INTEGRATION OF PV IN DEMAND RESPONSE PROGRAMS

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ABSTRACT

This article makes the case that distributed PV generation deserves a substantial portion of the credit allotted to demand response programs. This is because PV generation acts as a catalyst to demand response, markedly enhancing its effectiveness and, as a consequence, its value to the grid operators. This claim is backed by solid evidence from three utility case studies.

BACKGROUND

Demand Response: demand response (DR) programs provide grid operators with the equivalent of power generation by calling upon participating customers to curtail demand when needed to reduce risk of grid failure during times of peak loading. Participating customers receive a capacity credit in exchange for their willingness to be called upon to curtail load. The value of this credit may reach or exceed \$100/kW/year [1]

Demand response is typically implemented by load curtailment via direct utility load control or verifiable customer-operated load shedding. It may also be implemented by means of customer-sited emergency power generation (e.g., diesel generators, storage batteries). The key to obtaining DR credit is a verifiable kW reduction from baseline customer demand in response to a signal from the grid operator. This capability must generally be demonstrated by an off season test.

Customer-sited PV: The ability of dispersed PV generation to reduce peak demand, particularly at times of maximum grid stress, has been widely documented [2, 3, 4]. Unfortunately customer-sited PVs do not qualify for demand response credit because (1) on-site PV generation becomes part of the baseline defining a customer's load profile, and (2) PVs cannot be turned on at will for scheduled tests.

APPROACH

Through three case studies, we demonstrate that dispersed PV plus a modest DR program is equivalent, from a grid operator standpoint, to operating a much larger demand response program. Therefore PV deserves the monetary value that would be allotted to the large DR program, minus the value allotted to the smaller DR program operated in tandem with PV.

The three case studies include Rochester Gas and Electric (RG&E), Sacramento Municipal Utility District (SMUD), and New York City's Consolidated Edison (ConEd). For each utility, we obtained hourly load data for the year 2002 [5] and simulated site-time specific PV generation from satellite remote sensing. The satellite-based simulation of PV generation has been shown to be both accurate and effective for this type of investigation [6]. For the present analysis, we retained a fixed PV configuration – low tilt, southwest facing – well suited for mid afternoon peak matching.

We hypothesize that grid operators begin activating DR when load in their controlled service area exceeds a given threshold. This is a simplification of actual DR activation process, but it accounts for the primary factor justifying DR action: high demand that must be mitigated. This approach is illustrated in Fig. 1 for each selected utility during their peak demand month. In this illustrative` example, the assumption is that DR must meet all demand in excess of 80% expected peak loading. The light gray shaded area above the 80% thresholds and underneath the load curves represent the amount of DR the grid operator must activate. The figure also charts the output of a dispersed PV resource -- with a total rated output equal to 20% of each utility's peak load -- and illustrates the amount of DR needed to guaranty that PV plus DR meet all loads above the 80% threshold.

For all three utilities, the amount of DR needed in conjunction with PV is but a small fraction of the amount of DR operating alone.

CALCULATING PV DR CREDIT

We now ask the questions:

(1) Given a DR pool, sized in terms of expected yearly cumulative MWh load curtailment, what is the achieved demand offset?

(2) What is the achieved demand offset with the same DR pool used as a buffer to guaranty 100% PV peak shaving?

The answer to these questions is illustrated graphically in Fig. 2.

Taking RG&E for instance, with a DR pool of 400MWh per year (amounting to 0.005% of the energy distributed by RG&E), the utility will achieve a peak load reduction of 47 MW. However, deploying 132 MW of PV on the RG&E grid will insure a load reduction of 132 MW with the same 400 MWh DR pool. Using similar conditions for ConEd leads to a peak reduction of 350 MW without PV and 930 MW with PV. For SMUD, the figures are respectively 88MW and 260 MW.

