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# Financing End-Use Solar Technologies in a Restructured Electricity Industry: Comparing the Cost of Public Policies



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# Abstract

Renewable energy technologies are capital intensive. Successful public policies for promoting renewable energy must address the significant resources needed to finance them. Public policies to support financing for renewable energy technologies must pay special attention to interactions with federal, state, and local taxes. These interactions are important because they can dramatically increase or decrease the effectiveness of a policy, and they determine the total cost of a policy to society as a whole.

This report describes a comparative analysis of the cost of public policies to support financing for two end-use solar technologies: residential solar domestic hot water heating (SDHW) and residential rooftop photovoltaic (PV) systems. The analysis focuses on the cost of the technologies under five different ownership and financing scenarios. Four scenarios involve leasing the technologies to homeowners in return for a payment that is determined by the financing requirements of each form of ownership. For each scenario, we examine nine public policies that might be used to lower the cost of these technologies: investment tax credits (federal and state), production tax credits (federal and state), production incentives, low-interest loans, grants (taxable and two types of nontaxable), direct customer payments, property and sales tax reductions, and accelerated depreciation.

Five major findings emerge from our analysis:

1. The cost of public policies to promote SDHW and PV technologies is lowest for ownership and financing scenarios that are already at or close to the levels targeted by the policies (e.g., homeowner financing and publicly owned utility financing).

2. Subsidies are more effective for the three equipment-leasing scenarios in which the equipment owners pay taxes (i.e., all but the publicly owned utility) than they are for the homeowner financing scenario because tax effects are multiplied for commercial entities. Nevertheless, the costs of policies for commercial entities is still higher than for comparable policies targeting homeowners who are financing systems on their own.

3. Consideration of indirect costs is important because many policies simply involve revenue transfers among the federal, state, and local governments. For all policies, the inclusion of indirect costs reduces or eliminates many of the apparent differences in direct costs. We show that a more politically attractive policy with low direct cost may, in fact, be identical in total cost to a less politically attractive policy with higher direct cost.

4. Including indirect costs is important for capturing the total costs of the policies. Under the homeowner financing scenario, indirect costs are not additional costs, but offset some direct costs. Under the three equipment leasing scenarios in which the equipment owners pay taxes, the inclusion of indirect costs makes policies more expensive than their direct cost.

5. The total cost of a policy is determined by the time period over which subsidies are paid out. Under the homeowner financing scenario, subsidies paid out over a longer term (direct customer payment, production incentives or tax credits) were lower in cost than subsidies paid up-front (investment tax credits, grants). Under the equipment leasing financing and ownership scenarios, subsidies paid up-front were lower in cost than those paid out over time.

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# Acronyms and Abbreviations

| | |
|---|---|
| A&E | Architectural and engineering |
| AMT | Alternative Minimum Tax |
| C&I | Commercial and industrial |
| CEC | California Energy Commission |
| DSCR | Debt service coverage ratio |
| EAG | Energy Alliance Group |
| EPAct | Energy Policy Act |
| IOU | Investor-owned utility |
| ITC | Investment tax credit |
| MACRS | Modified accelerated cost recovery system |
| NUD | Non-utility developer |
| O&M | Operation and maintenance |
| POU | Publicly owned utility |
| PTC | Production tax credits |
| PV | Rooftop residential photovoltaic system |
| REPI | Renewable Energy Production Incentive |
| ROE | Return on equity |
| SDHW | Solar domestic hot water heating system |
| SMUD | Sacramento Municipal Utility District |
| WACC | Weighted average cost of capital |

# Executive Summary

Electricity industry restructuring requires policymakers to re-evaluate public policies for promoting renewable energy. Current policies were developed when the electricity industry was dominated by vertically integrated firms with retail monopoly franchises. Restructuring is rapidly changing this situation. Several states are considering or have adopted new public policies to continue support for renewable energy during industry restructuring.

This report describes a comparative analysis of the cost of public policies to support financing for two end-use solar technologies: residential solar domestic hot water heating (SDHW) and residential rooftop photovoltaic (PV) systems. The analysis focuses on the cost of the technologies under five different ownership and financing scenarios, including:

- Homeowners using a home-equity loan
- Investor-owned utilities using the traditional revenue requirement approach
- Publicly owned utilities using the traditional revenue requirement approach
- Third-party, non-utility developer (NUD) using corporate financing
- Third-party, non-utility developer (NUD) using project financing

The final four scenarios involve leasing the technologies to homeowners in return for a payment that is determined by the financing requirements of each form of ownership. Equipment leasing to homeowners could be an important option for lowering the costs of renewable energy technologies because commercial developers are eligible for tax and other policy benefits that are not available to homeowners.

Our results confirm that the current costs of SDHW and especially PV, are generally higher than current retail electricity prices. With respect to ownership and financing, it is generally cheaper for homeowners to finance the purchase of the technologies with a home equity loan rather than to lease them—contrary to our initial expectations—because the equipment leasing scenarios had more expensive financing requirements. The one exception is when publicly owned utilities lease solar domestic hot water heating equipment, which is cost-competitive at current retail electricity prices.

In order to highlight the differences in cost caused by the financing requirements for each ownership scenario, we fixed other costs, such as the installed cost and operation and maintenance costs of the technologies. However, some believe that economies of scale may be associated with centralized purchase and operation of end-use solar technologies rather than individual purchase and operation.

**Table ES-1. The Economics of Residential End-Use Solar Technologies**

| Ownership/Financing Scenarios | | Solar Domestic Hot Water Real Levelized Price (¢/kWh) | Photovoltaic Real Levelized Price (¢/kWh) |
|---|---|---|---|
| Homeowner Financing | | 11.3 | 21.0 |
| Equipment Leasing | Investor-Owned Utility | 13.5 | 27.3 |
| | Publicly Owned Utility | 8.6 | 15.2 |
| | Nonutility Developer, Corporate Financed | 12.3 | 24.6 |
| | Nonutility Developer, Project Financed | 17.3 | 43.1 |

To explore this issue, we present, in compact format, the results of an extensive sensitivity analysis of our assumptions. From these results, the reader can easily determine how costs would change if the following assumptions were to change: saved energy (capacity factor), installed cost, debt rate, equity rate, technology lifetime, property tax, lease price escalation rate, sales tax, O&M expense, minimum debt service coverage ratio, debt term, federal income tax rate, equity fraction, or state income tax rate. Results indicate that installed costs or O&M costs would have fall dramatically for the equipment leasing scenario costs to be equal to those for the homeowner financing scenario.

After analyzing SDHW and PV costs, we examined nine public policies that might be used to lower the cost of these technologies: investment tax credits (federal and state), production tax credits (federal and state), production incentives, low-interest loans, grants (taxable and two types of nontaxable), direct customer payments, property and sales tax reductions, and accelerated depreciation. To facilitate comparisons among the policies, we calculated how much each would cost if it lowered the cost of the technologies to a predetermined amount ($0.10/kWh for SDHW and $0.15/kWh for PV).

We calculated the costs of the policies in two ways. First, we calculated the direct cost of each policy, which is the amount of money that the policy provides directly to an owner or developer. Second, because the policies interact in subtle ways with taxes paid by owners or developers, we calculated the effect of each policy on the amount of tax paid to federal, state, and local governments. Accounting for both direct and indirect costs provides a more complete measure of the policies' total cost to society. Figure ES-1 summarizes our PV findings for homeowners, and Figure ES-2 summarizes our PV findings for non-utility developers using corporate financing.

**Figure ES-1. Cost of Policies to Reduce the Cost of PV to 15¢/kWh for Homeowners**

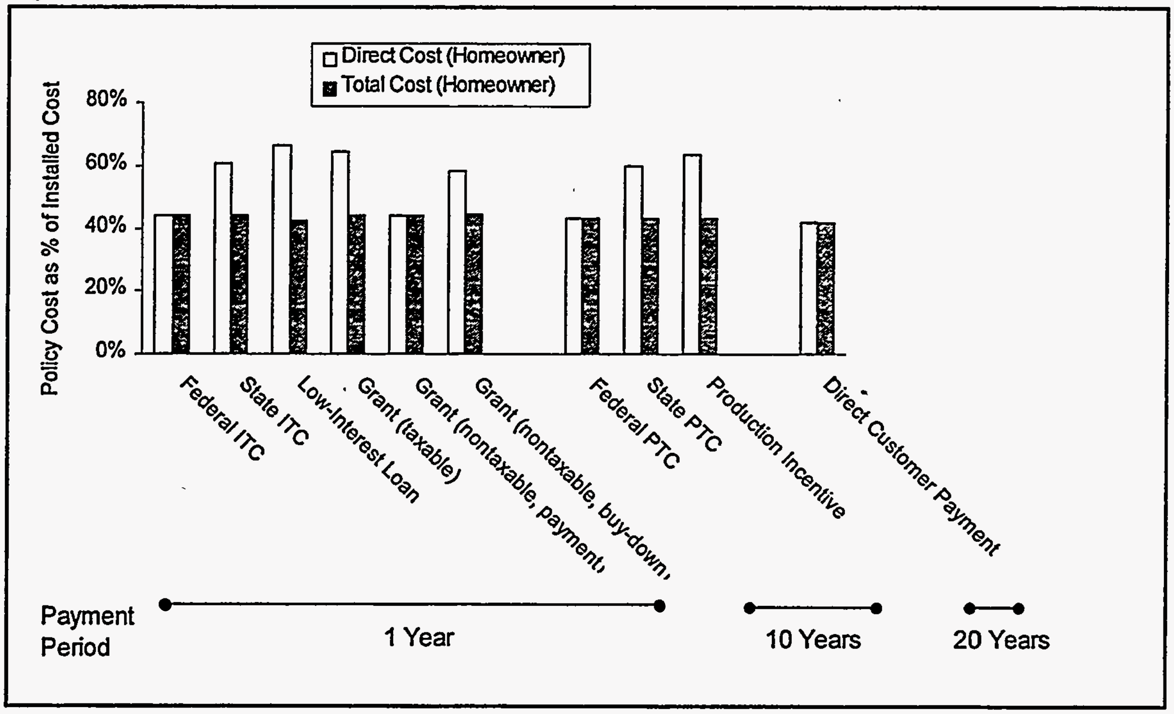
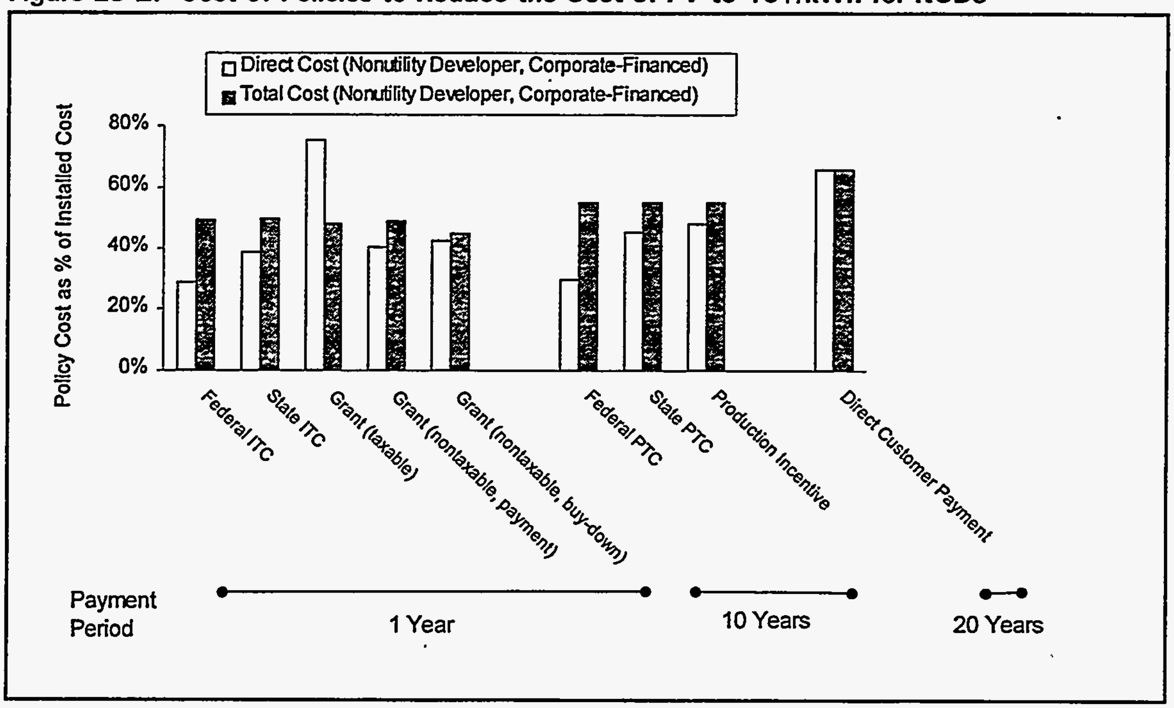



**Figure ES-2. Cost of Policies to Reduce the Cost of PV to 15¢/kWh for NUDs**



These five major findings emerge from our policy analysis:

1. The cost of public policies to promote SDHW and PV technologies is lowest for ownership and financing scenarios that are already at or close to the levels targeted by the policies (e.g., homeowner financing and publicly owned utility financing).

2. Subsidies are more effective for the three equipment-leasing scenarios in which the equipment owners pay taxes (i.e., all but the publicly owned utility) than they are for the homeowner financing scenario because tax effects are multiplied for commercial entities. Nevertheless, the costs of policies for commercial entities is still higher than for comparable policies targeting homeowners who are financing systems on their own.

3. Consideration of indirect costs is important because many policies simply cause revenue transfer among the federal, state, and local governments. For all policies, the inclusion of indirect costs reduces or eliminates many of the apparent differences in direct costs. We show that a more politically attractive policy with low direct cost may, in fact, be identical in total cost to a less politically attractive policy with higher direct cost.

4. Including indirect costs is important for capturing the total costs of the policies. Under the homeowner financing scenario, indirect costs are not additional costs, but offset some direct costs. Under the three equipment leasing scenarios in which the equipment owners pay taxes, the inclusion of indirect costs makes policies more expensive than their direct cost.

5. The total cost of a policy is determined by the time period over which subsidies are paid out. Under the homeowner financing scenario, subsidies paid out over a longer term (direct customer payment, production incentives or tax credits) were lower in cost than subsidies paid up-front (investment tax credits, grants). Under the equipment leasing financing and ownership scenarios, subsidies paid up-front were lower in cost than those paid out over time.

This last finding has important implications for discussions about the incentive properties of policies for the equipment leasing ownership and financing scenarios. Some argue that policies that feature up-front payments provide poor incentives compared to policies that link payments to the output of the solar technologies. We have shown that policies that link payment to output can be more costly (under the equipment leasing financing scenarios). By quantifying the additional costs of policies that link payment to output, the trade-offs among incentives/disincentives and the costs of policies can be identified.

Renewable energy technologies are capital intensive. Successful public policies for promoting renewable energy must address the significant resources needed to finance them. Public policies to support financing for renewable energy technologies must pay special attention to interactions with federal, state, and local taxes. These interactions are important because they can dramatically increase or decrease the effectiveness of a policy, and they determine the total cost of a policy to society as a whole.

# Introduction

Electricity industry restructuring requires policymakers to re-evaluate existing and consider new public policies for promoting renewable energy. Current policies were developed when the electricity industry was dominated by vertically integrated firms with retail monopoly franchises. Restructuring is rapidly changing this situation. Several states are considering or have adopted explicit public policies to continue supporting renewable energy. Wires charges, in particular, have received significant attention as a promising approach to underwrite the cost of and provide marketing support for renewable energy projects (CEC 1997).

This report describes a comparative analysis of the cost of public policies to support financing for two end-use solar technologies: residential solar domestic hot water heating (SDHW), and rooftop residential photovoltaic (PV) systems. We calculate the cost of the technologies under five different ownership and financing scenarios, including:

- Homeowners using a home-equity loan
- Investor-owned utilities using the traditional revenue requirement approach
- Publicly owned utilities using the traditional revenue requirement approach
- Third-party, non-utility developer (NUD) using corporate financing
- Third-party, non-utility developer (NUD) using project financing

The last four of these scenarios involve leasing the technologies to homeowners in return for a payment that is determined by the financing requirements of each form of ownership. Equipment leasing represents a potentially important way to lower costs, because commercial developers are eligible for many tax and other policy benefits that may not be available to homeowners.

We consider both existing public policies, such as enhanced federal and state investment tax credits or production incentives, as well as new policies, such as reliance on wires charges to support low-interest loans, grants, or direct payments to homeowners. Policies that do not influence financing directly, such as renewable portfolio standards, net metering, and green marketing, are not included in our analysis. However, our approach provides a logical starting point for discussing them. As an example of this linkage, we include an appendix that describes the implications of our approach for net metering policies.

We rely on pro-forma, cash-flow spreadsheet models to determine the cost to homeowners of developing the technologies under different policies and ownership and financing scenarios. We express costs on a levelized basis in units of $/kWh, which represents the cost to the homeowner of the energy used displaced by the end-use solar technology.[1] The difference between this cost and the effective retail price of electricity[2] provides an estimate of the price premium required of a homeowner to acquire the technology.[3] In the context of restructuring, this price premium also represents an estimate of the costs that funds from a wires charge or some other public policy could be used to "buy down."[4] We estimate the direct cost of these policies, as well as their net impact on federal, state, and local government revenues.[5]

Our findings rely on system performance and current economic conditions drawn from the central valley in California. However, we have designed our analysis tools to accommodate a wide variety of input assumptions regarding the performance and cost of end-use solar technologies, current and future public policies to promote their adoption, and the economic environment in which the technologies and policies will operate. Our findings, therefore, should be regarded as illustrative of these capabilities.

This report is organized as follows. In Chapter 2, we document the development of the initial assumptions used and the ownership and financing scenarios created to examine the economics of end-use solar technologies. In Chapter 3, we present our initial findings on the cost of the technologies to homeowners and determine the relative importance of the uncertainties inherent in our assumptions through a sensitivity analysis. In Chapter 4, we identify current and proposed public policies to promote end-use solar technologies and analyze their effectiveness in lowering the cost of end-use solar technologies to homeowners. In Chapter 5, we compare the direct and total cost of these policies for lowering the cost of the technologies to pre-determined levels. In Chapter 6, we summarize our findings and discuss their significance and limitations. More detailed discussion of selected topics is contained in five appendices, which follow the references: Appendix A contains detailed

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1 SDHW can displace either electric or non-electric domestic hot water heating fuels. Our results suggest that the economics of SDHW are more favorable for systems that displace electricity. Hence, we have chosen to focus on SDHW from the standpoint of the electricity use that they could displace.

2 The effective retail price of electricity for PVs is influenced by net metering laws. Our analysis estimates the total cost of a PV system. Net metering affects the value of the system to a homeowner. See Appendix E for a discussion on net metering.

3 This price premium might be addressed through green pricing schemes.

4 This price premium might also be thought of the cost of implementing a renewable portfolio standard for these technologies.

5 The economic costs of end-use solar technologies and of public policies to promote them are critical factors to consider in the design of public policies. However, we recognize that they are not the only factors to consider. For example, we do not consider marketing or customer acceptance issues associated with end-use solar technologies. Similarly, we do not discuss the incentive properties of the policies. Some of these issues are discussed in Chapter 6 of the report.

documentation and sample outputs for the analysis tool; Appendix B displays complete results from the sensitivity analysis in Chapter 3; Appendix C reports additional findings from the policy analysis in Chapter 4; Appendix D provides details on the direct and indirect costs of the policies discussed in Chapter 5; and Appendix E discusses net metering.

# Assumptions Used to Estimate the Cost of Residential End-Use Solar Technologies

## 2.1 Overview

In this chapter, we describe our procedures and document our assumptions for estimating the cost of residential end-use solar technologies. The analysis tool is a highly flexible set of pro forma, cash-flow spreadsheet models of the economics of end-use solar technologies. The primary output of the models is the levelized cost of electricity displaced or produced for the homeowner by an end-use solar technology. From a homeowner's perspective, the difference between the effective retail electricity price and this levelized cost represents the price premium (or cost savings) associated with owning or leasing an end-use solar technology.

Documentation of our estimation procedures describes the development of information on: (1) the performance and cost characteristics of SDHW and PV technologies; (2) the financial particulars of five ownership and financing scenarios we consider (use of home equity loans for residential homeowners and four equipment leasing business development scenarios); and, (3) general features of the economic environment in which the technologies operate, such as federal, state, and local taxes, as well as current public policies for renewable energy. Our results and their sensitivity to changes in these assumptions are presented in Chapter 3.

## 2.2 Two Residential End-Use Solar Technologies

This section describes the two residential end-use solar technologies examined in this report, solar domestic hot water heating (SDHW) and grid-connected rooftop photovoltaic power systems (PV). We also document the performance and cost assumptions used in our base case analysis, which draw primarily from California data sources.

### 2.2.1 Solar Domestic Hot Water

SDHW uses solar energy to heat water flowing through a series of rooftop panels. The system is generally supplemented by an auxiliary gas or electric water heater that makes up the difference between a household's demand for hot water and the hot water produced by the SDHW. The SDHW system we examine is an active, closed-loop system that uses glycol.[6]

[6] This system pumps the glycol through the panels then heats the household water through a heat exchanger. It has a relatively high efficiency and good freeze protection.

We developed our base-case assumptions from three sources: the Sacramento Municipal Utility District (SMUD) SDHW Program (Murley and Osborn 1995), the Energy Alliance Group (EAG) business plan for utilities to lease SDHW equipment to residential customers (EAG 1997), and the California Energy Commission (CEC) analysis of water heating systems for new buildings (Wong 1996). Table 2-1 summarizes the cost and performance assumptions we developed from these sources.

Although all three sources provided estimates of total cost, we decided to rely on estimates from the SMUD program because the SMUD values are the only ones based on actual installations. The SMUD program offered customer rebates and installed 320 SDHW systems in 1993. The average total installed cost per system was $2,580 (and the average rebate was $930).[7] This corresponds to a pre-sales tax capital cost of $2,378, which was rounded to $2,400.

We also relied on the SMUD program's measured energy savings. The average amount of electricity saved by systems installed through SMUD's 1993 SDHW Program was projected to be 2,928 kWh/year. Statistical bill analysis indicated that the actual savings were 2,582 ± 555 kWh/year (Murley and Osborn 1995). We assume that the yearly energy saved per system is 2,600 kWh.[8, 9]

Operating expenses include operation and maintenance (O&M), administration, insurance, and other miscellaneous costs. Both EAG (1997) and CEC (Wong 1996) estimate O&M costs at $40 per system-year for an active SDHW system. Both organizations made two important assumptions in order to arrive at this estimate: (1) significant market penetration;[10]

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7 EAG estimated the installed capital cost to be $2,010 per system ($2,181 after sales tax). This was based upon a survey of suppliers' prices for several thousand systems ordered over a period of several years (EAG 1997). The CEC estimated a similar cost of $2,250 ($2,441 after sales tax), which was based upon the assumption of installing systems in 100+ units in a new housing development (Wong 1996).

8 EAG estimates system performance of 3,208 kWh/year using F-chart and weather data from Green Bay, Wisconsin. CEC estimates system performance of 2,572 kWh/year based on information provided by the Florida Solar Energy Center using Sacramento weather data.

9 Although we are using historical data from a particular geographic region, we have the capability of estimating system performance under a variety of conditions using the software package F-chart.

10 The EAG business plan assumes that 7,425 systems will be sold in the utility's service territory. The CEC assumes that at least 100 systems will be installed in a single subdivision. In both cases, this would bring down the cost of maintenance by reducing the travel time between routine inspection and repair visits (EAG 1997 and Wong 1996).

and (2) no removal and reinstallation of the systems for reroofing.[11] For the life of their business plan, EAG estimates that the weighted average ratio between the maintenance costs and all other costs (administration, insurance, and incidental) is 8 to 9. Thus, the entire operating expense is $40 + (9/8)×$40, or $85 per system-year.

EAG assumes that the equipment will last 20 years (although their economic analysis is conducted for only 15 years to reflect the possibility that some customers will terminate contracts early). The CEC assumes that the equipment lifetime will be 30 years. We assume a 20-year equipment lifetime.[12] Performance deterioration is assumed to be negligible over this period.

**Table 2-1. Solar Domestic Hot Water Cost and Performance Assumptions**

| Parameter | Value | Source |
|---|---|---|
| Energy Saved per System per Year | 2,600 kWh | SMUD |
| Installed Capital Cost (w/o sales tax) | $2,400 per system | SMUD |
| Installed Capital Cost (w/ sales tax) | $2,604 per system | 8.5% sales tax (California) |
| Operating Expenses (including both O&M and administration) | $85 per system year | EAG |
| Equipment Lifetime | 20 | EAG |
| Performance Deterioration | 0% per year | Assumed |

### 2.2.2 Grid-Connected Rooftop Photovoltaics

PV systems convert incident solar energy directly into DC electricity. An inverter is then used to convert the DC power into AC, which can be substituted for utility-supplied power. Historically, most PV systems have been installed by residential customers who are not connected to the utility grid; the high cost of the alternative—extending transmission lines to these customers—makes PV highly cost effective. In contrast, we consider grid-connected rooftop PV, which do not require the costly, on-site energy storage (batteries) needed for off-grid systems.

11 The CEC (Wong 1996) estimates that an additional $200 to $250 expense would be incurred if the solar systems were installed on roofs that require replacement before the end of the life of the solar technology. This cost would be very sensitive to local labor rates. One contractor in the Oakland, CA area indicates that a typical removal-reinstallation job costs $400 (Ansley 1997).

12 Equipment lifetime is equivalent to economic lifetime (or length of lease) in our analysis.

The cost and performance assumptions for PVs summarized in Table 2-1 are derived primarily from the real-life experience of SMUD's PV Pioneers program (Osborn and Collier 1996). PV Pioneers is the largest utility-sponsored, grid-connected residential PV project to date, with over 340 residential and commercial systems installed.

In the residential sector, SMUD's 1996 program installed 4-kW rooftop PV systems at a turn-key cost of $5.36/Watt. With an 8.5% California sales tax, the total installed capital cost before tax was $4.94/Watt, which was rounded to $5.00/Watt. Operating expenses include O&M, administrative, insurance, and other miscellaneous costs. We derived a total operating expense of $160 per system year (increasing with inflation) based on the information reported for the SMUD program. We also rely on SMUD's economic analysis, which assumes that the systems will last 30 years, and SMUD's assumption of no performance deterioration over time.

We base electricity generation on a separate SMUD analysis for PV systems installed at the optimum angle for Sacramento (Wenger, Hoff, and Pepper 1996). This study reports a capacity factor of 0.207.

**Table 2-2. Photovoltaic Cost and Performance Assumptions**

| Parameter | Value | Source |
|---|---|---|
| Rated Power of Unit | 2 kW | |
| Installed Capital Cost (w/o sales tax) | $5.00 per Watt | SMUD |
| Installed Capital Cost (w/ sales tax) | $5.43 per Watt | 8.5% sales tax (California) |
| Operating Expense (includes O&M and administrative expenses) | $160 per system-year | SMUD |
| Equipment Lifetime | 30 years | SMUD |
| Performance Deterioration | 0% per year | SMUD |
| Capacity Factor | 0.207 | Wenger, Hoff, and Pepper (1996) |

## 2.3 Ownership and Financing Options for End-Use Solar Technologies

Residential end-use solar technologies have traditionally been financed by homeowners, but, individual homeowners have not been able to take advantage of some public policies, such as tax credits, to promote renewable energy. The leasing of end-use solar technologies is an innovative option that could allow homeowners to take advantage of these policies. In addition, leasing may allow project developers to take advantage of economies of scale in purchasing, financing, administering, and maintaining the technologies. By sharing some of these benefits, developers may be able to offer the technologies at lower total cost to homeowners.

We consider five ownership and financing scenarios for end-use solar technologies: a homeowner financing alternative and four equipment leasing alternatives in which a developer finances systems to be leased to homeowners. The three types of developers we consider are: (1) a third-party, non-utility developer (NUD) relying on either corporate or project financing, (2) an investor-owned utility (IOU), and (3) a publicly owned utility (POU). The homeowner financing scenario examines the financing of an individual system for personal use; the equipment leasing scenarios involve a developer financing an aggregation of systems to be leased to homeowners. Pro forma, cash-flow spreadsheet models for each option track revenues, costs, debt payments, and taxes over the economic lifetime of the system.

The primary output of our evaluation is the levelized cost of electricity either displaced by (in the case of SDHW) or produced by (in the case of PV) the end-use solar technology.[13] We also calculate local, state, and federal government revenues (or expenses) from taxes and subsidies.

The following is a description of the five ownership scenarios and the financing assumptions we have made for each. Many of the assumptions are taken from a recent report examining financing alternatives for windpower development (Wiser and Kahn 1996). Table 2-3 summarizes the assumptions used to model for each scenario. Additional descriptions of the scenarios and printouts of the cash flows for the base case are presented in Appendix A.

