1980s; however, further analysis as to evaporation and seepage losses and land-use loss must be made to clarify this. However, at the projected 1986 array cost of $500 per peak kilowatt, the costs associated with off-season water storage exceed the incremental cost of pumping on-season only. Thus, large scale storage does not appear to be promising for irrigation.

B. Social Viability

In this section, the costs and benefits of solar photovoltaics for irrigation are computed for the society as a whole, without consideration of who bears the costs or enjoys the benfits. In the next section, costs and benefits from the viewpoint of the farmer are computed.

If the cost of solar photovoltaic arrays follows ERDA's projections, solar energy for irrigation purposes will be come profitable in the early to middle 1980s in the Southwest and Midwest. These results are remarkably robust and insensitive to variations in discount rates, fuel inflation rates, or level of targets costs in the year 2000.

The costs and benefits under all scenarios are graphed in Figures 2-5. The solid, downward sloping lines represent the costs; the dashed, upward sloping lines, the present value of benefits in each year of investment. Where benefits equal or exceed costs under any scenario, the system is viable. Summaries of these figures are shown in Tables IX through XII.

Under any set of assumptions, solar energy for irrigation becomes profitable in Arizona, California, and Texas around the same time, and one to three years earlier than in Nebraska. Reducing the fuel inflation rate from four percent to two percent postpones the viability of solar irrigation by about one or two years in the Southwest but somewhat longer in Nebraska.

Under an optimistic scenario - where the discount rate is five percent; the fuel inflation rate is four percent; the year 2000 target level is $100; and system support costs are equal to $546/kilowatt (pk) - the use of solar photovoltaics in irrigation becomes profitable by 1983 in Arizona, California and Texas and 1986 in Nebraska (see Table VIII for the array price function used to calculate these dates).

Under the most conservative scenario - where the discount rate is eight percent; the fuel inflation rate is two percent; the year 2000 target array level is $300; and system support costs, $1052/kilowatt (pk) - the use of solar photovoltaics becomes profitable by 1990 in Arizona, 1989 in California, 1991 in Texas, and after the year 2000 in Nebraska. The year at which solar photovoltaics becomes viable under all scenarios is indicated in Tables 9-12, column a.

It should be noted that the year in which solar photovoltaics become profitable in irrigation is not identical to the optimum year. Because the cost of arrays is expected to decline rapidly during the 1980's, the postponement of the purchase of arrays can result in an increase in net benefits. So long as the rate of increase in net benefits from year-to-year is greater than the discount rate, it pays to postpone the investment. The