In the above example, the grid operator benefits from an operational capacity increase of respectively 280%, 265% and 295% for RG&E, ConEd and SMUD, using the same DR pool but benefiting from the presence of a dispersed PV resource on its grid. In other words, the grid operator receives an effective monetary discount because it does not need to purchase additional DR. Therefore it is only fair that any PV plant operating within the DR control area receive a financial credit commensurate with the windfall it bestows on the grid operator. Further processing the data reported in Fig. 2, we can extract the capacity credit that PV should receive. This is plotted in Fig. 3 for each considered utility, as a function of total installed PV capacity. Interestingly, this deserved capacity credit, of the order of 60-75%, is not much different from the statistical Effective Load Carrying Capability derived for the same utilities [3] but the present estimate is based, not on statistical grounds, but on a firm, worst case evaluation of capacity.

In closing this section, note that we defined the DR pools in terms of cumulative yearly MWh and not in terms of instantaneous MW capability. This choice is realistic because: (1) grid operators will tend to rotate their DR customers, and more importantly, (2) the limit to DR applicability is not instantaneous, but integrated: for instance, the environmental problems created by use of DR diesels in New York City are a function of cumulative output (MWh) and not instantaneous (MW); likewise, load curtailment discomfort (hence the willingness of customers to take part in a DR program) is linked to MWh and not MW – a building can coast acceptably for a short time with very high HVAC load reduction, but will reach unacceptable discomfort levels if a smaller load reduction is imposed for prolonged periods of time. Nevertheless, for those who favor a strict MW definition of the DR pool, we also extracted the PV credit reported in the light gray curves in Figs. 3.

CONCLUSION

We have presented evidence supporting the thesis that any PV power plant, user-sited, residential or other, installed within a control area where a grid operator administrates a DR program, deserves to receive a credit for capacity. This credit should be commensurate with the windfall a dispersed PV installation provides to the grid-operator by enhancing the effectiveness of its DR program (hence limiting the need for the grid-operator to purchase a larger program).

As a final note, extrapolating from the data presented in this paper, it is reasonable to envision, based upon EPRI's estimate of 45 GW (6.4% of US peak capacity) to be provided by DR [7], that 150 GW of PV could reliably account for 20% of US peak capacity and receive commensurate capacity credit.

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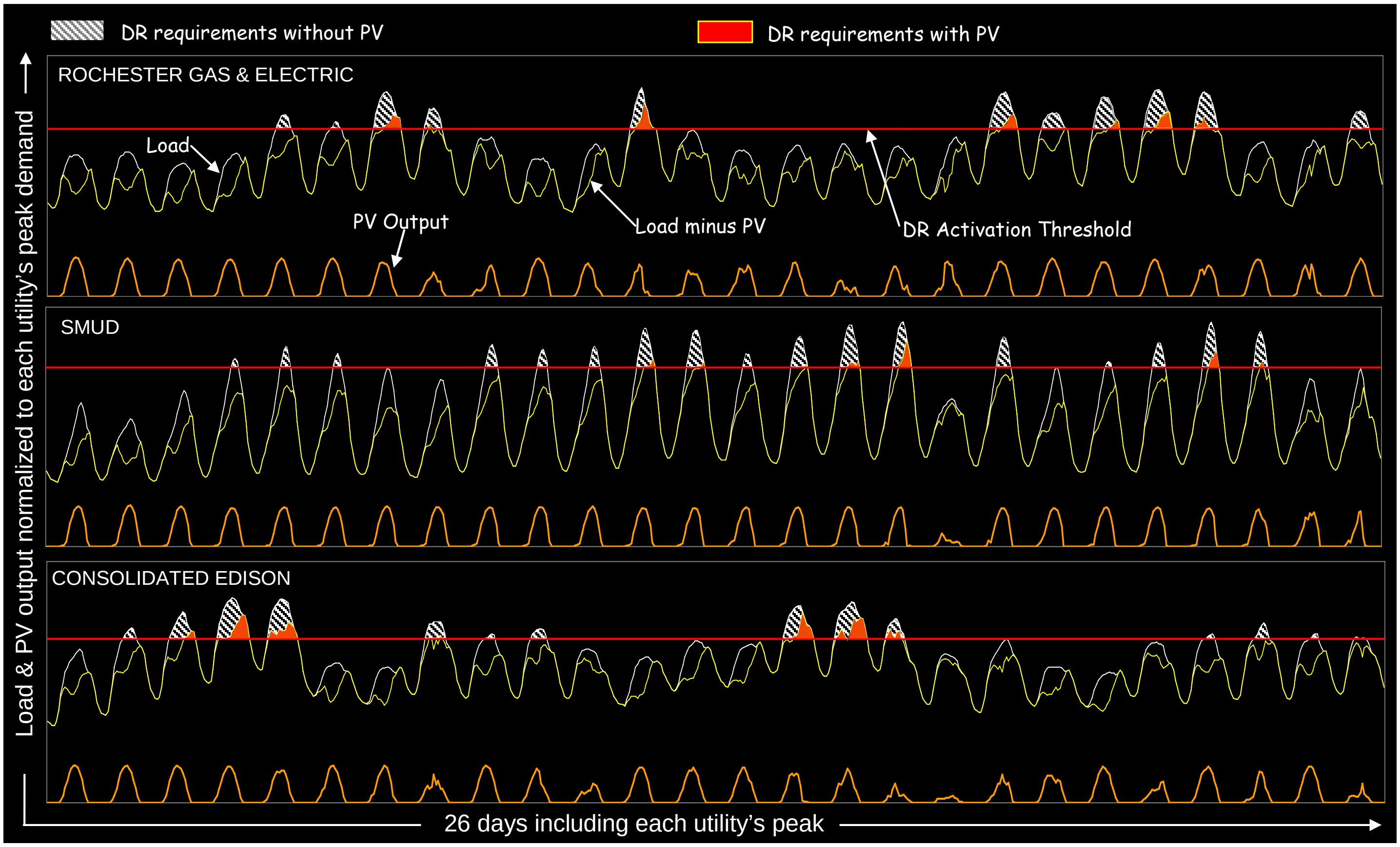

