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PV-DSM: POLICY ACTIONS TO SPEED COMMERCIALIZATION

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ABSTRACT

Pacific Gas and Electric Company (PG&E) recently applied Demand-Side Management (DSM) evaluation techniques to photovoltaic (PV) technology to develop the concept of photovoltaics as a Demand-Side Management option (PV-DSM). The analysis demonstrated that PV-DSM has the potential to be economically attractive. Two criticisms in response to that analysis are that the assumptions of 25 year financing and a 25 year evaluation period are unrealistic. This paper responds to those criticisms and documents the mathematical relationships to calculate the value of PV-DSM from a customer's perspective. It demonstrates how regulatory and government agencies could implement policies to resolve both issues and speed PV commercialization.

BACKGROUND

Financial pressures and environmental concerns associated with traditional electric utility practices are encouraging utilities to satisfy customer demand using innovative approaches. One approach is to reduce demand using Demand-Side Management (DSM) programs. Several utilities have determined that this approach is cost-effective and have implemented aggressive DSM programs. Another approach is to satisfy increased demand with renewable energy. One promising renewable technology is photovoltaics (PV).

Previous attempts at integrating PV into the utility grid have focused on either the utility's side of the meter (supply side) or the customer's side of the meter (demand side). Recent work by Pacific Gas and Electric Company (PG&E) and others synthesized these two perspectives by proposing a utility-customer partnership [1,2,3]. The analysis demonstrated that such a partnership may help to overcome the economic barrier to grid-connected PV plants by applying the DSM approach to PV technology. The utility's role is to use financial incentives to encourage customers to install PV systems in areas of high utility value (areas where PV can be used to delay transmission and distribution system upgrades [4]); the customer's role is to own the PV system. This partnership is called PV-DSM.

Figure 1 shows the potential results of a PV-DSM partnership with a commercial customer. Based on the assumptions in Appendix A (including a $6,500/kW installed capital cost, 12 percent discount rate, 25 year loan, 25 year evaluation period, and 25 year system life), PV can be marginally cost-effective for both the utility and the customer [1,2]. The right side of the figure shows that, for strategically sited PV systems, value to the utility is greater than the cost: the utility benefits economically. The left side of the figure shows that, for the correct customer, value to the customer is greater than the cost: the customer benefits economically.

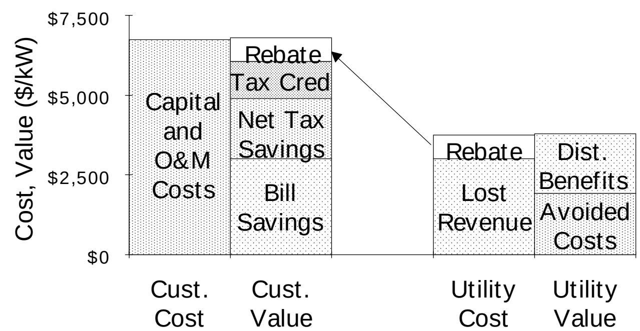

Fig. 1. Economic potential of PV-DSM partnership.

OBJECTIVE

Two key assumptions in this analysis were that customers could obtain 25 year financing and would use a 25 year evaluation period. Both assumptions have been criticized as being unrealistic. In particular, it has been suggested that banks will not offer loans with 25-year terms for PV equipment, nor will commercial customers employ such a long decision-making horizon. This paper responds to those criticisms. It documents the mathematical relationships to calculate the value of a PV-DSM investment from a customer's perspective (see Appendix B). The bulk of the paper then uses these relationships to suggest policy actions to address the criticisms and speed commercialization.