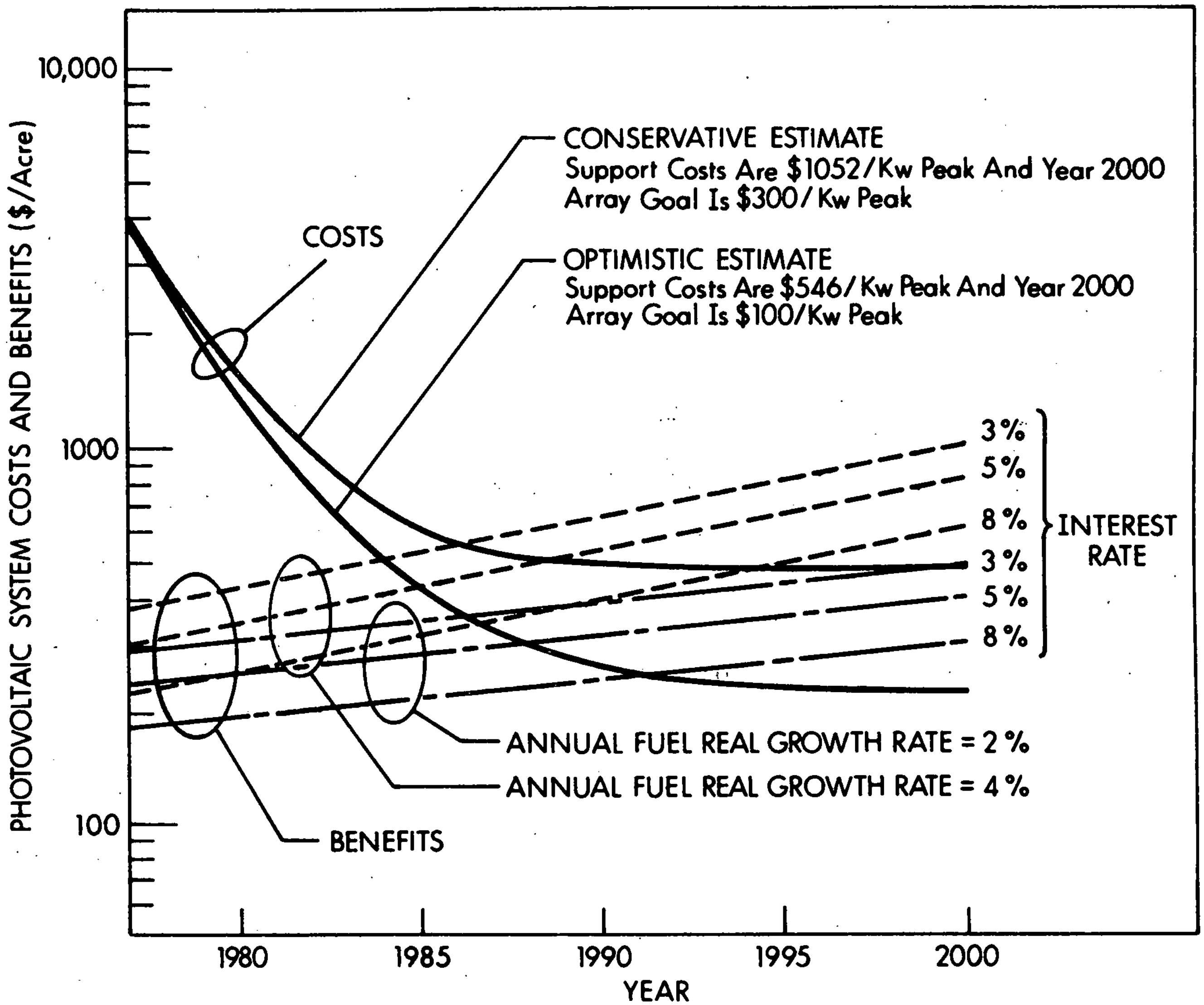


Figure 2. PHOTOVOLTAIC SYSTEM COSTS Vs BENEFITS (Per Acre) – NEBRASKA, 1977-2000

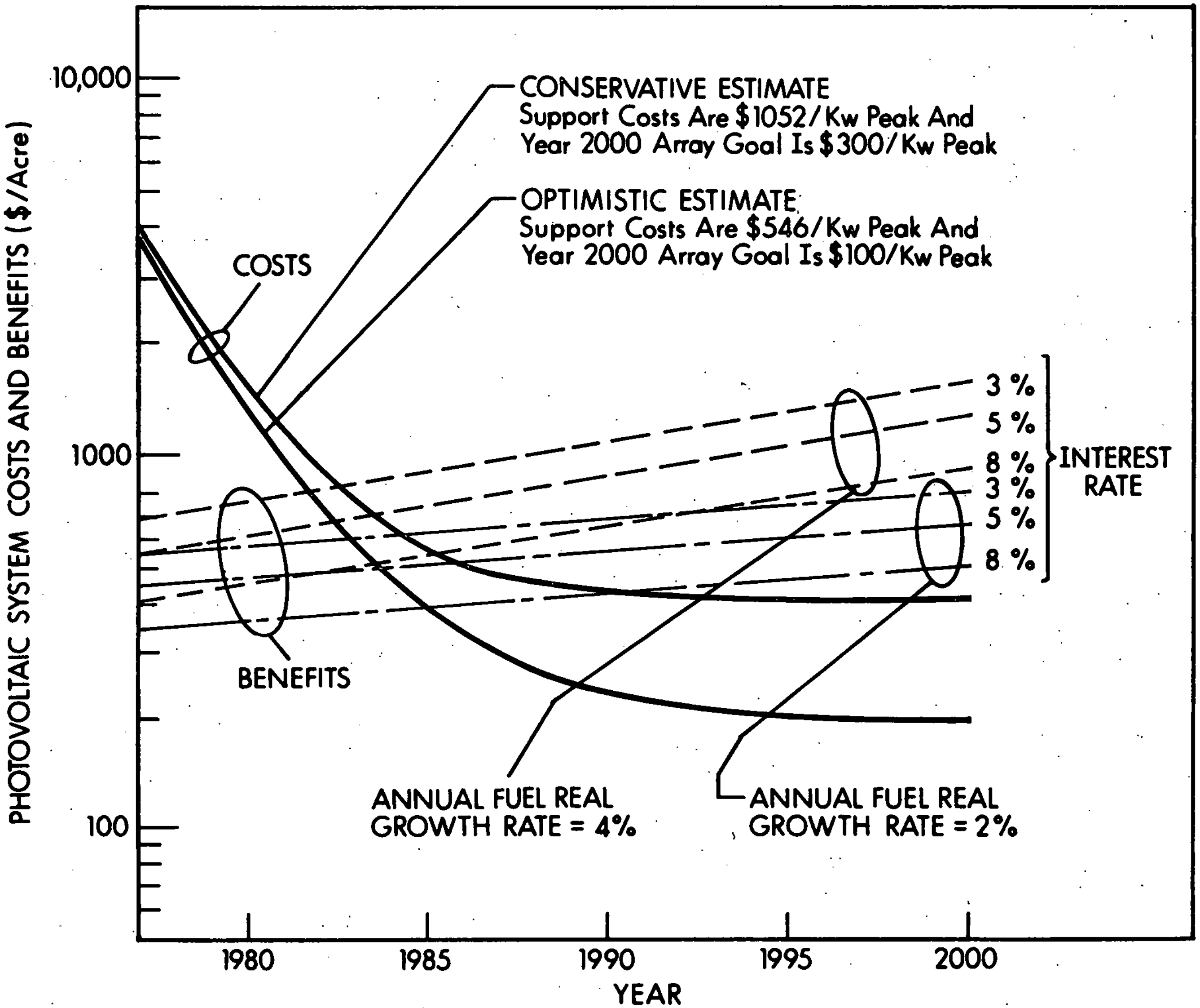


Figure 3. PHOTOVOLTAIC SYSTEM COSTS Vs BENEFITS (Per Acre) – TEXAS, 1977–2000

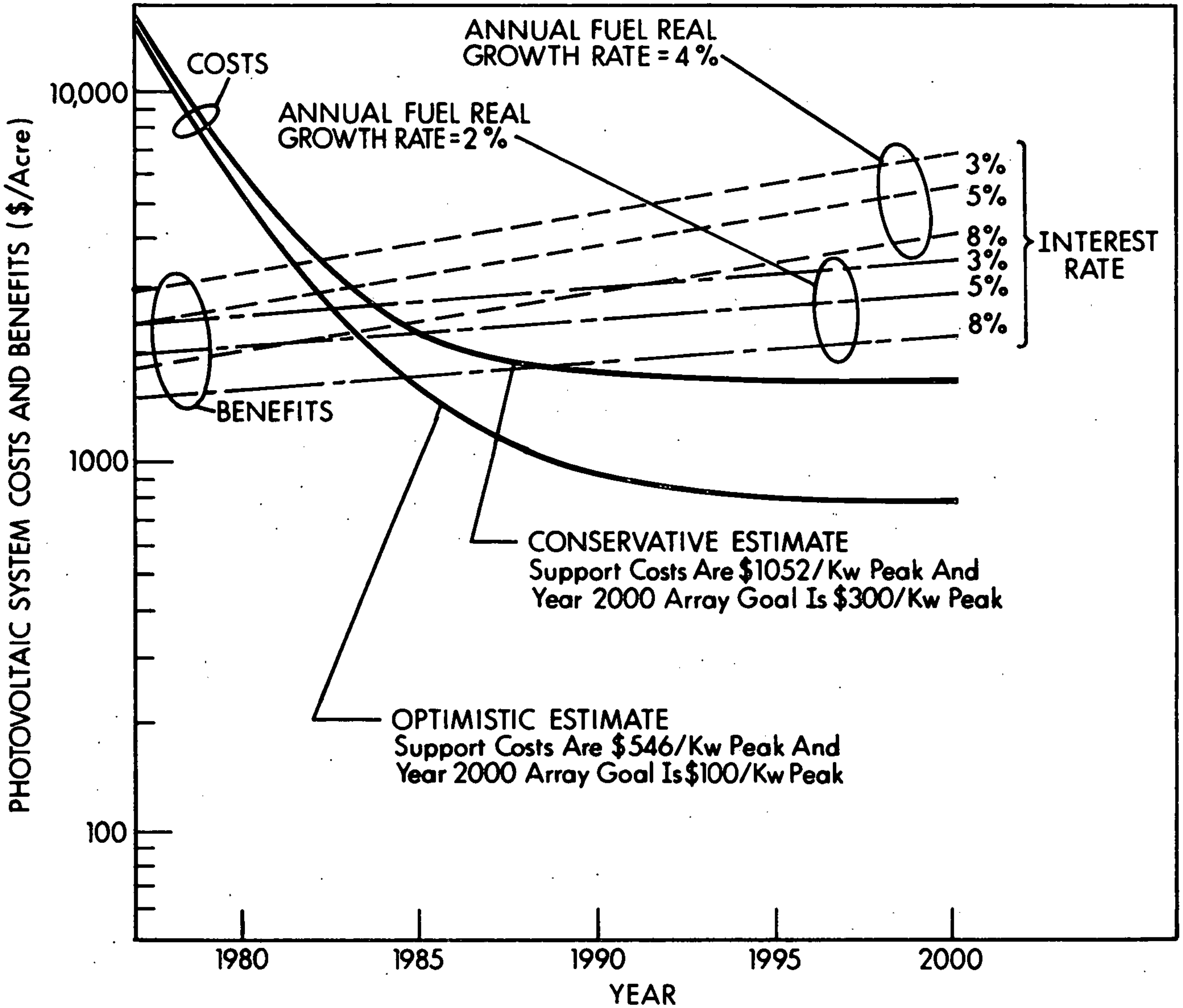


Figure 4. PHOTOVOLTAIC SYSTEM COSTS Vs BENEFITS (Per Acre) — ARIZONA, 1977-2000

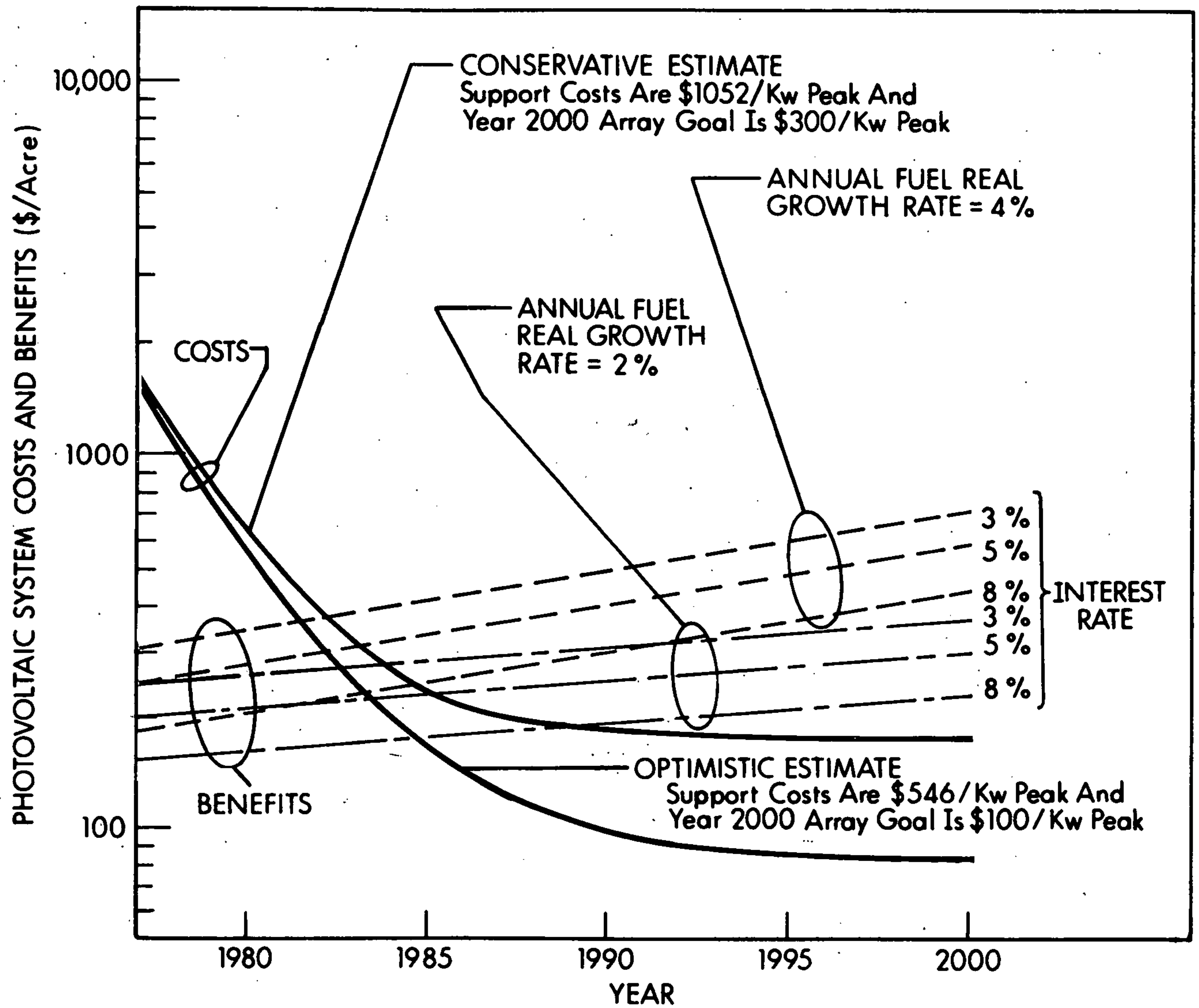


Figure 5. PHOTOVOLTAIC SYSTEM COSTS Vs BENEFITS
(Per Acre) — CALIFORNIA, 1977 - 2000

rule for determining the optimum year for the investment is to select the year h, in which net benefits discounted to the present are maximum:

$$\max \text{PRESENT VALUE (h)} = \text{NET BENEFIT}_h / e^{ih}$$

where h = 0 in 1977 and i = discount rate

Returning to the optimistic and conservative scenarios, one finds that the optimal time of investment is approximately seven years after solar photovoltaics become commercially profitable. In a few cases, where the discount rate is less than the fuel growth rate (an unlikely event)* the optimal lies beyond the year 2000. Under the optimistic scenarios, the optimal year of investment in arrays is in 1996 in California and Arizona, 1997 in Texas, and after 2000 in Nebraska. Under the conservative scenario, the optimal year of investment is after the year 2000 in all four states. The optimum year for each scenario is indicated in Tables IX-XII, column b.

C. Commercial Viability

The farmer's commercial calculations differ from the above by the consideration of taxes. Both fuel charges and interest payments on arrays are tax deductible. Second, depreciation as an accounting item is generally more rapid than actual physical depreciation. Here we assume that level-payment financing is available for the life span of the arrays, over which they are depreciated on a sum-of-years-digits basis; and that the farmer is taxed at R percent at the margin. Let I_t stand for interest payments; A_t for amortization; B_t for annual benefits as computed above; D_t for annual depreciation; and i for the discount rate, here the lending rate. An investment tax credit of 10 percent is also assumed for the entire value of the investment. The farmer is assumed to pay income taxes at a 20 percent marginal rate.

The present value of an investment in solar arrays, where 100% financing is available, equals:

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*If fuel rates increases faster than the discount rate, owners of fuel resources would maximize their wealth by storing rather than selling fuel. The result would be a once-and-for-all price increase that would induce fuel production.[7]

$$PV_j = (1-R)\sum_{t=j+1}^{j+T} \frac{B_t - I_t}{(1+i)^{t-j}} + R\sum_{t=j+1}^{j+T} \frac{D}{(1+i)^{t-j}} - \sum_{t=j+1}^{j+T} \frac{A_t}{(1+i)^{t-j}} + 0.1*COST_j$$

Taking taxes and financing into account generally shortens the period before which solar systems are viable. Under the conservative scenario, the year of viability is brought forward three years in California and four years in Arizona and Texas, but viability still lies beyond the year 2000 in Nebraska. Under the optimistic scenario, there is a one year (earlier) change in the year of viability in all four states.

It should be noted that these results are somewhat sensitive to maintenance costs. While the results published here assumed that maintenance costs equaled one percent of total system costs (at 1986 prices), simulations with two percent maintenance costs were also tried. The higher maintenance costs add one to two years to the year of viability. This sensitivity to maintenance has important implications for the field test projects. First, particular care should be taken in measuring maintenance costs. Second, in the design of photovoltaic systems, attention should be given to minimizing maintenance requirements.

V. POLICY IMPLICATIONS

The cost-benefit and commercial calculations of the profitability of utilizing solar photovoltaic power for irrigation shed light on two basic questions: What is the likelihood of the diffusion of this innovation prior to the year 2000? What incentive schemes might the federal government adopt to accelerate the adoption of photovoltaic systems?

A. The Rate of Diffusion of Innovation

Individuals differ in their likelihood of adopting an innovation. Some people are prone to be the first to innovate simply for the prestige value; others are inherently conservative. These individual differences give rise to the well-known logistic curve of adoption, in which a fairly long period elapses before the pioneers account for as much as five percent of the market, then there is a swarm of adoptions, the market becomes saturated, and finally a few stragglers adopt after a long period of time. The individual differences are less significant than the fact that the rate of innovation is proportional to its profitability, as shown in Grilches's path-breaking study of the adoption of hybrid corn by farmers.[4]

In the case of solar photovoltaics, one might observe in Nebraska, for example, that some farmers adopt the new system in the beginning of the 1980s (a bit before it becomes viable), perhaps a total of ten percent adopt it by the mid 1980s (when the system becomes commercially viable), and market saturation is reached in the late 1990s (long after the optimal year of investment).

B. The Role of Public Policy

Public policy is currently operating on both the supply and demand side for solar photovoltaics. On the supply side, ERDA is financing the purchase, and indirectly subsidizing, the production of solar cells. This should facilitate the attainment of its cost targets, through the realization of economies of scale and learning by doing on the part of suppliers. On the demand side, the Solar Photovoltaic Field Tests and Applications Project can reduce some of the uncertainties of the system, particularly with respect to reliability and maintenance costs, which here were estimated by only the crudest rules of thumb.

The computations here suggest yet another area in which public policy can accelerate the adoption of solar photovoltaic system. The curve of net commercial value of investment, discounted to the present, around the optimal year is quite flat (Figures 6-9). This suggests that small tax credits can have great leverage in accelerating adoption. For example, the optimal year of innovation under the most conservative assumption is about 1993 in Arizona, California and Texas. In the Arizona case, the present value of the net benefit one year before the optimum is less by only two-tenths of one percent of the cost of the investment. In other words, a tax credit of one-tenth of a percent could accelerate adoption by one year. The necessary tax credit to accelerate adoption by two years is only about two percent; by three years, about five percent; by four years, about ten percent; by five years, about sixteen percent.

