

# Incorporate Distributed Resources Into the Distribution Planning Process

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Utility planning traditionally has focused on building facilities to meet load growth. Today, utilities also face non-conventional planning options such as distributed resources (DR). Over the last decade, techniques have been developed to compare DR alternatives with conventional wires-based solutions on a common economic basis. A more complete comparison is achieved by combining both engineering and economic perspectives. The following describes a flexible methodology that provides insight into the value of DR in a particular distribution planning area.

DR planning could address several scenarios, including:

- A local government makes a commitment to renewable energy. Where should DR be located and will it free up distribution capacity?
- Load is growing, but slowly, and a new substation is needed. Could DR defer this expenditure while maintaining adequate reliability? In a case like this, DR could likely take a long time to pay dividends.
- Load is growing too quickly to site and build a substation or line. Can DR bridge the gap?
- A company wants to install an interconnected generator. Can it be done safely?
- Another company wants capacity credit for its generator. How much generation is reasonably needed?

## A Commitment to Renewable Resources

In 2002, the City of Palo Alto Utilities (CPAU; Palo Alto, California, U.S.) made a commitment to employ renewable resources by setting a target to add new renewable resources equivalent to 10% of its annual electric load by 2008, and 20% by 2015. Because of CPAU's strong interest in siting renewable generation resources, an adaptable methodology was developed that analyzed previously unrecognized system benefits into the overall feasibility and economic assessment.

Through a partnership with the California Energy Commission (CEC) Public Interest Energy Research (PIER) program, a method was refined that has been applied at CPAU and three other partner utilities.

The following describes analytical techniques that were developed to support the planning process and quantify the value of DR. The focus will be on capturing the value of DR with respect to distribution system capacity. Other elements commonly considered are losses and power quality. Generally, it is assumed that DR will reduce annual power delivery losses, but this is not always the case. Therefore, it is important to keep track of losses as capacity simulations are performed. With renewable DR, an important power-quality issue to evaluate is voltage deviation. Many types of renewable DR have varying power output that is not

dispatchable. On systems with long feeders, this can present additional challenges for maintaining satisfactory voltage regulation.

## The Process

Figure 1 illustrates the process by which DR options are incorporated into the planning process. As shown, the first question to ask is: What level of cost is justified? If the cost of a particular DR solution significantly exceeds the potential value, it does not make sense to include that option in subsequent analysis. A high-level economic screening analysis can weed out options that are not cost effective.

Perspective is critical when estimating the value of DR. It is important to estimate the value of DR to the utility, the DR owner and from a broader social perspective to get the complete financial picture. While this step is largely economic, circuit simulations sometimes are necessary to quantify the value. Keep in mind that “value” may include many diverse benefits, including intangibles such as environment and power quality. It is common for renewable DR evaluations to include benefits for reducing consumption of fossil fuels and emissions from fossil-fueled generation. This can be a significant decision driver for the environmentally conscious. On the other hand, if a particular technology cannot provide power when it is needed, a cost penalty may be applied that will reduce the value of the DR solution.

After eliminating the options that are too costly, the next screen is to eliminate those options that are not feasible. For example, if trying to address an evening peaking constraint, solar photovoltaic generation without storage is not a good solution. It may reduce the purchased power bill for the utility, but it does not solve the delivery problem on the distribution system. Some circuit analysis is required for more extreme scenarios. A good typical example requiring analysis would be to determine the feasibility of placing 10 MW of generation 5 miles (8 km) out on a 12-kV feeder.

Given a set of feasible alternatives, which is the best? This is where combined economic and engineering analysis really shines. By performing annual simulations of the system, the net impact of each DR alternative on the operation, efficiency and reliability of the system can be assessed by computing engineering metrics, including loss reductions and a lower risk of unserved energy (UE), calculating what these benefits are worth and comparing to the DG costs.

