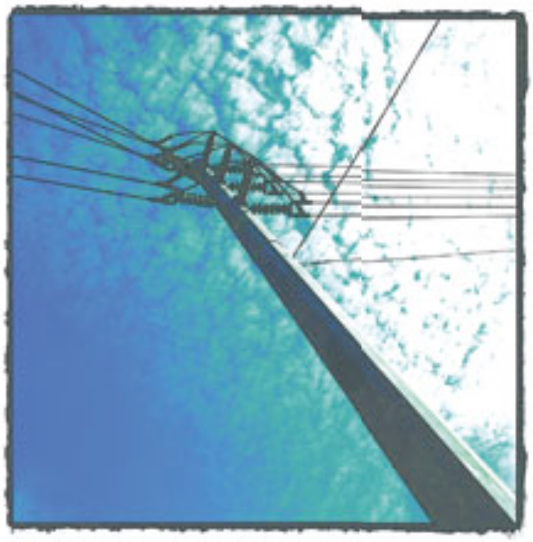
DISTRIBUTED ENERGY
THE JOURNAL FOR ONSITE POWER SOLUTIONS



DG Coming to the Grid's Rescue

California study totals up the value of onsite power to electric companies.

BY DAVID ENGLE

"Distributed generation hurts utilities!" cry electric company engineers who believe that haphazardly sited engines threaten grid safety. The result: Prohibitively high connection charges are imposed.

"DG really helps utilities," say others, including rate-setting commissioners in California and New York in 2004, the US Department of Energy, assorted consumer advocacy groups, and the DG industry.

Which view is right?

Perhaps there's a better question: Which side can back up its claim with compelling, reliable facts? Both sides have struggled with the complexities of quantifying potential benefits or harm and yielding solid, credible data. Both sides offer sweeping but "basically unsubstantiated" claims, observes Peter Evans, CEO of New Power Technologies (NPT) in Los Altos Hills, CA. NPT develops management solutions for the power industry. Missing from the debate, however, were methodologies for serious DG impact studies, resource optimization analysis, and comparative technology assessments. Until recently, Evans points out, no one had been able to solve puzzles like right-sizing DG resources (from the grid's standpoint), where resources should go, or what actual dollar value they would bring to the utility company.

All of this has now radically changed. During 2003–2004, NPT led a research team that produced a landmark study in nearby Silicon Valley showing these critical issues can indeed be addressed reliably—probably for the first time ever. Along with Evans and NPT, 10 other co-participants included Optimal Technologies Inc. of Benicia, CA, which provided principal optimization technology and services for the study; Cupertino Electric, which assisted in developing the system model; the Silicon Valley Manufacturing Group (SVMG); and consultancies Rita Norton & Associates, William M. Stephenson, and Roy Skinner. Funding for the study, and strong state-level encouragement, came from the Public Interest Energy Research (PIER) program within the California Energy Commission (CEC), both of which have long been major sponsors and benefactors of DG-related research and development (R&D).

To serve as a test-case system for undertaking this DG-on-grid analysis, Evans and the SVMG solicited the participation of Silicon Valley Power (SVP), a municipal network of 850 buses serving the city of Santa Clara. SVP's transmission backbones include two 115-kV main feeds, a 60-kV transmission system, and 48 or more distribution feeders of 12 kV, lightly loaded off of about 422 customer locations. That works out, Evans notes, to nearly 1,000 line segments with 106 switchable branches connecting them, 101 switchable capacitors, and six onsite generators with megawatt and megavar capability already in the mix.

What the Study Found

After several months of studying grid optimization with DG sets, Evans issued his report to the CEC, from which the following summary and discussion is adapted. In essence, researchers learned that, indeed, small generators sited strategically on the distribution system would yield potentially tremendous improvements to system efficiency. Moreover, further gains and benefits would accrue to the interconnected transmission system. DG's value to both would be realized not only by the additional reserve power provided, but, even more so, from DG's ability to ease power delivery across hundreds of strained, occasionally redundant, energy-sapping distribution lines.

In any grid system, hundreds and even thousands of kilowatts are squandered in the task of moving amps across needlessly long distances squeezing through local bottlenecks and loop flows. The results: weaker voltage profiles, voltage instability, and poor power quality. Properly positioned DG can greatly reduce system congestion and curtail waste of this sort. The potential savings should readily cost-justify, and subsidize, many cogen investments.

For example, as the report notes, unstable voltage must often be boosted to maintain a sufficient minimum. But if more stable distribution system voltages could be achieved—a potential byproduct of many DG projects—it would reduce the need for wasteful over-amping.