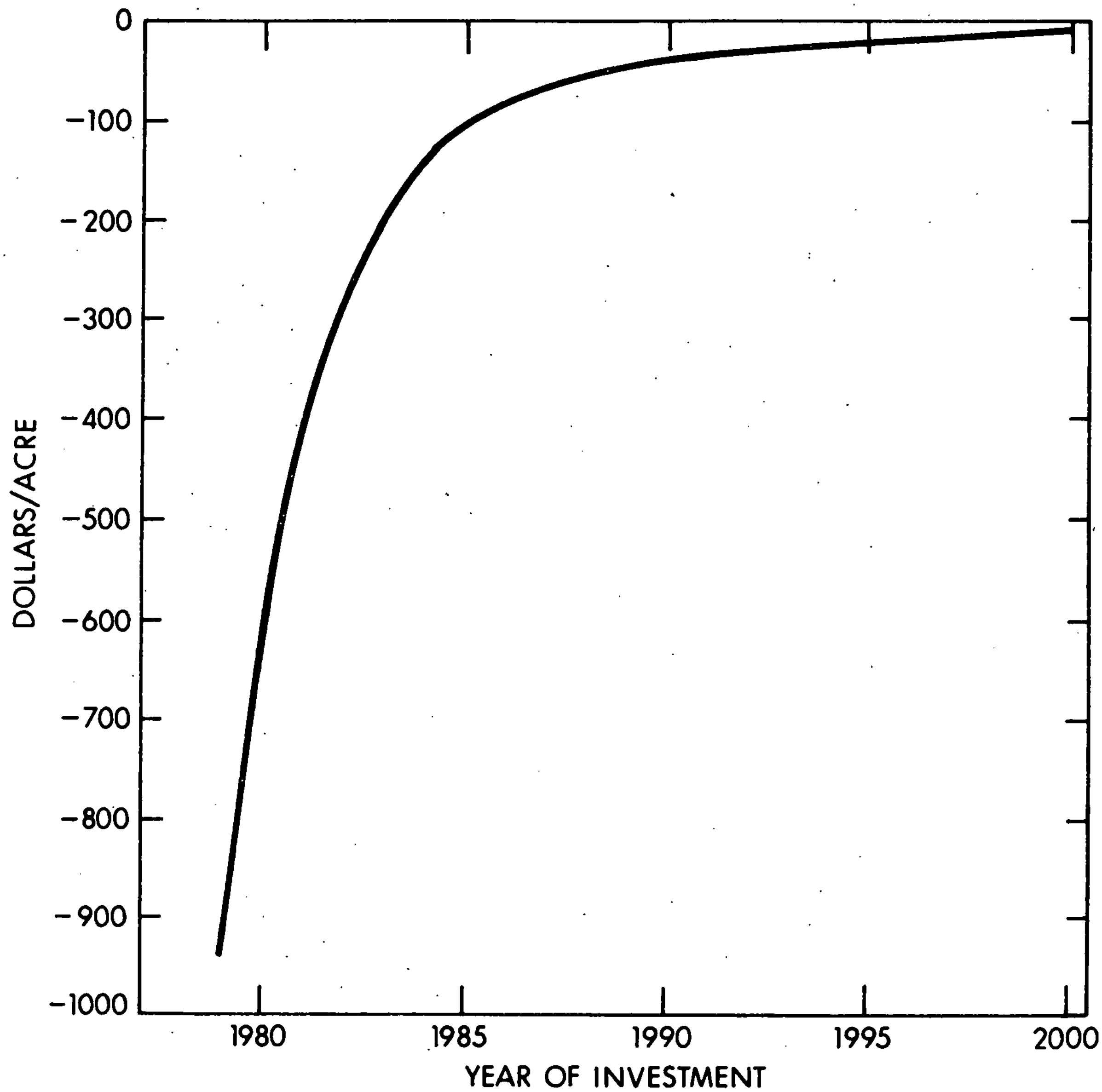

Figure 6 NET COMMERCIAL BENEFIT OF PHOTOVOLTAIC SYSTEM BROUGHT FORWARD TO 1977, CONSERVATIVE SCENARIO – NEBRASKA

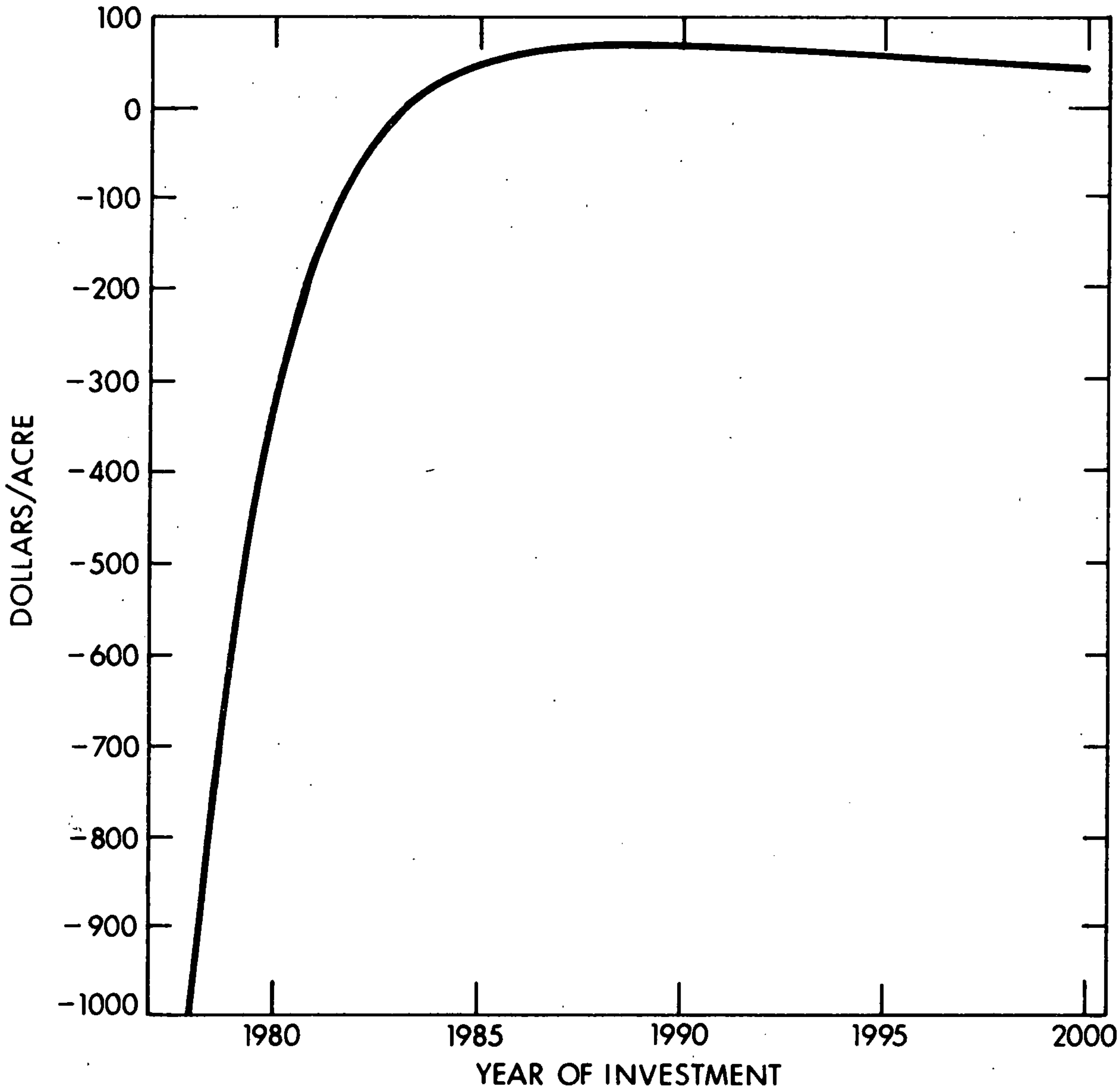

Figure 7 NET COMMERCIAL BENEFIT OF PHOTOVOLTAIC SYSTEM BROUGHT FORWARD TO 1977, CONSERVATIVE SCENARIO – TEXAS

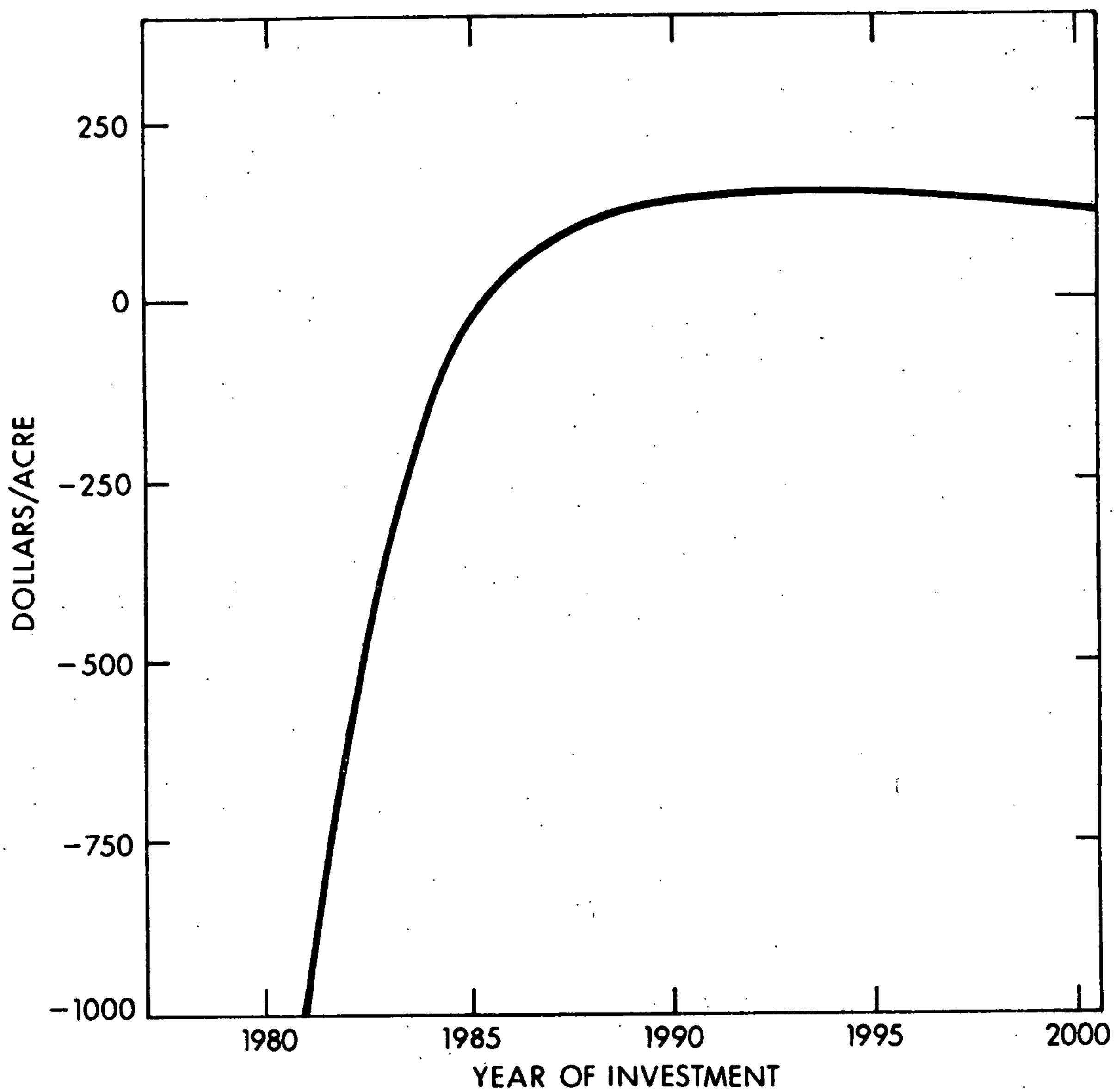

Figure 8. NET COMMERCIAL BENEFIT OF PHOTOVOLTAIC SYSTEM BROUGHT FORWARD TO 1977, CONSERVATIVE SCENARIO – ARIZONA

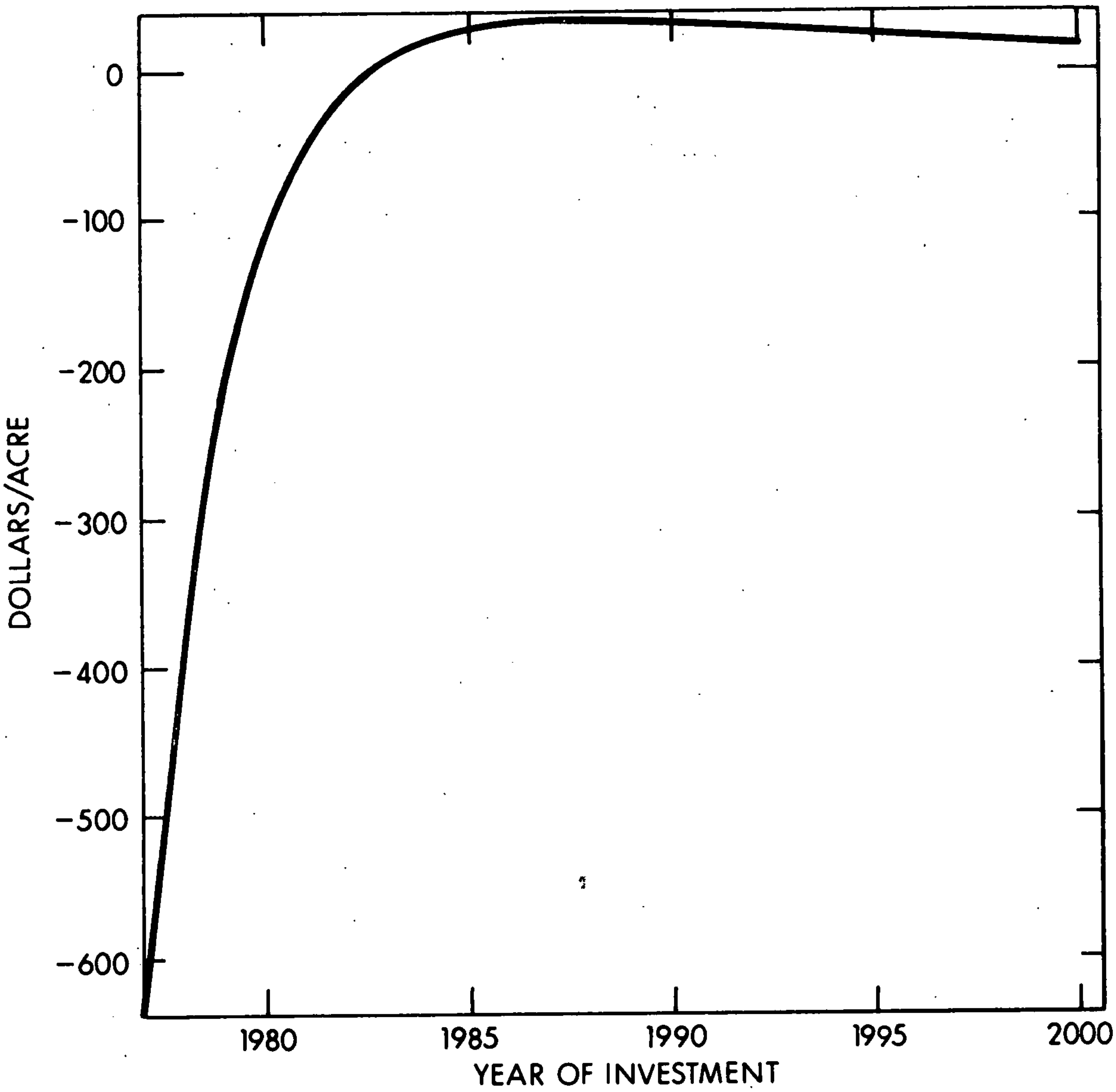

Figure 9 NET COMMERCIAL BENEFIT OF PHOTOVOLTAIC SYSTEM BROUGHT FORWARD TO 1977, CONSERVATIVE SCENARIO—CALIFORNIA

The tax credits necessary to accelerate adoption five years before the optimum are calculated for all locations and permutations of assumptions (re: rates of fuel increase, discount rates, target prices, support costs). These estimates are pooled to provide a distribution of tax credits, whose mode is in the 10-13 percent range. This suggests that rather small tax credits can have significant impact on accelerating adoption. To the extent that the costs of solar photovoltaics is sensitive to the volume of production, acceleration of the adoption process can be self-fulfilling, in the sense of bringing the cost curve to its asymptotic limit sooner than expected.

TABLE I. Quantity of Energy Used in Units of Fuel for On-Farm Pumping of Irrigation Water in the United States, 1974.

STATE & REGION	ELECTRICITY	DIESEL	GASOLINE	NATURAL GAS	L.P.G.
			GROUNDWATER		
	1000 kWH	1000 Gal		Mil. cu. ft	1000 Gal.
North Dakota	17,445	302	142	0	59
South Dakota	12,850	732	204	0	1,187
Nebraska	926,210	84,140	3,289	6,166	94,569
Kansas	131,744	7,747	1,938	19,383	16,961
NORTHERN PLAINS	1,088,248	92,922	5,573	25,551	112,776
Mississippi	21,752	5,372	1,120	0	1,400
Arkansas	76,932	3,167	9,905	248	19,808
Louisiana	25,174	5,527	3,457	432	1,080
DELTA STATES	123,858	14,066	14,482	680	22,289
Oklahoma	108,197	3,563	2,229	5,943	11,143
Texas	1,268,040	5,220	6,530	60,401	32,649
SOUTHERN PLAINS	1,376,236	8,783	8,759	66,344	43,792
Montana	36,431	591	687	7	66
Idaho	1,482,899	1,299	3,250	406	2,031
Wyoming	201,484	1,561	244	122	610
Colorado	397,900	1,178	300	4,700	1,842
New Mexico	398,884	9,383	7,825	15,161	17,117
Arizona	2,081,935	0	0	14,432	0
Utah	265,079	4,365	2,548	91	455
Nevada	372,417	7,862	492	0	615
MOUNTAIN	5,237,024	26,238	15,345	34,918	22,736
Washington	593,187	0	0	0	0
Oregon	437,614	364	0	0	0
California	4,428,386	0	0	1,164	0
PACIFIC	5,459,186	364	0	1,164	0
Hawaii	695,434	0	723	0	0