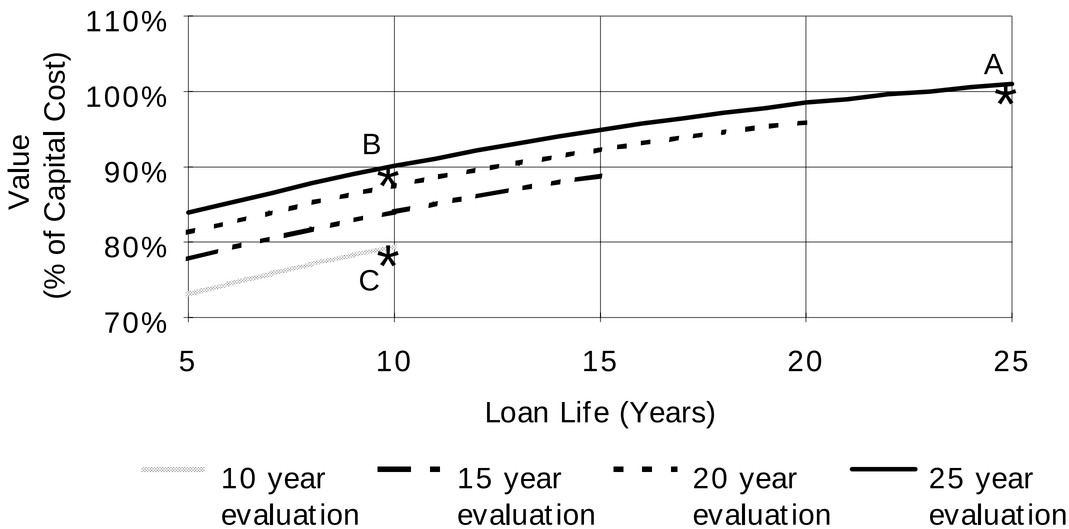

Fig. 2. Value versus loan life and evaluation period.

This paper focuses on a commercial customer ownership scenario. Other scenarios, such as utility or third-party ownership, as well as other customer types, such as residential customers, need to be considered in the future.

IMPACT OF NEW ASSUMPTIONS ON VALUE

The grouping of customer costs and values in Figure 1 is somewhat arbitrary. This paper regroups them by considering O&M costs to be a negative value; it transfers O&M costs to the value side of the equation. Value can then be compared directly to capital cost to determine cost-effectiveness. Expressing value as a percentage of capital cost provides a simple way of determining PV-DSM economics: values exceeding 100 percent denote cost-effective applications.

Figure 2 shows the relationship between customer value (expressed as a percent of capital cost) and loan life for several different assumed evaluation periods. Point A on the graph corresponds to the base case scenario summarized in Appendix A, with a 25 year evaluation period and a 25 year loan life. As mentioned earlier, the value to the customer under this scenario is slightly greater than 100 percent (i.e., it is slightly cost-effective). Point B represents the situation if the assumed loan life is reduced to 10 years, while maintaining a 25 year evaluation period. Value in this case decreases to about 90 percent of capital cost. Finally, Point C illustrates the result if both the loan life and evaluation period are simultaneously reduced to 10 years. Under this scenario, value decreases to 80 percent. (Note: This figure paints an overly pessimistic picture of the reduction in value as evaluation period decreases, because it assigns no salvage value to the system after 10 years despite the fact that the equipment still has substantial market value).

POLICIES TO SPEED COST-EFFECTIVENESS

Using the more pessimistic (although, perhaps, more realistic) loan life and evaluation period assumptions suggested by critics (Scenarios B and C) results in a 10 to 20 percent decrease in value to the customer. But the overall picture may not be so bleak. There are a number of policies that might be pursued by governmental and regulatory agencies to offset this and move value back up toward a 100 percent, or cost-effective, figure. The following sections present some possibilities.

Low-Interest Loans

One way to increase value is to offer low-interest loans, subsidized by state or federal governments or, perhaps, by other utility ratepayers (if state regulators determine this is an appropriate policy to pursue). Figure 3 plots how customer value varies with interest rate for each of the three scenarios depicted in Figure 2. Scenario A is the base case, assuming a 25 year loan life and evaluation period. Scenarios B and C are identical to A in all aspects except loan life and evaluation period. Scenario B assumes a 10 year loan life, while Scenario C assumes both a 10 year loan life and a 10 year evaluation period.