Moreover, researchers found that system voltage stability is closely linked to optimal distribution of the system's reactive power resources, or var. What impact does DG have here? The question can now be answered using breakthrough software from Optimal Technologies called AEMPFAST (pronounced "aim-fast"). Using this tool, Evans' team evaluated and quantified both active (kilowatt and megawatt) and reactive (var and MVar) power flows and events that could lead to cost-justifiable DG sites. Evans' conclusion: "There's a lot more you can do with reactive power," he says, "from a distributed generator, toward providing system benefits."

Sharing Benefits With Adopters

What this insight also suggests is that a prospective DG adopter whose generator might provide such benefits should probably receive some kind of compensation or inducement. Optimal Technologies CEO Roland Schoettle suggests that these might come, for example, "through appropriately structured ancillary power markets, where these benefits are quantified and ranked as alternatives." DG resource optimization on a grid, he adds, "would make certain that all the lowest cost-benefit alternatives would be known and ranked" in utility management decisions, "not just the traditionally obvious ones using standard utility methods."

Schoettle's AEMPFAST also assessed SVP customer demand response measures designed for reducing system peak demand. AEMPFAST's study established that demand response, wherever onsite power is applied, has greater system benefits in certain locations within a distribution system than in others. Hence, the widely asserted "safety risk" to grid security, so often leveled at DG projects, is just the opposite of the truth: Risks are actually lowered by the presence of DG, AEMPFAST learned. Again, says Evans, utilities "would be acting in their self-interest" by giving out carefully targeted incentives to DG adopters, especially where the result is peak-demand reduction.

Evans says other kinds of grid benefits accrue, including "all network-related, avoided, or deferred additions"; improved supply-demand margins; reduced dependence on electricity spot markets; deferred costs; reduced fuel costs; lowered emissions and related costs; and easier integration of future customer-driven onsite power projects into the grid. Lastly, with customer-owned DG in the right places, low-voltage buses can sometimes be eliminated outright.

All in all, then, grids can be "tuned up" with DG networks and made more efficient, says Evans, "by minimizing real power losses and reactive power consumption."

To illustrate, Evans notes that on a 60-kV main feeder (such as at SVP) at a transmission-to-distribution stepdown point where the feeder connects to a 12-kV line (and that, in turn, to low-voltage buses), a system will typically show voltage variability. Although this isn't a problem from an engineering standpoint, he says, "It's waste, and it presents an opportunity for optimization." By carefully measuring these and assorted other losses, then determining and ranking how they'd be reduced by a customer-installed generator nearby, a grid-improvement value results. And again, in incentive terms, a portion should be rebated to the adopter.

Another example: A customer installing a 150-kW combined heat and power system might allow for eliminating a nearby low-voltage bus, or might flatten the overall voltage profile on that 12-kV line. The current would become more consistent. This would reduce wastage, thereby saving the utility something in the low four-figures each year.

DG is but one of several solutions to be applied systematically in a well-optimized grid. Others include, Evans says, "More automated remote switching, changeable topology, controllable capacitors, distribution automation, sophisticated demand-response programs," and assorted others. "That's the direction this will head to. Distributed generation is maybe the most important piece of that, but it is not the only piece."

Siting for Maximum Benefit

Back, now, to the question of precisely where generators should go, and their potential dollar value. Here AEMPFAST's tools for DG-on-grid analysis are able to integrate complex interrelated functions: system security, voltage profiles, reliability, congestion, minimum loss, minimum generation cost, minimum emission, minimum maintenance, locational marginal costs, congestion mitigation, and sophisticated asset optimization. Schoettle adds that his product "is not based on the mathematical engines now prevalent," and so "does not suffer from their limitations." AEMPFAST analyzes a grid's physical condition, virtually in real time (or with only a few seconds' lag) and seeks to give system engineers best-possible resource deployment choices. In so doing, it also ranks every component as to its net benefit, and to meeting the optimization objectives. These, says Schoettle, "can be multiple and varied, and can include both engineering and business objectives." Even very fine detail and micro-analysis is possible. Evans notes that in the SVP study, "We could actually go down to line segment–by–line segment" to detect waste and to quantify savings opportunities, as well as doing the assessment device by device. Schoettle also notes that customer onsite power projects can often accomplish distribution savings and efficiencies "if located and sized optimally" to solve problems, "as well as serving the customer cost-effectively."