### 2.3.1 The Homeowner

We consider a homeowner who obtains a 20-year home equity loan to finance 100% of an end-use solar technology. The fixed installment loan carries an interest rate of 9.0% (Jones 1997). The interest payment is deductible from the homeowner's income taxes. We calculate the expenses, taxes, and debt payments for each year of the life of the solar technology. The present value of these cash flows is then annualized and divided by annual electricity production (or avoided consumption) to determine a levelized cost, expressed as \$/kWh of electricity.

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13 Levelized cost is calculated by annualizing the present value of total costs and dividing this quantity by the annual energy produced. The Weighted Average Cost of Capital (WACC) is used as the discount rate. Although the WACC does not necessarily represent the opportunity cost of capital, it offers some indication of the relative risk profiles of the different ownership alternatives.

We make the same technology cost and performance assumptions for both homeowners and developers who lease solar technologies. These assumptions are not necessarily equally applicable in both cases, however. For example, on the one hand, a homeowner would certainly not bear the administrative cost that a developer incurs to market a technology, so our estimate of the homeowner's operating expenses is high. On the other hand, homeowners are unlikely to capture the economies of scale in O&M costs that a developer might be able to realize, so our estimate for the homeowner's operating cost is low. Thus, the possible inaccuracies would tend, but cannot be assumed, to offset each other. Similar concerns arise regarding whether homeowners could purchase individual systems at the same cost as a developer purchasing many systems at one time, and when a homeowner would begin paying property taxes on a solar technology. We explore these and related issues in the sensitivity analysis in Chapter 3.

### 2.3.2 The Non-Utility Developer

The NUD is a private, commercial entity that purchases and installs end-use solar technologies on residential rooftops and then charges homeowners a lease price (in $/kWh) based on the cost of producing or displacing electricity. Currently, only NUDs are able to take advantage of the 10% investment tax credit (ITC) for solar installations available under the Energy Policy Act of 1992 (see Section 2.4).

The NUD can fund its activities either through project or corporate financing.

#### *Project Finance*

Historically, project finance has been the favored technique for developers of independent power projects, especially renewable energy and gas-turbine cogenerators. The essence of project finance is that capital is raised for a specific project and is repaid strictly from the revenues and assets of that project. Thus, loans are non-recourse (or limited recourse) in nature; lenders only have a claim on the revenues and assets of the project, and the parent company is usually not liable if the project is unable to meet its debt obligations. Project finance also keeps debt off the developer's balance sheet. This is especially important for small developers, who would quickly have problems increasing their debt if each project were financed on a common balance sheet (Nevitt 1994).

Project finance is often more costly than corporate finance because it transfers risks from the developer to lenders and investors who in turn, require a higher return as compensation, which increases the cost of capital.

**Table 2-3. Financing Assumptions for Different Business Development Scenarios**

| | | Equipment Leasing | | | |
|---|---|---|---|---|---|
| | Homeowner Financing | POU | IOU | NUD (Corporate Finance) | NUD (Project Finance) |
| Debt Rate | 9.0% | 5.5% | 7.5% | 7.5% | 9.5% |
| Debt Term | 20 years | na[14] | na[15] | na[16] | 10 years |
| Equity Rate | na | na | 12% | 12% | 18% |
| Minimum DSCR | na | na | na | na | 1.4 |
| Debt Fraction | 100% | 100% | 50% | 50% | Optimized[17] |
| Discount Rate[18] | 6.1%[19] | 5.5% | 8.3% | 8.3% | Variable[20] |
| Lease Price Escalation Rate[21] | na | na | na | na | 3.5% |

14 The debt term does not impact the levelized cost of power because the discount rate is the same as the debt rate in this scenario.

15 The IOU model spreads the cost of debt over the economic lifetime of the project. Debt term is not a variable in the IOU model. See the IOU model description in Appendix A for a more detailed explanation.

16 As with the IOU model, the corporate-financed NUD is assumed to spread the cost of debt over the life of the project.

17 The NUD, project-financed debt fraction is optimized to obtain the lowest price of electricity, subject to the constraints of minimum DSCR and minimum ROE. See text for details.

18 The discount rate is assumed to be the weighted average cost of capital (WACC) for.all scenarios. WACC = Debt Fraction*Debt Rate*(1 - Effective Income Tax) + Equity Fraction*Equity Rate.

19 The discount rate for the homeowner is the debt rate less the tax effect resulting from the deductibility of the interest payments.

20 The discount rate for a NUD using project-financing depends on the debt fraction, which is optimized for each set of assumptions. If the debt fraction is 50%, the discount rate is 11.95%.

21 The lease price escalation rate only affects the project-financed NUD alternative.

Debt is usually less expensive than equity. Lenders require lower rates because they include a number of requirements in their contracts to reduce the risk of default. First, debt has seniority over equity; any operating income from the project is paid to debt holders in full before equity investors receive any disbursements. Second, lenders require minimum debt service coverage ratios (DSCR). The DSCR is the ratio of operating income to debt obligation in a given year. Lenders evaluate a project based upon the project's ability to service the debt. Tax credits and depreciation cannot be accrued to the lender; hence, they cannot be used to service the debt. By requiring projects to forecast a DSCR above a minimum value in each year of the loan, the lender receives extra assurance that the debt will be paid. Third, lending agreements often specify an absolute maximum debt fraction even if the minimum DSCR is met. Our analysis uses a mortgage-style debt amortization schedule with equal payments throughout the life of the loan.

Equity investors are less risk-averse than lenders but demand a higher cost of capital. They are paid second to debt holders, but they have an "up side" potential if the project is more profitable than expected. In addition, they can accrue tax credits and accelerated depreciation benefits.

Developers using project finance optimize capital structure, subject to the constraints imposed by the loan (see Wiser and Kahn 1996). Generally speaking, developers try to maximize the debt fraction. However, it is not possible to finance a project with 100% debt because of the minimum DSCR and maximum debt fraction requirements. The greater the debt fraction, the lower the DSCR will be for each year of the project. Because the DSCR may not fall below a minimum value in any year of the loan, this effectively constrains the debt fraction. For capital-intensive renewable energy projects, the minimum DSCR usually constrains the debt fraction before its maximum is reached.

The debt fraction can often be increased if the revenue stream (i.e., lease payments from homeowners) is front loaded. If, for instance, the lease payments are flat over the life of the project rather than increasing with inflation, the minimum DSCR constraint can be better mitigated in the early years of the project; a larger debt fraction can be obtained. Because it is unclear that homeowners would be willing to make front-loaded payments, we assume that the lease price escalation rate is simply the inflation rate (3.5%).

Project finance also incurs higher transaction and legal costs than corporate finance. Capital raised using corporate finance involves issuing stocks or bonds that are sold and traded through well-defined channels in the capital markets. Capital raised using project finance proceeds on a more ad hoc basis in which lenders and investors are approached individually. Because every project is financed differently, legal particulars and legal costs can vary greatly.

The financing assumptions for this development scenario are difficult to estimate because end-use solar technologies have never been financed using project finance. As a starting point for our analysis, we rely on assumptions developed by LBNL for NUD, project-financed windpower plants (Wiser and Kahn 1996)[22]. These assumptions are as follows: debt rate = 9.5%, debt term = 10 years[23], equity rate = 18%, minimum DSCR = 1.4; the debt fraction is optimized to achieve the lowest financing costs given the constraints of the minimum DSCR and the equity rate.

*Corporate Finance*

Corporate finance, as we model it, differs from project finance in several important ways. First, we assume the developer raises capital on the basis of the balance sheet of the entire firm rather than for any specific project. The capital structure for a given project is, thus, fixed by the firm's capital structure. Because project risk is mixed with overall risks to the firm, the cost of capital is usually lower than it would be with project financing. Second, we assume debt is acquired through corporate bonds that pay interest, in the form of coupon payments, during their life and pay the principal at the maturity date. Although this differs from the mortgage-style debt of project financing, we have assumed that the revenue stream needed to pay the mix of bonds can be roughly approximated using a mortgage-style loan. Third, we assume that debt payments do not need to come from a specific source. Hence, project-specific DSCRs are not important.[24]

We assume that a developer using corporate finance would be a corporation with a credit rating similar to that of an IOU. The assumed parameters are: debt rate = 7.5%, debt term = 20 years, equity rate = 12%, and debt fraction = 50% (Wiser and Kahn 1996).

22 In the past, independent power project developers were able to obtain long-term fixed-price power purchase agreements from the utility. Because the agreements were typically take-or-pay, market risk was greatly reduced. Indeed, the power purchase agreement was historically the most important asset the developer had available to lower the cost of capital. How developers of end-use solar technologies would demonstrate a comparably stable revenue stream to the capital markets is not clear. Hence, financing costs could be even higher because of increased market risk.

23 Wiser and Kahn assumed a debt term of 12 years. We have reduced this to 10 years in order to match the debt term with the historical length of the production incentive and production tax credit policies.

24 The assumptions we make are controversial. For example, it is sometimes argued that companies should assess projects on the basis of the project-specific risk; the hurdle rate should be higher than average for riskier projects (Brealey and Myers 1991). We make our assumptions only to distinguish clearly between two stylized forms of financing: corporate and project finance. Reversing our assumptions would only lead to a situation in which corporate financing is for all intents and purposes identical to project financing.

### 2.3.3 The Investor-Owned Utility

The IOU development scenario is similar to NUD corporate financing in that capital is raised based upon the balance sheet of a large corporation and the debt fraction is fixed. As noted, we use the same assumptions in both cases regarding capital structure and cost of capital However, we use a revenue-requirement approach that reflects current regulatory practices in the electric utility industry. The revenue-requirement approach involves estimating the revenues required from ratepayers in order to recover operating costs, taxes, debt payments, and provide an equity return for each year.

### 2.3.4 The Publicly Owned Utility

The salient feature of the POU development alternative is its low cost of capital. POUs are able to finance projects with 100% debt in the form of tax-exempt bonds. Debt is generally less expensive than equity, and tax-exempt bonds are a relatively inexpensive form of debt. The financing assumptions for the POU are: debt rate = 5.5% and debt fraction = 100%.

POUs pay fewer taxes than their private counterparts because they are public entities. They do not pay either federal or state income taxes. Most pay property taxes only on the unimproved value of the land that is used for their projects (Wiser and Kahn 1996). Because end-use solar technologies would be placed on the roofs of dwellings owned by homeowners, POUs would not own any land that could be taxed; we therefore assume that they would pay no property tax on the equipment.

## 2.4 Current Economic Environment and Public Policies for End-Use Solar Technologies

Table 2-4 summarizes key features of the current economic environment and public policies for end-use solar technologies. We assume 3.5% for the general inflation rate. Federal and state corporate marginal income taxes are 35% and 6%, respectively, consistent with the values used in the EPRI TAG Manual (EPRI 1993).[25] We assume the marginal federal income tax for homeowners to be 28%, the most common tax bracket. State income tax payments are deductible for purposes of calculating federal income taxes. Current California state sales tax is 8.5%.

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[25] We assume that the homeowner does not pay income taxes for the electricity produced by PV systems. In California, our base case state, the net metering law allows PV owners to turn their meter backwards when the PV system produces more power than they are demanding. Thus, the homeowner is generally offsetting power purchased from the utility, rather than selling power to the utility. See Appendix E for a longer discussion of net metering laws.

Property taxes can vary by locality from 1% to 10%. We assume that the local property tax rate is 3% of the net book value[26] in the base case following Hadley, Hill, and Perlack (1993). When property is leased to a homeowner, the party to whom the property taxes are assessed can depend upon the locality (Ing 1997). The homeowner or lessor may pay. We assume that the lease contract allows for the lessor to pay the property taxes except in the case of the POU (see Section 2.3.4).

Three federal public policies currently affect the ownership and financing scenarios. POUs are eligible for a ten-year $0.015 per kWh (1992 dollars) Renewable Energy Production Incentive (REPI). NUDs, but not IOUs, are eligible for a 10% federal investment tax credit (ITC). Both IOUs and NUDs may depreciate solar property in five years using the Modified Accelerated Cost Recovery System (EEREC 1995). See Chapter 4 for more complete descriptions of these policies. Currently, our base case, California, has no additional public policies that directly influence financing for end-use solar technologies.

**Table 2-4. Base-Case Economic Parameters and Policy Environment**

| | | Parameter Applies to: | | | |
|---|---|---|---|---|---|
| **Parameter** | **Value** | **Home** | **NUD** | **IOU** | **POU** |
| Federal Income Tax (Corporate) | 35% | | ✓ | ✓ | |
| Federal Income Tax (Individual) | 28% | ✓ | | | |
| State Income Tax | 6% | ✓ | ✓ | ✓ | |
| State Sales Tax | 8.5% | ✓ | ✓ | ✓ | ✓ |
| Property Tax | 3% of book value | ✓ | ✓ | ✓ | |
| Inflation Rate | 3.5% | ✓ | ✓ | ✓ | ✓ |
| REPI Payments | $0.015 per year for 10 years ($1992) | | | | ✓ |
| Investment Tax Credit | 10% | | ✓ | | |
| Tax Depreciation | 5-year MACRS | | ✓ | ✓ | |

26 Book value is used as a proxy for the fair market value of the equipment. We assume that it starts as the capital cost of the system in year one and declines using straight line depreciation over the life of the project.

# The Cost of Residential End-Use Solar Technologies

## 3.1 Overview

This chapter reports our initial findings on the cost of end-use solar technologies. We describe the levelized cost to the homeowner under each ownership and financing scenario. We then explore the sensitivity of our findings to changes in the assumptions.

## 3.2 The Cost of Residential End-Use Solar Technologies

Table 3-1 presents real and nominal levelized costs of electricity for each of the five financing and business development scenarios.[19] These costs represent the amount that each project developer must charge homeowners in order to meet the developer's capital recovery criteria, as defined in the previous section. Crudely, the levelized cost is the revenue required by each developer to meet its financing requirements.

**Table 3-1. The Economics of End-Use Solar Technologies**

| | Solar Hot Water[20] | | | | Rooftop Photovoltaic (¢/kWh) | |
|---|---|---|---|---|---|---|
| | (¢/kWh) | | ($/mmBtu) | | | |
| Ownership | Real Levelized Cost | Nominal Levelized Cost | Real Levelized Cost | Nominal Levelized Cost | Real Levelized Cost | Nominal Levelized Cost |
| Homeowner | 11.3 | 15.0 | 22.4 | 29.7 | 21.0 | 31.1 |
| NUD, Project Financed | 17.3 | 21.7 | 34.3 | 43.0 | 43.1 | 56.9 |
| NUD, Corporate Financed | 12.3 | 15.9 | 24.4 | 31.5 | 24.6 | 34.7 |
| Investor-Owned Utility | 13.5 | 17.5 | 26.7 | 34.7 | 27.6 | 39.1 |
| Publicly Owned Utility | 8.6 | 11.4 | 17.0 | 22.6 | 15.2 | 22.8 |

19 Real levelized costs are calculated net of the assumed inflation rate (3.5%/year); nominal levelized costs are calculated including this rate of inflation.

20 Levelized costs for SDHW are reported in both ¢/kWh and $/mmBtu to represent displaced electric and gas water heating, respectively. The conversion factor is 1.98 $/mmBtu per ¢/kWh based on Energy Factors of 0.89 and 0.6 for electric and gas water heaters, respectively (Wong 96).

$$1\ ¢/\text{kWh} \times (1\ \text{kWh}/3{,}413\ \text{Btu}) \times (0.6/0.89) \times (10^6\ \text{Btu/mmBtu}) = 1.98\ \$/\text{mmBtu}$$

The remainder of this report discusses SDHW only from the standpoint of displaced electricity use.

The POU financing scenario is the cheapest at a real levelized cost of 8.6¢/kWh for SDHW and 15.2¢/kWh for PV. Homeowner financing is next in cost at 11.3¢/kWh for SDHW and 21.0¢/kWh for PV. NUD corporate financing costs more, at 12.3¢/kWh for SDHW and 24.6¢/kWh for PV. IOU financing is slightly more expensive at 13.5¢/kWh for SDHW and 27.6¢/kWh for PV. The NUD, project-financed alternative is the most expensive at 17.3¢/kWh for SDHW and 43.1¢/kWh for PV.

These results suggest that, from the homeowner's point of view, financing with a home equity loan is generally less expensive than leasing. This result derives largely from the assumed deductibility of interest paid on a home equity loan. Simply put, deducting interest payments lowers the apparently high cost of capital to the homeowner (from 9.0 %/year down to 6.1 %/year) below that of all potential equipment lessors, with the exception of the POU.

More generally, the effective discount rate for each financing scenario explains the differences in cost to the homeowner. Referring back to Table 2-3, the ordering of discount rates starts from the POU at the low end, and is followed by Homeowner, IOU, NUD corporate financing, and NUD project financing at the high end. While IOU and NUD corporate financing have the same effective discount rate, the cost for the NUD corporate financing scenario is slightly lower than for the IOU scenario because NUD corporate financing enjoys the current federal ITC of 10% while the IOU is not eligible for the tax credit.

It is important not to confuse differences in levelized cost to the homeowner with real differences in the societal cost of the technologies. For each ownership and financing scenario, the capital and operating (hence, societal) cost of the technologies remains unchanged. Differences in cost to the homeowner represent the cumulative impact of both differences in the risk profiles of various investors and the effects of current public policies on options for financing the technologies. For example, the low cost of the technologies for the POU reflects the low cost of debt and absence of equity, as well as the REPI payment. In this case, the risks associated with the technologies are in effect being underwritten by POU ratepayers as well by the federal, state, and local government (to whom the POU does not pay taxes). Similarly, we have already noted that the deductibility of interest payments contributes to the homeowner's low apparent cost of financing with a home equity loan.

It is difficult to determine how much federal, state, and local entities and the different risk preferences of various potential investors contribute to the differences in the cost of the technologies to the homeowner. Yet, a critical question for future public policies to promote end-use solar technologies is: Just who is paying? And how much are they paying? In Chapter 5, when we examine current and potential policies, we will make these payments explicit, as well as identify the entities responsible for them.

## 3.3 The Relative Importance of the Uncertainties Inherent in Assessing the Cost of End-Use Solar Technologies

The results presented above are based on a large number of assumptions. In this section, we report on a sensitivity analysis to assess the relative importance of each one of them.

The sensitivity analysis consists of individually varying the assumptions documented in Chapter 2. Graphical summaries of our findings are presented in Appendix B.

Generally speaking, we find that changes in assumptions lead to roughly linear changes in the levelized cost of the technologies. Accordingly, the sensitivity results can be summarized as a slope, which represents the percent change in real levelized price relative to the percent change in the individual assumption. Tables 3-2 and 3-3 report these slopes for SDHW and PV, respectively.

The slopes presented in Tables 3-2 and 3-3 can be used by the reader to approximate the effects of changes on the final levelized cost to the homeowner.[21] For example, consider an IOU developing a SDHW project in a locality with a property tax of 4.5% rather than the 3% we initially assumed. This is a 50% change in the property tax. From Table 3-2, the slope is 0.10 for property tax in the SDHW/IOU case. To find the percent change in the real levelized price of power, multiply the slope by the percent change in property tax: $0.10 \times 50\% = 5\%$. Thus, the new real levelized price is: 13.5¢/kWh * (1 + 0.05) = 14.2¢/kWh.

The findings we report in Tables 3-2 and 3-3 are listed in descending order (i.e., from the largest slope to the smallest). A larger slope means that, for the same percentage change, the final levelized cost is more influenced by changes in the assumption than for those with smaller slopes. Of course, the range over which an assumption varies can differ, so greater variation in one assumption compared to another can also lead to larger impacts on the final levelized cost.

Considering both size of slope and range of variation, we have grouped our findings into three categories: significant, somewhat significant, and not significant. These categories represent our assessment of the size of the uncertainties inherent in our evaluation.

21 The slopes were computed by linearizing the difference in levelized cost resulting from an increase and decrease of 10% about the initial assumption. Instances where the assumption of linearity is inappropriate are noted with an asterisk on the Tables. See also Appendix B for plots of the full range of sensitivities considered.

*Significant*

By far, the greatest source of uncertainty in our initial evaluation is the cost and performance of the end-use solar technologies. For both SDHW and PV, changes in our assumptions for energy savings (SDHW) or capacity factor (PV), followed by capital cost have the largest influence on the levelized cost of the technologies. The slopes for the energy performance are greatest; each percentage change in output leads to a roughly equal percentage change in levelized price. The slopes for capital cost are nearly as large (especially for PV).

Moreover, the technology performance assumptions are subject to great variability. The SMUD bill analysis of SDHW system performance reports ±20% accuracy (Murley and Osborn 1995). For PV systems, Wenger (1996b) reports capacity factors of 14.3% in Washington to 23% in Hawaii, which would lead to changes in levelized costs ranging from +45% to -10% (depending on the ownership/financing scenario) about our initial results. Of course, we would expect variability within California to be smaller than variability across the country.

Debt rate, equity rate, and equipment lifetime follow energy performance and capital cost in significance, but are markedly less influential. The sensitivity of cost to debt rate will be important in Chapter 4 when we consider the effects of low-interest loan policies. The slope associated with equipment lifetime is a function of the discount rate. For example, the slope is significantly larger for the POU, which has a low discount rate, than for the project-financed NUD, which has a high discount rate.

*Somewhat Significant*

Two assumptions have smaller slopes but are subject to greater ranges in variation. These include: (1) property tax, which can vary between 1% and 10% of book value, depending on the locality; and (2) sales tax, with a slope that is one-third smaller in scale than the property tax but which can also vary greatly (between 0% and 9%, depending on the state). In Chapter 4, we will consider the effects of policies that might lower these rates.

Five additional assumptions are significant for only certain technologies or ownership and financing scenarios: (1) operating expenses have a larger impact on SDHW than PV because of lower capital costs (however, we do not expect this to be a large source of error because these costs are unlikely to vary by more than ±50%, which corresponds to a cost variation of ±10-15%). (2) minimum DSCR, (3) lease price escalation rate[22] both only affect the

22 A plot of cost against the lease-price escalation rate will have a local minimum where the debt fraction is maximized. In general, the local minimum is the point at which the DSCR in the first and last years of the debt are both equal to the minimum DSCR. It is roughly linear on either side of the optimum value. Please refer to Figures B-15 and B-16 in Appendix B for plots.

project-financed NUD alternative, (4) debt term, again, affects primarily NUD project financing,[23] (5) the equity fraction for PV is significant for the project financed NUD because of the large difference between the debt rate and equity return, and the high capital cost of the PV system.[24]

*Not Significant*

The state income tax rate, O&M expense for PV, and equity fraction for SDHW are of negligible importance for all ownership and financing scenarios. The federal income tax rate only has a significant impact on the cost of solar power for the homeowner ownership and financing scenario.[25]

Performance Deterioration Rate - Performance deterioration is not included in this analysis because the base case is assumed to be 0% per year. Figures B-29 and B-30 in Appendix B plot the cost sensitivity to greater rates of performance deterioration. We find that it has a small impact but we do not expect it to be significant.

23 Debt term has no impact on the homeowner and POU scenarios because, with our assumptions, we have made the discount rate effectively identical to the debt rate. These assumptions may be controversial. In addition, a shorter debt term for homeowners increases the yearly debt payment; revenue would become a constraint for some. Also, note that the IOU and corporate-financed NUD scenarios do not allow for variation in this parameter.

24 On the other hand, the equity fraction for NUD project financing is optimized on a project-specific basis; hence, it is not truly an independent variable.

25 The homeowner ownership and financing scenario only receives tax benefits (in the form of debt interest deductions) while all other scenarios receive both benefits and burdens (in the form of debt interest deductions, accelerated depreciation, and tax credits on one hand and taxed revenues on the other) that offset each other somewhat.

Table 3-2. Solar Domestic Hot Water Sensitivities[26]

| *Significant* | Home (12.3 ¢/kWh) | POU (8.6 ¢/kWh) | IOU (13.5 ¢/kWh) | NUD/corp (12.3 ¢/kWh) | NUD/project (17.3 ¢/kWh) |
|---|---|---|---|---|---|
| Energy Saved[27] | -1.01 | -1.13 | -1.01 | -1.00 | -1.01 |
| Installed Cost | 0.78 | 0.73 | 0.75 | 0.72 | 0.80 |
| Debt Rate | 0.44 | 0.35 | 0.15 | 0.16 | 0.19 |
| Equity Rate | na | na | 0.39 | 0.36 | 0.38 |
| Technology Lifetime | -0.33 | -0.51 | -0.45 | -0.38 | -0.11 |
| *Somewhat Significant* | | | | | |
| Property Tax | 0.09 | na | 0.10 | 0.11 | 0.13 |
| Lease Price Escalation Rate | na | na | na | na | 0.12[28] |
| Sales Tax | 0.06 | 0.06 | 0.06 | 0.05 | 0.06 |
| O&M Expense | 0.22 | 0.38 | 0.25 | 0.27 | 0.20 |
| Minimum DSCR | na | na | na | na | 0.23 |
| Debt Term | na | na | na | na | -0.20 |
| *Not Significant* | | | | | |
| Federal Income Tax | -0.21 | na | 0.01 | -0.14 | -0.03 |
| Equity Fraction | na | na | 0.03 | 0.04 | na[29] |
| State Income Tax | 0.0 | na | 0.0 | -0.02 | 0.0 |

26 The values presented in this table are slopes that relate a percentage change in the quantities in the left-hand column to percentage changes in the cost of the technology. See text for a sample application of these slopes.

27 Linear approximation is not good for large (more than ±10%) changes.

28 Not linear over the entire range examined. See Footnote 3 and Figures B-15 and B-16 in Appendix B.

29 Although the equity fraction is important for the project-financed NUD alternative, it is not an independent variable.

Table 3-3. Photovoltaic Sensitivities[30]

| Significant | Home (21.0 ¢/kWh) | POU (15.2 ¢/kWh) | IOU (27.6 ¢/kWh) | NUD/corp (24.6 ¢/kWh) | NUD/project (43.1 ¢/kWh) |
|---|---|---|---|---|---|
| Capacity Factor[31] | -1.01 | -1.06 | -1.01 | -1.02 | -1.01 |
| Installed Cost | 0.94 | 0.91 | 0.93 | 0.91 | 0.95 |
| Debt Rate | 0.94 | 0.65 | 0.24 | 0.22 | 0.22 |
| Equity Rate | na | na | 0.62 | 0.65 | 0.56 |
| Technology Lifetime | -0.25 | -0.65 | -0.42 | -0.22 | -0.05 |
| *Somewhat Significant* | | | | | |
| Property Tax | 0.11 | na | 0.12 | 0.14 | 0.16 |
| Sales Tax | 0.07 | 0.07 | 0.07 | 0.05 | 0.07 |
| Lease Price Escalation Rate | na | na | na | na | 0.16[32] |
| Debt Term | na | na | na | na | -0.23 |
| Minimum DSCR | na | na | na | na | 0.25 |
| Equity Fraction | na | na | 0.38 | 0.39 | na[33] |
| *Not Significant* | | | | | |
| O&M Expense | 0.09 | 0.14 | 0.08 | 0.10 | 0.05 |
| Federal Income Tax | -0.37 | na | -0.03 | -0.17 | -0.03 |
| State Income Tax | -0.04 | na | 0.0 | 0.0 | 0.0 |

30 The values presented in this table are slopes that relate a percentage change in the quantities in the left-hand column to percentage changes in the cost of the technology. See text for a sample application of these slopes.

31 Linear approximation is not good for large (more than ±10%) changes.

32 Not linear over the entire range examined. See Footnote 3 and Figures B-15 and B-16 in Appendix B.

33 Although the equity fraction is important for the project-financed NUD alternative, it is not an independent variable.

# Public Policies to Support Financing for End-Use Solar Technologies

## 4.1 Overview

In this chapter, we begin our examination of public policies to support financing for end-use solar technologies. We consider policies traditionally used to promote renewable energy technologies, such as investment tax credits, accelerated depreciation, and production incentives, as well as more recent approaches, focusing specifically on those that might rely on wires charges to underwrite them, such as grants, low-interest loans, and direct customer payments. We describe current policies and identify the modifications we have made to them for our examination. We present findings on the effectiveness of each policy in lowering the levelized cost of the technologies to a homeowner. We also discuss some of the issues associated with "double-dipping" rules governing the interaction between the policies and the existing federal 10% investment tax credit.

## 4.2 Analysis of Public Policies to Support Financing for End-Use Solar Technologies

We examine eight public policy options for promoting end-use solar technologies: investment tax credits (federal and state), accelerated depreciation (federal and state), production tax credits (federal and state), production incentives, low interest loans, grants (taxable and nontaxable), property and sales tax reductions, and direct customer payments. See Table 4-1.

