Distributed Generation: Hype vs. Hope

Separating myth from reality in identifying DG applications.

By Jonathan A. Lesser, Ph.D. and Charles D. Feinstein, Ph.D.

IT'S NO SECRET THAT DISTRIBUTED GENERATION technologies have become more efficient and less costly. As a result, the potential of distributed generation (DG) to provide cost-effective alternatives to central-station generating facilities and traditional "poles and wires" investments for electric distribution has increased. But despite the loudest voices of DG's greatest proponents—manufacturers and, in some cases, utility regulators—DG isn't viable in all situations, and rumors of the death of traditional utility investments are greatly exaggerated.

DG technologies, especially fuel cells, are receiving increasing attention in the popular press as the "Holy Grail" of distributed generating technology. For example, in "Dreams of the New Power Grid," which appeared in the March 2002 issue of *Popular Science*, the goal is fuel cells in every home. That article quotes one fuel cell proponent who compares price projections for fuel cells to the rapid drops in prices for VCRs. Alas, images of microturbines and fuel cells humming away quietly and reliably in millions of basements remain just that: images. While DG has filled certain niche applications well, some of the promised technological breakthroughs have not materialized as quickly as expected. Furthermore, like the proverbial tortoise, generation manufacturers have continued to improve the efficiency and cost-effectiveness of traditional generation technologies.

So what role *can* DG play in the future? Answering that question is critical for utilities, regulators, and, especially, consumers who will continue to demand greater quantities of electricity. Utilities, developers, regulators, and consumers all have an interest in ensuring that the best applications of distributed resources are identified, lest DG be over-sold and have its real promise squandered.

A number of regulatory initiatives establishing DG programs have begun in states as diverse as California and Vermont. In the fall of 2001, the New York State Public Service Commission (NYPSC) issued an order requiring the electric utilities it regulates to participate in a pilot program designed to test the applicability of DG alternatives.[1] The Vermont Department of Public Service is currently engaged in a collaborative program with the state's electric utilities to develop standards for evaluating and installing DG. Indiana's regulators also have begun a similar process to investigate the role of DG.

All of these efforts will need to address a variety of environmental, reliability, and safety issues. The fundamental test of DG, however, ought to be its impact on the bottom line: will it increase utility costs and lead to higher customer rates?

Through case studies and the development of an economic model that evaluates DG alternatives using advanced investment analysis techniques, we have discovered several critical issues surrounding the economics of DG. Our studies have specifically incorporated future uncertainties concerning market prices, operating costs, and load growth, as well as reliability consequences. We believe that successful DG applications can be identified only after analyzing these critical issues. Otherwise, regulators and utilities risk unpleasant surprises.

The Danger of Hyperbole

There has been no shortage of mythology developed about the applicability of DG technologies. As has been observed with many previous emerging technologies, the claims almost surely exceed what DG applications can possibly provide. The danger of such "irrational exuberance" is, of course, unmet expectations: if DG is too broadly promoted as an alternative to central-station generating supplies and traditional transmission and distribution (T&D) capacity investments, the entire concept cannot help but fail. DG will be installed where it ought not to be, and fail to provide the hoped for advantages to utilities and their customers.

We have found four common myths pervading DG and its application:

- DG is cheaper than traditional system power;

- DG makes sense because traditional electric utilities will be obsolete in the not-too-distant future;
- DG can defer traditional T&D system investments; and
- Even if it is more expensive today, DG investments should be emphasized because T&D investments are likely to become stranded in the (not-too-distant) future.

Myth 1: DG is Cheap

Cheap. Modular. Who could ask for anything more? Unfortunately, it's not quite true. The most common commercially available DG technologies are either simple-cycle turbines or diesel generators. These tend to have higher capital costs and higher operating costs than central-station alternatives, owing to diseconomies of scale and higher heat rates. And, while the fuel cell Holy Grail continues to improve, it has yet to become commercially viable.

It is true than DG applications may be able to avoid some T&D costs at the margin, including system losses. But installing DG can just as easily require additional T&D costs, such as more sophisticated monitoring, switching, and safety systems. Furthermore, the environmental impacts of fossil-fueled DG technologies may be higher than those associated with central-station generation, precisely because DG is designed to be installed near customer loads, where more individuals can be affected by pollutant emissions.[2] That is why we sometimes observe local environmental regulators adamantly opposing the very DG installations that utility regulators are promoting—an untenable situation for any electric utility.

