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PHOTOVOLTAICS FOR DEMAND-SIDE MANAGEMENT UTILITY MARKETS: A UTILITY/CUSTOMER PARTNERSHIP APPROACH

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ABSTRACT

Photovoltaic (PV) systems located at customer sites can be used to meet utility needs for demand-side management (DSM) applications. PV-DSM can also represent a high-value intermediate market for PV in the utility sector. Maximum value for PV in DSM applications can be achieved by incorporating a dispatching capability to PV systems (through the addition of storage). This enables utilities to evaluate PV systems as a peak-shaving technology. To date, peak-shaving has been the higher value DSM application for U.S. utilities. Our analysis of the value of dispatchable PV-DSM systems indicates that small-scale, customer-sited systems are approaching competitive cost levels in several regions of the U.S. that have favorable load matching and peak demand pricing characteristics. This paper presents the results for PV-DSM systems located within the service territories of five case study utilities.

INTRODUCTION

Utility system peak loads tend to coincide with long, hot sunny days during the summer when high solar insolation is also available. Several recent studies have found that PV output matches closely the daily peaks for summer demand [1]. As a result, PV technologies could deliver high-value power to a utility system in a technically and economically comparable way to DSM peak management programs already in use in the U.S. utility sector. In evaluating the future direction of PV technologies, the U.S. Department of Energy identifies utility peak power reduction technologies as the market segment where PV can be most competitive in the near term.

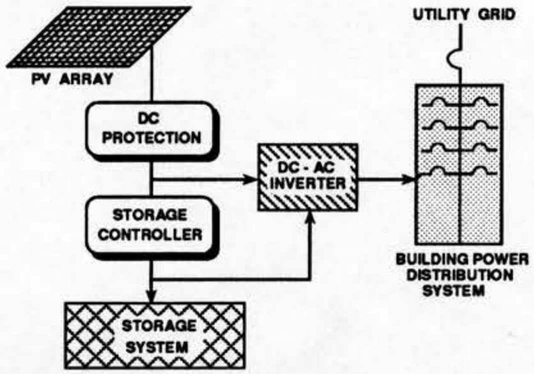
To date, PV has been investigated largely as an energy supply option. Not surprisingly, in a recent survey of utility managers and state regulators conducted by the Center for Energy and Environmental Policy (CEEP), University of Delaware, DSM ranked as the most preferred option for meeting future load growth [2]. In that same survey, utility managers and state regulators ranked PV well below DSM, and even after next-generation nuclear power, in meeting capacity needs through the end of the century. This low ranking of PV is based primarily on a supply-side analysis of the technology in which PV's high capital cost precludes it from competing with other supply-side options. As a consequence, utility investment in PV remains modest.

Recently, several utilities, including Pacific Gas and Electric and Niagara Mohawk, have expressed interest in investigating in PV as a DSM option [3,4]. This paper focuses on research being conducted by CEEP in conjunction with Delmarva Power (DP&L), a Mid-Atlantic utility servicing most of Delaware and parts of Virginia and Maryland, which indicates that PV-DSM is closer to commercial viability than previously thought. The results of an economic analysis of a PV-DSM system for five case study utilities suggest that PV, when deployed in a DSM role, is approaching cost-effectiveness, especially when a unique utility/customer investment partnership is established for the purpose of purchasing PV-DSM systems.

THE CONCEPT OF PV-DSM

The concept of PV-DSM under investigation by CEEP and DP&L differs from ones explored elsewhere. Under our design, PV technology is deployed in an integrated system design that incorporates some form of energy storage. Figure 1 illustrates this type of system diagrammatically. Most other PV-DSM applications attempt to maximize the energy provided by the system to the customer (i.e., maximum energy savings). In contrast, our application seeks to maximize the power that can be made available for peak management purposes (i.e., maximum peak demand reduction). During the five to ten peak demand days, our system could be dispatched to achieve utility peak-load reduction as needed. On non-peak days, our PV-

DSM system could provide value to the customer in the form of shaved building load and reduced energy needs. Such an application could be especially valuable to commercial customers because the rates they pay usually include demand charges. These charges often constitute a far greater portion of the commercial customer's bill than energy charges.



Source: Center for Energy and Environmental Policy, University of Delaware

Figure 1 Block Diagram of a Dispatchable PV Peak Shaving System with Storage

A peak-shaving PV-DSM system offers a utility the capacity to dispatch the technology for load-reduction purposes. Conventional load-reducing DSM programs, such as direct load control (DLC), interrupt the normal operation of electric equipment and, thus, reduce the service this equipment provides to the customer. Dispatchable PV-DSM has the comparative advantage of not interrupting the service provided by the electric equipment. Furthermore, the level of load reduction that can be credited to the system can exceed the rated capacity of the PV array. During the morning hours of low demand, a PV-DSM system can use its storage component to accumulate energy value. Alternatively, the storage system can be charged using off-peak grid electricity. The batteries in our system are sized according to the amount of energy produced by the array prior to dispatch. The maximum of the twelve months determines the amount of storage included in the PV-DSM system. When the dispatch order is given during the utility's peak demand hours, the output of the array can be combined with the stored energy of the system to achieve a higher credited capacity than the PV array's rated capacity.