In all of our analysis, we assume both that investors are able to claim the tax benefits we examine and that these benefits are not subject to recapture through the Alternative Minimum Tax (AMT).[34] Federal and state tax policies can cause projects to have negative tax loads in their early years. We assume that equity holders have sufficient tax burdens elsewhere in their portfolios in order to reap the benefits of these policies.

When "double dipping" restrictions apply, we assume that a developer will take advantage of the combination of policies that results in the lowest levelized cost to the homeowner while still satisfying the revenues required to meet the developer's cost of capital. In other

34 See Hadley, Hill, and Perlack (1993) for a description of the AMT and its effects on renewable energy projects.

Table 4-1. Summary of Policies Considered

| Policy Option | Existing Policy | Current Application | Alternate Policy Designs Considered | Eligibility |
|---|---|---|---|---|
| Investment Tax Credit - Federal | 10% (Reduces depreciable base by 50% of credit) | NUD | 10% - 50% of capital cost for NUD, 0% - 50% of capital cost for others (Continued 50% reduction in depreciable base) | All but POU |
| Investment Tax Credit - State | None | na | 0% - 50% of capital cost (Reduces state depreciable base by value of credit) | All but POU |
| Accelerated Depreciation | 5 years (Federal and state) | NUD, IOU | 5 and 1 year for home, 1 year for NUD, IOU (Federal and state considered separately) | All but POU |
| Production Tax Credit - Federal | None | na | 0 - 10¢/kWh for 10 years ($1992) | All but POU |
| Production Tax Credit - State | None | na | 0 - 10¢/kWh for 10 years ($1992) | All but POU |
| Production Incentive | 1.5¢/kWh for 10 years ($1992) | POU | 1.5¢/kWh - 10¢/kWh for 10 years ($1992) for POU<br>0 - 10¢/kWh for 10 years ($1992) for others (Taxable) | All |
| Loan Interest Rates (Low-Interest Loan Policy) | 9.0% for home<br>9.5% for NUD/proj<br>7.5% for NUD/corp<br>7.5% for IOU<br>5.5% for POU | All | 0% - 9.0% for home<br>0% - 9.5% for NUD/proj (eliminates 10% ITC)<br>0% - 7.5% for NUD/corp (eliminates 10% ITC)<br>0% - 7.5% for IOU<br>0% - 5.5% for POU | All |
| Grant - Taxable[35] | None | na | 0% - 50% of capital cost (Reduces depreciable base by value of the grant) | All but POU |
| Grant - Nontaxable[36] | None | na | 0% - 50% of capital cost (Reduces depreciable base by value of the grant) | All |
| Property Tax | 3% (Base case) | All but POU | 0% - 10% of book value (Using straight line depreciation) | All but POU |
| Sales Tax | 8.5% (Base case) | All | 0% - 10% of capital cost | All |

[35] Modeled as a cash payment in the beginning of the first year.

[36] Modeled as a cash payment in the beginning of the first year..

words, a developer will only take advantage of a new subsidy if it leads to a lower levelized cost to the homeowner. As a result, the plots of results for some policies may be discontinuous as developers switch from an existing policy to a new one.

The remainder of this chapter is organized into separate discussions for each policy. Each discussion begins with a short description of the policy.[37] For existing policies (i.e., the federal investment tax credit, accelerated depreciation, and the Renewable Energy Production Incentive), this description starts with the policy as it is currently implemented. We then identify the ownership and financing scenarios that could hypothetically be affected by a policy and the ways in which such a policy might interact with other, primarily existing federal tax policies. Our findings are summarized graphically and briefly discussed in the text.

## 4.3 Federal and State Investment Tax Credits

Investment tax credits (ITCs) directly reduce the tax burden of a tax-paying entity in the first year of project operation, proportional to the capital cost of the investment made. An ITC can reduce either federal or state income taxes. POUs are not eligible for ITCs because we have assumed that they do not pay income taxes.

The Energy Policy Act (EPAct) of 1992 (H.R. 776) extended the federal 10% investment tax credit for certain businesses investing in "solar energy property." However, certain restrictions apply to the ITC: (1) it is not applicable to IOUs[38] or homeowners; it is only available to NUDs (both corporate and project financed). (2) If the investment is financed in whole or in part by subsidized energy financing[39] or tax-exempt, private activity bonds, then the ITC can be applied only to the unsubsidized portion of the investment.[40] (As each of the subsequent policies are discussed, we will examine the impact of this so-called "double dipping" restriction of the ITC.) (3) When the ITC is used, the depreciable base of the property is reduced by 50% of the value of the credit (Short, Packey, and Holt 1995).

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[37] See Rader and Wiser (1997) for more comprehensive descriptions of these and other policies.

[38] Internal Revenue Code Section 48(a)(3) states, "The term 'energy property' shall not include any property which is public utility property..."

[39] Internal Revenue Code Section 48(a)(4)(C) states, "the term 'subsidized energy financing' means financing provided under a Federal, State, or local program a principal purpose of which is to provide subsidized financing for projects designed to conserve or produce energy."

[40] "The purchaser of the eligible equipment must choose between the tax credit, on the one hand, and subsidized energy loans and nontaxable grants, on the other hand." (JTC Blue book, Conference Report, Crude Oil Windfall Profits Tax Act, 1980, p. 136).

Figure 4-1. Federal ITC - SDHW

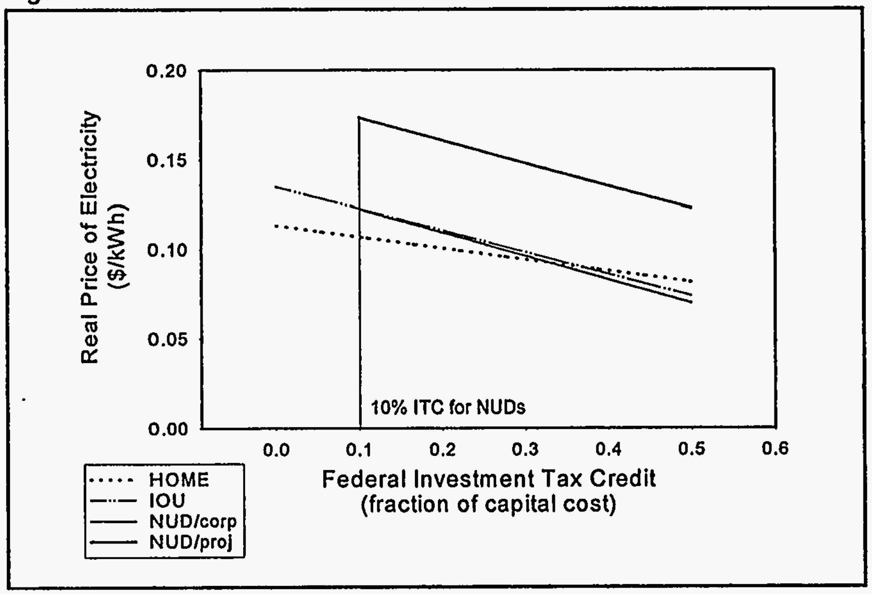



Figure 4-2. Federal ITC - PV

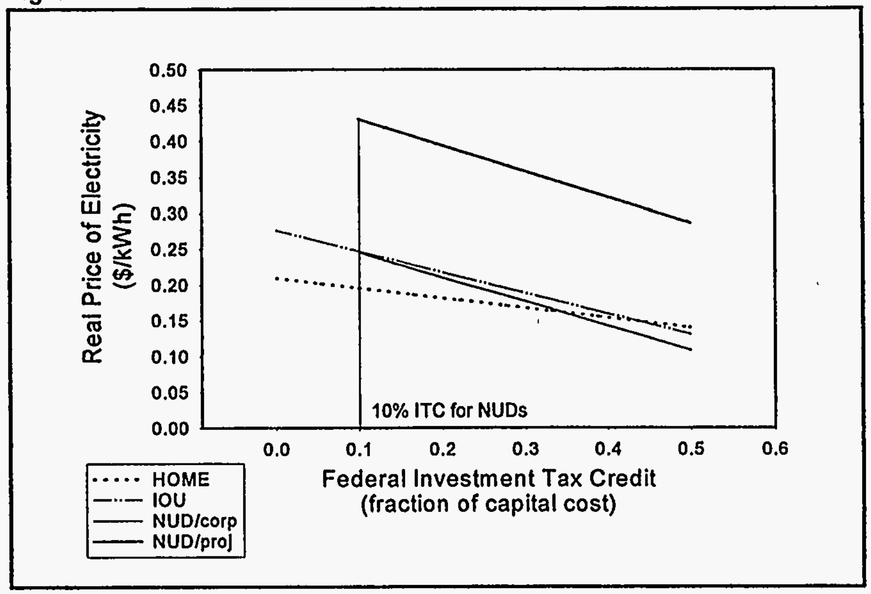



Figure 4-3. State ITC - SDHW

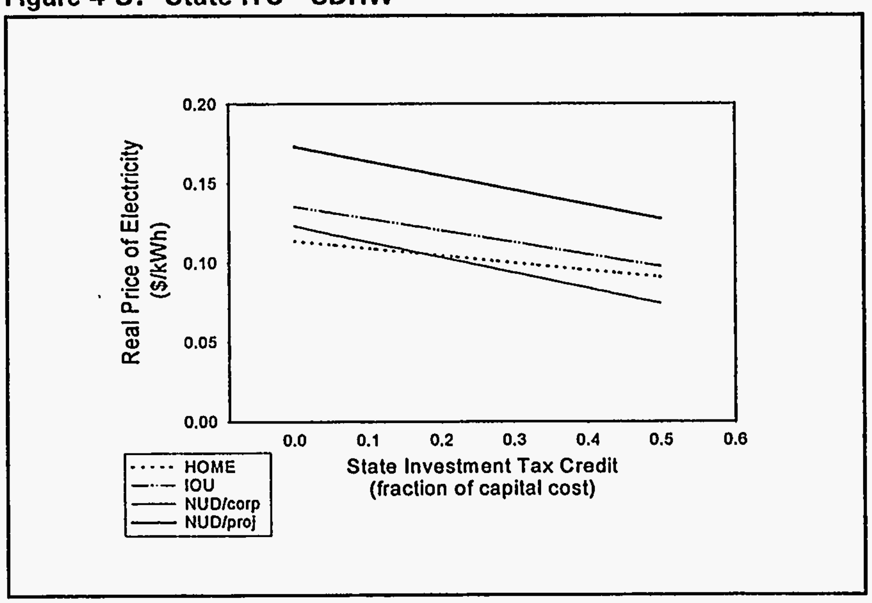
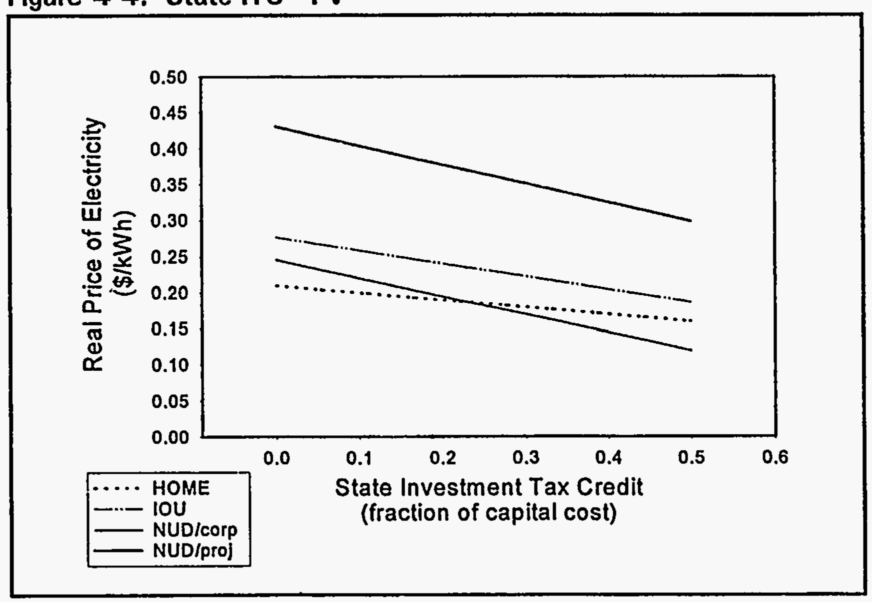



Figure 4-4. State ITC - PV



Although several states have a state ITC for solar energy property, California, our base case, currently does not.[41] In our analysis of state ITC policies, we assume that, if a state provides an ITC, whatever federal ITC is in place remains in effect.[42] Historically, state tax credits have reduced the depreciable base for state taxes (but not federal taxes) by the value of the credit, however, the tax code could be written such that no reduction in depreciable base occurs (Schwent 1997). Following the historical precedent, we assume that state investment tax credits do reduce the depreciable base by the full value of the credit. Due to different impacts on the depreciable base and because state taxes are deductible from taxable income for federal taxes, a state ITC will have a different effect than a federal ITC of the same size.

We examine the effect of both federal and state ITCs. We consider federal ITCs in excess of the current 10% available to NUDs (both corporate and project financed). We also examine a range of federal ITC subsidies for the IOU and homeowner. We assume that all of the restrictions described previously apply to the federal ITCs we examine. We also examined a range of state ITC subsidies for the NUDs, IOU, and homeowner.

Figures 4-1 and 4-2 illustrate the effect of federal ITCs on the real levelized cost to the homeowner for each applicable ownership and financing scenario (i.e., all by POU) for SDHW and PV, respectively. Figures 4-3 and 4-4 illustrate the effects of state ITCs.

The effect of federal and state ITCs is greater for IOUs and NUDs than it is for homeowner financing. This is a generic result that applies to all subsidy policies. The reason lies with the commercial nature of the transaction entered into by the non-homeowner developers with the homeowners who lease the technologies from them. (The homeowner who owns and finances the technologies with a home equity loan does not enter into a commercial transaction with herself.) Accordingly, revenues received from the homeowner are taxed. Yet, by receiving the ITC, the commercial developer is able to lower the revenue they must collect from the homeowner; thereby lowering the total income subject to taxation. The subsidies effectively leverage additional government funds to commercial developers, in the form of income tax savings. The value of taxed subsidies (e.g. production incentive or

41 Arizona has a 25% ITC with a $1,000 maximum for residential customers; Hawaii has a 35% ITC with a $1,750 maximum for residential customers and a 35% ITC with no maximum for commercial entities; Massachusetts has a 15% ITC with a $1,000 maximum for residential customers; North Carolina has a 40% ITC with a $1,500 maximum for residential customers and a 35% ITC with a $25,000 maximum for commercial entities— both can be carried over up to five years; North Dakota gives a 5% ITC per year for three years for both residential and commercial entities; Oklahoma had an ITC that expired in 1995, with an extension still pending— it was a 30% ITC with a $25,000 maximum for residential customers and a 20% ITC with a $150,000 maximum for commercial entities—both could be carried over for five years; Oregon has a 35% ITC over five years (10% in years 1 and 2, 5% in years 3, 4, and 5) for commercial entities (Wenger 1996b).

42 "...credits against State and local income taxes are not taken into account because the deductibility of these taxes under the Federal income tax implies that the effect of these credits is equivalent to the effect of a taxable grant." (JTC Blue book, Conference Report, Crude Oil Windfall Profits Tax Act, 1980, p. 136).

taxable grant) and untaxed subsidies (e.g. tax credits) for commercial developers and homeowners are given in Table 4-2.[43]

**Table 4-2. The Value of Taxed and Untaxed Subsidies for Homeowner Financing and Equipment Leasing Ownership and Financing**

| | Homeowner Financing | Equipment Leasing Ownership and Financing |
|---|---|---|
| Taxed Subsidies | $Subsidy \times (1 - Tax\ Rate)$ | Subsidy |
| Untaxed Subsidies | Subsidy | $\frac{Subsidy}{1 - Tax\ Rate}$ |

## 4.4 Federal and State Accelerated Depreciation

Depreciation allows commercial, tax-paying developers to reduce their taxable income by an amount proportional to the original value of their capital assets. Traditionally, depreciation schedules permit equal annual depreciation deductions over the life of an asset. Section 168 of the Internal Revenue Code specifies a Modified Accelerated Cost Recovery System (MACRS) that allows commercial developers to accelerate the schedule of depreciation deductions for certain types of property. In particular, the capital cost of solar property may be depreciated over five years (EEREC 1995). State income tax depreciation schedules vary from state to state, but generally defer to the federal code. In Chapter 3, we assumed that the state tax depreciation schedule corresponded exactly to the federal tax depreciation schedule.

We examine a reduction in the depreciation period from five years to one year. We examine the effects of these changes on IOUs and both NUDs. (Recall that POUs are assumed to no pay income taxes and are hence not eligible for this policy). We separately examine the effects of changes to either the federal or the state depreciation schedule.

Currently, Idaho allows residential customers to deduct the capital cost of solar energy property from state income taxes over several years.[44] These deductions essentially mimic

43 This equation is exact for IOUs because we assume that they collect exactly the revenue required to cover operating and finance costs in each year. The equation is an approximation for NUDs because we do not assume exact collection of costs on an annual basis. Instead, we assume exact collection on a present value basis over the life of the technologies. In addition, some policies also affect the debt fraction of the project-financed NUD alternative.

44 Idaho allows residential customers to deduct 100% of their solar investment in four years; 40% in Year 1 and 20% in Years 2, 3, and 4 with a maximum of $5,000 per year (Wenger 1996b).

a depreciation schedule for the homeowner. We use this precedent to examine the effect of such a policy on residential customers under both a five-year and one-year depreciation schedule.

Tables 4-2 and 4-3 report the effect of different federal depreciation schedules on the real levelized cost to homeowners for SDHW and PV, respectively. Tables 4-4 and 4-5 report these effects for different state depreciation schedules.

Since the IOU and NUD (corporate- and project-financed) are already eligible for five-year federal and state depreciation schedules, the only values that differ in the column labeled "5-year" (from the basic results already presented in Chapter 3) are those for the homeowner, which was not eligible for any form of depreciation in the earlier analysis.

The impact of further reducing the federal depreciation period from five to one year reduces the levelized cost by less than seven percent. Reducing the federal depreciation period has a bigger effect than reducing the state depreciation period because the federal tax rate is higher.

Introducing a five-year federal depreciation schedule for homeowners lowers levelized costs by about 20%. Further reducing the federal depreciation period to one year has a much smaller effect, as does introducing a state depreciation schedule. As was discussed previously in reviewing the ITC findings, the effect of lowering a depreciation schedule from five years to one year has a greater effect on the IOU and NUD ownership and financing scenarios than it has on the homeowner-financing scenario.

**Table 4-3. Real Levelized Cost of SDHW for Different Accelerated Federal Tax Depreciation Schedules**

| Developer | 5-Year (¢/kWh) | 1-Year (¢/kWh) |
|---|---|---|
| IOU | 13.5 | 12.9 |
| NUD/Corporate-financed | 12.3 | 11.4 |
| NUD/Project-financed | 17.3 | 16.2 |
| Homeowner | 9.8 | 9.6 |

**Table 4-4. Real Levelized Cost of PV for Different Accelerated Federal Tax Depreciation Schedules**

| Developer | 5-Year (¢/kWh) | 1-Year (¢/kWh) |
|---|---|---|
| IOU | 27.6 | 26.3 |
| NUD/Corporate-financed | 24.5 | 22.2 |
| NUD/Project-financed | 43.1 | 39.7 |
| Homeowner | 17.5 | 17.1 |

**Table 4-5. Real Levelized Cost of SDHW for Different Accelerated State Tax Depreciation Schedules**

| Developer | 5-Year (¢/kWh) | 1-Year (¢/kWh) |
|---|---|---|
| IOU | 13.5 | 13.4 |
| NUD/Corporate-financed | 12.3 | 12.2 |
| NUD/Project-financed | 17.3 | 17.2 |
| Homeowner | 11.1 | 11.1 |

**Table 4-6. Real Levelized Cost of PV for Different Accelerated State Tax Depreciation Schedules**

| Developer | 5-Year (¢/kWh) | 1-Year (¢/kWh) |
|---|---|---|
| IOU | 27.6 | 27.5 |
| NUD/Corporate-Financed | 24.5 | 24.3 |
| NUD/Project-Financed | 43.1 | 42.7 |
| Homeowner | 20.4 | 20.4 |

## 4.5 Federal and State Production Tax Credits

Production Tax Credits (PTCs) are the tax-policy equivalent to a production incentive (to be described next). EPAct created a PTC of 1.5¢/kWh ($1992) for ten years for wind and closed-loop biomass power systems (EEREC 1995). We consider both federal and state versions of such a tax credit extended to all tax-paying ownership and financing scenarios. As with state ITCs, we assume that neither a state nor a federal PTC would reduce the 10% federal ITC.

To allow direct comparison between PTCs and production incentives, we limit the PTCs to 10 years and report them in ($1992). Figures 4-5 and 4-6 report the effect of different federal PTC subsidies for SDHW and PV, respectively. Figures 4-7 and 4-8 report the corresponding findings for state PTCs.

As with previous tax policies, the relative effect of a production tax credit is greatest for the commercial (i.e., non-homeowner) ownership and financing scenarios. Among the commercial development scenarios, the effects are greatest for the corporate-financed NUD and IOU because the PTC tends to decrease the amount of debt that a project-financed NUD can carry. Since state taxes are deductible from federal taxable income, a state PTC has a slightly smaller impact than a federal PTC.

## 4.6 (Renewable Energy) Production Incentive

A production incentive is a cash payment that is awarded on the basis of energy produced.[45] Production incentives (along with production tax credits) create a stronger incentive for developers to ensure that their systems actually produce energy than do incentives based solely on the capital cost of the systems. EPAct created a Renewable Energy Production Incentive (REPI) of 1.5¢/kWh ($1992) for ten years, administered by the U.S. Department of Energy for investments by POUs in renewable energy technologies (EEREC 1995). The objective was to provide an incentive for POUs comparable to those provided to tax-paying developers (such as the federal investment tax credit and accelerated depreciation), but which recognized that POUs do not pay income taxes to the federal government.[46]

A production incentive (PI) has been proposed as a means for distributing funds collected through a wires charge to support financing for renewable energy projects. We assume that when a PI is paid to a tax-paying entities, such as NUDs, IOUs, and homeowners, it is taxed as income. Consequently, we assume that a PI would not trigger the "double dipping" provisions of the 10% federal ITC (see the discussion of Taxable Grants below).

45 Note that REPI payments are only made for power that is actually produced and measured. Thus, developers would have to measure the actual power produced to receive the REPI, even if they are paid by a simple monthly lease.

46 However, unlike tax incentives, which are written into the tax code, REPI payments must be re-appropriated by the U.S. Congress each year. Thus, REPI payments currently represent a more uncertain income stream than their tax incentive counterparts (Wiser and Pickle 1997).

Figure 4-5. Federal PTC - SDHW

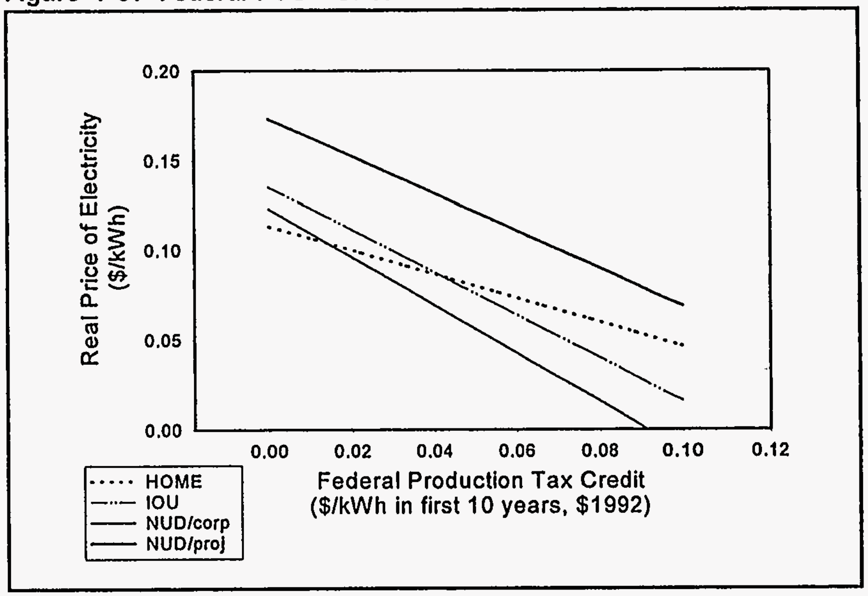



Figure 4-6. Federal PTC - PV

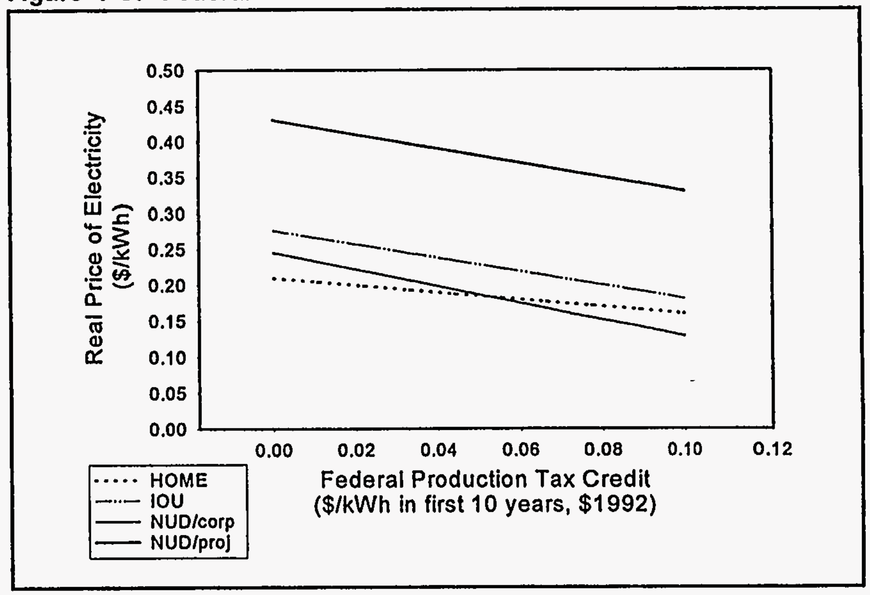



Figure 4-7. State PTC - SDHW

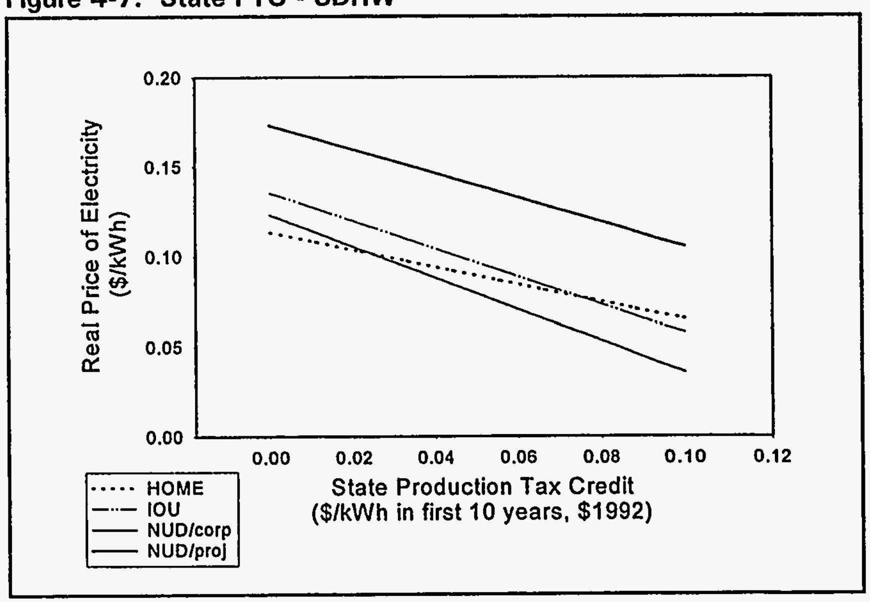
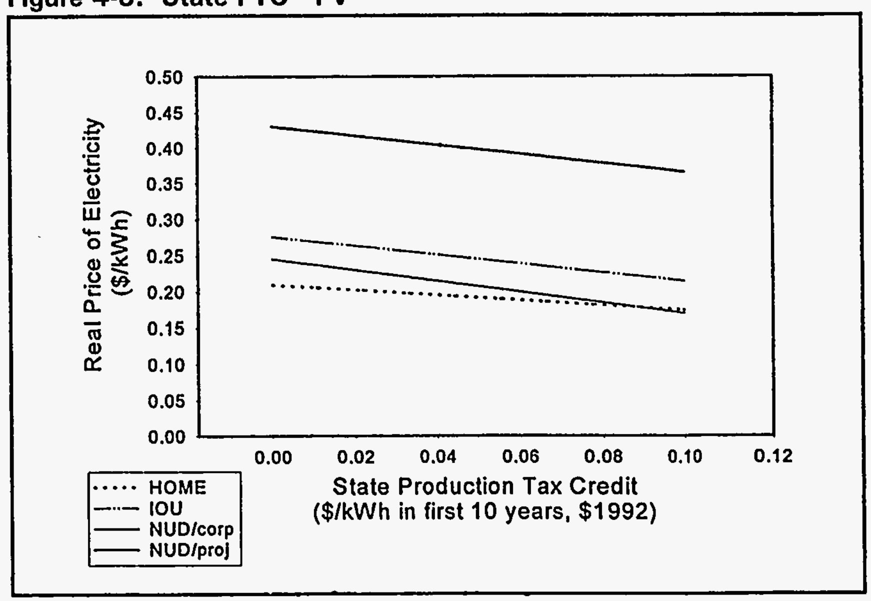



Figure 4-8. State PTC - PV



PIs have an additional benefit for NUDs using project financing. Since a PI is a cash payment, a NUD can use it to pay both debt and equity holders (rather than just equity holders, as with tax incentives). A PI can thus help cover a NUD's minimum DSCR and increase the amount of debt that a project can bear (Wiser and Kahn 1996). Higher debt fractions lower the levelized cost of the technologies.