Figure 1: Illustrating DR requirements with and without PV. In this illustrative example, all loads in excess of 80% of peak are to be met by DR or DR+PV.

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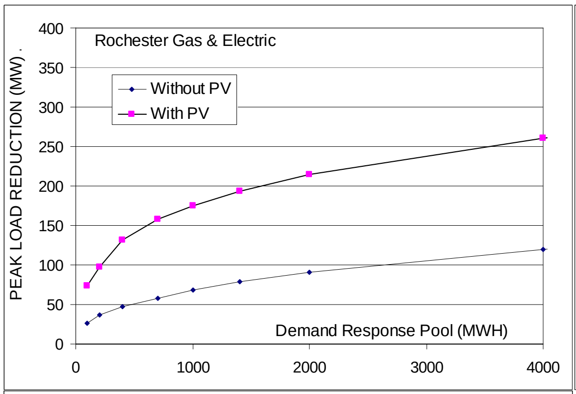

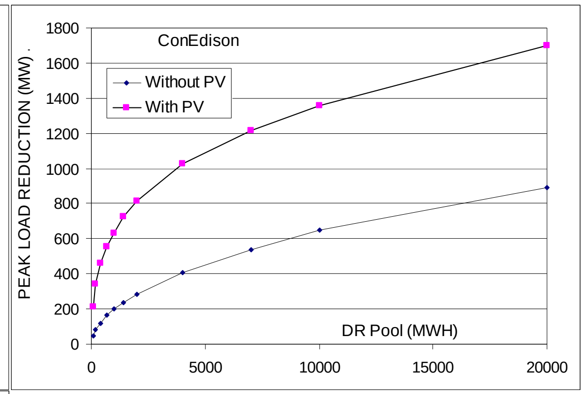

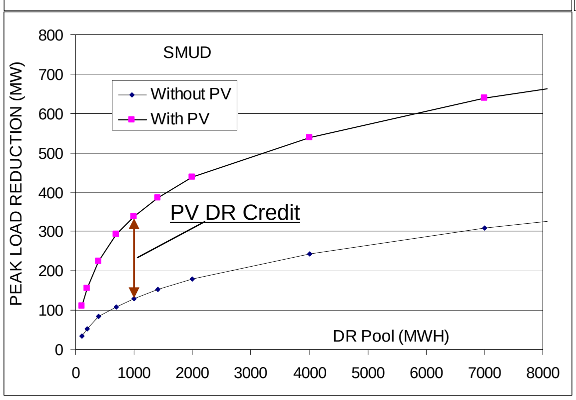

Figure 2: Peak load reduction achieved with and without PV as a function of the DR pool size. The difference between the two curves represents the DR credit deserved by PV. *E.g., as shown at left for SMUD, with a 1,000 MWhr DR pool, the DR credit of 340 MW of PV should be ~ 210 MW*