To illustrate how to use Figure 3, suppose that a customer has a 10 year loan life and a 25 year evaluation period (i.e., Scenario B applies). At the base case loan interest rate of 12 percent, value is about 90 percent of capital cost. Customers would have to be offered low-interest loans at 6 percent to increase value by 10 percent to reach a cost-effective level. For the more pessimistic Scenario C, even a zero percent loan would not be enough to achieve cost-effectiveness. A low-interest loan would need to be combined with some other policy action to reach cost-effectiveness in Scenario C.

<u>Increased Tax Credits</u>

Increased tax credits can also be used to boost cost-effectiveness. Figures 4 and 5 plot, for each of the three scenarios, value as a function of federal and state tax credit levels. For example, either a 26 percent federal tax credit or a 28 percent state tax credit would make Scenario B cost-effective. Reaching cost-effectiveness for Scenario C requires either a 42 percent federal tax credit or a 48 percent state tax credit.

<u>Tax-Exempt Rebates</u>

Rebates for traditional DSM programs are currently taxable. Customer value would increase if these incentives were tax-exempt. Value would increase by about 4 percent at the base case rebate level of $750.

<u>Buy-Down Programs</u>

Finally, governmental agencies could provide lump-sum payments to effectively "buy down" the purchase price of PV equipment. Figure 6 plots customer value versus PV equipment capital cost. The figure shows that value, from a commercial customer's perspective, is not as sensitive to capital cost as one might expect. Scenario B requires a $1,500/kW buy-down (from $6,500/kW to $5,000/kW) for cost-effectiveness; Scenario C requires a $3,100/kW buy-down (from $6,500/kW to $3,400/kW).

<u>Effects of Multiple Policy Actions</u>

It is likely that one policy action in isolation will not be sufficient to achieve significant PV market penetration. In this case, multiple policy actions could be pursued simultaneously. Caution must be exercised when combining policy actions, however, since some variables interact in a non-linear fashion. For example, the value of tax credits are dependent on the purchase price of PV. So the value of combining a buy-down program with increased tax credits cannot be obtained by simply adding together the impacts of each action pursued in isolation. In order to accurately assess the impact of multiple policy alternatives (and varying input assumptions) the reader is encouraged to enter the Appendix B equations in a spreadsheet and perform sensitivity studies.

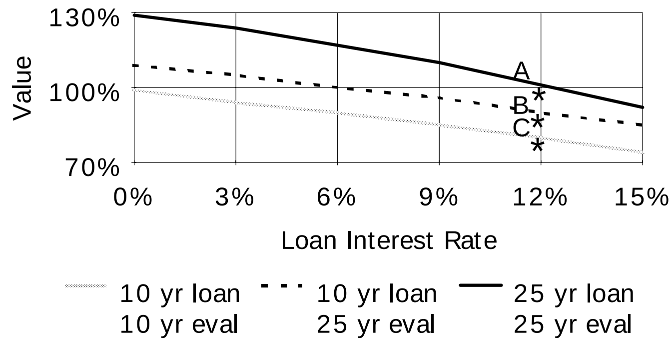

Fig. 3. Value versus interest rate (12% discount rate).

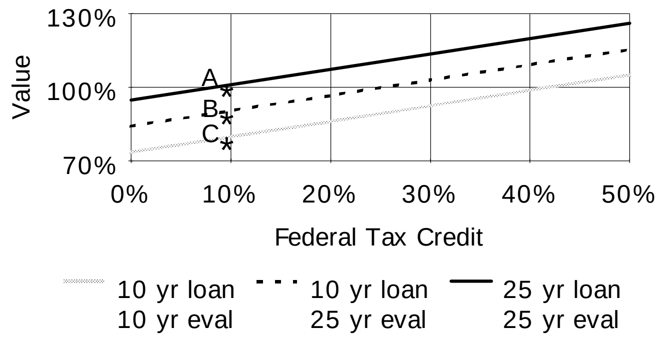

Fig. 4. Value versus federal tax credit level.