For the POU ownership and financing scenario, we examine PI payments above the current 1.5¢/kWh ($1992) but following EPAct, make these payments available for only the first 10 years. For all other scenarios, we examine a range of taxable PI payments, again lasting for the first 10 years ($1992).

Figures 4-9 and 4-10 illustrate the effect of different PIs on the levelized cost to the homeowner of SDHW and PV, respectively.

Like ITCs and accelerated depreciation schedules, PIs have larger impacts on the commercial ownership and financing scenarios (IOUs and both NUDs) than on the homeowner ownership and financing scenario. The added benefit for project-financed NUDs (i.e., increased ability to carry debt) is also clearly visible.

## 4.7 Low-Interest Loans

Low-interest loans lower the cost of debt. Some have suggested that funds collected through a wires charge could be used to subsidize the cost of debt for renewable energy technologies.

We examine the effect of low-interest loans on levelized costs in each of the five ownership and financing scenarios. However, depending on the source and control of the funds used to underwrite them, they might be considered a form of subsidized financing and trigger the "double dipping" rules of the federal 10% ITC.[47] We have assumed that the 10% federal ITC will not be applied to the portion of the capital investment financed by a low-interest loan.

Figures 4-11 and 4-12 illustrate the effect of low-interest rate loans on each of the five ownership and financing scenarios for SDHW and PV, respectively. The starting point for each scenario is the current interest rate we earlier assumed was available under each scenario (see Chapter 2).

47 If the funds are collected and distributed by a government entity, then low-interest loans would be considered a form of subsidized financing, and the 10% federal ITC would be eliminated. If, however, they are funded by ratepayers through a wires charge and no government entity collects or controls the funds, then they might not be considered subsidized financing.

Figure 4-9. Production Incentive - SDHW

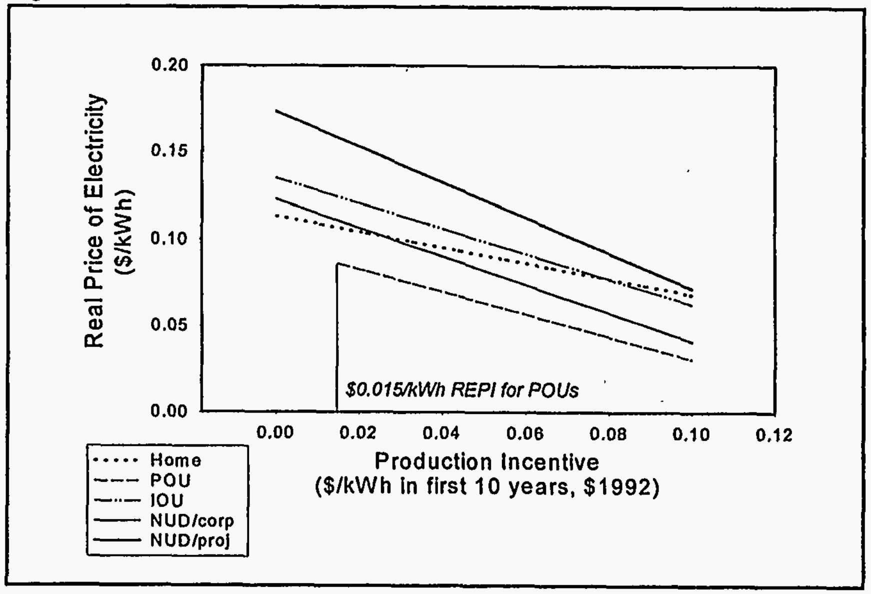



Figure 4-10. Production Incentive - PV

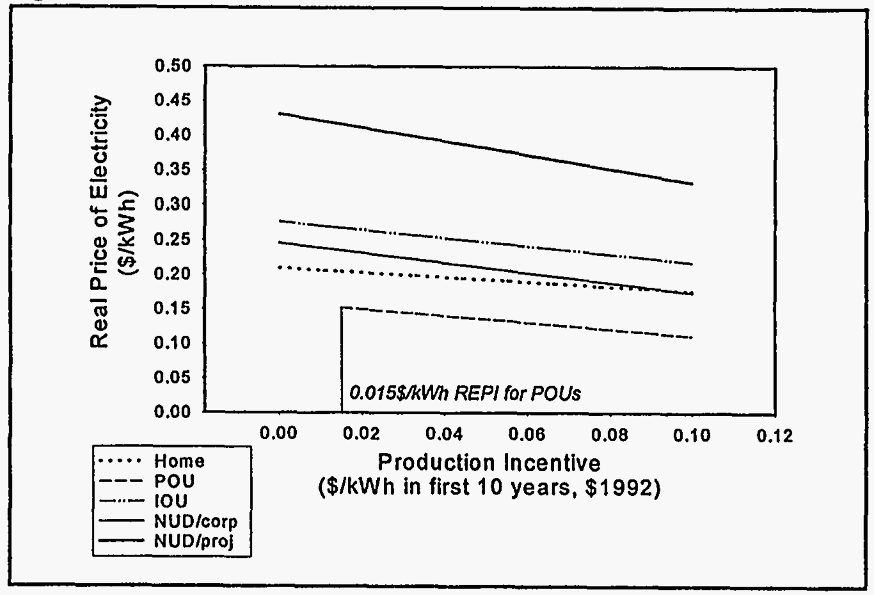



Figure 4-11. Low-Interest Loan - SDHW

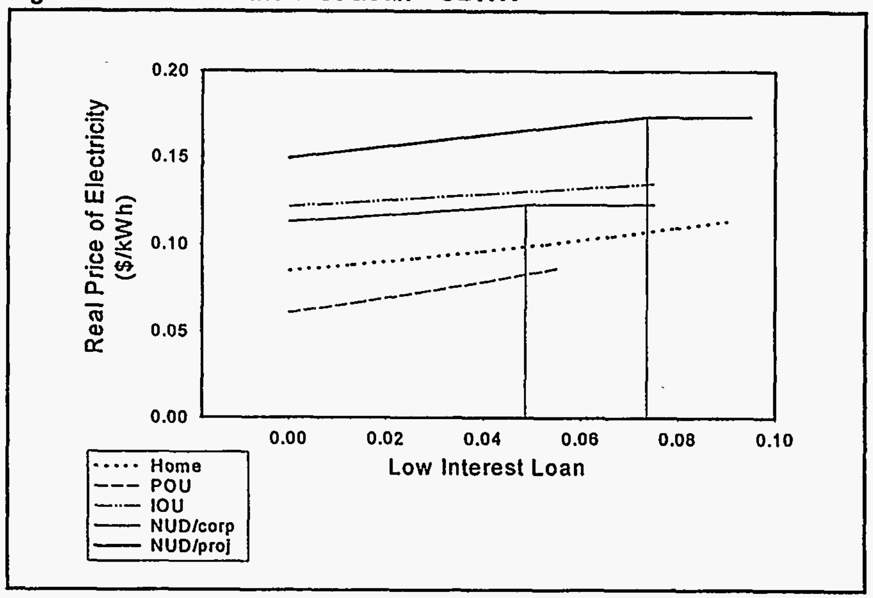
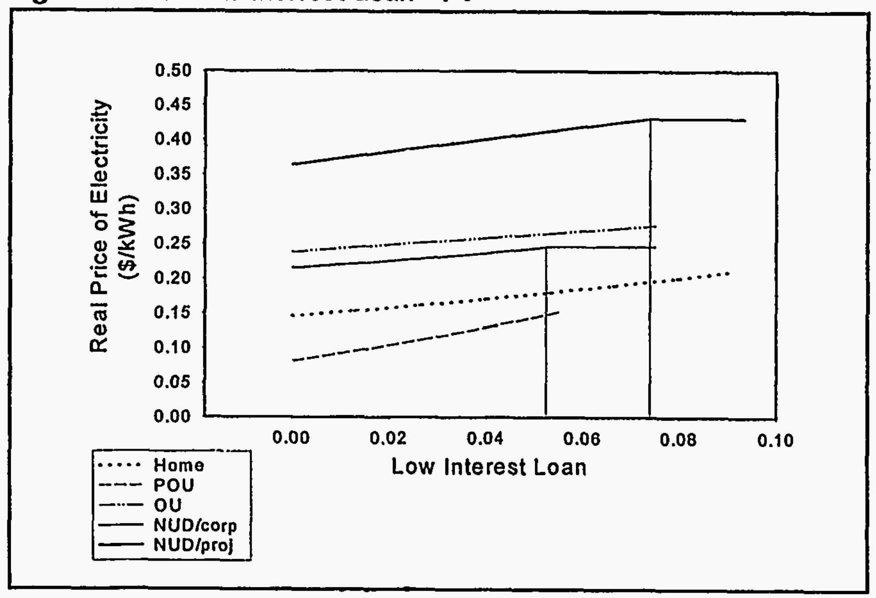



Figure 4-12. Low-Interest Loan - PV



Not surprisingly, the effects are greatest for those ownership and financing scenarios that involve the greatest amount of debt (homeowner, POU, and project-financed NUD). The project-financed NUD also benefits from the opportunity to increase the amount of debt the project can carry.

Under both NUD ownership and financing scenarios, lower interest rates do not reduce levelized costs until the interest rate is below a certain threshold. That is, until this threshold is crossed, the current federal 10% ITC leads to lower costs than the lower interest rate. After this point, the loss of the ITC due to the "double dipping" rules is less important than the lower cost of debt.[48] For SDHW, the threshold interest rates are 4.9% for the corporate-financed and 7.3% for the project-financed NUD. For PV, the thresholds are 5.5% and 7.4%, respectively.

## 4.8 Taxable and Nontaxable Grants

A grant is a one-time payment that offsets a portion of the capital cost of a technology. Grants for renewable energy technologies have also been suggested as candidates for funding through a wires charge on electricity.

Grants may be either taxable or nontaxable. We assume that a grant funded through a wires charge would be taxable, while a grant funded by the government would not be taxable. The distinction is important for the "double dipping" restrictions described earlier.[49] We assume that a nontaxable grant is a form of subsidized financing, which would reduce the basis for the federal ITC by the value of the grant[50], and that a taxable grant is not a form of subsidized financing, which would have no impact on the ITC.[51]

Both the taxable and the non-taxable grants are modeled as a cash payment in the first year of the project.[52] They reduce the depreciable base by the value of the grant.

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48 For example, the corporate-financed NUD has a debt fraction of 50%; it receives only a 5% ITC if it accepts the low-interest loan.

49 The distinction is not important for the POU ownership and financing scenario since we assume the POU does not pay income taxes.

50 Thus, a 10% non-taxable grant would reduce the ITC by 10%.

51 "Grants which are taxable are not taken into account under these rules..." (JTC Blue book, Conference Report, Crude Oil Windfall Profit Tax Act, 1980, p. 136).

52 The nontaxable grant will also be modeled as a buy-down of the capital cost for some development scenarios in the Chapter 5 cost analysis.

Figure 4-13 and 4-14 illustrate the effects of nontaxable grants on real levelized costs to the homeowner under all five ownership and financing scenarios for SDHW and PV, respectively.

As with the other tax subsidies, the effect of a nontaxable grant is greater for tax-paying, commercial ownership and financing scenarios (IOU and NUDs) than it is for the noncommercial or nontax-paying scenarios (POUs and homeowners).[53] Indeed, the effects on the POU and homeowner financing scenarios are roughly equal (i.e., the results have the same slope).

Figures 4-15 and 4-16 illustrate the effects of taxable grants on real levelized costs to homeowners under four ownership and financing scenarios (all except POU) for SDHW and PV, respectively.

As expected taxable grants are less effective than nontaxable grants for the IOU and homeowner financing scenarios. They are also less effective than nontaxable grants for both NUD scenarios, despite the reduction in the federal ITC that they trigger.

## 4.9 Property and Sales Tax Reductions

Property taxes vary from county to county (usually, ranging between one and ten percent) and the methods used to assess them can differ substantially. State sales taxes tend to range between zero and nine percent (U.S. Advisory Commission on Intergovernmental Relations 1992). Several authors have cited property and sales taxes to be a major burden for renewable energy technologies relative to conventional fuel technologies (Hadley, Hill, and Perlack 1993; Jenkins, Chapman, and Reilly 1996; Burtraw and Shaw 1995).[54]

The effects of changes in property and sales taxes was examined earlier as part of the sensitivity analysis presented in Chapter 2. Figures B-11 and B-12 in Appendix B illustrate the effect of different property tax rates on the levelized cost to homeowners for SDHW and PV, respectively. Figures B-13 and B-14 in Appendix B illustrate the effects of different sales tax rates.

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53 Because the grant is not taxed, it has the same subsidy as tax credits (see earlier discussion of ITCs).

54 These authors base their findings on differences in the tax treatments of capital costs and operating (including, fuel) costs. Renewable energy technologies tend to be capital intensive. Thus, they incur large sales taxes when purchased and high property taxes each year thereafter compared to less capital intensive fossil fuel energy technologies. While fossil fuel energy technologies later pay sales taxes on fuel, these taxes are paid out over the life of the project and, in present value terms, are alleged to lead to lower total costs for these technologies compared to renewable energy technologies.

Figure 4-13. Nontaxable Grant - SDHW

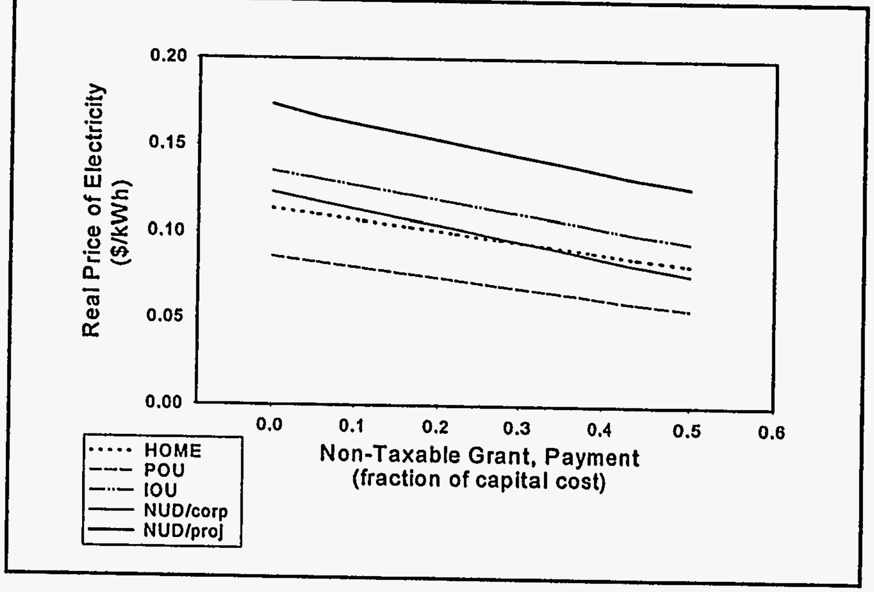



Figure 4-14. Nontaxable Grant - PV

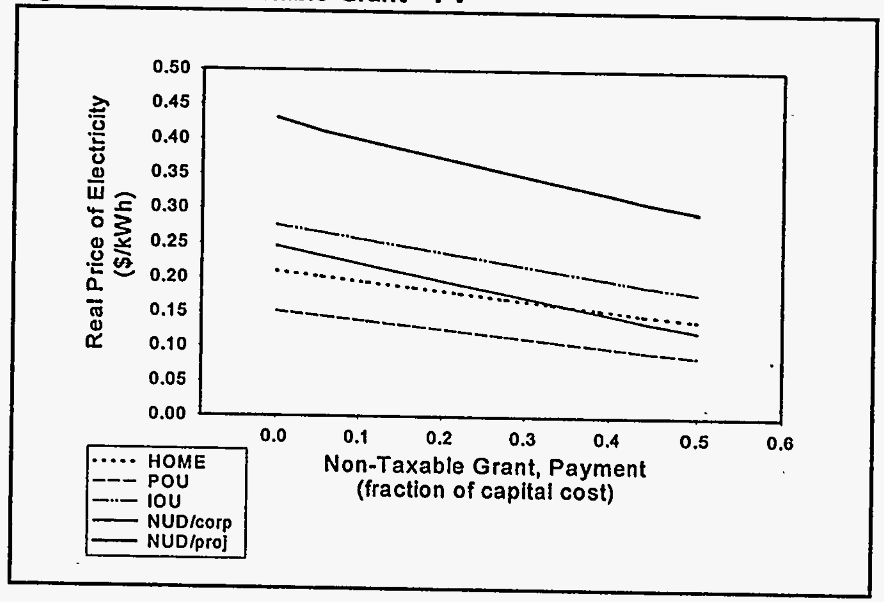



Figure 4-15. Taxable Grant - SDHW

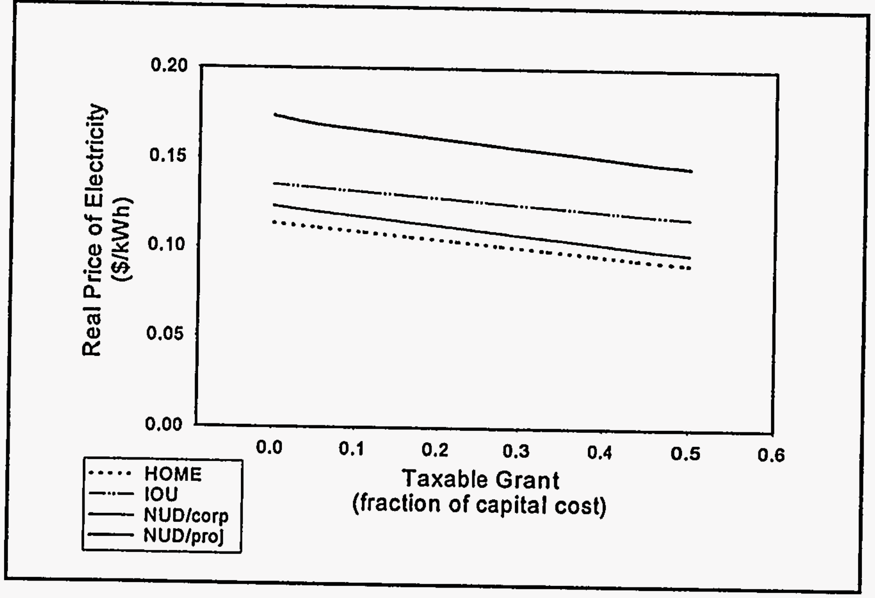
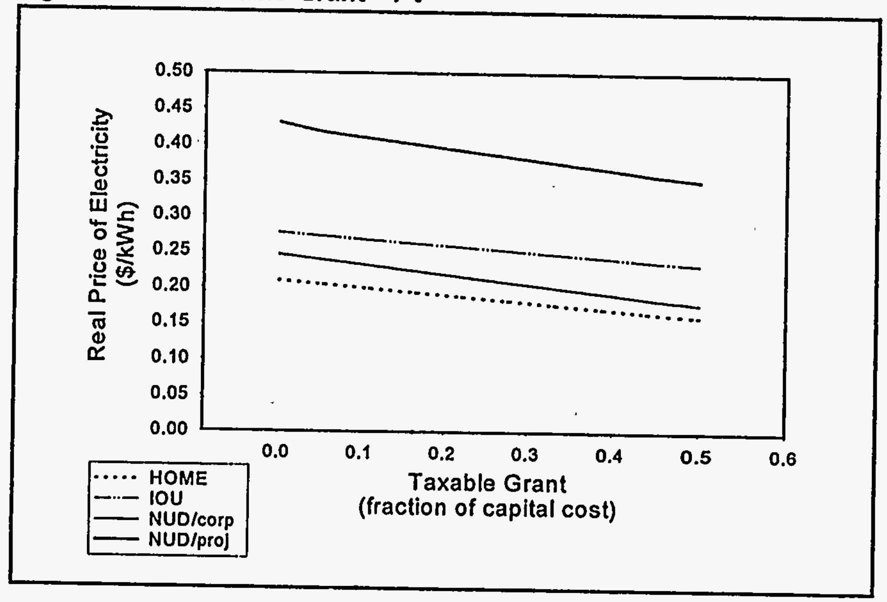



Figure 4-16. Taxable Grant - PV



As these figures suggest, the value of reductions in property and sales taxes depends ultimately on the current level of these taxes. Nevertheless, elimination of either tax does not lower costs to the levels achievable by the other policies considered in this chapter.

Between the two taxes, we find that levelized costs are far more sensitive to changes in property tax rates than they are to changes in sales tax rates for both technologies under all ownership and financing scenarios. The project-financed NUD is particularly sensitive to property taxes because these taxes reduce the amount of debt a project can carry because of the minimum DSCR constraint.

## 4.10 Direct Customer Payment

Finally, we also consider an annual direct payment to the homeowner to lower the cost of the end-use solar technologies for each of the development scenarios. This policy is paid out over time like a production incentive. However, unlike a production incentive, it is always paid directly to the homeowner. Some have these payments could be funded by a wires charge. In principle, these payments could be implemented in conjunction with other "upstream" policies targeting developers, although the tax implications of simultaneous policies for homeowners and developers has not been determined.[55] We discuss our findings for this policy in Chapter 5 because its impact is exogenous to (and, therefore identical for) each ownership and financing scenario.

[55] We are aware of efforts by the California Energy Commission, through its Renewables Program Committee, to clarify these tax implications with the U.S. Treasury (Wiser 1997).

# Comparing the Costs of Public Policies to Support Financing for End-Use Solar Technologies

## 5.1 Overview

In Chapter 4, we examined the effectiveness of various public policies to support financing of end-use solar technologies in isolation from one another. In this chapter, we evaluate the relative effectiveness of the policies in achieving a common goal. Specifically, we determine the design or subsidy level required under each policy in order to reduce the homeowner's cost of the SDHW and PV systems to a pre-specified value. We then calculate an upper bound on the total cost of the policies by considering their direct costs, as well as their potential indirect costs (or benefits) to federal, state, and local governments.

## 5.2 Comparing Public Policies to Support Financing for End-Use Solar Technologies

The levelized cost targets we have chosen for our comparative analysis are $0.10/kWh for SDHW, and $0.15/kWh for PV. We did not choose identical cost targets because, as we found in Chapter 3, the cost of PV is significantly higher than the cost of SDHW.

We pay close attention to the net fiscal impact of policy changes on all affected parties. For example, increasing federal investment tax credits reduces revenue to the federal government in two ways: the credit itself reduces revenues and also results in a smaller revenue stream that can be taxed. The increased credit allows a developer to lease a solar technology system at a lower cost, reducing the taxable revenue stream per system. Revenues to state government are also reduced by the same logic. Accounting for these and other interactive effects among policies is critical to develop a comprehensive picture of the full cost of public policies and to understand which entities bear the costs.

This chapter focuses primarily on investment tax credits, production tax credits, production incentives, grants, and direct customer payments because not all policies can reduce the homeowners' cost for systems to the target levels. The policies that were not able to lower costs to the target levels include: low-interest loans (except to the homeowner and POU), accelerated depreciation, and reduced property and sales taxes. Analysis of the maximum cost reductions available from these policies is presented in Appendix C.

## 5.3 Designing Public Policies to Support Financing for End-Use Solar Technologies

Tables 5-1 and 5-2 report the policy designs or subsidy levels necessary for each public policy to lower the levelized cost of the end-use solar technologies for each ownership and financing scenario to the target levels. Table 5-1 does not report results for the POU ownership and financing scenario because, based on the findings presented in Chapter 3, the cost of SDHW is already less than $0.10/kWh. In Table 5-2, policies not applicable for the POU scenario (i.e., tax incentives) are indicated.

**Table 5-1. Policy Design or Subsidy Levels to Reduce the Cost of SDHW to 10¢/kWh**

| Policy | Home-owner | IOU | NUD Corporate | NUD Project |
|---|---|---|---|---|
| Target Capital Cost (Base Cost $2,400) | $2,003 | $1,578 | $1,794 | $1,149 |
| Federal ITC | 21% | 35% | 27%[56] | 68%[57] |
| State ITC | 30% | 47% | 23% | 80% |
| Federal PTC (¢/kWh, 10 years, $1997) | 2.4 | 3.6 | 2.0 | 8.4 |
| State PTC (¢/kWh, 10 years, $1997) | 3.3 | 5.4 | 3.1 | 12.8 |
| Production Incentive (¢/kWh, 10 years, $1997) | 3.5 | 5.7 | 3.3 | 8.6 |
| Low Interest Loan | 5.8% | nf | nf | nf |
| Grant (taxable) | 30% | 97% | 45% | 139% |
| Grant (nontaxable, payment) | 21% | 43% | 24% | 79% |
| Grant (nontaxable, buy-down) | 26% | nc | 24% | nc |
| Direct Customer Payment (¢/kWh, 20 years, $1997) | 1.3 | 3.5 | 2.3 | 7.3 |

Note: nf = not feasible: this policy cannot lower the cost to the target value.
nc = not considered: this policy was not considered for this development alternative.

56 The existing 10% federal ITC is increased to this new level.

57 The existing 10% federal ITC is increased to this new level.

**Table 5-2. Policy Design or Subsidy Levels to Reduce the Cost of PV to 15¢/kWh**

| Policy | Home-owner | POU | IOU | NUD Corporate | NUD Project |
|---|---|---|---|---|---|
| Target Capital Cost ($/W) (Base Cost $5/W) | | 4.93 | 2.52 | 2.87 | 1.57 |
| Federal ITC | 43% | na | 52% | 38%[58] | 88%[59] |
| State ITC | 57% | na | 70% | 38% | 106% |
| Federal PTC (¢/kWh, 10 years, $1997) | 14.3 | na | 15.7 | 9.7 | 33.2 |
| State PTC (¢/kWh, 10 years, $1997) | 19.9 | na | 24.2 | 15.0 | 51.1 |
| Production Incentive (¢/kWh, 10 years, $1997) | 21.1 | 2.3[60] | 25.8 | 15.0 | 34.1 |
| Low Interest Loan | 4% | 5% | nf | nf | nf |
| Grant (taxable) | 61% | na | 146% | 72% | 187% |
| Grant (nontaxable, payment) | 44% | 1.5% | 65% | 39% | 106% |
| Grant (nontaxable, buy-down) | 54% | nc | nc | 39.1% | nc |
| Direct Customer Payment (¢/kWh, 20 years, $1997) | 11 | 0.2 | 13 | 10 | 28 |

Notes: na = not applicable: this policy is not applicable to this development alternative.
nf = not feasible: this policy cannot lower the cost to the target value.
nc = not considered: this policy was not considered for this development alternative.

It is useful to begin by comparing policies to outright reductions in the capital cost of the systems. Public polices to promote emerging technologies are often viewed as temporary supports until the cost of the new technologies falls low enough for them to compete directly in the market. The first "policy" presented in each table is the capital cost of the technology necessary to reduce the cost of technologies to the homeowner to the target level under each ownership and financing scenario.[61] These findings are drawn directly from the sensitivity analysis discussed in Chapter 3 (see Figures B-3 and B-4 in Appendix B).

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58 The existing 10% federal ITC is increased to this new level.

59 The existing 10% federal ITC is increased to this new level.

60 The existing 1.5¢/kWh ($1992) REPI is increased to this new level.

61 These cost reductions can be thought of as hypothetically resulting from either increased economies of scale in production or technological breakthroughs from R&D efforts.

The capital costs reported in Tables 5-1 and 5-2 mirror the findings in Chapter 3. The cost of systems is directly related to the effective discount rate associated with each ownership and financing scenario. A higher effective discount rate leads to a higher cost to the homeowner. Accordingly, the capital cost required under each scenario must be lower as the discount rate increases.

The results for the public policies exhibit a consistent trend: state investment and production tax credits must be higher than federal tax credits because state taxes are deductible from taxable revenue for federal income tax purposes. Similarly, the size of the grant required depends on whether or not it is taxable.