Myth 2: Traditional Electric Utilities are Soon to be Obsolete

This myth may have been divined by the same pundits who predicted that Enron would become the world's dominant electric, gas, water, and broadband company. At the very least, many utilities would likely take exception to such pronouncements of their imminent demise, as they continue to provide safe and highly reliable electric supplies. DG technologies may play an increasingly important role in helping utilities meet customers' differing needs for power quality and reliability, but it is not at all clear that many customers will want to be in the electric generation business. Furthermore, the "generator-in-a-box" technology for the basement of every house, which will provide electricity cost-effectively and with high reliability like today's water heaters and furnaces, does not yet exist.

Myth 3: DG Can Defer Traditional T&D Investments

Of all of the myths claimed for DG, its ability to defer traditional "poles and wires" investments is probably the most cited. The argument goes as follows: by installing DG, utilities can avoid the need to upgrade substations and circuits, thereby saving themselves and their customers millions of dollars. But while DG may defer the need for some system upgrades, such deferral should be seen as a *consequence* of installing DG, not a goal.

While DG has filled certain niche applications well, some of the promised technological breakthroughs have not materialized as quickly as expected.

The goal should be to reduce utility and ratepayer costs without sacrificing reliability and power quality. A moment's thought shows that, from a strict economic standpoint, introducing DG applications to further a goal of deferring T&D investments as long as possible will not result in any savings for utilities or their customers. This is precisely the same flawed economic reasoning that many regulators used to promote demand-side management (DSM). By using the same "avoided cost" methods as was done for DSM, DG investments are selected as long as their average cost is no greater than the T&D alternatives and, ultimately, no savings in average costs are realized by utilities or consumers (not to mention the additional regulatory oversight costs.) Instead, as we discuss in the next section, applying a more sophisticated economic analysis can identify the most beneficial applications for DG.

Myth 4: DG Should be Emphasized Today to

PUF 6/1/02.92 5/3/02 11:59 AM Page 24

REDUCE THE POTENTIAL FOR FUTURE "STRANDED" T&D COSTS

The logic of this myth would require utilities to install DG even if such investments were uneconomic, in order to lessen the likelihood of stranding future assets. In doing so, however, utilities easily could be found to be violating their obligation to serve or, in the case of unbundled utilities providing only distribution service, their obligation to connect. Of course, it may be perfectly sensible for utilities to invest in distributed resources even when not strictly economic in order to better understand the ramifications of DG on T&D systems. But neither utilities nor regulators should have to cloak such legitimate research and experimentation behind poorly conceived economic concepts.

If these myths are not dispelled, it is far more likely that utilities will install distributed resources in situations where they are uneconomic, thus raising costs for all, and hindering beneficial implementation of DR/DG in the long run. Fortunately, using a more sophisticated economic approach, we can identify the circumstances under which DR/DG has the greatest economic value. Thus, applications of distributed resources can be more appropriately targeted. In that way, they will be more likely to produce "win-win" situations that reduce overall costs and improve reliability.

The Appropriate Economic Framework

So what makes a DG application economic? Fundamentally, most DG applications require a tradeoff between higher costs and greater flexibility. One of the great advantages of DG is its modularity and flexibility: a utility can install several megawatts of new DG capacity as needed, rather than building large, central-station generating plants or signing long-term purchase-power agreements. This is particularly beneficial because load growth at the local level is more uncertain than at the overall utility level. At the local level, we often see load growth occurring in fits and starts (what economists call a "lumpy," rather than a smooth process). By providing additional flexibility, DG can allow utilities to improve their use of scarce capital, while continuing to meet customer needs. Capturing the true economic value of this flexibility is important if DG is to be installed where it can provide the greatest economic benefits.

To capture that economic value, we developed with the Electric Power Research Institute (EPRI) an economic framework to evaluate DG applications based on advanced investment analysis techniques. Our approach incorporates future uncertainties concerning market prices, operating costs, and load growth, and shares common aspects with the financial and real options models that are increasingly popular, in that they can determine the most valuable investment strategies today and in the future.[3] We have found that these uncertainties can make or break DG economics. To evaluate DG opportunities, we consider other options that can meet necessary engineering specifications for a local distribution planning area. Then, we compare all of those options on an equal basis, much as a financial analyst would compare alternative investments.

For example, in one study we looked at a local distribution area that encompassed an area with a growing residential/commercial presence, with a large new shopping mall, commercial office space, and new residential housing developments. However, the timing of that new load growth is uncertain: although several large chain stores committed to opening in the new mall, strict land use regulations and continuing court challenges made the timing uncertain. The same was true of anticipated residential housing developments.