Other	256,192	17,214	14,141	8	14,146
UNITED STATES	14,236,501	159,589	59,036	128,665	215,739

Source: 6

TABLE II. Irrigation Energy Characteristics of Major States, 1974

	ENERGY CONSUMED		COST OF ENERGY CONSUMED		QUANTITY OF ELECTRIC ENERGY USED		QUANTITY OF NATURAL GAS ENERGY USED		QUANITY OF DIESEL & GASOLINE ENERGY USED	
	TRILLION BTU's	NATIONAL RANK	MILLION $	NATIONAL RANK	% OF U.S. TOTAL	NATIONAL RANK	% OF U.S. TOTAL	NATIONAL RANK	% OF U.S. TOTAL	NATIONAL RANK
Texas	72.6	1	87.2	2	8.9	3	46.9	1	5.4	5
Nebraska	30.8	2	78.9	3	6.5	4	4.8	5	40.0	1
Arizona	22.2	3	52.5	4	14.6	2	11.2	4	--	--
New Mexico	21.2	4	31.2	5	2.8	9	11.8	3	7.9	2
California	16.3	5	89.4	1	31.1	1	0.9	8	---	--
TOTAL(% OF U.S.)	70%		65%		64%		76%		53.3%	

Source: 6

TABLE III. Irrigation, Insolation and Economic Characteristics of the Four Water Resource Producing Areas Studied.

Parameters	Nebraska 55*	Texas 79	Arizona 87	California 101
Irrigation Demands				
1. Pumping depth (ft)	71	187	381	135
2. Surface water lift (ft)	20	40	0.1	10
3. % of ground water	60	95	81	50
4. 10 BTU to lift	1281	4680	7047	1084
5. 10 BTU to lift and apply	1330	4909	7096	1133
6. Acre-ft applied	1.83	1.50	5.50	3.17
7. Conventional BTU/acre	2434	7364	39028	3592
8. Solar BTU/acre	560	1694	8976	824
9. Solar kWH/acre	164	495	2621	241
Supply of Insolation				
10. Pumping months	Jul-Aug	Apr-Sep	Mar-Oct	Mar-Oct
11. Drying months	Oct-Mar	NA	NA	NA
12. Insolation annual (kWH)	2040	2818	2639	2546
13. Insolation on-season (kWH)	427	1555	1940	1908
14. Insolation surplus (kWH)	1613**	1264	699	638
15. Pk kW/needed	0.384	0.318	1.35	0.126
Economic Factors, $/acre in 1977				
16. Value of irrigable acreage	2000	800	1700	2250
17. Value of unirrigable acreage	900	100	0	450
18. Maintenance, conventional	1.46	4.42	23.42	2.15
19. Conventional irrigation	7.31	22.10	117.10	10.77
20. Conventional drying	2.44	0	0	0
21. Reduced domestic purchase	2.88	1.71	1.14	1.14
22. Increased domestic sales	8.80	7.36	18.42	1.16

Sources

1. Dvoskin and Heady (Table I)
2. Dvoskin and Heady (Computed from Table VI)
3. Dvoskin and Heady (Table IX)
4. Assume pump efficiency ca. 60%, conversion efficiency ca. 23%
5. Assume application requires 14 ft head
6. Sloggett, state totals (Table IX)

*Water Resource Council Producing areas

**Insolation surplus for Nebraska includes that needed for crop drying as shown in Table VI.

TABLE III. Irrigation, Insolation and Economic Characteristics of the Four Water Resource Producing Areas Studied (Cont'd).