The results for the individual ownership and financing scenarios highlight the importance of explicitly considering the tax consequences of policies. In Chapter 3, we found that existing policies did not change the basic ordering of the scenarios from highest to lowest cost from that implied by each scenario's discount rate[62]—a finding that is also reflected in the capital cost results above. These results, too, follow this overall pattern, with the exception of the homeowner self-financing ownership scenario. As described in Chapter 4, the equipment leasing ownership and financing scenarios are fundamentally different from the homeowner self-financing scenario from a tax standpoint. Among the equipment leasing ownership and financing scenarios, the results follow a predictable pattern associated with discount rates. The policy design levels required for the project-financed NUD are the highest; those for the corporate-financed NUD are lowest.

## 5.4 The Cost of Public Policies to Support Financing for End-Use Solar Technologies

Tables 5-3 and 5-4 report the cost of the policies identified in Tables 5-1 and 5-2. We calculated the cost of the policies in two ways. First, we calculated the direct cost of each policy, which is the amount that the policy apparently pays directly to the owner or developer. Second, because the policies interact in subtle ways with the taxes that are paid by the owner or developer, we also calculated the indirect cost of each policy, which represents the net change in taxes paid to the federal, state, and local government. That is, purchase or lease of a system in conjunction (as a result of the policy) changes the tax

62 An exception is the federal ITC, which lowers the cost to the homeowner under NUD corporate financing below that under IOU ownership, despite identical discount rates.

Table 5-3. The Cost of Policies to Reduce the Cost of SDHW to 10¢/kWh ($/SDHW System)

| Policy | Homeowner Direct Cost | Homeowner Total Cost | IOU Direct Cost | IOU Total Cost | NUD Corporate-Finance Direct Cost | NUD Corporate-Finance Total Cost | NUD Project-Finance Direct Cost | NUD Project-Finance Total Cost |
|---|---|---|---|---|---|---|---|---|
| Capital Cost Reduction | 0% | 0.8% | 0% | 13.3% | 0% | 5.3% | 0% | 28.5% |
| Federal ITC | 21.6% | 21.6% | 35.3% | 48.2% | 17.6% | 28.5% | 59.3% | 87.4% |
| State ITC | 30.0% | 21.6% | 47.6% | 48.0% | 23.8% | 28.6% | 81.2% | 88.5% |
| Federal PTC | 21.3% | 21.3% | 31.5% | 51.5% | 18.2% | 32.1% | 74.9% | 113.4% |
| State PTC | 29.6% | 21.3% | 48.4% | 51.5% | 28.0% | 32.1% | 115.3% | 113.4% |
| Production Incentive | 31.5% | 21.3% | 51.5% | 51.5% | 29.8% | 32.1% | 76.9% | 92.9% |
| Low-Interest Loan | 28.0% | 18.0% | nf | nf | nf | nf | nf | nf |
| Grant (taxable) | 32.0% | 21.6% | 102.5% | 48.9% | 46.9% | 27.5% | 146.8% | 81.5% |
| Grant (nontaxable, payment) | 21.6% | 21.6% | 44.2% | 48.5% | 24.8% | 28.0% | 80.4% | 84.5% |
| Grant (nontaxable, buy-down) | 28.9% | 21.9% | nc | nc | 25.6% | 26.2% | nc | nc |
| Direct Customer Payment | 20.3% | 20.3% | 55.1% | 55.1% | 36.2% | 36.2% | 114.8% | 114.8% |

Notes: na = not applicable: this policy is not applicable to this development alternative.
nf = not feasible: this policy cannot lower the cost to the target value.
nc = not considered: this policy was not considered for this development alternative.

Table 5-4. Cost of Policies to Reduce the Cost of PV to 15¢/kWh ($/PV System)

| Policy | Homeowner | | POU | | IOU | | NUD Corporate-Finance | | NUD Project-Finance | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Direct Cost | Total Cost | Direct Cost | Total Cost | Direct Cost | Total Cost | Direct Cost | Total Cost | Direct Cost | Total Cost |
| Capital Cost Reduction | 0% | 0.8% | 0% | 0.1% | 0% | 22.0% | 0% | 11.1% | 0% | 57.1% |
| Federal ITC | 43.7% | 43.7% | na | na | 53.0% | 72.4% | 28.4% | 49.5% | 79.0% | 133.0% |
| State ITC | 60.7% | 43.7% | na | na | 71.6% | 72.2% | 38.4% | 49.7% | 108.1% | 134.5% |
| Federal PTC | 43.0% | 43.0% | na | na | 47.3% | 77.4% | 29.3% | 55.2% | 99.8% | 167.6% |
| State PTC | 59.7% | 43.0% | na | na | 72.8% | 77.4% | 45.0% | 55.2% | 153.5% | 167.6% |
| Production Incentive | 63.5% | 43.0% | 1.5% | 1.5% | 77.4% | 77.4% | 47.9% | 55.2% | 102.4% | 140.3% |
| Low-Interest Loan | 66.6% | 42.2% | 1.4% | 1.4% | nf | nf | nf | nf | nf | nf |
| Grant (taxable) | 64.6% | 43.7% | na | na | 154.0% | 73.5% | 75.5% | 47.9% | 197.1% | 125.4% |
| Grant (nontaxable, payment) | 43.7% | 43.7% | 1.5% | 1.5% | 66.4% | 72.8% | 40.1% | 48.8% | 107.9% | 129.4% |
| Grant (nontaxable, buy-down) | 58.3% | 44.2% | nc | nc | nc | nc | 42.4% | 44.7% | nc | nc |
| Direct Customer Payment | 41.8% | 41.8% | 1.4% | 1.4% | 87.7% | 87.7% | 66.1% | 66.1% | 195.6% | 195.6% |

Notes: na = Not applicable: this policy is not applicable to this development alternative.
nf = not feasible: this policy cannot lower the cost to the target value.
nc = not considered: this policy was not considered for this development alternative.

revenues that each level of government would collect (or pay out).[63] Accounting for both direct and indirect costs provides a more complete measure of the net fiscal impact of the policies on society. Appendix D details the disaggregated impacts on federal, state, and local revenues.

These costs are calculated as differences from a base case in which the systems are purchased or leased without the policy. All costs are calculated as a present value using a common discount rate (6.5%).[64] For ease of comparison, costs are expressed as a percentage of the installed cost of the systems. As reported in Chapter 2, the capital cost of SDHW and PV are $2,400 and $20,000 per system.

### 5.4.1 General Findings

1. *The cost of policies is lowest for the ownership and financing scenarios that are already at or close to the levels targeted by the policies* (e.g., homeowner financing and publicly owned utility financing). This is a fairly obvious and straightforward finding. The additional subsidy required from a policy for technologies that are close to being cost effective under a particular ownership scenario is only that additional increment of funding required to make the technology cost effective. This is seen most clearly in the capital cost results presented in Tables 5-1 and 5-3.

2. *Subsidies are more effective under the three equipment-leasing ownership and financing scenarios in which the equipment owners pay taxes (i.e., all but the publicly owned utility) than they are under the homeowner financing scenario.* In our base case results, we observed that the effective discount rate was roughly correlated with the levelized costs of the systems. We find that this correlation is also true for the equipment leasing scenarios in which the equipment owners pay taxes but not for the homeowner financing scenario. As noted earlier in Chapter 4, tax effects of policies are multiplied for the three equipment leasing scenarios. For example, these effects create a situation where the cost of policies under non-utility corporate financing scenario are only slightly higher than their cost under the homeowner financing scenario (despite the higher effective discount rate associated with

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63 Examples of indirect tax revenue effects include: the recursive tax effects discussed in Section 4.3, decreases in state tax deduction for federal taxes, and reductions in interest payment deductions. We only consider taxes that are directly related to the project: state and federal income taxes of the project owner, state sales taxes on the equipment, and local property taxes on the equipment.

64 All tax revenues and policy costs are reported as present values. All revenues and payments are assumed to be made at the end of the year. The only exception is for grants, which are paid at the beginning of the first year. The discount rate used is 6.5%, which is what Jenkins, Chapman, and Reilly (1996) use for government agencies in their tax analysis. It is also almost identical to the 6.6% nominal discount rate recommended by the NIST Handbook 135, *Energy Prices and Discount Factors for Life-Cycle Cost Analysis 1995*, for federal projects dealing with conservation and renewables (Short, Packey, and Holt 1995).

the nonutility corporate financing scenario). Nevertheless, the costs of the policies remain higher than those of the comparable policy targeted to homeowners financing systems on their own.

3. *Consideration of indirect costs is important because many policies represent no more than revenue transfers among federal, state, and local governments.*[65] The direct costs of policies do not account for transfers among federal, state, and local revenues. For example, the direct cost of a federal investment tax credit is lower than the direct cost of a state investment tax credit, yet the sum of the direct and indirect costs is identical for these two policies. For all policies, the inclusion of indirect costs eliminates or reduces many apparent differences in the direct cost of the policies.

This finding has implications for the political viability of different policies. A policy with lower direct (or apparent) cost may be more politically acceptable than a policy with a higher direct cost even though the policies have nearly identical costs when indirect costs are included. For example, an federal investment tax with a direct cost of 35.3% of the installed cost of a SDHW under IOU financing is required to lower the cost of SDHW to 10¢/kWh while a taxable grant of more than 100% of the installed cost of such a system is required to achieve this same cost reduction. Yet, the combined direct and indirect costs of these policies are almost identical, 48.2% and 48.9%, respectively.[66]

4. *Including indirect costs is important for capturing the total cost of policies.* The sum of direct and indirect costs of policies may be either higher or lower than the direct costs depending on the ownership and financing scenarios.

Under the homeowner financing scenario, indirect costs are not additional cost but benefits that offset direct costs. That is, a policy that lowers the cost of financing also lowers the amount of interest that is paid and hence can be deducted. For example, a lower interest deduction increases taxable income and thereby increases income taxes. In other words, some of the subsidy provided by the policy is taken back in the form of higher income taxes. Thus, including indirect costs lowers the sum of direct and indirect costs for certain policies (state ITC, state PTC, production incentive, low-interest loan, taxable grant, and nontaxable grant with buy-down) below the policies' direct costs. For policies with no indirect costs (federal ITC, federal PTC, nontaxable grant w/payment, and direct customer payment), direct costs are unchanged.

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65 This finding does not apply to the publicly owned utility ownership and financing scenario because a publicly owned utility is assumed to pay no taxes.

66 The taxable grant must be so much larger because about 60% of its direct value is eroded by two indirect tax effects: it is subject to taxation, and it reduces the depreciable base by 100% of its value (rather than only 50% for the ITC).

Under the equipment leasing ownership and financing scenarios, lower financing costs reduce interest payments as well as fees the equipment owner must charge homeowners. Gross revenue and interests costs are reduced simultaneously in a recursive fashion that lowers the total amount of income taxes owed. The net effect is that the sum of the direct and indirect costs of a policy is higher than the direct cost for almost every scenario.

For taxable grants, direct and indirect costs are lower than direct costs alone for the same reason these costs are lower than direct costs under the homeowner financing scenarios. For direct customer payments there are no indirect costs..

5. *The total cost of policies is determined by the time period over which subsidies are paid out.* For the homeowner-financing scenario, subsidies paid out over a longer term (direct customer payment, production incentives or tax credits) are lower in cost than subsidies paid up-front (investment tax credits, grants). Under the equipment leasing financing and ownership scenarios, subsidies paid up-front are lower in costs than those paid out over time.

As with our base case results, the explanation lies with the effective discount rate associated with the ownership and financing scenarios in comparison to that of the entity providing the subsidy. We assumed a 6.5% discount rate for evaluating the present value of all policies. When the effective discount rate is lower than 6.5% (as it is in the homeowner-financing scenario), up-front payments are more costly. When the effective discount rate is higher (as it is in the equipment-leasing ownership and financing scenarios) payments over time are more costly.

To understand this phenomenon, remember that the 6.5% discount rate represents the time-value of funds to society. When an ownership and financing scenario has a lower effective discount rate than society's discount rate, the present value of funds paid out over time is higher to this owner than to society. Similarly, when an ownership and financing scenario has a higher effective discount rate than that of society, the present value of funds paid up-front has a higher value to this owner than it does to society.

This finding also has important implications for discussions about the incentive properties of policies under the equipment-leasing ownership and financing scenarios. Some argue that policies that feature up-front payments provide perverse incentives than policies that link payments to the output of the solar technologies. We have shown that policies that link payments to output can be more costly (under the equipment leasing financing scenarios). By quantifying the additional costs of policies that link payments to output, we can understand the trade-offs between the incentives/disincentives and the costs of the policies.

### 5.4.2 Specific Findings

In the remainder of this chapter we describe results that are specific either to each end-use solar technology or each ownership and financing scenario.

For SDHW, we find that the policies targeting homeowner financing have the lowest total cost among the various ownership and financing options considered.[67] For this scenario, low-interest loans followed by direct customer payments have the lowest total costs. These policies are the least expensive because they are paid to the homeowner, who has a lower discount rate than the government, over 20 years.

When taxable and nontaxable grants both involve payments to the revenue stream in the first year, they have the same total cost. In an alternate version of the nontaxable grant (buy-down style), it was modeled as a reduction in capital cost. In this case, it reduces the size of the loan and consequently reduces the long-term interest deduction subsidy. Thus, it is even more of an up-front payment than the ITC or conventional payment-style grant. Because of this, it is more expensive for the homeowner (low discount rate) alternative, but less expensive for the corporate financed NUD (high discount rate) alternative.

There is no inherent reason why a taxable grant policy could not be designed in this same fashion. This artifact of our modeling highlights the following finding: A policy that reduces the size of the loan through a first-year payment is highly effective for ownership and financing scenarios that have a higher discount rate than the government or subsidy provider.

For PV, policies targeting POUs are lowest in cost; direct customer payments and low-interest loans are the least expensive. Policies targeting homeowner financing are next in total cost, again with direct customer payments and low-interest loans lowest in total cost.

Policies targeting NUD corporate financing are next lowest in cost for both SDHW and PV. Among the policies, capital cost buy-down style nontaxable grants, followed by payment-style grants, federal and state ITCs have the lowest cost.[68] Nontaxable grants are lowest in total cost for the IOU and NUD project financing, followed closely by federal and state ITCs.

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67 Recall that we did not consider SDHW public policies for the POU ownership and financing scenario because our analysis in Chapter 3 shows that the levelized cost target ($0.10/kWh) has already been reached (exceeded).

68 The difference in cost between payment-style grants and ITCs is the differential impacts the policies have on the depreciable base.

# Developing Public Policies to Promote Renewable Energy in a Restructured Electricity Industry—Next Steps

Renewable energy technologies are capital intensive. Successful public policies for promoting renewable energy must address the significant resources needed to finance them (Wiser and Pickle 1997). Public policies to support financing for renewable energy technologies must pay special attention to interactions with other federal, state, and local taxes. These interactions are important because, on one hand, they can dramatically increase or decrease the effectiveness of a policy, and, on the other hand, they determine the total cost of a policy to society as a whole.

This report has analyzed the direct and total cost of public policies designed to support financing for residential end-use solar technologies. Our analysis clarifies the relationships between the basic economics of end-use solar technologies, innovative business ownership and financing options for deploying these technologies, and the total cost of public policies to enhance these options. Nevertheless, our analysis represents only a starting point for discussion. In what follows, we outline some of the issues that require further investigation.

First, our sensitivity analysis quantified the importance of system cost and performance for the final cost of the systems. Although we relied on recent measured cost and performance data to develop our assumptions, they are uncertain. In particular, we did not explicitly consider the ability of non-homeowner developers to further lower costs through bulk purchasing, or to improve performance through better site selection and equipment orientation. Instead we assumed that both homeowners and non-homeowners would face the same capital and operating costs and obtain the same energy performance from the technologies.[69]

Second, we only examined the cost dimension of the many challenges and opportunities that end-use solar technologies face in the market. Our basic findings suggest that currently, neither end-use solar technology would be judged cost effective by a direct comparison of the economic cost of the technologies to their economic value (roughly, the value of avoided electricity purchases). Yet, we cannot ignore the fact that end-use solar technologies have gained limited acceptance in the marketplace and that this acceptance is unlikely to be based solely on economic evaluations. Indeed, the literature is full of discussions of the "market

[69] We have designed our tool to facilitate links with LBNL's Geographic Information System laboratory (Marnay, et al. 1997). Establishing these links would allow us to derive performance analytically based on locally varying conditions, which would improve our ability to represent the energy benefits of the technologies more precisely.

barriers" that appear to explain under-investment in cost-effective energy-efficiency measures.[70] Therefore, we must accept that economic value is only one of many issues that must be addressed in creating a market for these technologies. In particular, we have not considered the many non-economic benefits (and costs) associated with reliance on end-use solar technologies.

Third, as noted, we focused on economic cost at the expense of a broad examination of market adoption, which limited the policies we considered to those involving cash transfers in one form or another to support financing. We did not model customer adoption or market penetration. Therefore, we did not account for the possibility that, even though policies directed at non-homeowner developers may be more costly, there may be a larger societal benefit. That is, if these developers can realize economies of scale in buying, selling, financing, and maintaining these technologies, they may be more successful in installing them in larger numbers compared to the current situation, which depends entirely on homeowners acting individually. In the same vein, we did not examine public policies that might directly involve promotion or green marketing for end-use solar technologies, though we recognize that policies such as these are likely to be critical elements of an integrated suite of public policies to stimulate the market for these technologies.

Fourth, our focus on economic cost allowed us to identify, but not assess, the incentive properties associated with the public policies we considered. Specifically, we found that up-front payments could be provided at lower total cost than payments spread over time, owing to the lower discount rate we assumed would apply to the government or other agency providing these payments. Yet, the literature suggests that up-front payments can create perverse incentives to developers and that payments for performance, spread over time, offer superior incentive properties.[71] We have shown that policies with these superior incentive properties cost more to society than those with weaker incentive properties. However, we have not examined these incentives in sufficient detail to allow trade-offs to be made between them.

In summary, we have conducted a comprehensive analysis of the direct and indirect costs of public policies that might support financing for end-use solar technologies under a variety of ownership and financing scenarios. Examining the costs of such policies is a critical element in designing more effective policies in the future. However, it is not the only element. Other issues, such as consumer and developer behavior, must be considered as well. We believe our analysis provides an important beginning for these discussions.

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70 See Golove and Eto (1996) for a recent review of this literature.

71 See Kahn and Stoft (1989) for a review of this literature.

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# Description of Financial Models

## A.1 Overview

This appendix describes the cash-flow models used in this report. Four different pro forma cash-flow models were used to analyze the five development alternatives. The NUD, IOU, and POU models were based on models developed by Wiser and Kahn (1996) to analyze hypothetical wind-power projects. Please refer to their report for a more complete explanation of those models.

## A.2 Homeowner

The homeowner model calculates the expenses, taxes, and debt payments for each year of the life of a solar end-use technology. These payments are then levelized and divided by energy production to determine the real levelized price of electricity. Figures A-1 and A-2 represent the base-case models for the homeowner alternative using solar domestic hot water (SDHW) and photovoltaic (PV) technologies, respectively.

## A.3 Non-Utility Developer

### A.3.1 Project-Financed NUD

The project-financed NUD model works as follows: operating income is calculated for each year of a project's economic lifetime. This income is then compared with the debt obligation to obtain a series of DSCRs. The model also calculates the after-tax net equity cash flow (including taxes, tax credits, and depreciation)[72]. An iterative solving routine is then run to minimize the cost of electricity by changing the debt fraction, given constraints on minimum DSCR and minimum return on equity (ROE). Real and nominal levelized costs of electricity are derived from this result. Figures A-3 and A-4 depict the base-case models for the project-financed NUD alternative using SDHW and PV technologies, respectively.

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72 The net tax liability is often negative in the early years of a project because of tax credits and depreciation. It is assumed that the equity investors have a sufficient tax burden elsewhere to absorb these tax savings and are not subject to the alternative minimum tax. Thus, tax saving do not need to be carried forward or backward.

### A.3.2 Corporate-Financed NUD

A single model is used for corporate- and project-financed NUD, but it is used slightly differently for corporate finance. First, the debt fraction is held constant. Second, the price of electricity is solved iteratively to obtain the desired equity rate without any further constraints. Figures A-5 and A-6 represent the base-case models for the corporate-financed NUD alternative using SDHW and PV technologies, respectively.

## A.4 Investor-Owned Utility

The IOU development scenario is similar to the corporate-financed NUD in that capital is raised based on the balance sheet of a large corporation and the debt fraction is fixed. However, because of the regulated nature of IOUs, a revenue-requirement (RR) model is used that is specific to the electric utility industry. The RR model calculates the revenues that ratepayers needed to match the operating costs, taxes, debt payments, and equity return for each year. The required revenue stream is then discounted to obtain a levelized price of electricity. Figures A-7 and A-8 show the base-case models for the IOU alternative using SDHW and PV technologies, respectively.

## A.5 Publicly Owned Utility

The public utility cash-flow model is the simplest of the third-party ownership scenarios. It calculates the revenue needed to cover operating expenses and debt payments minus the REPI payments in each year over the economic lifetime of a project. These required revenues are then discounted to derive the real and nominal levelized costs of electricity. The debt is serviced in mortgage-style constant payments. Although municipal bonds are not paid in this fashion, one could rationalize that bonds are not project-specific and that the utility has multiple outstanding bonds with various maturity dates, resulting in relatively constant payments. Therefore, this type of analysis is typically used for POUs (Wiser and Kahn 1996). The debt term does not impact the levelized cost of power because the discount rate is the same as the debt rate in this scenario. Figures A-9 and A-10 depict the base-case models for the POU alternative using SDHW and PV technologies, respectively.

# Detailed Sensitivity Analysis

The following is an exhaustive set of sensitivity analyses about our baseline assumptions. It is used to identify key parameters that may (1) be a source of uncertainty in our base-case calculations, (2) vary geographically, or (3) be an opportunity to use a policy to promote end-use solar technology (EUST). The graphs plot the value of the parameter versus the real levelized cost of electricity for each of the relevant development scenarios.

Energy Saved (SDHW) - Figure B-1 is a plot of the real levelized cost as a function of the energy saved by the solar hot water system.

Capacity Factor (PV) - Figure B-2 is a plot of the real levelized cost as a function of the capacity factor. The capacity factor varies geographically and has a significant price impact. It can range from 14.3% in Washington to 23% in Hawaii (Wenger, Niche Markets 1996).

Installed Capital Cost - Figures B-3 and B-4 are plots of the real levelized cost as a function of the installed capital cost for SDHW and PV, respectively. Our policy discussion in Chapter 4 relates each subsidy option to the equivalent reduction in capital cost.

Debt Rate - Figures B-5 and B-6 are plots of the real levelized cost as a function of the debt interest rates for SDHW and PV, respectively. The debt rate also has a significant impact on price, especially for the 100% debt-financed POU development alternative. Thus, this could be a significant source of uncertainty in our base-case results. This relative sensitivity also makes low-interest loans an attractive policy option (see Chapter 3).

Equity Rate - Figures B-7 and B-8 are plots of the real levelized cost as a function of the equity rate for SDHW and PV, respectively. Price is very sensitive to equity rate. Thus, this could be a large source of uncertainty in our assumptions for IOU and NUD alternatives.

Equipment Lifetime - Figures B-9 and B-10 are plots of the real levelized cost as a function of the equipment for SDHW and PV, respectively. Thus, the slope is significantly larger for the POU than for the project-financed NUD. For low-discount-rate alternatives, this may be a significant source of uncertainty.

Property Tax - Figures B-11 and B-12 are plots of the real levelized cost as a function of the property tax rates for SDHW and PV, respectively. The slope is not large, but the potential range makes this parameter important. A reduction or elimination of property tax may be used in conjunction with other policies to promote EUST; detailed analysis is in Chapter 3.

Sales Tax - Figures B-13 and B-14 are plots of the real levelized cost as a function of the sales tax rates for SDHW and PV, respectively. The sales tax has a smaller slope but a similar range to the property tax. Chapter 3 considers its reduction or elimination as part of a suite of policies.

Lease Price Escalation Rate - Figures B-15 and B-16 are plots of the real levelized cost as a function of the lease price escalation rates for SDHW and PV, respectively. How the price of electricity is structured in the lease can have a large impact on the project-financed NUD development alternative. The local minimum is associated with the highest possible debt fraction.

O&M Expense - Figures B-17 and B-18 are plots of the real levelized cost as a function of the lease price escalation rates for SDHW and PV, respectively. This rate has a much larger effect on the SDHW technology because it is a larger portion of the total cost.

Debt Term - Figures B-19 and B-20 are plots of the real levelized cost as a function of the debt terms for SDHW and PV, respectively. The largest impact is on the project-financed NUD alternative where a longer debt term can help to mitigate the minimum DSCR financing constraint.

Minimum DSCR - Figures B-21 and B-22 are plots of the real levelized cost as a function of the minimum DSCRs for SDHW and PV, respectively. Only the project-financed NUD alternative is relevant. Since no EUST ventures have ever been project financed, our base-case assumption is very uncertain.

Equity Fraction - Figures B-23 and B-24 are plots of the real levelized cost as a function of the equity fraction for SDHW and PV, respectively.

Federal Income Tax - Figures B-25 and 26 are plots of the real levelized cost as a function of the federal income tax rates for SDHW and PV, respectively. This is only important for the homeowner alternative.

State Income Tax - Figures B-27 and B-28 are plots of the real levelized cost as a function of the state income tax rates for SDHW and PV, respectively. The effects of this parameter are negligible.

Performance Deterioration Rate - Figures B-29 and B-30 are plots of the real levelized cost as a function of the performance deterioration rates for SDHW and PV, respectively.