With these win-win criteria in mind, then, Evan's team launched the DG siting analysis. He assumed non-exporting generators that were switchable and dispatchable.

In the first what-if scenario, the DGs were limited to the light load on the feeder, meaning they could add only a maximum of 15% of the feeder power (meeting the cap under California's Rule 21 limit for expedited interconnections).

Given this input, then, AEMPFAST identified 382 customer sites where DG would help the grid significantly. The aggregated total in new generation would be optimize at 13.6 MW; that's about 36 kW per generator, totaling 3.4% of peak load.

A second what-if scenario optimized Silicon Valley Power's light feeders. California grid connection rules are more liberal here, permitting up to 60% of the adjacent load to come from non-exporting DGs. On these, Evan's group found 346 prime customer sites for onsite power, totaling 38 MW (9.7% of total peak load and about 110 kW per generator).

In AEMPFAST's number-crunching came one surprising twist: The data showed that relatively small DGs, averaging much less than 150 kW, can carry almost disproportionate impact. In fact, one of the highest-prioritized potential DG sites that AEMPFAST flagged called for a mere 7 kW to support one customer's 14-kW load. Nevertheless, this particular locale was so critical to the grid, Evans explains, that "adding capacity there would benefit the entire system."

For multiple reasons, small-footprint power projects are generally easier to position near the feeder loads than are megawatt-size ones. Likewise, smaller generators can more readily be optimally sized to match loads. "The sweet spot here," Evans says, "tends to fall somewhere between 100 and 300 kilowatts." In this size range, scores of cogen installations turned out to be very cost-effective for customers, especially when the analysis could assume low or subsidized up-front costs.

Next, the very best win-win deals carrying the highest value generally were found to exist near the ends of main feeders—an interesting finding in itself. By adding generation capacity there, Evans points out, "not only does it benefit the feeder, but the entire system." Generally speaking, the more remote the DG positioning, the greater the grid benefit. Less impressive but still cost-justifiable results emerge from proposed installations near existing DG plants.

In any event, location-specific analyses like these should be performed in ideal DG installations in the future, Evans and Schoettle believe. AEMPFAST does this as part of its site ranking. With the help of such tools, says Evans, "A utility can look at multiple permutations and load scenarios, multiple ways of controlling the units, identifying optimal locations, and then figuring out how far away from the optimal performance you get by using different locations."

Quantifying the Savings

The bottom line? The Silicon Valley grid—if fully DG-optimized—could achieve an impressive 31% reduction in real power losses. Along with this would come another 30% reduction in reactive power consumption, equal to 15.203 MVar. If the recommendations churned out by AEMPFAST were actually applied, the resulting reduction in losses would come, as Evans notes, "at three times the system's average loss rate." These numbers are particularly impressive, he adds, because SVP was already relatively well designed, maintained, and operated. In more stressed-out utility environments potential savings would be much greater.

Better still, because SVP's grid interconnects with Pacific Gas & Electric's transmission system, the latter also benefits to the tune of about 5 MW gained. In dollar terms, that could easily translate into thousands of dollars per day during peak loads.

Evans sums up: "These values are significant. They can be quantified. And they are real benefits to this network." Even so, he points out, most of that value still remains with the onsite DG customer—who, after all, has hypothetically paid for it. Customer outlays yield a windfall to utilities; as a result, customers should arguably get some of it back.

What It Means to DG's Future

A second NPT technology study, to be conducted in 2005 at the much larger, more complex Southern California Edison (SCE) network, will explore small-generator impact even more extensively. In scope and scale the SCE study will be nearly 20 times larger than the SVP demonstration, Evans notes. The SCE analysis will also look at DG's impact, for example, on winter peak, light load, and load-growth conditions. Research funding will come from a $5.4 million grant to Evans' firm from the CEC.

Beyond such public-private partnerships as these, various paths to a DG-optimized future are imaginable:

One possible route would be through regulatory commissions and utility rate-setting bodies. For example, Evans suggests, if a utility company sought major funding for transmission and distribution (T&D) upgrades, a panel of commissioners might require that a DG-friendly assessment first be done, at least to present an alternative. If the resulting choice came down to approving $100 million in rate hikes to pay for more wires or endorsing scores of customer-owned generators, most regulators would welcome the latter.