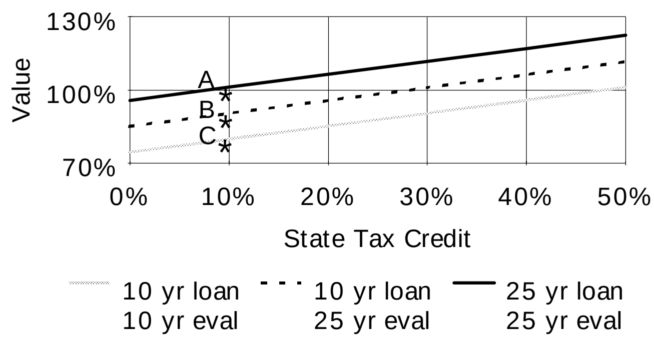

Fig. 5. Value versus state tax credit level.

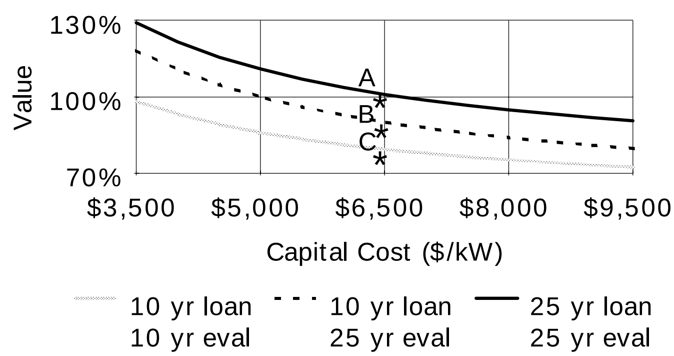

Fig. 6. Value versus capital cost.

Figures 7 and 8 demonstrate how multiple policy actions can work together to achieve cost-effectiveness for Scenarios B and C. Recall that Scenario B requires a 10 percent increase in value to attain cost-effectiveness (i.e., to reach 100 percent value). Figure 7 shows that this 10 percent boost can be achieved, for example, with an untaxed rebate combined with a 5 percent absolute increase in both tax credits. Alternatively, a 6 percent loan will also achieve cost-effectiveness without any changes in tax credits.

Scenario C, on the other hand, requires a 20 percent increase in value to attain cost-effectiveness. Figure 8 shows that this can be achieved, in a similar fashion, with a 6 percent loan, an untaxed rebate, and 5 percent higher federal and state credits.