Figure B-1. SDHW Energy Saved Sensitivity Analysis

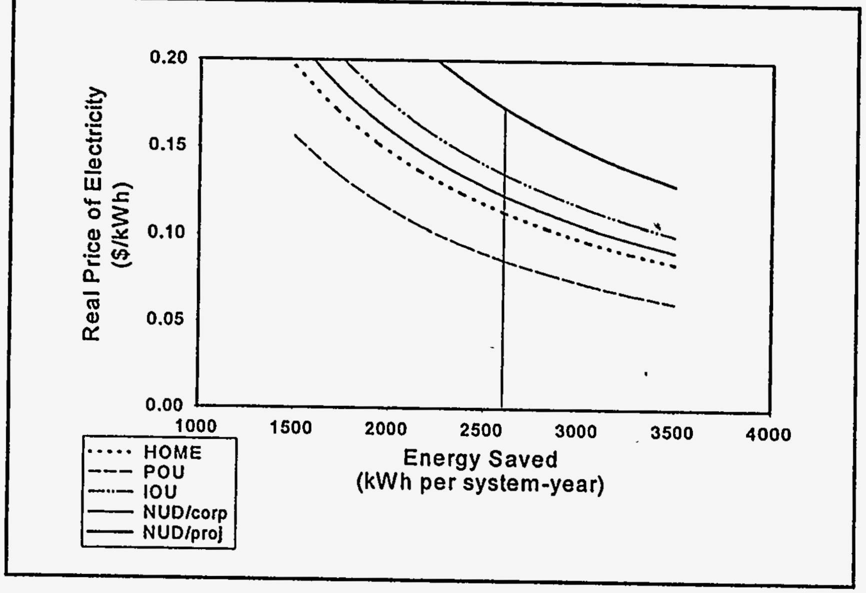



Figure B-2. PV Capacity Factor Sensitivity Analysis

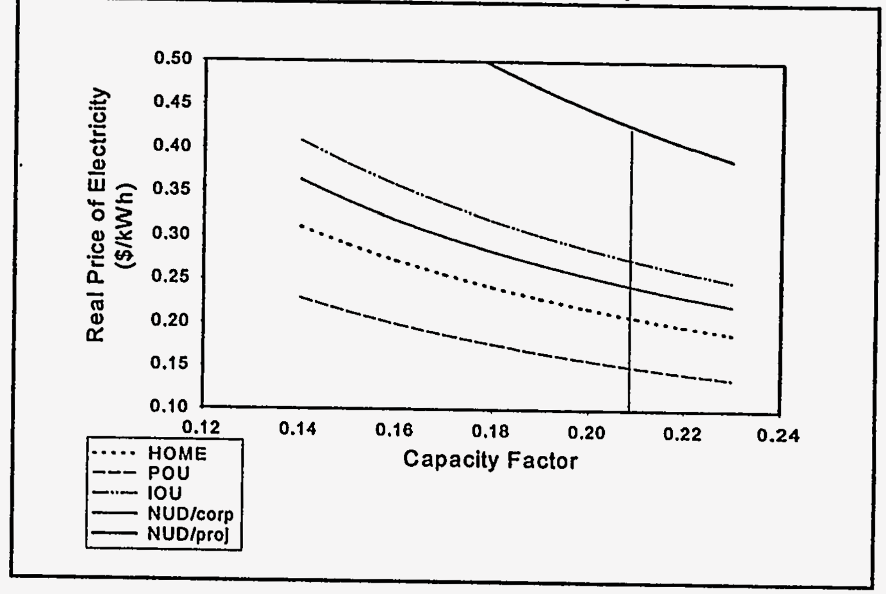



Figure B-3. SDHW Capital Cost Sensitivity Analysis

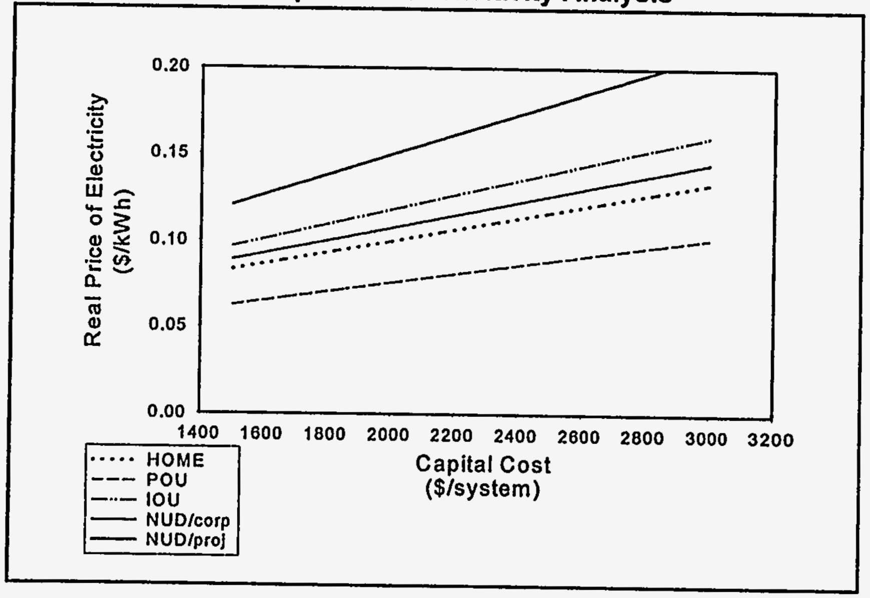



Figure B-4. PV Capital Cost Sensitivity Analysis

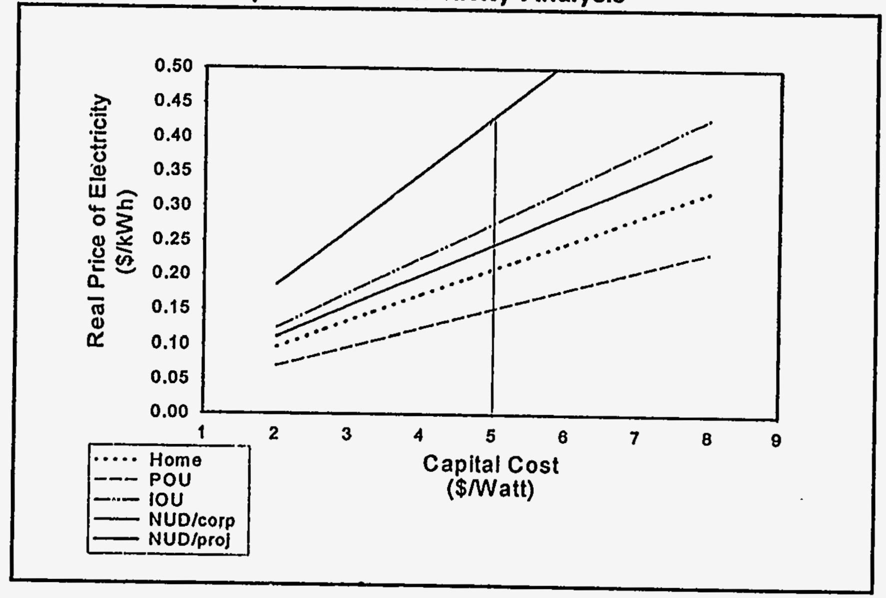


Figure B-5. SDHW Debt Rate Sensitivity Analysis

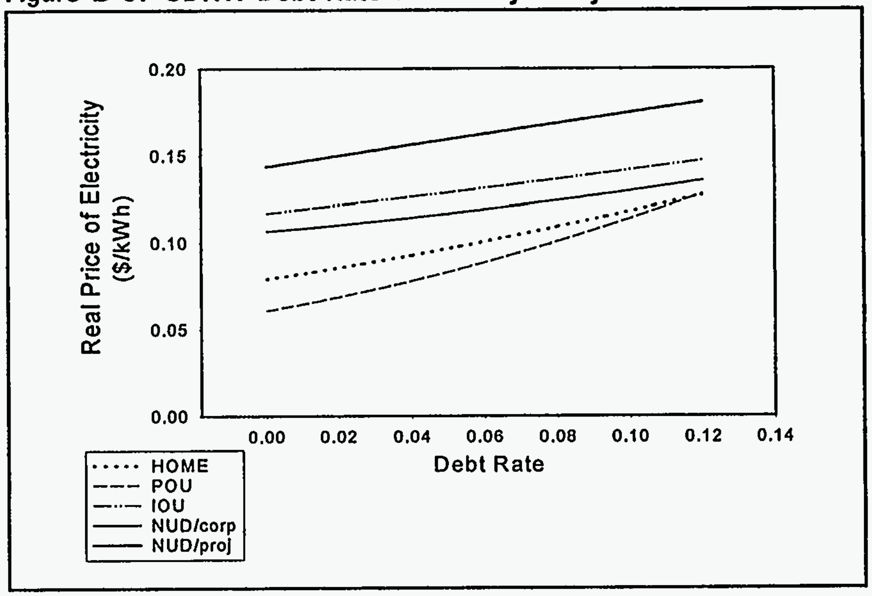



Figure B-6. PV Debt Rate Sensitivity Analysis

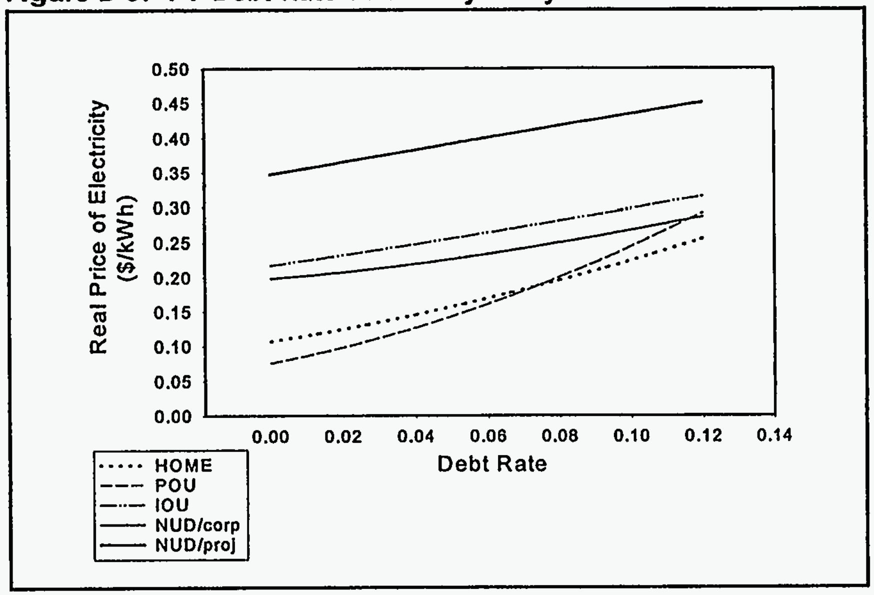



Figure B-7. SDHW Equity Rate Sensitivity Analysis

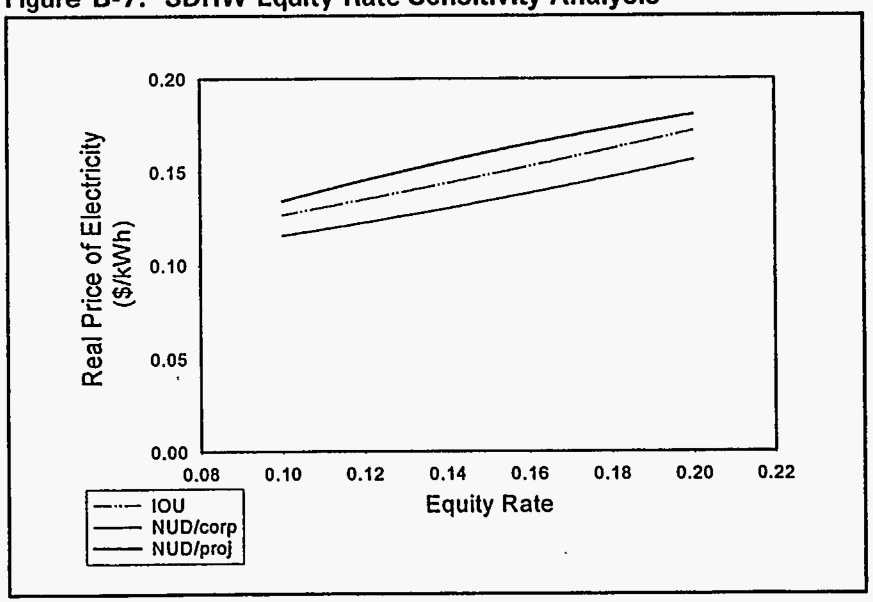



Figure B-8. PV Equity Rate Sensitivity Analysis

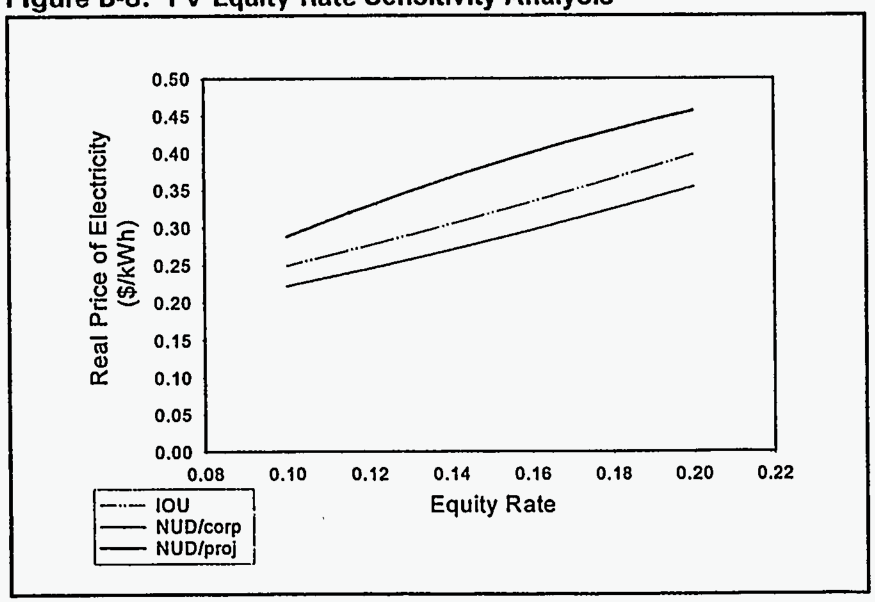


Figure B-9. SDHW Project Economic Life Sensitivity Analysis

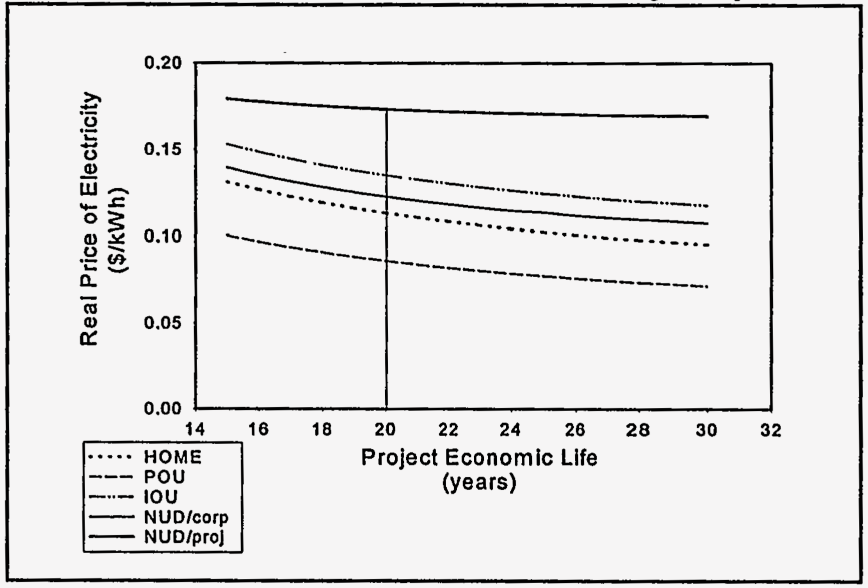



Figure B-10. PV Project Economic Life Sensitivity Analysis

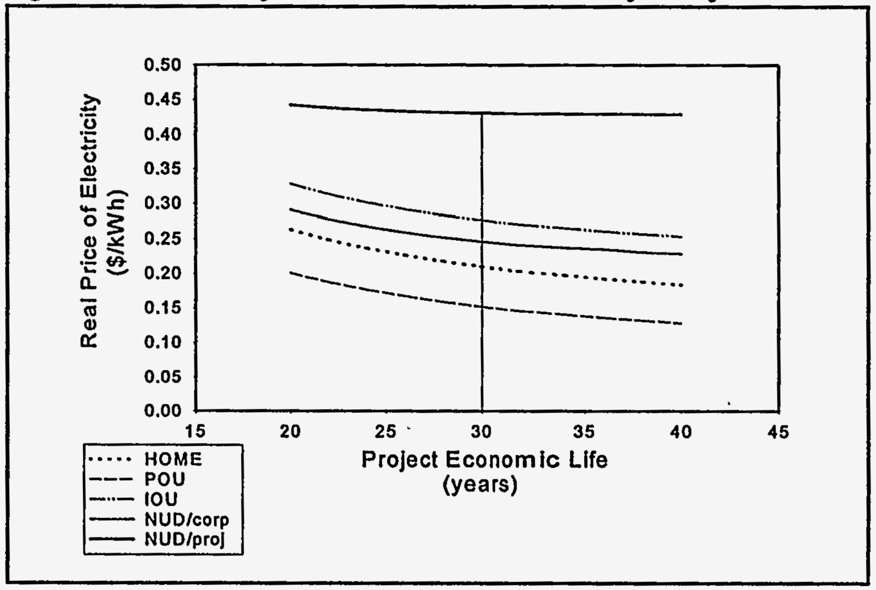



Figure B-11. SDHW Property Tax Sensitivity Analysis

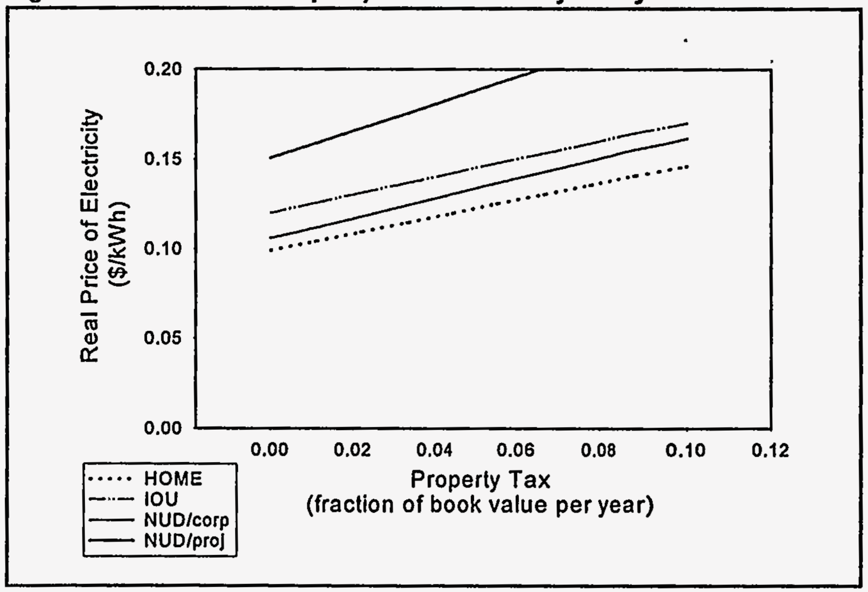



Figure B-12. PV Property Tax Sensitivity Analysis

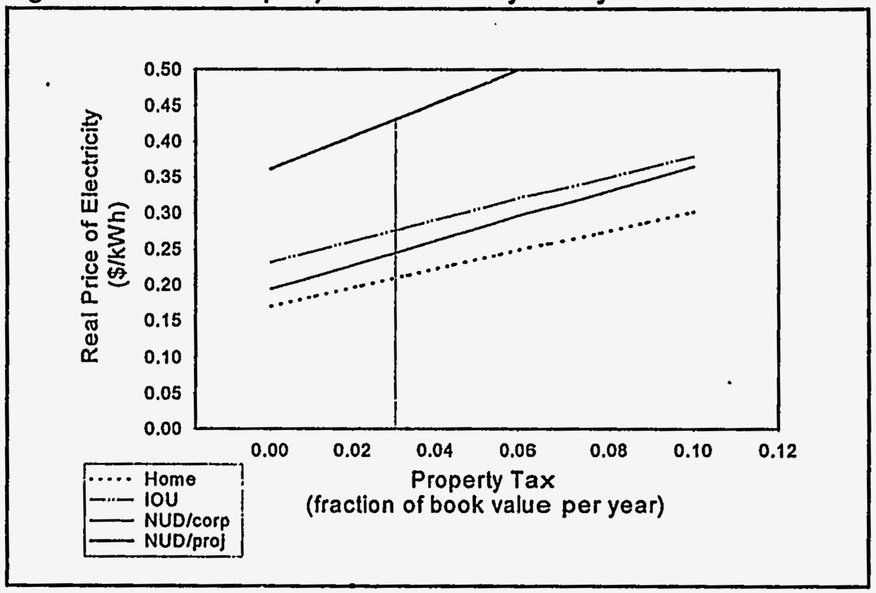


Figure B-13. SDHW State Sales Tax Sensitivity Analysis

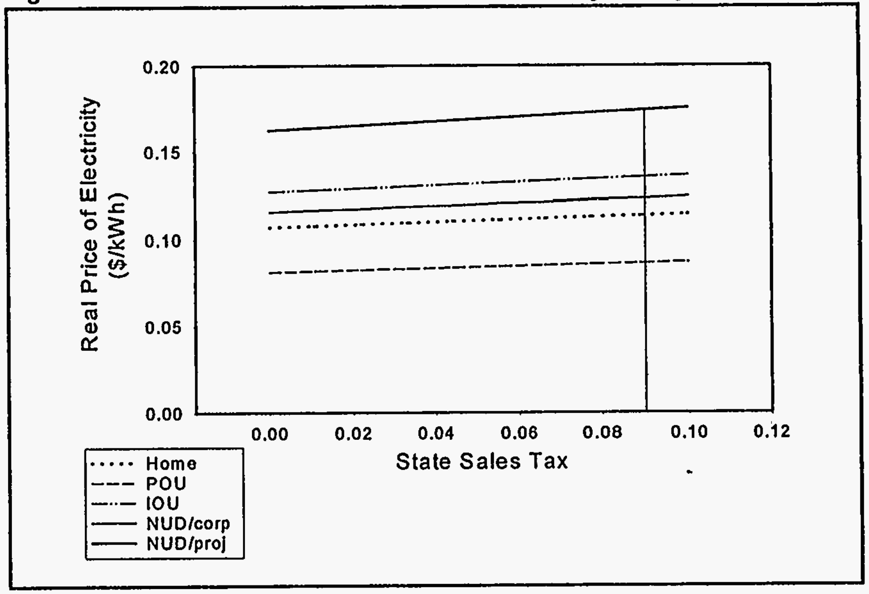



Figure B-14. PV State Sales Tax Sensitivity Analysis

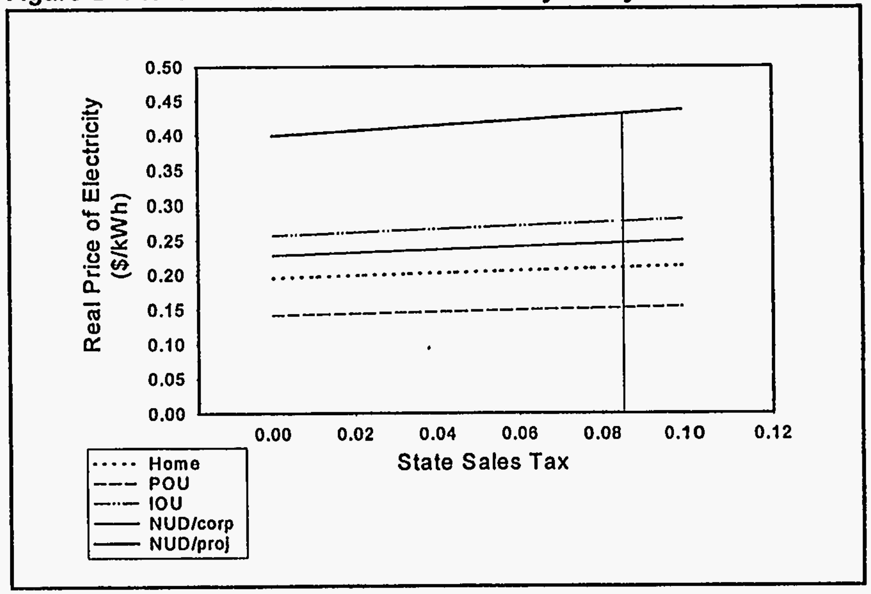



Figure B-15. SDHW Lease Price Escalation Rate Sensitivity Analysis

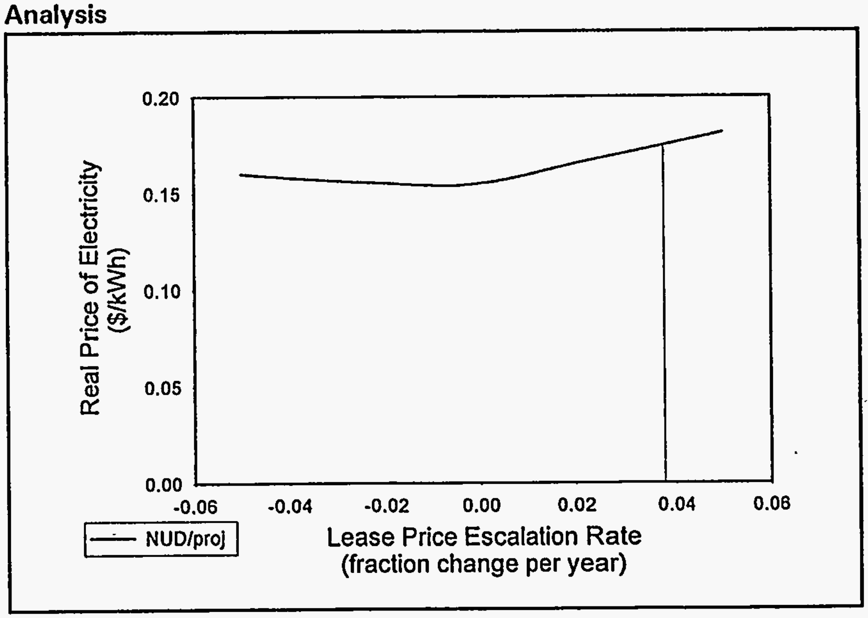



Figure B-16. PV Lease Price Escalation Rate Sensitivity Analysis

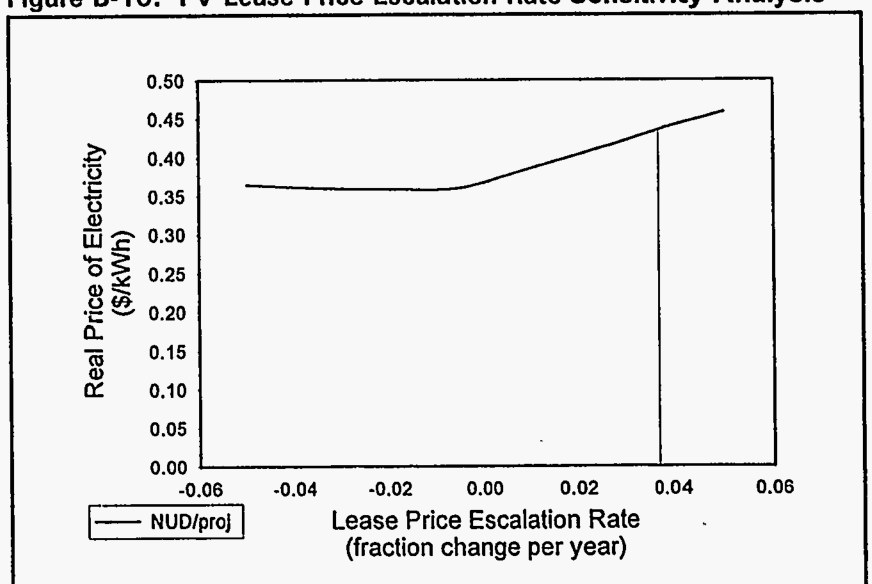


Figure B-17. SDHW Operating Expense Sensitivity Analysis

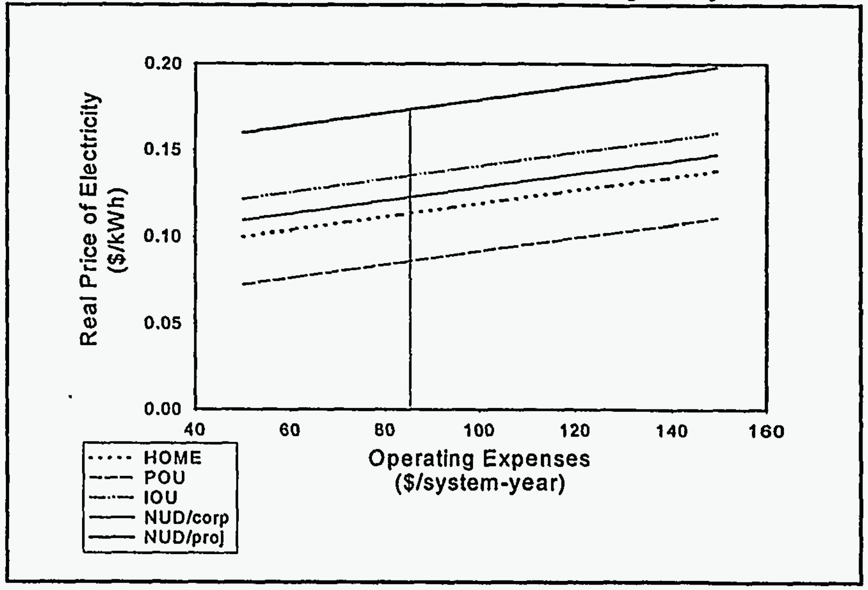



Figure B-18. PV Operating Expense Sensitivity Analysis

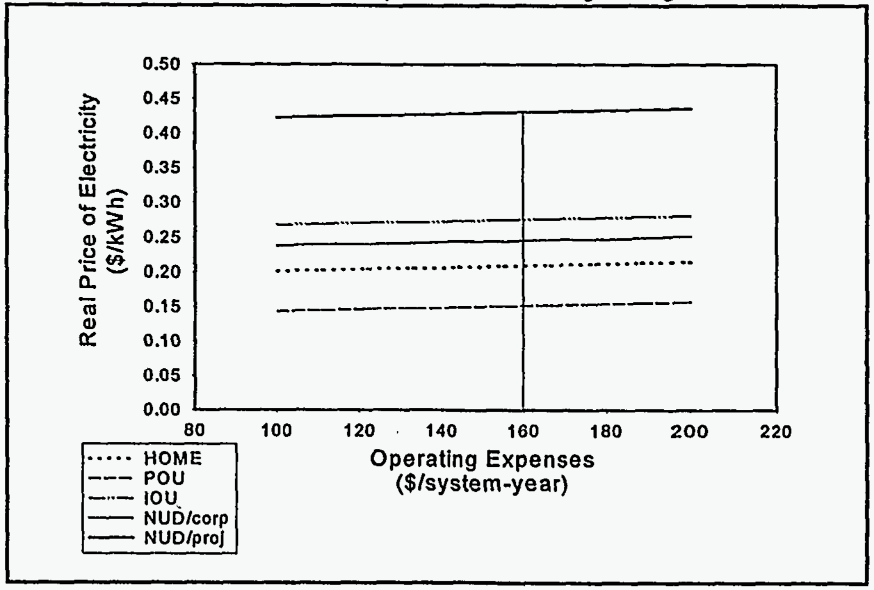



Figure B-19. SDHW Debt Term Sensitivity Analysis

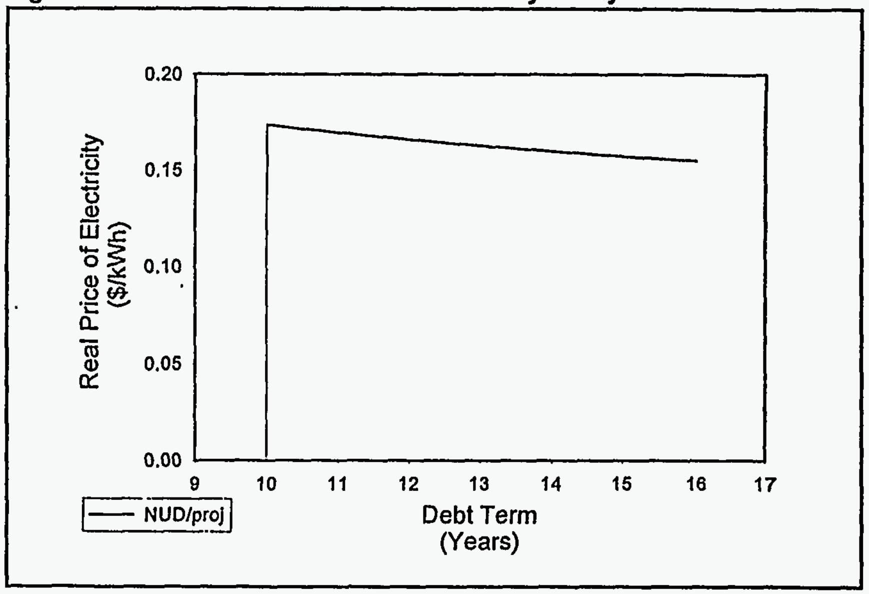



Figure B-20. PV Debt Term Sensitivity Analysis

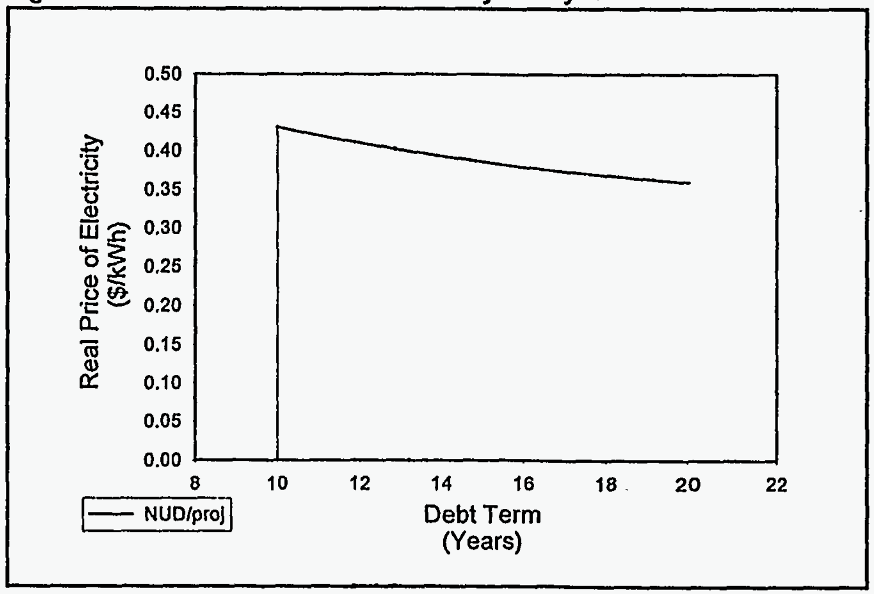


Figure B-21. SDHW Minimum DSCR Sensitivity Analysis

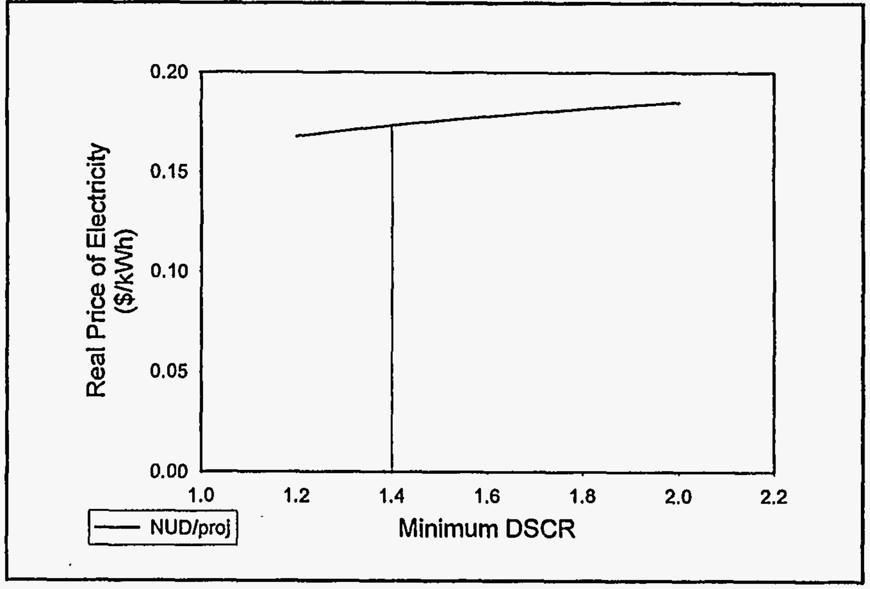



Figure B-22. PV Minimum DSCR Sensitivity Analysis

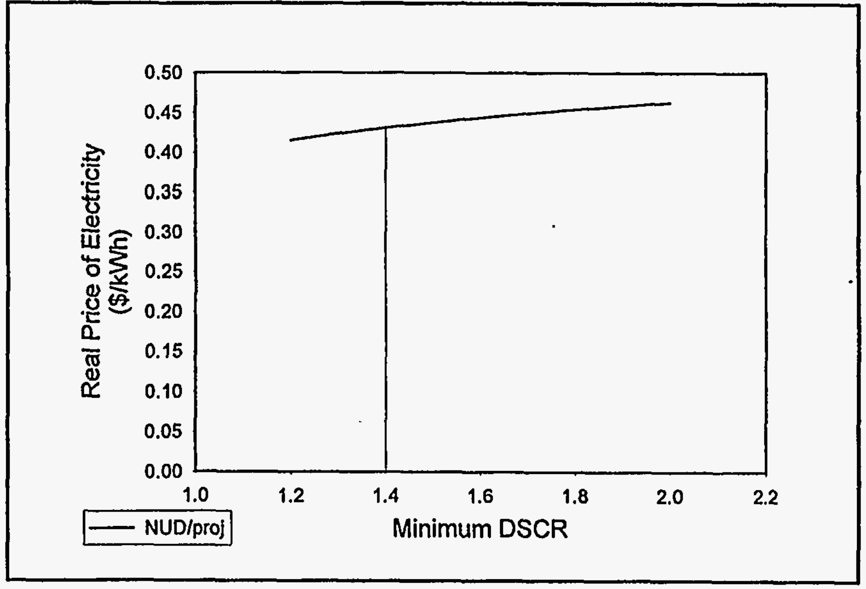



Figure B-23. SDHW Equity Fraction Sensitivity Analysis

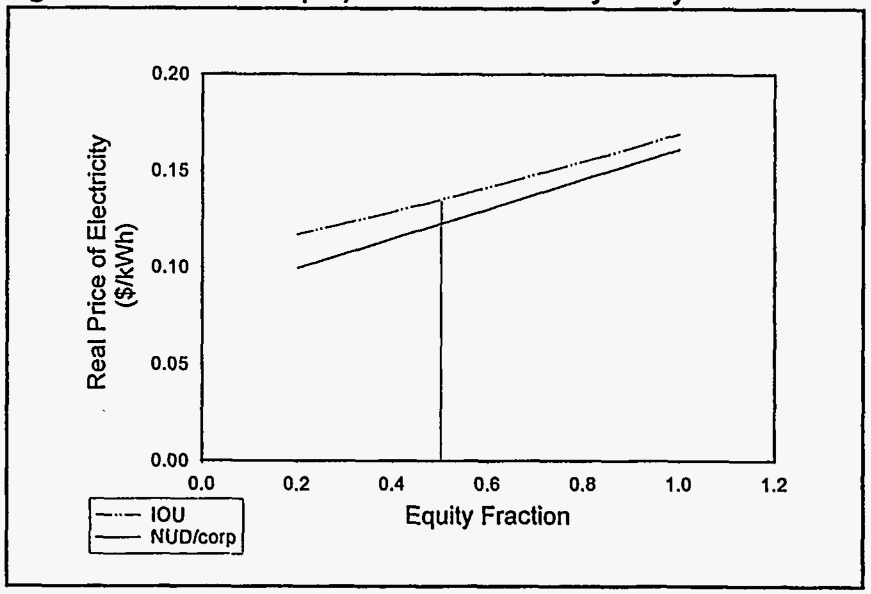



Figure B-24. PV Equity Fraction Sensitivity Analysis

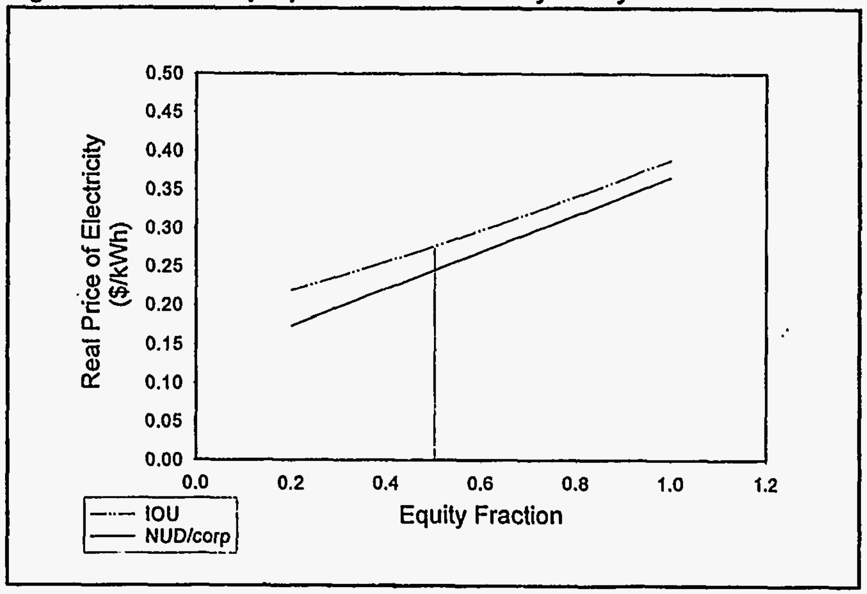


Figure B-25. SDHW Federal Income Tax Rate Sensitivity Analysis

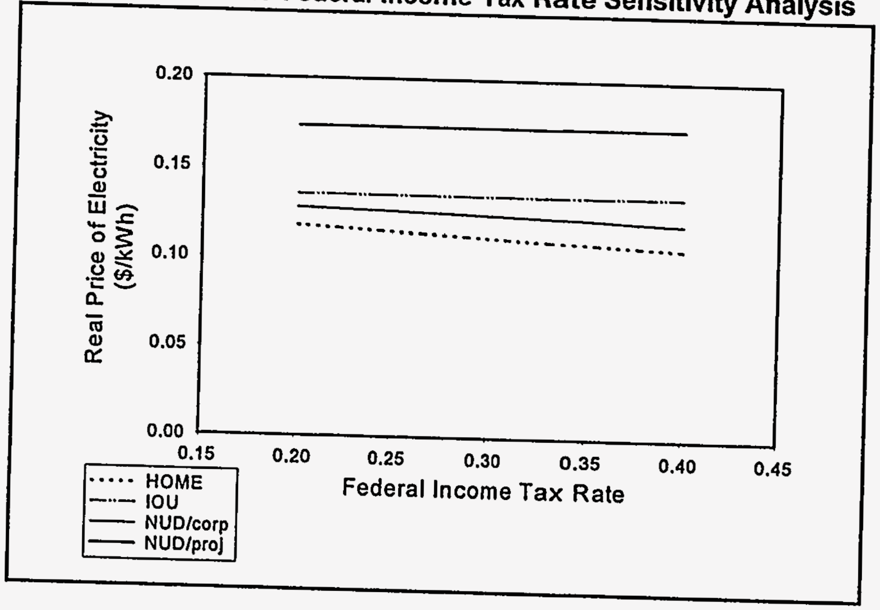



Figure B-26. PV Federal Income Tax Rate Sensitivity Analysis

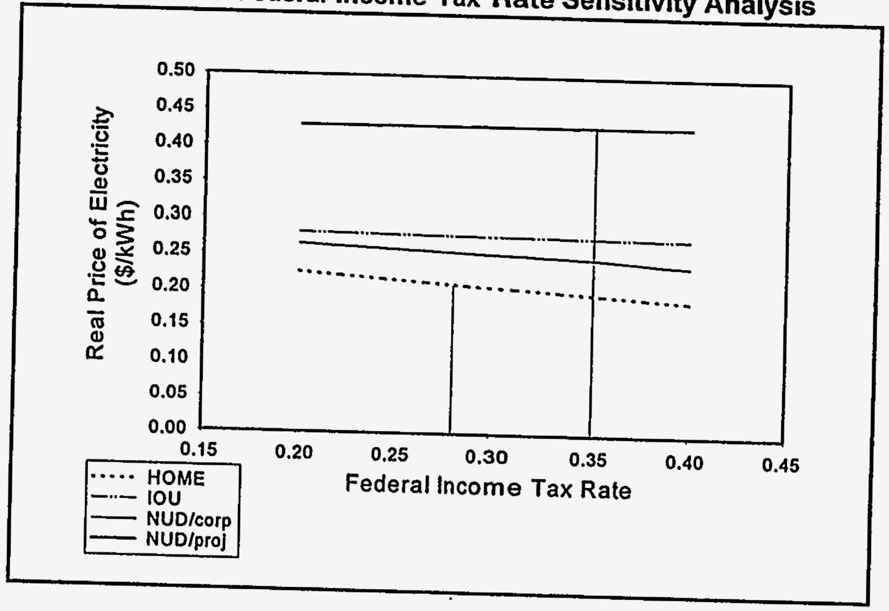



Figure B-27. SDHW State Income Tax Rate Sensitivity Analysis

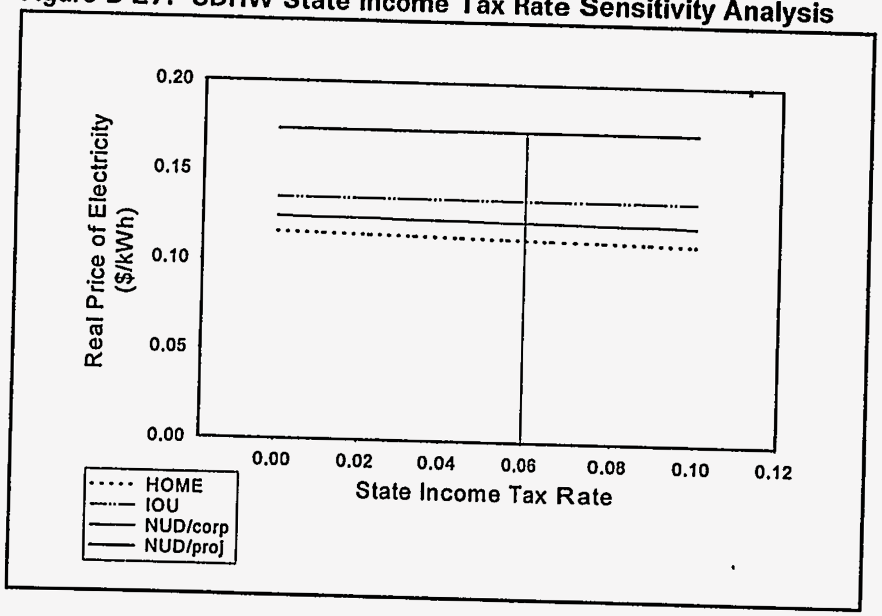



Figure B-28. PV State Income Tax Rate Sensitivity Analysis

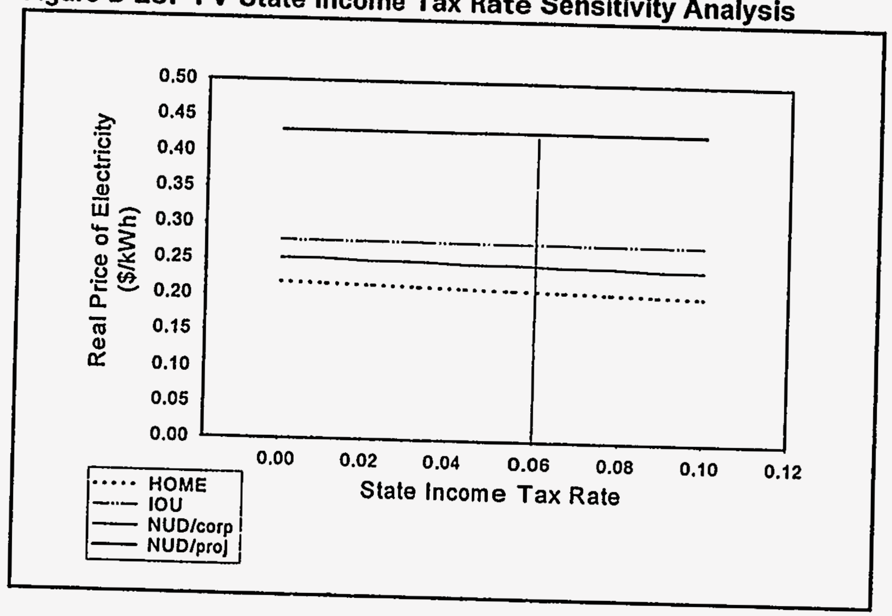


Figure B-29. SDHW Performance Deterioration Sensitivity Analysis

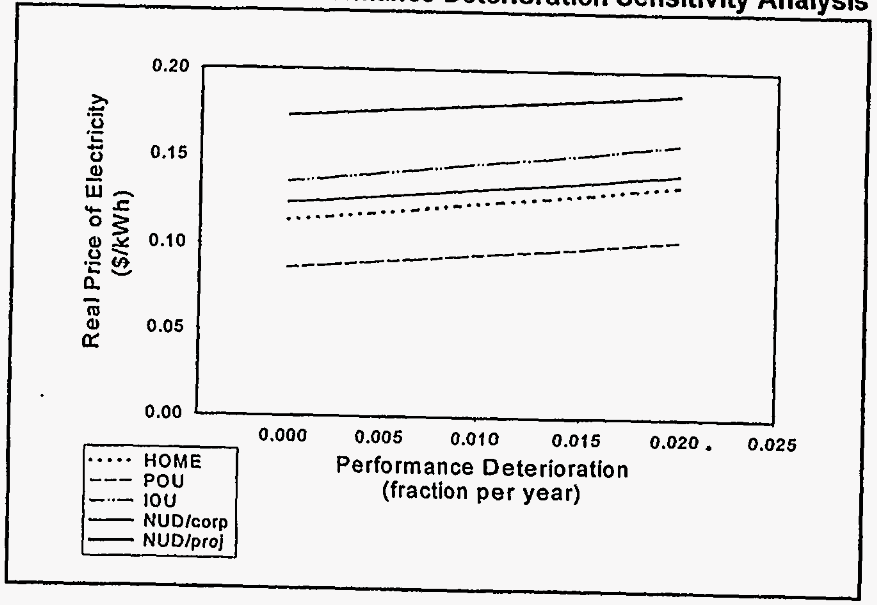
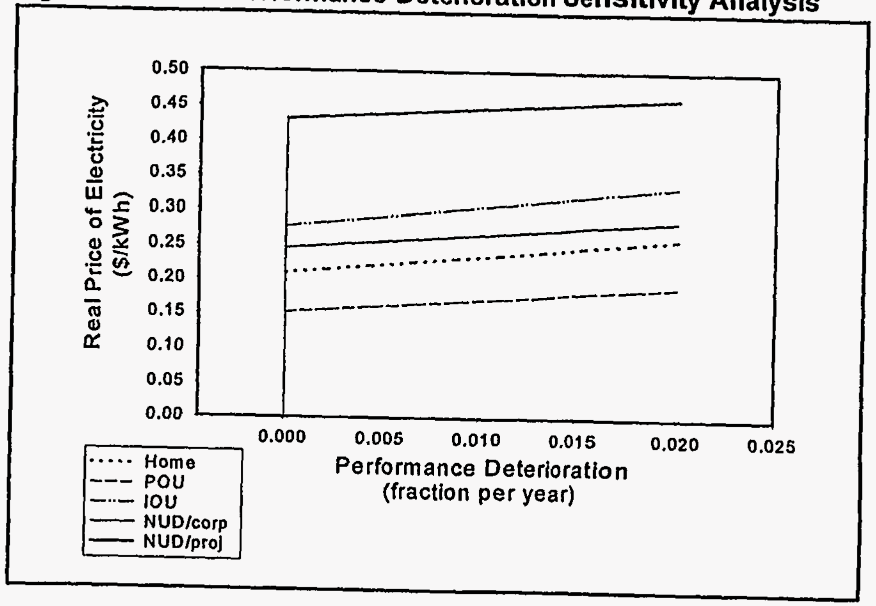



Figure B-30. PV Performance Deterioration Sensitivity Analysis



# Other Policies: Maximum Cost Reductions Possible

## C.1 Overview

Several policies were not considered in Section 3.4.1 because they are bounded in size. As stand-alone policies they cannot achieve the cost targets that we established. They are: sales and property tax reductions, low-interest loans, accelerated depreciation, and tax depreciation for homeowners. This appendix analyzes the maximum effect that each of these policies can have and their associated costs.

## C.2 Sales Tax Reduction

The elimination of the sales tax creates an upper bound on the size of the subsidy for a sales tax reduction. Table C-1 examines the impact of reducing the sales tax to 0% from the base case rate of 8.5%.

**Table C-1. Sales Tax Elimination Policy Analysis**

| Technology and Development Alternative | Cost of Power (¢/kWh) | ΔFederal | ΔState | ΔLocal | ΔTotal |
|---|---|---|---|---|---|
| SDHW - Homeowner | 10.7 | $40 | -$195 | -$43 | -$198 |
| SDHW - POU | 8.4 | $0 | -$204 | $0 | -$204 |
| SDHW - IOU | 12.7 | -$12 | -$207 | -$43 | -$262 |
| SDHW - NUD/corp. finance | 11.6 | $16 | -$205 | -$43 | -$232 |
| SDHW - NUD/proj. finance | 16.2 | -$34 | -$213 | -$43 | -$290 |
| PV - Homeowner | 19.5 | $437 | -$1,600 | -$443 | -$1,607 |
| PV - POU | 14.1 | $0 | -$1700 | $0 | -$1700 |
| PV - IOU | 25.6 | -$100 | -$1,718 | -$443 | -$2,261 |
| PV - NUD/corp. finance | 22.8 | $186 | -$1,695 | -$443 | -$1,954 |
| PV - NUD/proj. finance | 39.9 | -$590 | -$1,837 | -$443 | -$2,870 |

## C.3 Property Tax Reduction

The elimination of the property tax is the upper bound of this subsidy. Table C-2 examines the impact of reducing the property tax to zero percent from the base case three percent.