Sources (Cont'd)

10. Interviews
11. Interviews
12. Reference 9
13. See Table VI
14. See Table VI
15. See Table VI
16. Interviews
17. Interviews
18. Assume 1¢/kWH output
19. Assume $3.00/million BTU * line 7
20. Assume 122 kWH/acre (Ref. 5) @ 2¢/kWH
21. Assume 30 kWH/day, @5¢ kWH, off-season
22. Assume surplus sold to central power facility or used for heat @2¢/kWH

TABLE IV. Years in Future when Rising Fuel Costs Make Irrigation Unviable

STATE	PRODUCING REGION	ASSUMED REAL ANNUAL GROWTH RATE OF FUEL COSTS		
		0	2	4
Nebraska	55	∞	57	29
Texas	79	∞	42	21
Arizona	87	∞	48	39
California	101	∞	74	37

TABLE V. Energy Requirements for Irrigation, Per-Acre, Selected Producing Areas

STATE	PRODUCING AREA[f]	AVERAGE PUMPING DEPTH[a]	PER-ACRE FOOT 10^3 BTU ENERGY TO LIFT[b]	PER-ACRE FOOT 10^3 BTU TO LIFT AND APPLY[c]	SEASONAL ACRE-FT APPLIED[d]	CONVENTIONAL 10^3 BTU PER ACRE	SOLAR 10^3 BTU PER ACRE ELECTRICITY[e]	SOLAR kWH PER ACRE ELECTRICITY[g]
Nebraska	55	71	1281	1330	1.83	2434	560	164
Texas	79	187	4680	4909	1.50	7364	1694	495
Arizona	87	381	7047	7096	5.50	39028	8976	2621
California	101	135	1084	1133	3.17	3592	826	241

a Dvoskin and Heady (Table I)

b Dvoskin and Heady (Table VI); assumes some water from surface sources from Dvoskin and Heady (Table IX) and 60% pumping efficiency

c Application requires 14 foot head @3500 BTU/foot of lift/acre-foot = 49 x 10^3 BTU/acre foot

d Sloggett, state totals (Table IX)

e Conventional efficiencies are shown in Dvoskin and Heady (Table 5) to average about 20% for conventional fossil fuel motors from fuel content to motor output. An electric motor efficiency would be about 87%.

f Defined by Water Resources Council

g System electrical efficiency of 90% taken into account in equation (2) on page 6.

TABLE VI. Mean Daily Radiation, kWH/m²/day, Selected Producing Regions - Direct Normal (Tracking)/Total Incident (Tilted Panel Adjusted Monthly)**

	OMAHA (55)	EL PASO (87)	PHOENIX (87)	SANTA MARIA (101)
January	4.6/4.7	6.6/6.4	5.8/5.9	5.3/5.4
February	5.1/5.1	7.5/7.1	6.5/6.4	5.0/5.2
March	5.4/5.3	8.6/7.6	7.9/7.2*	7.1/6.7*
April	6.3/5.9	9.6/8.1*	9.3/7.9*	8.5/7.7*
May	6.5/6.0	10.7/8.5*	10.0/8.4*	9.1/8.9*
June	7.0/6.6	9.8/8.5*	9.3/8.1*	9.2/8.4*
July	7.2/6.7*	8.7/7.8*	8.6/7.7*	8.5/7.9*
August	7.3/6.3*	8.7/7.5*	7.7/7.0*	7.9/7.2*
September	5.8/5.5	7.7/6.9*	7.4/6.8*	7.2/6.7*
October	5.4/5.2	7.7/7.0	6.9/6.5*	7.0/6.6*
November	4.1/4.3	6.4/6.2	5.8/5.9	5.7/5.7
December	3.8/3.9	6.1/6.0	5.1/5.3	5.1/5.3

Source: 9

	OMAHA	EL PASO	PHOENIX	SANTA MARIA
a. Annual Insolation***	2040	2818	2639	2546
b. Insolation during Irrigation Season***	427	1555	1940	1908
c. Insolation during Crop Drying Season***	697	0	0	0
d. Irrigation Demand (kWH/acre)	164	495	2621	241
e. Crop Drying Demand (kWH/acre)	122	0	0	0
f. Peak kW Needed per Acre	0.384	0.318	1.35	0.126
g. Surplus Insolation (a-b-c)***	916	1264	699	638
h. Surplus kWH (g*f)	330	380	900	77

*Irrigation Season
**Defined by Water Resources Council
***These values for insolation represent the average of the Direct Normal and Total Incident presented in the table above. This was done so not to bias the results towards tracking or non-tracking systems, the average falls within ~ ± 5% of the two different systems.

TABLE VII. Incremental[1] Photovoltaic System Costs for Irrigation Utilization Exclusive of Arrays - AC Generation.

ITEM	PRICE ACHIEVABLE IN 1977 ($/kW-pk)	OPTIMISTIC PRICE IN 1986 ($/kW-pk)
Batteries[2]	$ 69[3]	$ 41[4]
Inverters[5]	255[6]	127[7]
Extra Pumps & Motors[8]	33	33
Generator[9]	-55	-55
Structure	500[10]	250[11]
Miscellaneous (wire, switch gear, battery shelter, etc.)	250	150
	$1052	$546

1. The costs shown are only those that would be incurred over what a conventionally powered irrigation system would require.
2. Battery requirements based on need of 21% of daily electric energy generation to smooth load to motor. Battery efficiency is 80%.
3. Battery cost is $50/kWH - replaced every seven years - salvage value is is 15%.
4. Battery cost is $30/kWH - replaced every 15 years - salvage value is 15%.
5. Inverters sized to 64% of peak array output due to batteries averaging the output over full day.
6. Based on $400/kVA - achievable at present with modest production run in 10 kVA to 100 kVA size range.
7. Based on $200/kVA - achievable in 1986 in large scale production run in 10 kVA to 100 kVA size range.
8. Based on pump system price (not counting well) of $77/HP (includes column, pump, bowl, motor, etc.). Further assumptions made were 1 kW needed to produce 1 HP (inefficiencies); HP requirement is 64% of peak kW generated because of battery smoothing; and one-third of cost eliminated because conventional system would require pump system sized at one-third solar pump system.
9. Based on present generator costs of $250/rated kW times ratio of average peak solar hours to daily hours (8.28/24.0) in summer times 64% due to battery smoothing.
10. Based on $50/meter installed.
11. Based on $25/meter installed.

TABLE VIII. Array Price* ($/pk kilowatt) vs Time

YEAR	PRICE
1976	$15,000
1977	10,000
1978	6,990
1979	4,800
1980	3,310
1981	2,310
1982	1,630
1983	1,170
1984	850
1985	640
1986	500

*This price functions represents a combination of flat plate and concentrator technologies. It passes through the 1976 price for flat plate arrays of $15,000, through the ERDA goal of $2000 for concentrator arrays in 1980-1982, and through the ERDA goal of $500 in 1986 for both flat plate and concentrator arrays. The algorithm used to represent this function until 1986 was:

$$P(\$/\text{pk kilowatt}) = 200 + 14800e^{-j/2.565}$$

where $j = 0$ in 1976

In the period between 1986 and 2000, the array price is expected to decrease further to between $100 and $300 per peak kilowatt. The algorithms used for this time period were:

$$\underline{P}(\$/\text{pk kilowatt}) = 300 + 14{,}700e^{-j/2.327}$$

where year 2000 goal is $300

and $j = 0$ in 1976

$$\underline{P}(\$/\text{pk kilowatt}) = 100 + 14{,}900e^{-j/2.764}$$

where year 2000 goal is $100

and $j = 0$ in 1976

TABLE IX

NEBRASKA SITE

20 YEAR INVESTMENT PERIOD

TARGETED PRICE FOR PANELS IN YEAR 2000 $/KW	INITIAL SUPPORT COST $/KW	ANNUAL RATE OF INCREASE OF FUEL COST	DISCOUNT RATE	a. COST-BENEFIT BASIS YEAR OF VIABILITY	b. COST-BENEFIT BASIS OPTIMAL YEAR	c. COMMERCIAL BASIS YEAR OF VIABILITY	d. COMMERCIAL BASIS OPTIMAL YEAR
100	546	.02	.03	1987	2000+	1986	2000+
			.05	1989	2000+	1987	1998
			.08	1992	2000+	1989	1997
		.04	.03	1985	2000+	1984	2000+
			.05	1986	2000+	1985	2000+
			.08	1987	1997	1986	1994
	1052	.02	.03	1994	2000+	1990	2000+
			.05	2000+	2000+	1995	2000+
			.08	2000+	2000+	2000+	2000+
		.04	.03	1987	2000+	1985	2000+
			.05	1989	2000+	1987	2000+
			.08	1992	2000+	1989	2000+
300	546	.02	.03	1988	2000+	1986	2000+
			.05	1991	2000+	1988	2000+
			.08	2000+	2000+	1993	2000+
		.04	.03	1985	2000+	1984	2000+
			.05	1986	2000+	1985	2000+
			.08	1988	2000+	1986	1997
	1052	.02	.03	2000+	2000+	1994	2000+
			.05	2000+	2000+	2000+	2000+
			.08	2000+	2000+	2000+	2000+
		.04	.03	1987	2000+	1985	2000+
			.05	1990	2000+	1987	2000+
			.08	1995	2000+	1991	2000+

TABLE X

TEXAS

20 YEAR INVESTMENT PERIOD

TARGETED PRICE FOR PANELS IN YEAR 2000 $/KW	INITIAL SUPPORT COST $/KW	ANNUAL RATE OF INCREASE OF FUEL COST	DISCOUNT RATE	a. COST-BENEFIT BASIS: YEAR OF VIABILITY	b. COST-BENEFIT BASIS: OPTIMAL YEAR	c. COMMERCIAL BASIS: YEAR OF VIABILITY	d. COMMERCIAL BASIS: OPTIMAL YEAR
100	546	.02	.03	1983	1996	1983	1995
			.05	1984	1992	1983	1991
			.08	1986	1991	1984	1990
		.04	.03	1982	2000+	1982	2000+
			.05	1983	1997	1982	1995
			.08	1984	1991	1983	1990
	1052	.02	.03	1985	2000+	1984	2000+
			.05	1986	1997	1985	1994
			.08	1989	1997	1987	1993
		.04	.03	1983	2000+	1982	2000+
			.05	1984	2000+	1983	2000+
			.08	1985	1994	1984	1992
300	546	.02	.03	1983	2000+	1983	1996
			.05	1984	1991	1983	1990
			.08	1986	1991	1984	1989
		.04	.03	1982	2000+	1982	2000+
			.05	1983	2000+	1982	1997
			.08	1984	1990	1983	1989
	1052	.02	.03	1985	2000+	1984	2000+
			.05	1986	2000+	1985	1995
			.08	1991	2000+	1987	1995
		.04	.03	1983	2000+	1982	2000+
			.05	1984	2000+	1983	2000+
			.08	1985	1997	1984	1992

TABLE XI

ARIZONA

20 YEAR INVESTMENT PERIOD

TARGETED PRICE FOR PANELS IN YEAR 2000 $/KW	INITIAL SUPPORT COST $/KW	ANNUAL RATE OF INCREASE OF FUEL COST	DISCOUNT RATE	a. COST-BENEFIT BASIS YEAR OF VIABILITY	b. COST-BENEFIT BASIS OPTIMAL YEAR	c. COMMERCIAL BASIS YEAR OF VIABILITY	d. COMMERCIAL BASIS OPTIMAL YEAR
100	546	.02	.03	1983	1995	1982	1994
			.05	1984	1991	1983	1990
			.08	1985	1991	1984	1989
		.04	.03	1982	2000+	1981	2000+
			.05	1983	1996	1982	1994
			.08	1984	1990	1983	1989
	1052	.02	.03	1984	2000+	1983	2000+
			.05	1986	1995	1984	1993
			.08	1988	1996	1986	1992
		.04	.03	1983	2000+	1982	2000+
			.05	1984	2000+	1983	2000+
			.08	1985	1994	1984	1991
300	546	.02	.03	1983	1998	1982	1994
			.05	1984	1991	1983	1989
			.08	1985	1990	1984	1989
		.04	.03	1982	2000+	1981	2000+
			.05	1983	2000+	1982	1996
			.08	1984	1990	1983	1989
	1052	.02	.03	1984	2000+	1983	2000+
			.05	1986	1999	1984	1993
			.08	1990	2000+	1986	1993
		.04	.03	1983	2000+	1982	2000+
			.05	1984	2000+	1983	2000+
			.08	1985	1995	1984	1992

TABLE XII

CALIFORNIA

20 YEAR INVESTMENT PERIOD

TARGETED PRICE FOR PANELS IN YEAR 2000 $/KW	INITIAL SUPPORT COST $/KW	ANNUAL RATE OF INCREASE OF FUEL COST	DISCOUNT RATE	a. COST-BENEFIT BASIS YEAR OF VIABILITY	b. COST-BENEFIT BASIS OPTIMAL YEAR	c. COMMERCIAL BASIS YEAR OF VIABILITY	d. COMMERCIAL BASIS OPTIMAL YEAR
100	546	.02	.03	1983	1995	1982	1994
			.05	1984	1991	1983	1990
			.08	1985	1991	1984	1989
		.04	.03	1982	2000+	1981	2000+
			.05	1983	1996	1982	1994
			.08	1984	1990	1983	1989
	1052	.02	.03	1984	2000+	1983	2000+
			.05	1985	1995	1984	1993
			.08	1988	1995	1986	1992
		.04	.03	1983	2000+	1982	2000+
			.05	1983	2000+	1983	2000+
			.08	1985	1993	1984	1991
300	546	.02	.03	1983	1997	1982	1994
			.05	1984	1991	1983	1989
			.08	1985	1990	1984	1988
		.04	.03	1982	2000+	1981	2000+
			.05	1983	1999	1982	1995
			.08	1984	1990	1983	1988
	1052	.02	.03	1984	2000+	1983	2000+
			.05	1985	1998	1984	1993
			.08	1989	2000+	1986	1992
		.04	.03	1983	2000+	1982	2000+
			.05	1983	2000+	1983	2000+
			.08	1985	1995	1984	1991

REFERENCES

1. Dvoskin, D. and Heady, E.O., "Energy Requirements of Irrigated Crops in the Western United States", Iowa State University, Center for Agricultural and Rural Development, Miscellaneous Report (Nov. 1976).