From the local utility's standpoint, the problem was vexing. Without the necessary infrastructure, the new growth cannot be accommodated. Yet the utility has an obligation to serve. One option for the utility was to install a large new substation and several new feeder lines. That would provide sufficient capacity, but would require a large cash outflow. Additionally, if the development process were delayed or halted—a real possibility for this shopping development, which had been first proposed two decades earlier—the utility could find itself with much unused new distribution capacity, which would raise unpleasant regulatory issues. Alternatively, the utility could prepare the sites for modular DG installation, and bring in trailer-mounted combustion turbines. Although more expensive on a per-kW basis than the substation and feeders, the DG option would provide far greater flexibility. The DG could also defer the need for a new substation or it might allow a smaller, less expensive substation to be constructed. Although the mathematics is somewhat complicated, the question is straightforward: is the

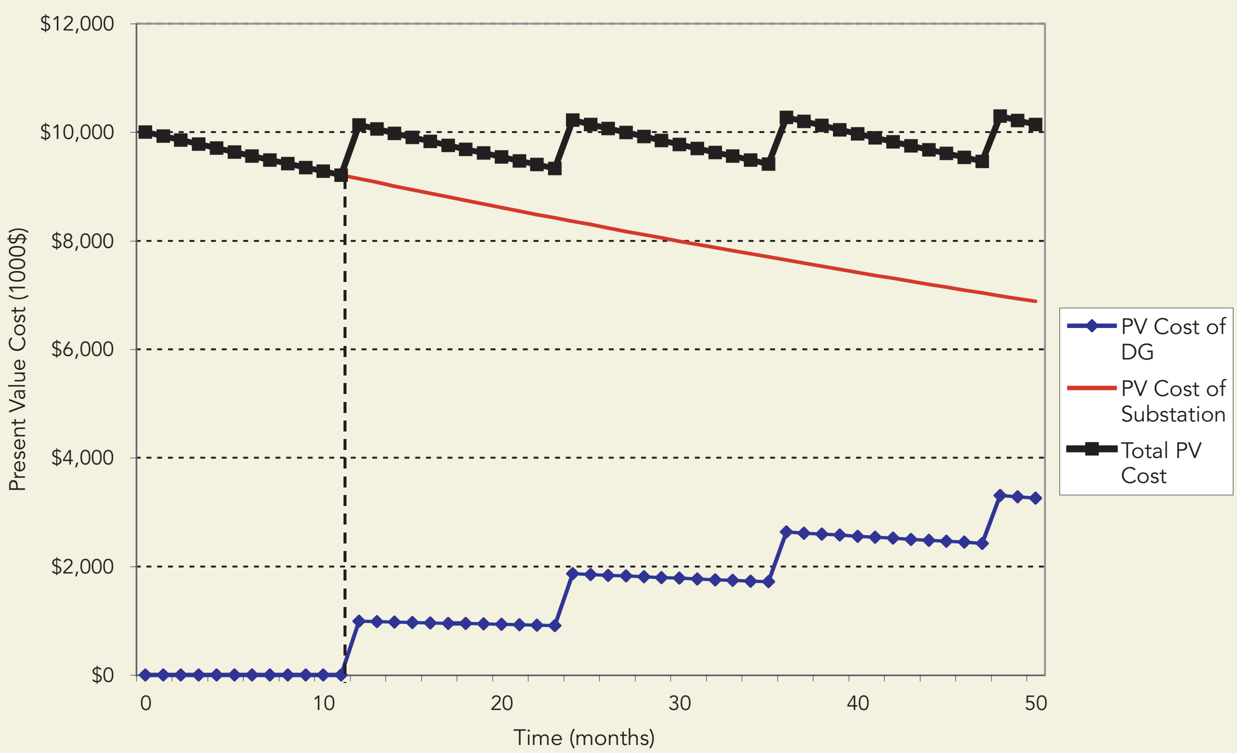
"insurance" value provided by the DG worth the additional cost to avoid the large cost commitment required to build the substation and feeder lines?

To see the tradeoff more clearly, it's easiest to show a hypothetical example where there is no uncertainty about costs or load growth. Figure 1 represents the utility's cost tradeoff. In the figure, we show the present value of the cost of installing 3 MW increments of DG every 12 months to match local area load growth, and the present value cost of installing a 100 MVa substation at various future times. As the substation is deferred longer into the future, its present value cost steadily declines. (We're assuming that the substation's purchase cost doesn't change.) The present value of the cost of the annual sequence of DG investments is a step function, such that the height of each step is the present value of the incremental investment. Therefore, the height of the steps continually decreases.