**Table C-2. Property Tax Elimination Policy Analysis**

| Technology and Development Alternative | Cost of Power (¢/kWh) | ΔFederal | ΔState | ΔLocal | ΔTotal |
|---|---|---|---|---|---|
| SDHW - Homeowner | 9.9 | $0 | $0 | -$540 | -$540 |
| SDHW - IOU | 12.0 | $0 | $0 | -$540 | -$540 |
| SDHW - NUD/corp. finance | 10.6 | -$33 | -$6 | -$540 | -$579 |
| SDHW - NUD/proj. finance | 15.1 | -$116 | -$21 | -$540 | -$677 |
| PV - Homeowner | 17.0 | $0 | $0 | -$5,656 | -$5,656 |
| PV - IOU | 23.2 | $0 | $0 | -$5,656 | -$5,656 |
| PV - NUD/corp. finance | 19.5 | -$448 | -$82 | -$5,656 | -$6,186 |
| PV - NUD/proj. finance | 36.1 | -$1,412 | -$258 | -$5,656 | -$7,326 |

## C.4 Low-Interest Loan

The upper bound of a low-interest loan policy is a zero-percent interest loan. Table C-3 examines the effects of such a policy.

**Table C-3. Zero-Percent Interest Loan Policy Analysis**

| Technology and Development Alternative | Cost of Power (¢/kWh) | Cost of Policy | ΔFederal | ΔState | ΔLocal | ΔTotal |
|---|---|---|---|---|---|---|
| SDHW - Homeowner | 7.9 | -$1,709 | $511 | $116 | $0 | -$1,081 |
| SDHW - POU | 6.1 | -$966 | $0 | $0 | $0 | -$966 |
| SDHW - IOU | 11.7 | -$690 | $0 | $0 | $0 | -$690 |
| SDHW - NUD/corp. finance | 11.3 | -$690 | $240 | $21 | $0 | -$429 |
| **SDHW - NUD/proj. finance** | 14.9 | -$685 | $26 | -$22 | $0 | -$681 |
| PV - Homeowner | 10.7 | -$18,137 | $5,574 | $1,271 | $0 | -$11,292 |
| PV - POU | 7.6 | -$10,052 | $0 | $0 | $0 | -$10,052 |
| PV - IOU | 21.7 | -$7,274 | $0 | $0 | $0 | -$7,274 |
| **PV - NUD/corp. finance** | 21.5 | -$7,274 | $2,330 | $239 | $0 | -$4,705 |
| **PV - NUD/proj. finance** | 36.4 | -$5,557 | -$462 | -$308 | $0 | -$6,327 |

# C.5 Accelerated Depreciation/Homeowner Tax Deduction

Allowing commercial entities to depreciate solar energy property in one year is the largest possible subsidy under this policy. Allowing homeowners to deduct 100% of their solar energy investment in the first year is an equivalent policy. These two policies are considered together in Table C-4.

**Table C-4. Federal One-Year Accelerated Depreciation/100% Homeowner Tax Deduction Policy Analysis**

| Technology and Development Alternative | Cost of Power (¢/kWh) | ΔFederal | ΔState | ΔLocal | ΔTotal |
|---|---|---|---|---|---|
| SDHW - Homeowner | 9.6 | -$684 | $0 | $0 | -$684 |
| SDHW - IOU | 12.9 | -$133 | -$9 | $0 | -$142 |
| SDHW - NUD/corp. finance | 11.4 | -$198 | -$21 | $0 | -$219 |
| SDHW - NUD/proj. finance | 16.2 | -$207 | -$22 | $0 | -$231 |
| PV - Homeowner | 17.1 | -$5,705 | $0 | $0 | -$5,705 |
| PV - IOU | 26.3 | -$1,115 | -$69 | $0 | -$1,184 |
| PV - NUD/corp. finance | 22.2 | -$1,783 | -$198 | $0 | -$1,981 |
| PV - NUD/proj. finance | 39.7 | -$2,066 | -$249 | $0 | -$2,315 |

**Table C-5. State One-Year Accelerated Depreciation/100% Homeowner Tax Deduction Policy Analysis**

| Technology and Development Alternative | Cost of Power (¢/kWh) | ΔFederal | ΔState | ΔLocal | ΔTotal |
|---|---|---|---|---|---|
| SDHW - Homeowner | 11.1 | $41 | -$147 | $0 | -$106 |
| SDHW - IOU | 13.4 | $0 | -$16 | $0 | -$16 |
| SDHW - NUD/corp. finance | 12.2 | -$10 | -$17 | $0 | -$27 |
| SDHW - NUD/proj. finance | 17.2 | -$8 | -$16 | $0 | -$24 |
| PV - Homeowner | 20.4 | $343 | -$1,222 | $0 | -$879 |
| PV - IOU | 27.5 | $2 | -$134 | $0 | -$132 |
| PV - NUD/corp. finance | 24.3 | -$85 | -$143 | $0 | -$228 |
| PV - NUD/proj. finance | 42.7 | -$111 | -$148 | $0 | -$259 |

# Full Cost Analysis of Policies

## D.1 Overview

This appendix disaggregates the costs of the policies discussed in Chapter 5 to each level of government (federal, state, and local).

## D.2 Disaggregated Cost Results

Tables D-1 through D-4 display the options for reducing the real levelized cost of SDHW to 10¢/kWh for the homeowner, IOU, corporate-financed NUD, and project-financed NUD alternatives, respectively (the POU is not modeled, because its cost is already below 10¢/kWh). Tables D-5 through D-9 show the options for reducing the real levelized cost of PV to 15¢/kWh for the homeowner, POU, IOU, corporate-financed NUD, and project-financed NUD alternatives, respectively.

The tables report: (1) the level of the policy necessary, (2) the present value of the direct cost of the policy to the entity that implements it,[73] (3) the present value of the indirect effects on federal, state, and local taxes, and (4) the present value of the total cost of the subsidy.[74] The results are presented as costs for a single system. The assumed capital costs for systems are $2,400 and $20,000, before taxes, for SDHW and PV systems, respectively.