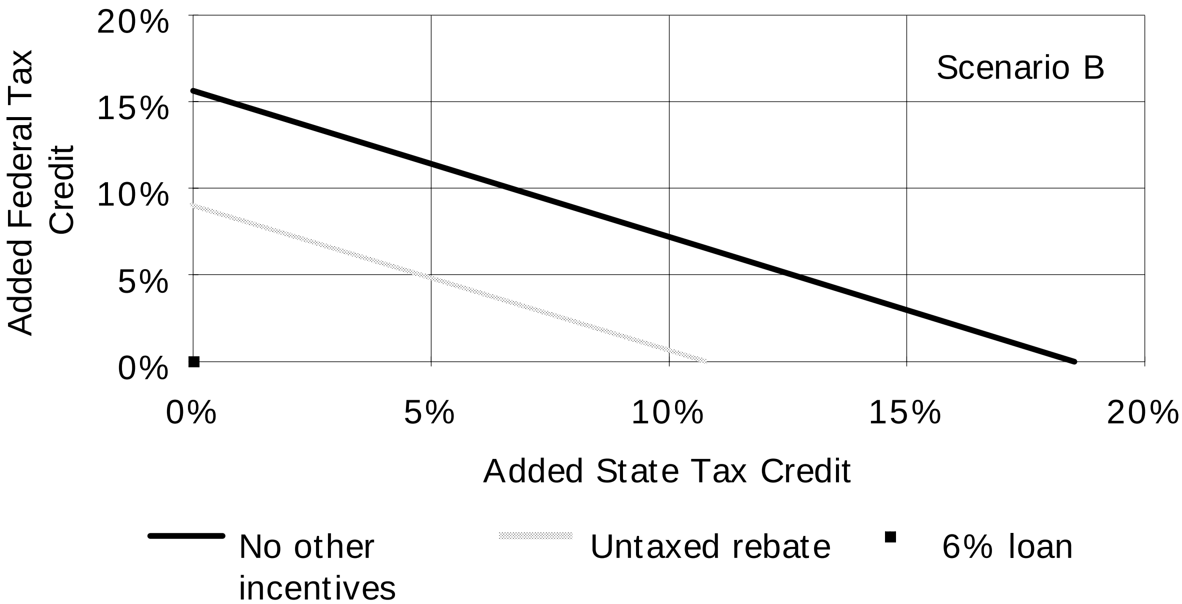

Fig. 7. Actions to achieve cost-effectiveness for Scenario B; a 10 year loan, 25 year evaluation period.

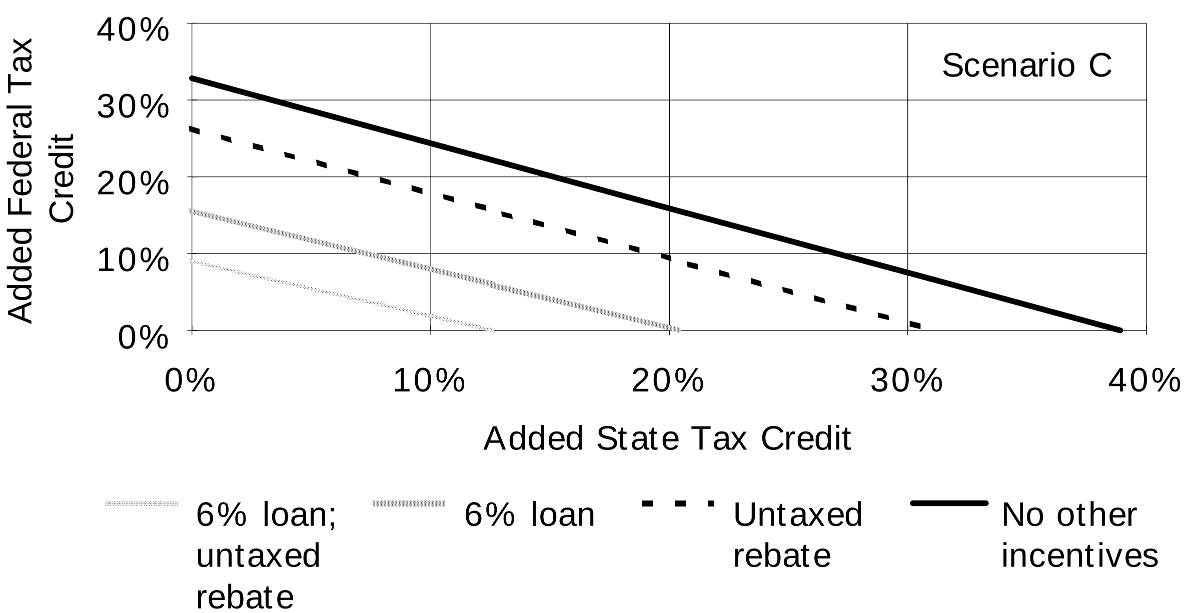

Fig. 8. Actions to achieve cost-effectiveness for Scenario C; a 10 year loan, 10 year evaluation period.

OTHER SENSITIVITIES

System Resale

As stated previously, the customer in Scenario C evaluates the economics of the PV-DSM system over 10 years, without any salvage value of the PV equipment. Since PV is projected to have lifetimes of about 25 years, with little performance degradation, the PV equipment actually has significant salvage value. Another way to achieve cost-effectiveness (which is less dependent on policy changes) may be to resell the system at the end of the 10 year period, perhaps to the utility. This may be a realistic option because, as Figure 2 shows, 80 to 90 percent of the system's economic value to the customer accrues during the first ten years of ownership.