2. Energy Research and Development Administration, "An Economic Analysis of Solar Water and Space Heating", DSE-2322-1 (Nov. 1976).

3. Ferraro, A.G., "Valuation of Property Interests for Ad Valorem Taxation of Extractive Industry and Agricultural Realty", Arthur D. Lynn (ed), The Property Tax and Its Administration, (Madison: University of Wisconsin).

4. Griliches, Z., "Hybrid Corn and the Economics of Innovation", *Science* (July 29, 1960).

5. Lane, D.E., Fischbach, P.E., and Teter, N.C., "Energy Uses in Nebraska Agriculture", University of Nebraska-Lincoln College of Agriculture, CC255 (1973).

6. Sloggett, G., "Energy Used for Pumping Irrigation Water in the United States, 1974", paper presented at Conference on Energy in Agriculture, Washington University (June 17, 1976).

7. Weinstein, M.C. and Zeckhauser, R.J., "The Optimal Consumption of Depletable Natural Resources", *Quarterly Journal of Economics* (May 1975).

8. Council for Agricultural Science and Technology, "Energy in Agriculture", Report No. 14, Iowa State University (Nov. 1973).

9. Boes, E.C. et al, "Distribution of Direct and Total Solar Radiation for the USA", Sandia Laboratories, Albuquerque, N.M., SAND76-0411 (Aug. 1976).

APPENDIX

COMPUTER PROGRAM USED IN COMPUTATIONS

The computer program written in support of this study calculates the net benefit of solar photovoltaic systems in various years starting with the present (1977). Gross benefits are taken as savings in fossil fuels and maintenance of conventional pumping equipment. Costs are largely front end - investments in arrays and support facilities but take into account cycle battery replacement. Benefits are calculated both on a simple cost-benefit basis and on a commercially financed basis. All inputs-outputs and calculations are per acre.

An additional feature of the program determines the optimal year for investing in a photovoltaic system and then computes the size of a special one-time investment tax credit that would be needed to give the equivalent net benefit over some number of preceding years. That credit would be in addition to the 10% rate used in the computation.

Inputs of the program are described in their program listing. Additionally, amortization tables apply to the various discount rates are supplied in a separate file.

Outputs from the Program:

Each run of the program can handle several sites. For each site, calculations are done for each target price (NTARG), each support cost (NSUP) each discount rate (NDISC) and each fuel rate (NFUEL), giving a total of NTARG * NSUP * NDISC * NFUEL separate cases. For each individual case a table is printed giving for each potential investment year the costs, gross benefit, net benefit, net benefit brought forward to the present (1977), and the two net benefits on a commercially financed basis. Additionally, a tabulation of special tax credits for equivalent benefit is provided for NCRED years back from the optimal year. A table is built using the values for the special tax credit for the NCRED'th year from each case in the entire program run. The table is printed out at the end of the run in a form that shows how many cases fall into each 2-1/2% increment. This allows a quick reading of the effects of various sizes of changes in the one-time investment tax credit.

For each site two plots are produced as shown in Figures 2-5 and 6-9. One shows the behavior of the financed net benefit against time for a single case, chosen in the study presented here to be the most conservative. The program as now set up must be modified internally to change the chosen case; it is not parametrically determined.

The other plot is complex and presents a great deal of data on one page. The data derives from two cases for the site chosen as follows :

Case 1 - the first target price, support costs and associated values listed in the input parameters.

Case 2 - the last target price, support costs, etc.

The plot shows costs and net benefits for the two cases. If the order of the input data is chosen carefully, the cost curves can represent the most conservative and the most optimistic cases, so that all other cases for the site would lie between them. There is a benefit curve are for each fuel rate and discount rate combination used in the run. These are actually two superimposed sets in the plots presented in this paper; input values were chosen to make them coincide.