The tables are organized in the following manner: the top line indicates the tax revenues (or costs) that the federal, state, and local governments receive (or lose) for each base-case system that is installed (with no new policy). For each policy option, the level and direct cost of the option is displayed on the left. On the right, under ΔFederal, ΔState, and ΔLocal, the change in the tax revenues (or costs) from the base case[75] is given. On the far right, under ΔTotal, the overall cost of the subsidy relative to the base case total is given. Presenting the

73 It may be the federal, state, or local government, or ratepayers through a wires charge.

74 All tax revenues and policy costs are reported as present values. All revenues and payments to and from the government are assumed to be made at the end of the year. The only exception are grants, which are paid at the beginning of the first year. The discount rate used for all government entities is 6.5%. This is the discount rate that Jenkins, Chapman, and Reilly (1996) use in their tax analysis. It is also almost identical to the 6.6% nominal discount rate recommended by the NIST Handbook 135, *Energy Prices and Discount Factors for Life-Cycle Cost Analysis 1995*, for federal projects dealing with conservation and renewables (Short, Packey, and Holt 1995). We only consider taxes that are directly related to the project: state and federal income taxes of the project owner, state sales taxes on the equipment, and local property taxes on the equipment.

75 The base case is assumed to be a system sold with no new policy.

information in this manner distinguishes the change that the policy creates from the status quo while still allowing the new tax level to be easily calculated by summing the values.

As an example, consider the case of a PI payment used to subsidize SDHW developed under the corporate-financed NUD alternative (Table D-3). In the base case, the federal government loses $249 per system, the state government gains $203, and the local government gains $540; the total tax revenue for all government entities is $494 per system. A PI payment of 3.3¢/kWh ($1997 for the first 10 years) is needed to reduce the real levelized cost to 10¢/kWh. The PI payment can be made by the federal, state, or local government, or by ratepayers through a non-bypassable wires charge. The present value of the cost to that entity is $716. The indirectly caused changes (relative to the base case) in the present value of the federal, state, and local tax revenues are: -$47, -$8, and $0, respectively. In this case, federal and state governments indirectly lose revenue (per system, relative to the base case) from the policy because of reduced income taxes (caused by the reduction in the cost of energy). The present valued total cost of the new subsidy is $771 per system relative to the base case. Assume that the federal government instituted a PI subsidy. The federal revenues lost per system relative to the base case would be -$716 -$47 = -$763. The total federal revenues lost per system would be -$763 -$249 = -$1,012. The same procedure applies for state, local, and total.

It is useful to compare the changes in policies required for lowering system costs to outright reductions in the capital cost of the systems. Public policies to promote emerging technologies are often viewed as temporary supports until the cost of the technologies becomes low enough for them to compete directly in the market. Hence, the first "policy" presented in each table is the effect of an autonomous capital cost reduction as a reference point. It also gives a reference for how much more (or less) tax revenue would be generated relative to the base case, per system, at this price, in the absence of an explicit subsidy.

**Table D-1. Policies to Reduce the Cost of SDHW to 10¢/kWh - Homeowner**

| | | | Federal | State | Local | Total |
|---|---|---|---|---|---|---|
| **Base-Case Tax Revenue (Cost per system) →** | | | **-$511** | **$88** | **$540** | **$117** |
| **"Policy"** | **Level** | **Cost** | **ΔFederal** | **ΔState** | **ΔLocal** | **ΔTotal** |
| **Capital Cost Reduction ($/W)** | **$2,003** | **NA** | **$85** | **-$15** | **-$89** | **-$19** |
| Federal ITC | 21.2% | -$519 | $0 | $0 | $0 | -$519 |
| State ITC | 29.5% | -$721 | $202 | $0 | $0 | -$519 |
| Federal PTC (¢/kWh)[76] | 2.4 | -$511 | $0 | $0 | $0 | -$511 |
| State PTC (¢/kWh)[77] | 3.3 | -$710 | $199 | $0 | $0 | -$511 |
| PI (¢/kWh)[78] | 3.5 | -$755 | $199 | $45 | $0 | -$511 |
| Grant (taxable) | 30.3% | -$767 | $202 | $46 | $0 | -$519 |
| Grant (nontaxable)[79] | 21.2% | -$519 | $0 | $0 | $0 | -$519 |
| Grant (nontaxable, capital cost buy-down)[80] | 26.2% | -$693 | $136 | $31 | $0 | -$526 |
| Low-Interest Loan[81] | 5.33% | -$775 | $227 | $52 | $0 | -$496 |
| Direct Customer Payment (¢/kWh)[82] | 1.3 | -$488 | $0 | $0 | $0 | -$488 |

76 10 years, $1997, increasing with inflation.

77 10 years, $1997, increasing with inflation.

78 10 years, $1997, increasing with inflation.

79 The standard version of the nontaxable grant is a payment in the first year of the project.

80 The capital cost reduction version of the nontaxable grant is a buy-down of the capital cost, which reduces the size of the capital expenditure that needs to be financed (in this case, a smaller loan is needed).

81 The cost of the low-interest loan is calculated in the following manner: The payment streams from two loans are modeled—the first at the base-case debt rate of the development scenario, the second at the low-interest debt rate being considered. The second payment stream is subtracted from the first, and the resulting yearly figures are discounted back to a present value. This should accurately represent the opportunity cost of capital lost to the entity giving the low-interest loan. The discount rate remains tied to the "market rate" loan. In other words, the discount rate remains unchanged from the base case.

82 20 years, $1997, increasing with inflation.

**Table D-2. Policies to Reduce the Cost of SDHW to 10¢/kWh - IOU**

| | | | Federal | State | Local | Total |
|---|---|---|---|---|---|---|
| Base-Case Tax Revenue (Cost per system) → | | | $157 | $233 | $540 | $930 |
| "Policy" | Level | Cost | ΔFederal | ΔState | ΔLocal | ΔTotal |
| Capital Cost Reduction ($/W) | $1,578 | NA | -$54 | -$80 | -$185 | -$319 |
| Federal ITC | 34.6% | -$847 | -$262 | -$48 | $0 | -$1,157 |
| State ITC | 46.7% | -$1,143 | -$2 | -$8 | $0 | -$1,153 |
| Federal PTC (¢/kWh) [83] | 3.6 | -$755 | -$406 | -$75 | $0 | -$1,236 |
| State PTC (¢/kWh) | 5.4 | -$1,161 | $0 | -$75 | $0 | -$1,236 |
| PI (¢/kWh) [84] | 5.7 | -$1,236 | $0 | $0 | $0 | -$1,236 |
| Grant (taxable) | 97.2% | -$2,460 | $1,087 | $198 | $0 | -$1,174 |
| Grant (nontaxable) [85] | 43.4% | -$1,061 | -$86 | -$16 | $0 | -$1,163 |
| Direct Customer Payment (¢/kWh) [86] | 3.5 | -$1,322 | $0 | $0 | $0 | -$1,322 |

83 10 years, $1997, increasing with inflation.

84 10 years, $1997, increasing with inflation.

85 This is the standard "payment" version of the nontaxable grant.

86 20 years, $1997, increasing with inflation.

**Table D-3. Policies to Reduce the Cost of SDHW to 10¢/kWh - NUD/Corporate**

| | | | Federal | State | Local | Total |
|---|---|---|---|---|---|---|
| Base-Case Tax Revenue (Cost per system) → | | | -$249 | $203 | $540 | $494 |
| **"Policy"** | **Level** | **Cost** | **ΔFederal** | **ΔState** | **ΔLocal** | **ΔTotal** |
| Capital Cost Reduction ($/W) | $1,794 | NA | $62 | -$51 | -$137 | -$126 |
| Federal ITC | 27.3%[87] | -$423[88] | -$221 | -$40 | $0 | -$684 |
| State ITC | 23.4% | -$572 | -$92 | -$23 | $0 | -$687 |
| Federal PTC (¢/kWh)[89] | 2.0 | -$437 | -$283 | -$51 | $0 | -$771 |
| State PTC (¢/kWh)[90] | 3.1 | -$673 | -$47 | -$51 | $0 | -$771 |
| PI (¢/kWh)[91] | 3.3 | -$716 | -$47 | -$8 | $0 | -$771 |
| Grant (taxable) | 44.5% | -$1,125 | $392 | $72 | $0 | -$661 |
| Grant (nontaxable)[92] | 24.3% | -$595 | -$57 | -$21 | $0 | -$673 |
| Grant (nontaxable, capital cost buy-down)[93] | 23.6% | -$614 | -$3 | -$11 | $0 | -$628 |
| Direct Customer Payment (¢/kWh)[94] | 2.3 | -$869 | $0 | $0 | $0 | -$869 |

87 The existing 10% federal ITC is increased to this new level.

88 This is the cost of the ITC above the base-case 10% level.

89 10 years, $1997, increasing with inflation.

90 10 years, $1997, increasing with inflation.

91 10 years, $1997, increasing with inflation.

92 This is the standard "payment" version of the nontaxable grant. A nontaxable grant reduces the basis for the 10% federal ITC by the amount of the grant.

93 This is the "capital cost reduction" version of the nontaxable grant. A lower amount of debt and equity is needed to finance the project. A nontaxable grant reduces the basis for the 10% federal ITC by the amount of the grant.

94 20 years, $1997, increasing with inflation.

**Table D-4. Policies to Reduce the Cost of SDHW to 10¢/kWh - NUD/Project**

| | | | Federal | State | Local | Total |
|---|---|---|---|---|---|---|
| Base-Case Tax Revenue (Cost per system) → | | | $443 | $329 | $540 | $1,312 |
| "Policy" | Level | Cost | ΔFederal | ΔState | ΔLocal | ΔTotal |
| Capital Cost Reduction ($/W) | $1,149 | NA | -$231 | -$171 | -$282 | -$684 |
| Federal ITC[95] | 68.2% | -$1,423[96] | -$571 | -$104 | $0 | -$2,098 |
| State ITC | 79.7% | -$1,949 | -$133 | -$43 | $0 | -$2,125 |
| Federal PTC (¢/kWh)[97] | 8.4 | -$1,798 | -$781 | -$142 | $0 | -$2,721 |
| State PTC (¢/kWh)[98] | 12.8 | -$2,767 | $188 | -$142 | $0 | -$2,721 |
| PI (¢/kWh)[99] | 8.6 | -$1,846 | -$324 | -$59 | $0 | -$2,229 |
| Grant (taxable) | 139.2% | -$3,522 | $1,325 | $242 | $0 | -$1,955 |
| Grant (nontaxable)[100] | 78.9% | -$1,929 | -$54 | -$45 | $0 | -$2,028 |
| Direct Customer Payment[101] (¢/kWh) | 7.3 | -$2,756 | $0 | $0 | $0 | -$2,756 |

95 The existing 10% federal ITC is increased to this new level.

96 This is the cost of the ITC above the base-case 10% level.

97 10 years, $1997, increasing with inflation.

98 10 years, $1997, increasing with inflation.

99 10 years, $1997, increasing with inflation.

100 This is the standard "payment" version of the nontaxable grant. A nontaxable grant reduces the basis for the 10% federal ITC by the amount of the grant.

101 20 years, $1997, increasing with inflation.

**Table D-5. Policies to Reduce the Cost of PV to 15¢/kWh - Homeowner**

| | | | Federal | State | Local | Total |
|---|---|---|---|---|---|---|
| Base-Case Tax Revenue (Cost per system) → | | | -$4,257 | $730 | $5,656 | $2,129 |
| "Policy" | Level | Cost | ΔFederal | ΔState | ΔLocal | ΔTotal |
| Capital Cost Reduction ($/W) | 3.41 | NA | $1,357 | -$233 | -$1,802 | -$678 |
| Federal ITC | 42.9% | -$8,740 | $0 | $0 | $0 | -$8,740 |
| State ITC | 59.6% | -$12,139 | $3,399 | $0 | $0 | -$8,740 |
| Federal PTC (¢/kWh)[102] | 14.3 | -$8,598 | $0 | $0 | $0 | -$8,598 |
| State PTC (¢/kWh) | 19.9 | -$11,941 | $3,343 | $0 | $0 | -$8,598 |
| PI (¢/kWh)[103] | 21.1 | -$12,703 | $3,343 | $762 | $0 | -$8,598 |
| Grant (taxable) | 61.2% | -$12,914 | $3,399 | $775 | $0 | -$8,740 |
| Grant (nontaxable)[104] | 42.9% | -$8,740 | $0 | $0 | $0 | -$8,740 |
| Grant (nontaxable, capital cost buy-down)[105] | 53.7% | -$11,656 | $2,287 | $521 | $0 | -$8,848 |
| Low-Interest Loan | 0.71% | -$13,322 | $3,970 | $905 | $0 | -$8,447 |
| Direct Customer Payment (¢/kWh)[106] | 11.0 | -$8,351 | $0 | $0 | $0 | -$8,351 |

102 10 years, $1997, increasing with inflation.

103 10 years, $1997, increasing with inflation.

104 This is the standard "payment" version of the nontaxable grant.

105 This is the alternate "capital cost reduction" version of the nontaxable grant. The size of the loan is reduced by the size of the grant.

106 30 years, $1997, increasing with inflation.

**Table D-6. Policies to Reduce the Cost of PV to 15¢/kWh - POU**

| | | | Federal | State | Local | Total |
|---|---|---|---|---|---|---|
| Base-Case Tax Revenue (Cost per system) → | | | -$1,071[107] | $1,700 | $0 | $629 |
| "Policy" | Level | Cost | ΔFederal | ΔState | ΔLocal | ΔTotal |
| Capital Cost Reduction ($/W) | 4.93 | na | $0 | -$24 | $0 | -$24 |
| Low-Interest Loan | 5.37% | -$274 | $0 | $0 | $0 | -$274 |
| PI (¢/kWh)[108] | 2.3[109] | -$290[110] | $0 | $0 | $0 | -$290 |
| Grant (nontaxable)[111] | 1.5% | -$303 | $0 | $0 | $0 | -$303 |
| Direct Customer Payment (¢/kWh)[112] | 0.2 | -$278 | $0 | $0 | $0 | -$278 |

107 The $1,071 loss to the federal government is from REPI payments that are already in effect. Although this is not a tax policy, it is a government expenditure.

108 10 years, $1997, increasing with inflation. This is in addition to the 1.5¢/kWh ($1992, increasing with inflation) REPI that currently exists for POUs.

109 The existing 1.5¢/kWh ($1992) REPI is increased to this new level

110 This is the cost of the PI above the base-case 1.5¢/kWh ($1992) REPI.

111 This is the standard "payment" version of the nontaxable grant.

112 30 years, $1997, increasing with inflation.

**Table D-7. Policies to Reduce the Cost of PV to 15¢/kWh - IOU**

| | | | Federal | State | Local | Total |
|---|---|---|---|---|---|---|
| Base-Case Tax Revenue (Cost per system) → | | | $1,273 | $1,932 | $5,656 | $8,861 |
| "Policy" | Level | Cost | ΔFederal | ΔState | ΔLocal | ΔTotal |
| Capital Cost Reduction ($/W) | 2.52 | NA | -$632 | -$959 | -$2,809 | -$4,400 |
| Federal ITC | 52.0% | -$10,600 | -$3,283 | -$599 | $0 | -$14,482 |
| State ITC | 70.2% | -$14,309 | -$36 | -$101 | $0 | -$14,446 |
| Federal PTC (¢/kWh)[113] | 15.7 | -$9,458 | -$5,093 | -$929 | $0 | -$15,480 |
| State PTC (¢/kWh) | 24.2 | -$14,551 | $0 | -$929 | $0 | -$15,480 |
| PI (¢/kWh)[114] | 25.8 | -$15,480 | $0 | $0 | $0 | -$15,480 |
| Grant (taxable) | 146.0% | -$30,798 | $13,612 | $2,483 | $0 | -$14,703 |
| Grant (nontaxable)[115] | 65.2% | -$13,282 | -$1,076 | -$196 | $0 | -$14,554 |
| Direct Customer Payment[116] (¢/kWh) | 12.6 | -$17,538 | $0 | $0 | $0 | -$17,538 |

113 10 years, $1997, increasing with inflation.

114 10 years, $1997, increasing with inflation.

115 This is the standard "payment" version of the nontaxable grant.

116 30 years, $1997, increasing with inflation.

**Table D-8. Policies to Reduce the Cost of PV to 15¢/kWh - NUD/Corporate**

| "Policy" | Level | Cost | ΔFederal | ΔState | ΔLocal | ΔTotal |
|---|---|---|---|---|---|---|
| | | | Federal | State | Local | Total |
| Base-Case Tax Revenue (Cost per system) → | | | -$2,186 | $1,673 | $5,656 | $5,143 |
| Capital Cost Reduction ($/W) | 2.87 | NA | $900 | -$718 | -$2,408 | -$2,225 |
| Federal ITC | 37.9%[117] | -$5,686[118] | -$3,557 | -$648 | $0 | -$9,891 |
| State ITC | 37.7% | -$7,678 | -$1,844 | -$410 | $0 | -$9,932 |
| Federal PTC (¢/kWh)[119] | 9.7 | -$5,855 | -$4,392 | -$801 | $0 | -$11,048 |
| State PTC (¢/kWh) | 15.0 | -$9,003 | -$1,244 | -$801 | $0 | -$11,048 |
| PI (¢/kWh)[120] | 15.9 | -$9,577 | -$1,244 | -$227 | $0 | -$11,048 |
| Grant (taxable) | 71.6% | -$15,101 | $4,663 | $850 | $0 | -$9,588 |
| Grant (nontaxable)[121] | 39.4% | -$8,024 | -$1,344 | -$391 | $0 | -$9,759 |
| Grant (nontaxable, capital cost buy-down)[122] | 39.1% | -$8,480 | -$262 | -$193 | $0 | -$8,935 |
| Direct Customer Payment[123] (¢/kWh) | 9.5 | -$13,224 | $0 | $0 | $0 | -$13,224 |

117 The current 10% federal ITC is increased to this new level.

118 This is the cost of the ITC above and beyond the current 10% federal ITC for NUDs.

119 10 years, $1997, increasing with inflation.

120 10 years, $1997, increasing with inflation.

121 This is the standard "payment" version of the nontaxable grant. A nontaxable grant reduces the basis for the 10% federal ITC by the amount of the grant.

122 This is the alternate "capital cost buy-down" version of the nontaxable grant. The size of the equity and debt that needs to be financed is bought down by the grant. A nontaxable grant reduces the basis for the 10% federal ITC by the amount of the grant.

123 30 years, $1997, increasing with inflation.

**Table D-9. Policies to Reduce the Cost of PV to 15¢/kWh - NUD/Project**

| | | | Federal | State | Local | Total |
|---|---|---|---|---|---|---|
| Base-Case Tax Revenue (Cost per system) → | | | $7,535 | $3,446 | $5,656 | $16,637 |
| "Policy" | Level | Cost | ΔFederal | ΔState | ΔLocal | ΔTotal |
| Capital Cost Reduction ($/W) | 1.57 | NA | -$5,176 | -$2,367 | -$3,885 | -$11,428 |
| Federal ITC[124] | 87.5% | -$15,789[125] | -$9,144 | -$1,668 | $0 | -$26,601 |
| State ITC | 106.1% | -$21,623 | -$4,292 | -$988 | $0 | -$26,903 |
| Federal PTC (¢/kWh)[126] | 33.2 | -$19,953 | -$11,473 | -$2,093 | $0 | -$33,519 |
| State PTC (¢/kWh)[127] | 51.1 | -$30,697 | -$729 | -$2,093 | $0 | -$33,519 |
| PI (¢/kWh)[128] | 34.1 | -$20,484 | -$6,408 | -$1,169 | $0 | -$28,061 |
| Grant (taxable) | 186.9% | -$39,415 | $12,131 | $2,212 | $0 | -$25,072 |
| Grant (nontaxable)[129] | 105.9% | -$21,585 | -$3,301 | -$996 | $0 | -$25,882 |
| Direct Customer Payment[130] (¢/kWh) | 28.1 | -$39,110 | $0 | $0 | $0 | -$39,110 |

124 The existing 10% federal ITC is increased to this new level.

125 This is the cost above and beyond the existing 10% federal ITC.

126 10 years, $1997, increasing with inflation.

127 10 years, $1997, increasing with inflation.

128 10 years, $1997, increasing with inflation.

129 A nontaxable grant reduces the basis for the 10% federal ITC by the amount of the grant.

130 30 years, $1997, increasing with inflation.

## D.3 Qualitative Description of the Indirect Cost Interactions

To develop a feel for the overall direction of our findings, we begin by describing qualitatively the indirect effects of each policy on federal, state, and local tax revenues. Often conflicting effects partially offset each other. The descriptions below should help in understanding the net impact of these effects.

### D.3.1 Capital Cost Reduction

- Reduces taxable revenue stream for IOU and NUDs because of lower lease price, causing a decrease in federal and state income tax revenues.
- Reduces the size of the 10% federal ITC for NUDs, causing an increase in federal income tax revenues.
- Decreases state sales tax revenues for homeowner, POU, IOU, and NUDs.
- Decreases local property tax revenues for homeowner, POU, IOU, and NUDs.

### D.3.2 Federal ITC

- Reduces taxable revenue stream for IOU and NUDs because of lower lease price, causing a decrease in federal and state income tax revenues.
- Reduces depreciable base for IOU and NUDs, causing an increase in federal and state income tax revenues.
- Tends to increase the equity fraction for project-financed NUD, causing a decrease in the debt payment and thus an increase in federal and state income tax revenues.

### D.3.3 State ITC

- Reduces taxable revenue stream for IOU and NUDs because of lower lease price, causing a decrease in federal and state income tax revenues.
- Lowers state income taxes, causing a decrease in the state income tax deduction from federal taxes, thus increasing federal tax revenues for homeowner, IOU, and NUDs.
- Lowers the depreciable base for state income taxes by 100% of the value of the ITC, increasing state tax revenues.
- Tends to increase the equity fraction for project-financed NUD, causing a decrease in the debt payment and thus an increase in federal and state income tax revenues.

### D.3.4 Federal PTC

- Reduces taxable revenue stream for IOU and NUDs because of lower lease price, causing a decrease in federal and state income tax revenues.
- Tends to increase the equity fraction for project-financed NUD, causing a decrease in the debt payment and thus an increase in federal and state income tax revenues.

### D.3.5 State PTC

- Reduces taxable revenue stream for IOU and NUDs because of lower lease price, causing a decrease in federal and state income tax revenues.
- Lowers state income taxes, causing a decrease in the state income tax deduction from federal taxes, thus increasing federal tax revenues for homeowner, IOU, and NUDs.
- Tends to increase the equity fraction for project-financed NUD, causing a decrease in the debt payment and thus an increase in federal and state income tax revenues.

### D.3.6 Production Incentive

- Reduces taxable revenue stream for IOU and NUDs because of lower lease price, causing a decrease in federal and state income tax revenues.
- PI payments are taxable income for homeowner, IOU, and NUDs; thus they cause an increase in federal and state income tax revenues.

### D.3.7 Taxable Grant

- Reduces taxable revenue stream for IOU and NUDs because of lower lease price, causing a decrease in federal and state income tax revenues.
- Grant is taxable income for homeowner, IOU, and NUDs; thus taxable grants cause an increase in federal and state income tax revenues.
- Tends to increase the equity fraction for project-financed NUD, causing a decrease in the debt payment and thus an increase in federal and state income tax revenues.

D.3.8 Nontaxable Grant (Payment)

- Reduces taxable revenue stream for IOU and NUDs because of lower lease price, causing a decrease in federal and state income tax revenues.
- Tends to increase the equity fraction for project-financed NUD (although has less of an effect than for tax credits and taxable grants), causing a decrease in the debt payment and thus an increase in federal and state income tax revenues.
- Reduces basis for 10% ITC for NUDs by the value of the grant, causing an increase in federal income tax revenues.
- Reduces the depreciable base by 100% of the value of the grant, causing an increase in both state and federal income tax revenues.
- Reduction of the 10% federal ITC increases the depreciable base for NUDs, causing a decrease in federal and state income tax revenues.

D.3.9 Nontaxable Grant (Buy-Down)

- Reduces taxable revenue stream for IOU and NUDs because of lower lease price, causing a decrease in federal and state income tax revenues.
- Reduces the size of the loan, causing a lower debt interest deduction for homeowner, IOU, and NUDs, thus increasing federal and state income tax revenues.
- Reduces basis for 10% ITC for NUDs by the value of the grant, causing an increase in federal income tax revenues.
- Reduces the depreciable base by 100% of the value of the grant, causing an increase in both state and federal income tax revenues.
- Reduction of the 10% federal ITC increases the depreciable base for NUDs, causing a decrease in federal and state income tax revenues.

D.3.10 Low-Interest Loan

- Reduces taxable revenue stream for IOU and NUDs because of lower lease price, causing a decrease in federal and state income tax revenues.
- Reduces debt interest deduction for homeowner, IOU, and NUDs, causing an increase in federal and state income taxes.
- Reduces the 10% federal ITC for NUDs by the debt fraction, causing an increase in federal income tax revenues.
- Reduction of the 10% federal ITC increases the depreciable base for NUDs, causing a decrease in federal and state income tax revenues.

D.3.11 Direct Customer Payment

- No indirect tax effects.

*APPENDIX E*

# Net Metering

This study has examined the cost to homeowners of end-use solar technologies under different ownership and financing scenarios and the effect of various public policies to lower these costs. In Chapter 3, we calculated the costs (on a per kWh basis for energy displaced or produced) that a developer must charge a homeowner in order to finance the technologies. In Chapter 5, we identified cost targets ($0.10/kWh for SDHW and $0.15 for PV) for use in comparing public policies. The targets were chosen somewhat arbitrarily, but were intended to indicate the costs at which the technologies might become competitive with utility-supplied electricity. However, as described in Chapter 6, we did not examine the customer adoption process or consider other issues associated with the market penetration of end-use solar technologies. In particular, we did not directly compare the costs of the technologies (which we did calculate) to their value to the homeowner (which we did not calculate).

Net metering laws affect the value a homeowner places upon the electrical output of a grid-connected PV system (Starrs 1996). The value of PV electricity production is determined either by the utility's retail rate for PV electricity production that is used to meet household electricity demands, or by the utility's avoided cost for PV electricity production in excess of household demand, which must then be sold to the utility. Net metering laws allow the homeowner to value a greater fraction of PV electricity production at the utility's retail rate. Since, in most parts of the U.S., utility retail electricity rates are significantly higher than utility avoided costs, net metering laws increase the value of electricity produced by grid-connected PV.

Net metering laws operate by allowing the electric meter on a household with a grid-connected PV to turn backwards whenever the PV system produces more electricity than the household requires. The "banking" feature allows the homeowner to meet a greater fraction of household electricity consumption with PV electricity production and thereby increase the value of electricity produced by the system.

Net metering laws also affect the sizing decision for grid-connected PV systems. PV sizing decisions are driven by the desire to maximize the value of the output from a PV system. Sizing for PV systems is complicated by the fact that both PV electricity production and household electricity demand fluctuate over time. Maximum PV output is rarely coincident with maximum household demand. Without a net metering law, there is a strong incentive to significantly undersize a PV system relative to maximum household electricity demand in order to minimize the amount of excess electricity produced because the excess would be sold to the utility at (currently, low) avoided costs. With a net metering law, a greater portion of PV production can be credited against household consumption (and hence valued at the retail rate) regardless of the coincidence of PV output and household demands. The amount that can be credited depends on the period between meter readings (or true-ups). It can range up to the point at which total PV production exceeds total household consumption within the period. Hence, net metering laws eliminate disincentives to undersize grid-connected PV systems and, other things being equal, would tend to increase the total amount of PV electricity that is produced.

Calculating the value of a net metering law is straightforward: With a net metering law, all PV production is valued at the retail rate. Without a net metering law, production in excess of coincident household demand is valued at the avoided cost, while production less than coincident household demand is still valued at the retail rate. The value of a net metering law is just the difference between these two situations, which is equal to the difference between the utility's retail rate and its avoided cost times the amount of PV electricity production that is in excess of coincident household demand.

Here is a simple numerical example that relates this calculation to the levelized costs presented earlier in the report: Assume 50% of PV production is in excess of coincident household electricity demand, the retail rate is \$0.10/kWh, and the avoided cost is \$0.02/kWh. If there is a net metering law, the value of PV production is \$0.10/kWh. If there is no net metering law, the value of PV production falls to \$0.06/kWh (= 0.50*\$0.10 + (1-0.50)*\$0.02). If, following the analysis in Chapter 5, a public policy is successful in lowering the cost to the homeowner to \$0.15/kWh, then under a net metering law the net cost to the homeowner of leasing the PV is \$0.05/kWh (= \$0.15 - \$0.10). Without a net metering law, the net cost is \$0.09/kWh (= \$0.15 - \$0.06) or nearly twice the cost.

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