The required resale price at any point in the system's life is calculated as follows:

$$P = \frac{L - V_{cum} - T_f \times UD_f - T_{se} \times UD_s}{1 - \left(T_f + T_{se}\right)}$$

$$P_e = P \times \left(\frac{n_s}{n_s - n}\right)$$

where: P = required resale price

P_e = price equivalent to new system

L = outstanding loan balance

V_{cum} = cumulative escalated value

UD = unused depreciation

n_s = system life

n = number of years

P is the resale price, in current dollars, required for the customer to earn the desired rate of return (which equals discount rate). This price can be adjusted for remaining system life to facilitate comparisons (P_e). Table 1 shows these prices for several scenarios at the end of 10 years based on a 10 year loan life. For example, the table shows that, for a 6 percent loan, 15 percent federal tax credit scenario, the customer could earn the desired rate of return by reselling the system for $2,400/kW (in 2003 $s). After adjusting for remaining system life (this makes the used system price comparable to the price of new systems), this price becomes $4,000/kW (2003 $s) . Since new systems presently cost on the order of $7,000/kW to $9,000/kW (or about $11,000/kW to $14,000/kW in 2003 $s), it is unlikely that prices for new PV systems will decline below a $4,000/kW price within ten years. Thus, utilities or third-party investors may be willing to purchase the used systems.

Table 1. Required resale prices ($/kW).

	Req. resale price [P] (2003 $s)	Price adj. for PV life [Pe] (2003 $s)	Current PV system price (2003 $s)
12% loan; 10% FTC	$7,000	$11,600	$11,000??
12% loan; 26% FTC	$3,500	$5,800	$11,000??
6% loan; 15% FTC	$2,400	$4,000	$11,000??

Discount Rate

One remaining issue is the sensitivity of the results to discount rate. Figure 9 plots value versus discount rate with all other parameters fixed (except loan interest rate, which equals discount rate).

Figure 9 shows that discount rate significantly impacts value for a 25 year loan, 25 year evaluation period (Scenario A). Value decreases by over 15 percent as discount rate increases from 10 percent to 20 percent. The value decreases by only 5 percent, however, for a 10 year loan, 10 year evaluation period (Scenario C). Thus, value is less sensitive to discount rate for a scenario with shorter loan life and evaluation period. This is fortuitous because, largely due to its subjectivity, it is difficult to obtain universal consensus on discount rate assumptions.

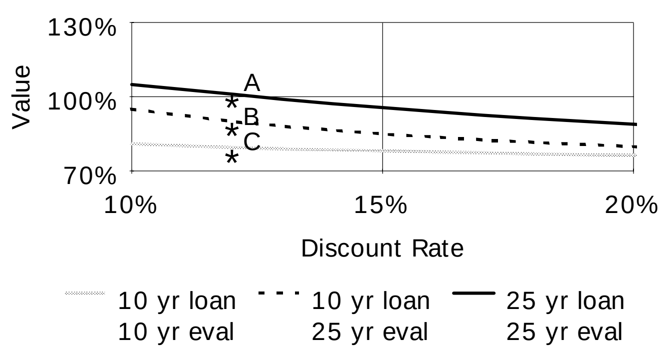

Fig. 9. Value versus discount rate.

CONCLUSIONS

A previous analysis showed that PV-DSM has the potential to be economically attractive to customers and utilities. Two key assumptions made in that analysis were 25 year financing and a 25 year evaluation period. This paper provides the mathematical relationships necessary to perform a PV-DSM analysis from a customer's perspective. It then uses these relationships to demonstrate the sensitivity of value to these assumptions.

The conclusion is that there are several possible regulatory and government actions that could improve cost-effectiveness and speed commercialization. They include offering low interest loans, increasing tax credits, eliminating taxes on the utility rebate, and/or buying down the purchase price of PV. For example, high tax-bracket commercial customers could earn a 12 percent rate of return in 10 years on a $6,500/kW system if they were offered a 10 year, 6 percent loan, a 5 percent additional tax credit, and the system was resold in ten years.

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RESEARCH NEEDS

Future work will focus on assessing the market. This will include customer acceptance of the concept, availability of financing, and acceptable evaluation lives and rates of return. Residential customers will be included, as they represent a potentially huge market with different evaluation criteria. Many residential customers are actually willing to pay a premium for environmentally preferred electricity and participate in programs which are not yet economic. This is in contrast to most commercial customers and building owners who evaluate energy related projects primarily on the basis of economics and cash flow.