The program listing, a sample input file and a sample amortization are reproduced on the following pages.

```
C  NOTES CN PRCGRAMMING TECHNICUES - SUBSCRIPTED VARIABLES ARE COPIED
C  INTC  SCALAR VALUES AS EARLY AS POSSIBLE  TO SAVE RECALCULATION OF LO
C  CATION IN ARRAYS OF VALUES NEEDED REPEATEDLY IN INNER LOOPS. SIMILAR-
C  LY, CONSTANTS WITHIN A GIVEN LCCP ARE CALCULATED AS SOON AS
C  PCSSIBLE (FCR EXAMPLE - CONSK).
C  ALTHCOGH IN THE PRCBLEM SOME LOCPS RUN FROM J=0 TO J=NYRFWD,
C  IT IS NECESSARY IN ARRAY REFERENCES TO START THE ARRAYS AT SUBSCRIPT
C  1; SC LOOPS RUN FRCM 1 TC NYRFWD+1. THE CORRECT VALUE OF J IS
C  USEE IN EQUATIONS WHEN NEEDED.
C
      DIMENSION A(20),R(20),CPI(20),CPD(20),RP(20),RS(20),CM(20)
     *,NYEAR(51),TITLE(20),FUELGR(6),DISC(6),ARRAY(51),TOTCST(51),
     *BENFIT(51,6,6),PV(51,6,6),TARGPR(10),DISCPV(51,6,6),ATPV(51,6,6)
     *,ATDISC(51,6,6),DETSVC(6),ANTABL(31,6),ICRED(40),ICPTYR(6,6)
     *,TAXINC(10,6,6),PEYEAR(51),POSPV(51),SUPCST(6),LIFBAT(6),BATCST(6)
     *,TAU(10)
C  THE NEXT 2 ARRAYS NEEDED TC FAKE PLOT ROUTINES INTO ALLOWING ENOUGH
C RANGE CN PLCT TC ACCOMMODATE ALL DATA, NEXT ARRAY FOR PLOT TITLE
      DIMENSICN FAKEX(3),FAKEY(3)
      REAL*8 PTITL(8)/'PV SYSTE','M VS CCN','VTL AT  ',
     *'    TC ','    TARG',' PRICE, ','    TO ','     SUP'/
      DATA ICRED/40*0/,IPLOTS/0/
C  BENEFITS ANE PV'S STCRED IN SUBSCRIPT ORDER: (J,FUELRATE,DISCOUNT)
C  PGM HANDLES MAX 20 SITES, 50 YEARS FORWARD, 6 EACH- FUEL & DISC RATES
C ,SUPPORT ANE EATTERY CCSTS, EATTERY LIFETIMES, UPKEEP RATES,
C 10 YEARS EACK IN FIGURING ADDITIONAL TAX CREDIT INCENTIVES,
C 10 TARGET PRICES ANE ASSOCIATED TAUS
      REAL*8 CCST/' COST   '/,PVT/'  NET  '/,BENFTT/' BENEFIT'/,
     *YEAR/'  YEAR  '/,DISCNT/'DISCNT  '/,FULRT/'FUELRT  '/
     *,EL/'        '/,PRSNT/'TO PRSNT'/
C
C***********************************************************************
C DESCRIPTICN CF NAMELIST INPUTS:
C
C      A        PEAK KILCWATTS CF POWER REQUIRED PER ACRE FOR SITE
C      CPI      COST CF CONVENTIONAL FUEL FOR IRRIGATICN FOR SITE
C      CPD      COST CF CCNVENTIONAL FUEL FOR DRYING FOR SITE
C      RP       RESIDENTIAL PURCHASES FORGONE
C      RS       RESIDENTIAL SALES
C      CM       COST CF MAINTENANCE OF CONVENTIONAL SYSTEM FOR SITE
C      FUELGR   ANNUAL RATES OF GRCWTH FOR FUEL COSTS
C      NFUEL    NUMEER OF FUELGR VALUES TO USE IN PROGRAM RUN
C      DISC     DISCOUNT RATES
C      NDISC    NUMEER OF DISCOUNT RATES TO USE IN PROGRAM RUN
C      NSITE    NUMEER CF SITES TO STUDY IN PROGRAM RUN
C      NYRDSC   NUMEER OF YEARS OVER WHICH TO DISCOUNT CCSTS AND BENEFITS
C      NYRFWD   NUMBER CF YEARS STARTING AT 1977 TO RUN STUDY
C      TARGPR   ERDA YEAR 2000 TARGET PRICES FOR SOLAR PANELS
C      TAU      TARGET PRICE BASED CCNSTANTS FOR CALCULATING ARRAY
C               COSTS
C      NTARG    NUMBER CF TARGET PRICES AND TAU'S TO USE IN PROGRAM RUN
C      SUPCST   PHOTOVOLTAIC SYSTEM SUPPORT COSTS
C      LIFBAT   EATTERY LIFETIMES
C      BATCST   BATTERY REPLACEMENT COSTS
C      NSUP     NUMBER OF SETS CF VALUES OF SUPCST, LIFBAT AND BATCST
```

```
C              TC USE IN COMPUTER RUN
C     TAXRAT  MARGINAL INCOME TAX RATE PAID BY FARMER
C     DETSVC  DEBT SERVICE - FRACTION OF TOTAL COST TO REPAY EACH YEAR
C              FOR EACH DISCOUNT RATE
C     SIGMAY  SUM OF INTEGERS FROM 1 TO VALUE OF NYRDSC VALUE - USED IN
C              "SUM OF THE DIGITS" DEPRECIATION CALCULATION
C     NCRED   NUMBER OF YEARS OVER WHICH TO CALCULATE ADDITIONAL
C              ONE-TIME INVESTMENT TAX CREDIT FOR EQUIVALENT NET BENEFIT
C     UPKEEP  ANNUAL MAINTENANCE OF PHOTOVOLTAIC SYSTEM
C     IPLOTS  FLAG TO INDICATE IF PLOTS SHOULD BE MADE
C*************************************************************************
C  IN THE NAMELIST THE DEBT SERVICE RATES MUST BE PUT IN WITH CARE-
C  JUST THE VALUES FOR THE NUMBER OF YEARS DISCOUNTED SHOULD BE ENTERED
C
C  AND IN THE SAME ORDER AS THE DISCOUNT RATES THEY DERIVE FROM.
C THE TABLES READ IN ON DATA SET 1 SHOULD BE IN THE SAME ORDER AS THEIR
C ASSOCIATED DISCOUNT RATES.
C THE VALUES IN SUPCST, BATCST, LIFBAT AND UPKEEP REFERRING TO THE SAME
C RUNNING CASE SHOULD BE IN THE SAME ORDER IN THE INPUT.
C BECAUSE OF PLOTTING PECULIARITIES IN THE PRESENT SETUP THE TARGET
C PRICES SHOULD BE LISTED IN THE NAMELIST MONOTONICALLY.
C  SEE NOTES NEAR STATEMENT 600.
C*************************************************************************
      NAMELIST/CB/A,CFI,CFD,RP,RS,CM,FUELGR,DISC,NFUEL,NDISC,
     *NSITE,NYRDSC,NYRFWD,NTARG,TARGPR,SUPCST,LIFBAT,BATCST
     *,TAXRAT,DETSVC,SIGMAY,NCRED,UPKEEP,IPLOTS,NSUP,TAU
C
      READ (2,CB)
C  STORE YEARS FOR PRINTING
      NFD=NYRFWD+1
      DO 2 JT=1,NFD
      NYEAR(JT)=JT+1976
2     FPYEAR(JT)=FLOAT(NYEAR(JT))
C FOLLOWING STATEMENTS DOWN TO 3 ARE FOR PLOTTING
C INITIALIZE FOR PLOTTING IF PLOT FLAG ON
      IF (IPLOTS .EQ. 0) GO TO 3
      CALL MODESG
      CALL TEKZZ(2,0,0,1)
      CALL TEKSCH('SS')
C SET UP SOME OF FAKE ARRAY VALUES
      FAKEX(1)=FPYEAR(1)
      FAKEX(2)=FPYEAR(1)
      FAKEX(3)=FPYEAR(NFD)+2.
      FAKEY(1)=20000.
      FAKEY(2)=50.001
      FAKEY(3)=50.001
3     CONTINUE
C  READ IN AMORTIZATION TABLES
C (AMORT TABLES HAVE 1 MORE ENTRY THAN NO OF YEARS DISCOUNTED OVER:YR 0)
      NDSCY=NYRDSC+1
      DO 5 JT=1,NDISC
5     READ (1,9989) (AMTABL(I,JT),I=1,NDSCY)
C  OUTER LOOP - OVER SITES
      DO 800 K=1,NSITE
C  READ IN TITLE OF SITE K
```

```
      READ (2,9999) TITLE
      AA=A(K)
      CMCURR=CM(K)
C  FIGURE MAINTENANCE COST - UPKEEP IS DEPENDENT ONLY ON SUPPORT COSTS
C AND HAS BEEN FIGURED EXTERNALLY IN $/PEAK KW
      CONST2=CMCURR-UPKEEP*AA
      CONSK=CFI(K)+CPD(K)+RP(K)+RS(K)
C
C 2ND LOOP - ON NUMBER OF SUPPORT AND BATTERY COST LEVELS
      DO 700 ISUP=1,NSUP
C
C  3RD LOOP - ON TARGET PRICE
      DO 690 ITARG=1,NTARG
C  4TH LOOP - ON NUMBER OF YEARS OF STUDY. CALCS FOR ALL FUEL &
C  DISCOUNT RATES WILL BE DONE FOR EACH YEAR B4 GOING TO NEXT YEAR
      DO 200 JJ=1,NPD
      JJP1=JJ+1
C  CALC COST OF ARRAY
C IF YEAR OF STUDY IS 1986 OR BEFORE USE TAU & CONSTANTS BASED
C ON $200 TARGET PRICE. IF AFTER 1986 USE PROPER VALUES
      IF(JJ.LE. 10)CURARY=(200.+14800.*EXP(-FLOAT(JJ)/2.565))*AA/.9
      IF (JJ .GT. 10)
     *CURARY=(TARGPR(ITARG) + (15000.-TARGPR(ITARG))*EXP(-FLOAT(JJ)/
     *TAU(ITARG)))*AA/.9
      ARRAY(JJ)=CURARY
C  CALC OVERALL COST
      TOTCST(JJ)=CURARY+SUPCST(ISUP)*AA
C
C  CALC BENEFIT - 5TH LOOP STEPS THRU DISCOUNT RATES, 6TH LOOP THRU
C  FUEL COST RATES FOR EACH DISCOUNT RATE
      DO 200 ID=1,NDISC
      CURRAT=DISC(ID)
C  CALCULATE ANNUAL COST FOR FINANCED OPERATION
      ANNUAL=TOTCST(JJ)*DETSVC(ID)
      DO 200 IFL=1,NFUEL
      CURFUL=FUELGR(IFL)
C
C  7TH (INNERMOST) LOOP - ON NUMBER OF YEARS DISCOUNTED
      WORK=0.
      JEND=JJ+NYRDSC
      DO 100 JT=JJP1,JEND
C  THE NEXT INSTR  RECREATE THE VALUE OF J (IN FLOATING PT)
      T=FLOAT(JT-1)
C  CALCULATE BENEFIT - DECIDE WHETHER THIS IS A BATTERY REPLACEMENT YEAR
C  AND ADD IN IF NEEDED
      TEMP=CONSK*EXP(CURFUL*T)+CONST2
C  TEST FOR BATTERY REPLACEMENT TIME. TEST USES MOD FUNCTION
C  WHICH RETURNS REMAINDER AFTER DIVIDING VARIABLE BY THE CONSTANT
C (I E BATTERY LIFE). WHENEVER THE REMAINDER = 0  A LIFETIME HAS PASSED.
      IF (MOD(JT-JJ,LIFBAT(ISUP)) .EQ. 0) TEMP=TEMP-BATCST(ISUP)*AA
100   WORK=WORK+TEMP/EXP(CURRAT*(JT-JJ))
      BENFIT(JJ,IFL,ID)=WORK
      BV(JJ,IFL,ID)=WORK-TOTCST(JJ)
C  CALCULATE BV ON A FINANCED BASIS.
C  5 TERMS ARE USED IN THE CALCULATION.
```

```
C  TERM 1. NET BENEFIT AFTER TAXES.
      TERM1=(1.-TAXRAT)*WORK
C  TERM 2. INTEREST EXPENSE - NOT TAXED.
      TERM2=0.
      DO 12C JT=JJP1,JEND
      IT=JT-JJ
C  LOOK UP INTEREST. AMORT TABLES GIVE CHANGE IN UNPAID PRINCIPAL FROM
C  YEAR TO YEAR. INTEREST= TOTAL ANNUAL PAYMENT - CHANGE IN UNPAID BAL-
C  ANCE FROM YEAR TO YEAR. IT RUNS FROM 0 TO NYRDSC BUT AMTABL DATA
C  IS STORED IN MEMBERS 1 THRU NYRDSC+1, HENCE OFFSETS IN SUBSCRIPTS
      AMORT=AMTABL(IT,ID)-AMTABL(IT+1,ID)
      WORKA=ANNUAL-AMORT*TOTCST(JJ)
12C   TERM2=TERM2+WORKA/EXP(CURRAT*FLOAT(IT))
      TERM2=TERM2*(1.-TAXRAT)
C  TERM 3. SAVING FOR TAX NOT PAID ON DEPRECIATION. DEPR. METHOD USED
C  IS 'SUM OF YEARS DIGITS'
      TERM3=0.
      DO 14C JT=JJP1,JEND
      IT=JT-JJ
C  FIGURE DEPRECIATION FOR THE YEAR.
      DEPREC=FLOAT(NYRDSC+1-IT)*TOTCST(JJ)/SIGMAY
14C   TERM3=TERM3 + DEPREC/EXP(CURRAT*FLOAT(IT))
      TERM3=TERM3*TAXRAT
C  TERM 4. AMORTIZATION - COMES DIRECTLY OFF OF NET BENEFIT
      TERM4=0.
      DO 16C JT=JJP1, JEND
      IT=JT-JJ
      AMORT=AMTABL(IT,ID)-AMTABL(IT+1,ID)
16C   TERM4=TERM4 + AMORT*TOTCST(JJ)/EXP(CURRAT*FLOAT(IT))
C  TERM 5. ONE SHOT INVESTMENT CREDIT
      TERM5=TOTCST(JJ)*.1
C  FIGURING ALL THE TERMS UP :
      ATPV(JJ,IFL,ID)=TERM1 - TERM2 + TERM3 - TERM4 +TERM5
C
C  NOW DISCOUNT BOTH PV'S BACK TO THE PRESENT
      DISCPV(JJ,IFL,ID)=PV(JJ,IFL,ID)/EXP(CURRAT*JJ)
200   ATDISC(JJ,IFL,ID)=ATPV(JJ,IFL,ID)/EXP(CURRAT*JJ)
C
C FIND OPTIMUM YEAR FOR INVESTMENT, FROM THAT FIGURE ADDITIONAL TAX IN-
C CENTIVE REQUIRED TO BRING YEAR OF INVESTMENT FORWARD 1 THRU NCRED
C YEARS. ALSO FOR THE NCRED'TH YEAR SAVE A TABLE OF HOW MANY CASES FALL
C INTO 'BUCKETS' SPANNING .025 IN ADDITIONAL RATE(FOR HISTOGRAMS).
      DO 40C ID=1,NDISC
      DO 40C IFL=1,NFUEL
C FIND OPTIMUM (MAX) YEAR
      LL=C
      OPTBEN=-1.E10
      DO 3C4 JJ=1,NFD
      IF(ATDISC(JJ,IFL,ID) .LE. OPTBEN) GO TO 304
      LL=JJ
      OPTBEN=ATDISC(JJ,IFL,ID)
3C4   CONTINUE
      IOPTYR(IFL,ID)=LL+1976
C FIGURE TAX INCENTIVES FOR NCRED YEARS BACK-MAX NO YEARS IS TO 1977
      I=MINO(LL,NCRED)
```

```
      DO 320 I=1,L
320   TAXINC(I,IFL,ID)=(OPTBEN-ATDISC(LL-I,IFL,ID))/TOTCST(LL-I)
C IF L = NCRED, ASSIGN INCENTIVE RATE TO 2.5% SIZE BUCKETS
      I=(TAXINC(L,IFL,ID)-.0001)/.025 + 1
400   ICRED(I)=ICRED(I)+1
C
C  DO PRINTOUT FOR SITE K
C  WILL HANDLE ONLY 2 FUEL RATES      HF 4/15/77
      I=1
      DO 600 L=1,NDISC,I
      II=I
C  CALC NO OF COLUMNS ON SHEET - MAX 12 + COST AND YEAR COLUMNS
      NCCL=NFUEL*I
      NC=NCCL-1
C  WRITE TITLE, HEADINGS
      WRITE (8,9998) TITLE
      WRITE (8,99975) NYRDSC,TARGPR(ITARG),AA,CMCURR, CFI(K),CFD(K),
     *RF(K),RS(K),SUPCST(ISUP),BATCST(ISUP),LIFBAT(ISUP),TAXRAT,UPKEEP
     *,NYEAR(1),(ARRAY(J),J=1,NFD)
      IF (I .EQ. 1) WRITE (8,9997) DISCNT,(DISC(L),J=1,NFUEL)
      IF (I .EQ. 1) GO TO 425
      II=I+1
      WRITE (8,9997) DISCNT,(DISC(L),J=1,NFUEL),(DISC(II),J=1,NFUEL)
425   WRITE (8,9996) (EI,J=1,NC)
      WRITE (8,9997) FULRT,((FUELGR(J),J=1,NFUEL),JJ=1,I)
      WRITE (8,9996) (EI,J=1,NC)
      WRITE (8,99948)
      WRITE (8,99945)
      WRITE (8,9994) YEAR,(BENFTT,PVT,PRSNT,PVT,PRSNT,J=1,NCOL), COST
      WRITE (8,9995) (BL,BL,BL,BL,BI,J=1,NCOL), BL
      WRITE (8,9990)
C  WRITE OUT TABLE OF BENEFIT & PV VALUES.
      DO 500 JJ=1,NFD
500   WRITE (8,9993)NYEAR(JJ),((BENFIT(JJ,IFL,ID),PV(JJ,IFL,ID),
     *DISCPV(JJ,IFL,ID),ATPV(JJ,IFL,ID),ATDISC(JJ,IFL,ID),
     *IFL=1,NFUEL),ID=L,II),TOTCST(JJ)
C
C WRITE OUT OPTIMUM BUY YEAR, TAX CREDIT ADDITION TABLE
      WRITE (8,9987) ((IOPTYR(IFL,ID),IFL=1,NFUEL),ID=L,LL)
      WRITE(8,9986) NCRED
      DO 550 JJ=1,NCRED
550   WRITE(8,9985) ((JJ,TAXINC(JJ,IFL,ID),IFL=1,NFUEL),ID=L,LL)
600   CONTINUE
C MAKE PLOTS OF COSTS VS TIME - 1 PLOT PER SITE. EACH PLOT SHOWS
C PV'S FOR EACH DISCOUNT RATE AT EACH FUEL RATE SHOWN WITH 2 TOTAL COST
C CURVES - 1 AT THE 1ST TARGET PRICE & SUPPORT COSTS GIVEN IN THE NAME-
C LIST AND 1 AT THE LAST TARGET PRICE & SUPPORT COSTS.
C THE IDEA IS TO SHOW THE EXTREMES OF BOTH KINDS OF COSTS AND
C CARE SHOULD BE TAKEN TO ORDER THE SUPPORT COST RELATED VALUES
C AND TARGET PRICES SO THAT THE ONES THAT HAVE THE EFFECT OF
C GIVING TH LOWEST OR HIGHEST COSTS APPEAR IN THE SAME RUNNING
C CASE TOGETHER.
C Y AXIS LOGARITHMIC
      IF (ITARG .EQ. 1 .AND. ISUP .EQ. 1) GO TO 602
C     IF (ITARG .EQ. 1 .AND. ISUP .EQ. NSUP) GO TO 602
```