An alternative to PV-DSM that can provide a dispatchable peak-shaving capacity is a battery-only system. Such a system would utilize off-peak, base-load generating units to charge a bank of batteries. The stored energy (minus round trip losses) would then be available for peak load dispatch. A dispatchable PV system is conceptually a better option than the battery-only system because: (1) the fuel costs for a PV unit are zero; (2) battery systems must purchase energy and a portion of that energy is wasted due to round trip losses; (3) the PV array, as well as its battery unit, supply energy at the time of dispatch and, therefore, the size of the battery bank is considerably smaller for this application than for the battery-only option; and (4) potential cost reductions for PV are much greater than for utility scale battery systems. In fact, our analysis illustrates that the present value revenue requirements (PVRR) for both battery-only systems and PV-DSM systems are approximately equal for intermediate demand charge scenarios ($13/kW and 3.6¢/kWh) and PV-DSM have a lower PVRR under a high demand scenario ($16.5/kW and 6.0¢/kWh) [5].

ECONOMIC ANALYSIS OF PV-DSM FOR FIVE CASE STUDY UTILITIES

To conduct an economic analysis of PV-DSM, CEEP, in conjunction with DP&L, has developed a spreadsheet model to estimate the benefits and costs associated with both non-dispatchable and dispatchable PV-DSM systems. This model was utilized to assess the economic viability of investments in both non-dispatchable and dispatchable peak shaving PV-DSM systems for five case study utilities. The five utilities under investigation are diverse in terms of their geographic location, size, and rate structures. The participating utilities are Niagara Mohawk Power Corporation (NMPC), Austin Municipal Utility (AUSTIN), Sacramento Municipal Utility District (SMUD), Delmarva Power & Light (DP&L), and an East-Coast Urban Utility (ECUU). Table 1 provides some basic characteristics of each utility.

Table 1
Selected Utility Characteristics

	NMPC*	DP&L	ECUU	SMUD	AUSTIN
Peak Demand Charges ($/kW)	11	13	43	9	13
Peak Energy Charge (¢/kWh)	5.7	4.0	6.8	5.9	2.8
Peak Demand (MW)	6,159	2,736	N/A	2,145	1,615

Note: * Winter-peaking; all others are summer-peaking.
Source: Center for Energy and Environmental Policy, University of Delaware

The performance of a 10 kW PV-DSM system with a 25 year life was assessed for the above utilities. Both non-dispatchable and dispatchable system designs were analyzed. Regional Typical Meteorological Year (TMY) data provided insolation values and temperatures for the utility service territories to estimate the AC output of a 10 kW PV array. System load data for each utility were compared to the PV array output to estimate potential load-reduction impacts from the operation of a PV-DSM system. A four-hour dispatch requirement was assumed and dispatch hours were set based on the utility's system load peak. To provide a modest credited capacity based on the coincidence between peak demand and the availability of the solar resource, one hour of buffer storage was included for non-dispatchable systems. Table 2 lists the credited capacities for the systems analyzed (equal to the coincident peak demand reduction averaged over the utility's three peak months from the operation of the PV-DSM system). An installed array cost of $7,500 per kW was assumed, including PV modules and all balance of system components. In addition, battery storage costs of $200 per kWh were used.

Table 2
Credited Capacity for a 10kW PV-DSM System
(kW)

	NMPC*	DP&L	ECUU	SMUD	AUSTIN
Non-Dispatchable	0.7	4.3	4.4	3.2	4.9
Dispatchable	4.5	14.9	12.2	17.2	15.3

Note: * Winter-peaking; all others are summer-peaking.
Source: Center for Energy and Environmental Policy, University of Delaware

Two ownership options were analyzed: utility-owned and customer-owned systems. Table 3 provides the benefit-cost ratios for these ownership options. The results presented in Table 3 suggest that the economics of PV-DSM are slightly more favorable for customer-owners. This is due largely to the tax treatment of capital investments afforded customers. However, investment in PV-DSM remains uneconomical under either ownership option in all utility service territories. Our results are consistent with analyses performed by PG&E, which suggest that, currently, the cost of PV systems exceed their value as DSM applications for both utilities and customers when each undertakes the necessary investment alone [3].