Another area of necessary research is evaluating the economic and (positive) environmental impact of mature PV-DSM programs. These impacts need to be investigated and the costs and benefits evaluated from society's perspective as a whole and incorporated into future analyses.

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APPENDIX A: BASE CASE ASSUMPTIONS

Type of customer	commercial
Incremental federal tax rate	34.0%
Incremental state tax rate	9.3%
Depreciation life	5 years
Federal tax credit	10.0%
State tax credit	10.0%
Customer's invested equity	20.0%
Loan interest rate	12.0%
Loan term	25 years
Annual electric rate inflation	5.5%
Annual general inflation	5.0%
Customer's discount rate	12.0%
First year utility bill savings [5]	$250/kW
First year O&M Cost	$21/kW
Utility rebate	$750/kW
System life	25 years
Evaluation period	25 years
Capital cost	$6,500/kW

APPENDIX B: PV-DSM CUSTOMER VALUE EQUATIONS

$$PVDSM_{npv} = V_{ub} + V_r + V_{tc} + V_d + V_f - C_c - C_{om}$$

$$V_{ub} = UB_1 \times \left(1 - T_f - T_{se}\right) \times \left(\frac{1}{j - r_e}\right) \times \left[1 - \left(\frac{1 + r_e}{1 + j}\right)^{n_s}\right]$$

$$V_r = R \times \left(1 - \frac{T_f + T_{se}}{1 + j}\right)$$

$$V_{tc} = C_c \times \left[\frac{TC_f + \left(1 - T_f\right) \times TC_s}{1 + j}\right]$$

$$V_d \approx C_c \times \left[\frac{T_f \times \left(1 - TC_f\right) + T_{se} \times \left(1 - TC_s\right)}{\left(1 + j\right)^{2.6}}\right]$$

$$V_{f(j=i)} = C_c \times \left(1 - dp\right) \times \left(T_f + T_{se}\right) \times \left\{1 + \frac{n_l \times i}{\left(1 + i\right) \times \left[1 - \left(1 + i\right)^{n_l}\right]}\right\}$$

$$V_{f(j \neq i)} = C_c \times \left(1 - dp\right) \times \left[1 + \frac{\left(T_f + T_{se}\right) \times i}{j - i}\right] \times \left\{1 - \frac{i \times \left(1 + i\right)^{n_l} \times \left[1 - \left(1 + j\right)^{n_l}\right]}{j \times \left(1 + j\right)^{n_l} \times \left[1 - \left(1 + i\right)^{n_l}\right]}\right\}$$

$$C_{om} = OM_1 \times \left(1 - T_f - T_{se}\right) \times \left(\frac{1}{j - r_i}\right) \times \left[1 - \left(\frac{1 + r_i}{1 + j}\right)^{n_s}\right]$$

$PVDSM_{npv}$ = net present value of total investment
V_{ub} = after – tax utility bill savings ($j \neq r_e$)
V_r = after – tax rebate
V_{tc} = after – tax tax credits
V_d = tax savings due to depreciation ($j < 30\%$)
$V_{f(j=i)}$ = tax savings due to financing when $j = i$
$V_{f(j \neq i)}$ = total savings due to financing when $j \neq i$
C_c = installed capital cost
C_{om} = operation and maintenance cost ($j \neq r_i$)
UB_1 = reduction in first year utility bill
OM_1 = first year operation and maintenance cost
T_f = federal tax rate
T_{se} = effective state tax rate = $(1 - T_f) \times Ts$
T_s = state tax rate
TC_f = federal tax credit
TC_s = state tax credit
R = utility rebate
dp = down payment
n_l = loan life
n_s = system life
j = discount rate
i = loan rate
r_e = *electric* rate inflation
r_i = general inflation

Note: Earlier work [1,2] combined all tax impacts except tax credits into one category (net tax savings). This paper eliminates that category and reallocates tax impacts to their sources. For example, since utility bills are tax deductible business expenses, lower utility bills correspond to higher taxes; utility bill savings are reduced by the increased taxes.