Finally, practical engineering questions must be asked: What are the requirements for acceptable voltage regulation? Are there any changes required to the protection system, such as raising ground fault trip levels? What is the risk of unintentional islanding? The process is not always a linear, top-to-bottom series of steps. After performing a pass-through of these steps, planners frequently revisit steps to fine-tune the decision-making process and evaluate new scenarios using different criteria.

## Measuring Incremental Capacity

The value that a DR installation provides is computed by determining how much additional load can be served compared to a base case. The basic method for assessing the impact on capacity is simplistically illustrated in Fig. 2. This figure shows a simulation of a daily load shape as the load grows over the years against normal and emergency limits. To effectively evaluate the impact of different DR operating patterns, the energy delivered over each limit is ascertained. The *emergency* (or maximum) limit represents engineering limits that should never be violated. Instead, as a last resort, load must be curtailed, resulting in UE. The *normal* limit is more subjective and reflects planning philosophies. It is used as a trigger for detailed planning studies or as a means to assess the risk of reliability problems with the power-delivery system. The energy exceeding normal (EEN) is used for a variety of purposes.

In practice, various limits imposed on a distribution can be exceeded simultaneously, which makes evaluation complex. The EEN or UE values are then computed for a range of system loading that incorporates future growth. The difference between the curves with and without DR yields an estimate of the incremental capacity the DR provides with respect to the planning criteria chosen.

Fig. 3 illustrates an EEN calculation for a weekly simulation of a proposed DR installation. The DR installation was large and could theoretically handle all of the load growth needs for some time. However, it was not located in a position to address all of the constraints of the system all the time. While it was effective for part of the day, it did not eliminate all of the EEN in areas of the system that experience an evening peak. Thus, an analysis method is needed that captures both the time- and location-specific impacts of the DR.

CPAU used this analysis approach to determine the impact of a 4-MW solar photovoltaic (PV) application. It was assumed that 4 MW of PV was distributed over the service area. Fig. 4 shows the assumed power output shape.

Figure 5 shows how this shape correlates to the CPAU annual load shape. There is a good match during the middle of the day, but as is the case with many PV applications, the load peak lasts a few hours longer than the PV source. Nevertheless, the solar PV is able to alleviate a substantial amount of system EEN.

To quantify the capacity gain achieved by the DR, Fig. 6 shows the incremental capacity curve versus total system load. This curve answers the question: How much can the load grow until the EEN is the same as the base case without DR? It is the horizontal difference between the two EEN curves. The 4 MW of uniformly distributed PV achieves an effective capacity gain of approximately 1.8 MW. In contrast, a more optimally sited 570-kW system of PV generation in Palo Alto provided an effective capacity gain of approximately equal to the amount of generation by effectively countering the EEN on particular feeders.

Generation that is capable of being dispatched as needed usually fares a little better in this analysis than non-dispatchable generation such as some renewables. Fig. 7 shows the same analysis for a hypothetical dispatchable 2-MW generator in a particularly good location on the system. The effective incremental capacity ranges from 2.5 MW to more than 4 MW as the system load increases (this suggests that if the basic topology of the power delivery system remains unchanged, the DR might be more valuable in the future).

These curves illustrate some interesting results:

- The incremental capacity curve is not constant with load. These curves generally increase to a point and then decline as constraints in other areas of the system begin to dominate.
- The incremental capacity can sometimes be much larger than the size of the resource. It can also be much smaller and often is for non-dispatchable renewable generation. There is often a “sweet spot” on distribution systems that address some particularly limiting constraints and allow for more load growth than other locations.
- Additional quantities of DR may be included, along with or in place of EEN, in the analysis to match planning concerns.

## Conclusion

Proper incorporation of “non-wires” alternatives such as DR into the distribution planning process merges both engineering and economic perspectives. The methodology described provides a means to determine the incremental capacity provided by such resources. This is particularly valuable in the evaluation of renewable generation since it can capture both the time- and location-specific value of DR as illustrated in the CPAU case study.

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