In this example, the lowest present value cost occurs after 11 months. Thus, the utility would be better off installing DG today and deferring the new substation for 12 months. Of course, in the interim, new information may come to light that would allow the utility to refine its planning further. If several industries decided not to build at the site, then the utility will not have devoted scarce capital to a large, and mostly unused, substation. Alternatively, if development is seen to be accelerating, the utility might be able to install additional DG and then build the substation. In general, the optimal timing will depend on the relative differences between per-kW installation costs, capacities of the DG and substation alternatives, fuel cost, and the utility's discount rate.

Incorporating uncertainty about DG fuel costs, electric market price, and load growth complicates the analysis, but the underlying logic remains. The difference is that we search for the lowest expected cost solution. In the approach we developed with EPRI, called the Area Investment Planning Model,[4] we simultaneously evaluate all possible distribution alternatives, installation constraints (such as timing and compatibility with previous installations), and uncertainty.[5] While this approach is more complex than a typical deter-

Figure 1: Optimal Timing for Installation of DG



ministic "avoided cost" approach, it is far more likely to capture the true value of DG investments and therefore identify greater benefits for utilities and customers.[6]

Identifying the Conditions Most Conducive for DG Applications

Fundamentally, the benefits of DG applications stem from the modularity the planning flexibility they can provide. Utilities and customers benefit when DG investments defer traditional large T&D capital investments, while lowering the overall present value of distribution and generation costs. In our past case studies, we have shown that the value of DG is greatest when there is a high degree of future load growth uncertainty.[7] If a utility knows precisely when local area loads will develop, then the value of flexibility is eliminated. Thus, DG applications can be thought of as providing "real option" value, whose value increases with greater uncertainty, and vanishes without uncertainty.

By providing additional flexibility, DG can allow utilities to improve their use of scarce capital, while continuing to meet customer needs.

It also turns out that the value of DG is greatest when load growth is not too rapid. As load growth rates increase, the value of the distributed resources decrease. While this may seem paradoxical—after all, DG can be brought in rapidly, such as with truck-mounted generators—DG's value decreases because the deferral benefits it provides decrease as load growth rates increase. Hence, the greater unit capital cost ($/kW) of distributed resources becomes more difficult to justify economically as the amount of deferral benefit decreases.

What Does the Future Hold?

No doubt, DG technologies will continue to improve. Perhaps the futuristic vision described in *Popular Science* and others will even be realized, with DG replacing many new central-station generation and local area T&D investments. Today, however, DG investments are not universally beneficial, and so it is critical to identify the conditions under which DG likely will provide the greatest possible benefits to utilities and their customers. But over-selling DG as a universal alternative is dangerous, since the greater the hyperbole, the more likely that expectations for DG will be unmet. Such a situation could result in wholesale rejection of DG, even when its benefits are clear.

We believe the best approach for utilities, regulators, and customers will be to identify those situations where DG applications can have the most value and focus development efforts there. Our work has shown that, when load uncertainty is great but the overall trend in load growth is relatively small, DG is likely to have the greatest benefits. In this era of increasing competition and greater energy market volatility, we expect those conditions increasingly to be found. F

Jonathan Lesser is Senior Managing Economist with Navigant Consulting Inc.

Charles Feinstein is President of VMN Consulting LLC.

1 *Opinion and Order Approving Pilot Program for Use of Distributed Generation in the Utility Distribution Planning Process, Opinion No. 01-5, October 26, 2001.*(N.Y.P.S.C.)

2 Oddly enough, in the 2002 Legislative session, a bill was introduced that would defined some fossil-fueled DG applications as "renewable energy" sources.

3 The approach we use is called "dynamic programming." It is a mathematical optimization technique that forms the basis for the solution of virtually all dynamic investment problems, and which is often used in "real options" analysis.

4 For a description of this model, see S. Chapel, C. Feinstein, P. Morris, and M. Thapa. *User's Manual: Area Investment Strategy Model.* 1999. EPRI. See also, C. Feinstein, P. Morris, and S. Chapel. "Capacity Planning Under Uncertainty: Developing Local Area Strategies for Integrating Distributed Resources." Energy *Journal*, Special Issue on Distributed Resources. 1998, 85-110.

5 A complete discussion can be found in C. Feinstein and J. Lesser. "Defining Distributed Resource Planning." *Energy Journal*, Special Issue on Distributed Resources. 1998, 41-62.

6 An analysis of the difference between this approach and the avoided cost method is given in J. Lesser and C. Feinstein. "Electric Utility Restructuring, Regulation of Distribution Utilities, and the Fallacy of "Avoided Cost" Rules." *J. Regulatory Economics* 15:93-110 (1999).

7 See also C. Feinstein, *Strategic Role of Distributed Resources in Distribution Systems*, EPRI, Palo Alto, CA: 1999, TR-114095.