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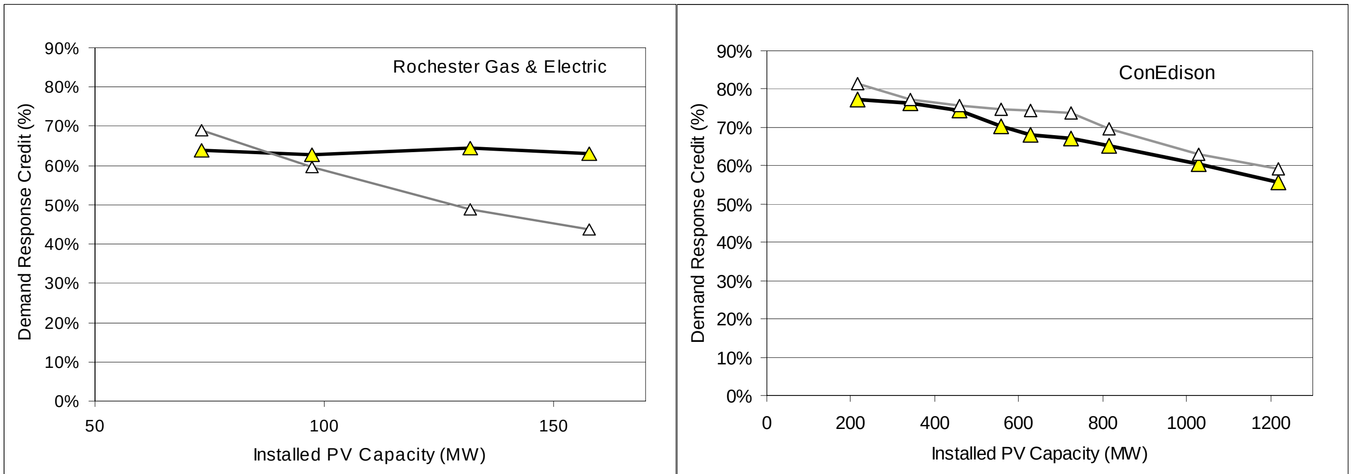

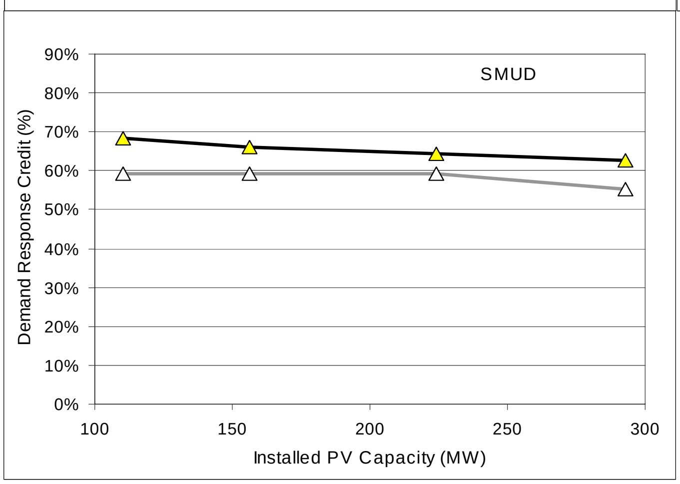

Figure 3: Demand response credit deserved by (% of installed PV capacity) as a function of installed PV capacity. The black curve was derived by quantifying DR pools in terms of yearly MWH. The grey curve was derived by quantifying DR pools in terms of instantaneous MW yield.

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