Or—positing a more collaborative approach—utility companies might offer financing to selected cogen adopters on a dollars-per-kilowatt-installed basis. Adopters would earn rebates by siting generators near particular buses. Deals would be subject to further terms such as kilowatt output levels, a non-exporting connection, networkability, lead lag var capability, and perhaps real-time variable controllable reactive power production. Cogen plant owners might agree to run their engines "at least 80% of the time during peak hours," Evans suggests, while also agreeing to curtail off-peak operation, or to comply with other terms that might be required. Given these grid-driven parameters, onsite power would then become a win-win-win solution for utilities, adopters, and developers.

At the state agency level, key players working to make DG-optimized grids and "ultra-networking" happen include the CEC as well as the California Independent System Operators (CAISO). The latter oversees most of the state's power transmission system, and this organization, says David Hawkins, its manager of special project engineering, "is strongly supportive of adding more distributed generation" to relieve transmission loads. DG resources, he believes, "can provide some real benefits both for customers and for transmission load relief during times of peak loading." Widespread implementation of DG, he adds, could become "a wonderful additional tool to help us avoid having to do major customer load-shedding." Hawkins served on Evans' technical advisory committee and is also working with Optimal Technologies on critical new tools for CAISO.

But before any large-scale deployment of grid-optimized DG becomes a reality, new technology for dispatching, remote monitoring, and control systems—currently under development—must mature (Look for "DG Getting Web-Enabled" in the March/April issue of Distributed Energy). Potentially hundreds of DG assets might be networked, and to coordinate them all engineers will need ways to activate specific ones quickly and efficiently "to manage loads and avert trouble," Hawkins notes. CAISO, he adds, is now teaming up with SCE and others to implement networked, inter-communicating distributed resources on a large scale. A demonstration project currently in the offing will probably turn out to be the largest coordinated DG application ever implemented.

Money to pay for such R&D will continue to flow to worthy undertakings like these, adds Mark Rawson, CEC's policy coordinator for DG and the commission's DG integration research program manager. CEC has already contributed $100 million (mainly through PIER) to develop and advance distributed power. PIER's past investments have supported the development of cleaner-burning and lower-cost generators, among other causes. Rawson anticipates that as interconnectivity matures, the CEC will appropriately revise California's energy policy to expand the role of DG. In turn, CEC's sister agency, the California Public Utilities Commission (CPUC), will alter utility rates and policies. Here, Rawson points out that, beginning early in 2004, the CPUC was already directing state utilities "to include the implementation of DG resources in determining distribution planning." In addition, "To the extent that utilities can determine that DG would be a more cost-effective solution than a traditional utility wires solution, the utilities were directed to pursue that as well."

As for the future at Optimal, Schoettle is promoting AEMPFAST to utilities and distribution system operators to "solve previously unsolvable problems" in grid management. Various current and pending tools that Optimal is offering will make it easier, faster, and more attractive for engineers to evaluate and implement DG projects. For example, grid operators can select DG-supported remedial actions, automate their network planning and emergency control, and carry out system restoration, Schoettle says.

Summing up, Evans points out that the icons of our electrical system—big smokestack power plants and miles of high-tension lines—are more antiquated than ever "and really quaint, when you think about it." More people are beginning to realize the obsolescence and inadequacy here. Grids are poised for being phased out and replaced with an "intelligent energy infrastructure," he says, "with transmission and distribution actively managed as an integrated network." In a modern electrical future, he says, "self-healing grids" will be capable of seamlessly adjusting to demands, loads, emergencies, and outages. Loads will be made more responsive to network conditions. DG resources will be embedded into grids extensively—together with remote generation. Energy services will be better tailored to meet widely disparate customer needs. And, when it's all finished, our new infrastructure will be far less brittle and prone to outages and much more flexible, customizable, and adaptable than what we have now.

"Today," Evans says, "we're demonstrating that these things are feasible and doable—and really not even that tough." As for immediate needs, though, it's now widely accepted that several of our urban centers face serious transmission crunches. Space for expansion to meet load growth no longer exists. Adding T&D isn't viable, because costs are prohibitive or local communities raise barriers, he adds. Urban markets especially will increasingly need their generation and grid-improvement solutions to be "located much closer to the loads." DG networks "are the way to go," he says. And, because utilities stand to gain significantly from DG optimization, "let them share the benefit," he suggests. "And everyone is better off."

La Mesa, CA–based writer **DAVID ENGLE** *specializes in construction-related topics.*

RETURN TO TABLE OF CONTENTS

Home | Search | Subscribe | About | News | Advertise | Register | Services | Calendar
Glossary | Contact Us | Current Issue | Back Issues | StormCon | Forester*Press*

P.O. Box 3100 • Santa Barbara, CA 93130 • 805-682-1300