Importantly, in all utility service territories, the potential benefits of dispatchable PV-DSM are considerably greater than those of a non-dispatchable (i.e., non-storage) system. When compared to the costs of each system, dispatchable options in all territories are closer to commercial viability. This is demonstrative proof of the importance of deploying PV in a dispatchable DSM mode over the more typical applications that emphasize maximization of energy output. The increased costs of a dispatchable

Table 3
PV-DSM Investment Options:
Benefit/Cost Ratio Comparisons

	NMPC*	DP&L	ECUU	SMUD	AUSTIN
Non-Dispatchable					
Utility Owned	0.40	0.48	0.51	N/A	N/A
Customer Owned	0.61	0.63	0.74	0.62	0.63
Dispatchable					
Utility Owned	0.41	0.66	0.52	N/A	N/A
Customer Owned	0.69	0.76	0.98	0.73	0.75

Note: * Winter-peaking; all others are summer-peaking.
N/A: These are municipal utilities and, therefore, the methods for estimating avoided costs and carrying charges are different from those employed by investor-owned utilities. Currently, methods are being refined to allow for meaningful comparisons.
Source: Center for Energy and Environmental Policy, University of Delaware

system are more than offset to the customer by increased demand savings and to the utility by avoided capacity costs.

UTILITY/CUSTOMER PARTNERSHIP

To speed the penetration of PV into the DSM market, an innovative utility-customer partnership may be needed. We propose a Green Investment Fund (GIF) that has customers and utilities contributing to a fund for the purpose of purchasing a PV-DSM system much in the same manner that "green pricing" joins both parties in a common effort to make advance purchases of technologies that are currently not cost-effective to the individual parties. Both strategies are intended to encourage early sales of new technology in the hope that such sales will stimulate more rapid price reductions by renewable technology manufacturers.

Unlike green pricing, a GIF does not require premium rates. Instead, customers are sought who would be willing to forego the bulk of potential bill savings that would accrue to customer-owners of PV-DSM systems and to invest, as well, a high percentage of the tax savings available to them. The commitments of bill and tax savings may be attractive to commercial customers who have an interest in promoting environmental values and/or technologies.

It is not likely that such savings would be realized because (in most cases, at least) customer-owned systems are not currently cost-effective. And, if the utility partner can assume the initial capital cost (which would then be repaid through tax and bill savings), a customer's participation in a GIF partnership would involve no additional out-of-pocket expenses. The customer might retain a portion of the bill savings for allowing the PV-DSM system to be installed on their premises. Although PV-DSM would have to compete with other DSM options, the environmentally friendly nature of this investment may offer special advantages to customers.

Under a GIF, the utility's contribution is based on its avoided cost. For a capacity-constrained utility, a useful proxy for the value of peaking capacity is the avoided cost of a gas-fired combustion turbine with the capacity factor set to zero. This is reasonable assuming that utility system peaks occur infrequently, and that the utility can take credit for the dispatchable capacity of the system. Double counting of customer and utility benefits is avoided if, during the time the system is dispatched by the utility for peak shaving, no energy or demand savings are calculated. Certain utility peak management programs utilizing customer-sited engine-generation operate in a similar fashion.

Table 4
PV-DSM Investment Options:
Benefit/Cost Ratio Comparisons
(Dispatchable System)

	NMPC*	DP&L	ECUU	SMUD	AUSTIN
Utility Owned	0.41	0.66	0.52	N/A	N/A
Customer Owned	0.69	0.76	0.98	0.73	0.75
Green Investment Fund	0.74	0.93	1.18	N/A	N/A

Note: * Winter-peaking; all others are summer-peaking.
N/A: Because the methods for estimating avoided costs and carrying charges has not been finalized for these municipal utilities, a GIF scenario could not be run.
Source: Center for Energy and Environmental Policy, University of Delaware

Under the assumption that a GIF receives the required regulatory sanction, we calculated the net present value benefits and costs of PV-DSM in the five case utilities' service territories. Table 4 compares the benefit-cost ratios for three investment options: customer-owned, utility-owned, and GIF. For the purpose of these calculations, we assumed that the customer contributed 80 percent of the potential bill savings and 100 percent of the tax savings available from the operation of a dispatchable PV-DSM system. The utility was assumed to contribute to the Fund the avoided capacity costs (at zero capacity factor) based on the credited capacity of the PV-DSM system operating in each service territory. And, it was assumed that the utility would manage the Fund and would be responsible for O&M. With these assumptions met, a GIF can be an effective vehicle for the development of PV-DSM.

CONCLUSIONS

The use of PV as a dispatchable peak shaving technology appears to provide higher value in utility DSM applications compared to supply-side or non-dispatchable DSM applications of PV. Our analysis indicates that PV-DSM is closer to commercial viability than previously thought and may be currently cost-effective for certain utilities with above-average commercial rates. An innovative utility/customer partnership is proposed in which benefits are pooled for the purpose of purchasing PV-DSM systems. Under this arrangement, the opportunity for PV to play a role in the utility DSM market is enhanced.

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