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C     IF (ITARG .EQ. NTARG .AND. ISUP .EQ. 1) GO TO 608
      IF (ITARG .EQ. NTARG .AND. ISUP .EQ. NSUP) GO TO 608
      GO TO 690
C SET PLOT MODE LOG IN Y
607   CALL SETSMG(24,1.)
      IF (ITARG .EQ. 1) PAUSE 12345
C ONLY 1 CALL TO GRAPHG - 1ST TIME THRU FOR SITE AT CURRENT SUPPORT COST
      IF (ITARG .NE. 1) GO TO 608
      CALL FMTSG(2,4,0,TARGPR(ITARG),PTITL(4))
      CALL FMTSG(2,4,0,TARGPR(NTARG),PTITL(5))
      CALL FMTSG(2,5,0,SUPCST(ISUP),PTITL(7))
      CALL FMTSG(2,5,0,SUPCST(NSUP),PTITL(8))
      CALL SETSMG(102,50.)
      CALL SETSMG(103,50.)
      CALL GRAPHG(3,FAKEX,FAKEY,40,TITLE(6),17,'POWER SYSTEM COST',
     *64,PTITL,'I','TIC')
C PLOT ONLY COST CURVE FROM 1ST OR LAST TARGET PRICE
608   CALL LINESG(NFD,FFYEAR,TCTCST)
C PLOT ONLY BENEFITS FROM 1ST TARG & SUP OR FROM LAST TARG & SUP
      IF(ITARG .EQ. 1 .AND. ISUP .EQ. 1) GO TO 610
      IF(ITARG .EQ. NTARG .AND. ISUP .EQ. NSUP) GO TO 610
      GO TO 690
610   DO 680 IFL=1,NFUEL
C SET LINE TEXTURE TO DIFFERENT LENGTH DASHES FOR EACH FUEL RATE
      CALL SETSMG(31,FLCAT(IFL))
C PLOT SETS OF LINES FOR ALL DISCOUNT RATES UNDER THIS FUEL RATE
C PLOT ONLY PTS WHERE PV IS OVER 100 - CONVERT PV'S SO ALL VALS UNDER 50
C ARE RESET TO SLIGHTLY OVER 50.0 (TO PLEASE THE LOG ROUTINE & TO CUT
C DOWN THE NUMBER OF CYCLES ON PLOT Y AXIS)
      DO 660 ID=1,NDISC
      DO 645 JJ=1,NFD
645   POSPV(JJ)=AMAX1(50.001,BENFIT(JJ,IFL,ID))
660   CALL LINESG(NFD,FFYEAR,POSPV)
680   CONTINUE
C RESET TO SOLID LINE PLOTS
      CALL SETSMG(31,0.)
C ONLY FINISH OFF PLOT AFTER ALL CASES ARE IN
690   CONTINUE
700   CONTINUE
      CALL FIIFRG(1)
C RESET TO NON-LOGARITHMIC
      CALL SETSMG(24,0.)
C THIS SECTION IS VERY SPECIFIC TO A LINCOLN CASE AND SHOULD BE ELIMINAT
C ED FROM THE GENERAL PURPOSE PROGRAM - FROM THIS COMMENT TO 740
C PLOT FINANCED PV BROT FORWARD TO PRESENT FOR MOST CONSERVATIVE CASE-
C TARGET PR=300,SUPPORT CODST=1052,DISCNT RATE=.08, FUEL RATE=.02.
C PLOT WILL BE MADE ONLY IF PLOT FLAG ON
      IF(IPLOTS .EQ.0) GO TO 800
      IF(TARGPR(ITARG) .NE. 300) GO TO 800
C LOCATE SUBSCRIPTS FOR WANTED FUEL & DISC RATES.
      DO 710 IFL=1,NFUEL
      IF(FUELGR(IFL) .EQ. .02) GO TO 715
710   CONTINUE
      GO TO 800
715   DO 720 ID=1,NDISC
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      IF(DISC(ID) .EQ. .08) GO TO 725
720   CONTINUE
      GO TO 800
725   DO 728 JJ=1,NFD
728   POSPV(JJ)=AMAX1(-1000.,ATDISC(JJ,IPL,ID))
      CALL GRAPHG(NFD,FPYEAR,POSPV(1),38,'YEAR OF STUDY - MOST CONSERVAT
     *IVE CASE',40,
     *'DOLLARS/ACRE, COMMERCIAL BROUGHT FORWARD',40,TITLE(6),'L')
      CALL FILPRG(1)
740   CONTINUE
800   CONTINUE
C
C WRITE OUT CONTENTS OF TAX CREDIT COUNTS. REUSE 'ARRAY' AND
C TOTCST ARRAYS
C SET UP HEADINGS FIRST, THEN WRITE HEADINGS, THEN DATA.
      TOTCST(1)=0.
      DO 950 I=1,16
      ARRAY(I)=.025*I
950   TOTCST(I+1)=ARRAY(I)
      WRITE(6,9984)  (TOTCST(I),ARRAY(I),I=1,16)
      WRITE(8,9984)  (TOTCST(I),ARRAY(I),I=1,16)
      WRITE  (6,9983)  (ICRED(I),I=1,16)
      WRITE  (8,9983)  (ICRED(I),I=1,16)
      JJ=0
      DO 960 I=17,40
960   JJ=JJ+ICRED(I)
      IF (JJ .EQ. 0) GO TO 990
      WRITE (6,9982) JJ
      WRITE (8,9982) JJ
990   IF (IPICTS .NE. 0) CALL EXITG
      RETURN
C
9999  FORMAT (20A4)
9998  FORMAT ('1',20A4/)
99975 FORMAT(' DISCOUNTED OVER ',I2,' YEARS'/
     *,' TARGET PRICE = ',F4.0,'  A = ',F5.2,' CM = ',F4.0,' CFI = ',
     *F6.2,' CFD = ',F5.2,' RP = ',F6.4,' RS = ',F7.4/' SUPPORT COST = '
     *,F6.0,'    BATTERY COST = ',F4.0,'    BATTERY LIFE =',I2,' YEARS',
     *'    TAX RATE = ',F3.2,'    UPKEEP= ',F6.2/
     *' ARRAY COST BY YEAR STARTING IN ',I4/
     *6(10(2X,F8.2)/))
9997  FORMAT (/1X,A6,8X,6(F4.2,46X))
9996  FORMAT ('+',7X,6(18('_'),A2,30X))
9995  FORMAT ('+ ____',12(A2,8('_')),A2,5('_'))
99948 FORMAT(//48X,'FINANCED',42X,'FINANCED')
99945 FORMAT(28X,'NET DISC  FINANCED  NET DISC',22X,
     *'NET DISC  FINANCED  NET DISC')
9994  FORMAT (A8,12(A8,2X),A5)
9993  FORMAT (2X,I4,12(2X,F8.2),2X,F5.0)
9990  FORMAT (/)
9989  FORMAT (12(F5.4,1X))
9987  FORMAT(////'  OPTIMUM YEAR TO BUY ON FINANCED BASIS:'/30X,I4,36X,I
     *4)
9986  FORMAT(/'    ADDITIONAL TAX CREDIT NEEDED TO MOVE BUY YEAR BACK 1
     * THRU',I3,' YEARS AS A PROPORTION OF COST FOR THAT YEAR'/
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     *28X,'NO. YRS  CREDIT',25X,'NO. YRS  CREDIT'/)
9985  FORMAT(31X,I2,5X,F3.2,30X,I2,5X,F3.2)
9984  FORMAT ('1'/8(1X,F4.3,'-',F4.3))
9983  FORMAT(/8(4X,I2,4X))
9982  FORMAT (' OVER .4 :',I3)
      END
```

SAMPLE AMORTIZATION TABLE FILE

```
1.000 .9635 .9258 .8871 .8471 .8060 .7636 .7200 .6751 .6288 .5811 .5320
.4814 .4293 .3757 .3204 .2635 .2048 .1444 .0822 .01821.0000 .9635 .9258
1.000 .9701 .9387 .9057 .8710 .8345 .7962 .7559 .7136 .6690 .6222 .5730
.5213 .4669 .4098 .3497 .2866 .2202 .1504 .0771 .0000
1.000 .9789 .9560 .9312 .9043 .8753 .8438 .8097 .7727 .7327 .6894 .6425
.5917 .5367 .4771 .4125 .3426 .2669 .1849 .0962 .0000
```

SAMPLE INPUT FILE

```
 &CB A=.384,.318,1.35,.126,CFI=7.305,22.095,117.09,10.77,
 CFD=2.44,0.,0.,0.,BP=2.88,1.7125,1.1375,1.1375,RS=8.80,7.36,18.42,1.16,
CM=1.46,4.42,23.42,2.15,
 NTARG=2,TARGPR=100.,300.,TAU=2.764,2.327,
 NSUP=2,BATCST=59.,59.,LIFBAT=7,7,SUPCST=546.,1052.,UPKEEP=13.0,
 NFUEL=2,FUELGR=.02,.04,
 NDISC=3,DISC=.03,.05,.08,DETSVC=.066552,.08025,.10186,
 NSITE=4,NYRDSC=20,SIGMAY=210.,NYRFWD=23,NCRED=5,TAXRAT=0.2,IPLOTS=1 &END
                                           NEBRASKA
                                           TEXAS
                                           ARIZONA
                                           CALIFORNIA
```