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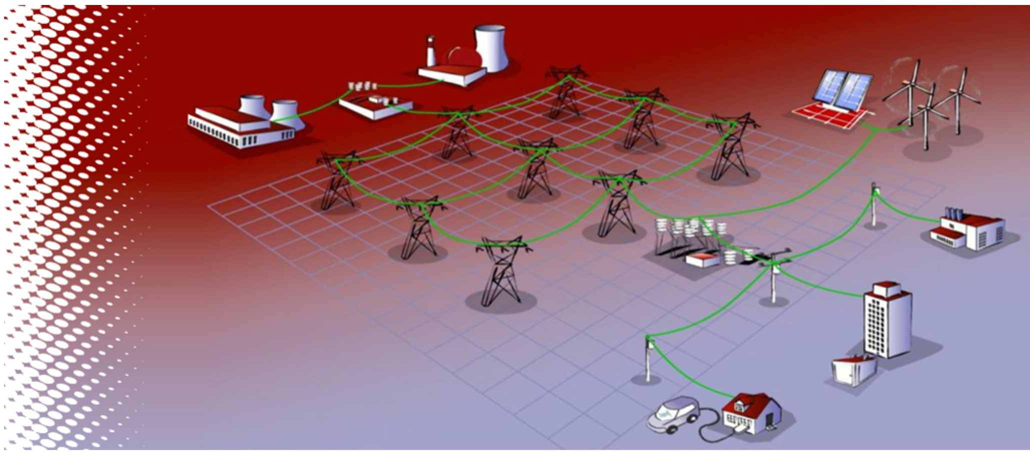

BUGS: The Next Smart Grid Peak Resource?

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BUGS: The Next Smart Grid Peak Resource?

What are BUGS and how can they become a significant Smart Grid peak resource? BUGS are Backup Generators, spread across the country in most businesses, which could fulfill most of the characteristics of a good peak resource (Figure 1).

Characteristics of a Good Peak Resource	Demand Response Program	Central-Station Peaker	BUGS for Peaks
Close to the Load	✓		✓
Dispatchable	✓	✓	✓
Rapidly Deployable (< 2 min)	✓		✓
Runs Only When Needed	✓	✓	✓
Can be Used Nearly Every Day*	✓	✓	✓
Inexpensive to Install	✓		✓
Builds on Existing Assets	✓		✓
Affordable to Run at Peak**	✓		✓
Consumer Engaged***	✓		✓
Environmentally Acceptable	✓	✓	✓

* A combination of direct load control and voluntary consumer demand response can be engaged every day.
** Affordable to run at peak is relative to wholesale spot market at times of peak demand.
*** Since changes in load are directly related to consumers, the best customer service will have consumers engaged in the process of addressing peak demand.

Figure 1: Comparison of Peak Resources

Tomorrow's grid will accommodate and enable a wide variety of generation and storage options; this is a Principal Characteristic of the Smart Grid. Consumer-owned backup generators (BUGS) - distributed generation (DG) units used today for either emergency or standby applications - are plentiful and well distributed. This largely untapped fleet could also be used to flatten the utility load profile and/or supplement the utility generation fleet, and properly integrated, can have an environmental as well as economic benefit. They are broadly distributed, quick to startup and shutdown, close to the point of consumption, readily deployable and more responsive than large, traditional power sources.

Of the more than 220 GW of distributed generation in the United States, 170 GW are dedicated to emergency or standby applications, hence the name BUGS. Yet, this mostly unused capacity could be modified and then called upon to significantly benefit consumers and utilities by addressing the peak load. A Portland General Electric demonstration showed a significantly lower BUGS modification cost per kW (~$175/kW) as compared to new simple cycle gas turbine costs (~$800/kW).

BUGS are predominately diesel fueled reciprocal engines. At first glance, running these units more of the time might be seen as an environmental negative. However, analysis indicates BUGS actually offer a reduction in CO_2, NO_X, and SO_X when compared to the operation of gas turbine peaking units. Due to the considerable ramp-up and ramp-down times for central-station peakers, all of which occur at sub-optimal heat rates (higher emissions per MWh), the actual total emissions associated with addressing the peak can actually be less by applying BUGS to peaking applications. This is made possible because the quick startup times of DG units allows them to remain off until they are needed, avoiding emissions associated with idling. For example, engaging half the BUGS fleet at 200 hours/year for peak demand would yield more than a million tons per year of emissions reductions, mainly CO_2.

Using BUGS as a peak resource is one option enabled by the Smart Grid. A more complete discussion of this key resource can be found in "Backup Generators (BUGS): The Next Smart Grid Peak Resource," Pullins, Zheng, Miller, National Energy Technology Laboratory, DOE/NETL-2010/1406, March 2010; http://www.netl.doe.gov/smartgrid/referenceshelf/whitepapers/BUGS_The%20Next%20Smart%20Grid%20Peak%20Resource%20%28April%202010%29.pdf

The Smart Grid enables the BUGS fleet to be dispatchable and intelligently applied to the right peak locations on the grid. BUGS also require two-way flow of power on the distribution grid which requires more grid intelligence to remain reliable and economic.

Is a program to use BUGS as a peak load resource necessary or even sensible? Let's look at the record. From the NETL report, the last 15 years have seen the nation overbuild gas turbine generation capacity (see Figure 2) in an attempt to satisfy peak demands. But this has come at great capital expense, along with the high operating costs of an expensive fuel, and with very low capacity utilization (gas turbine "peakers" are used only about 11% of the time).

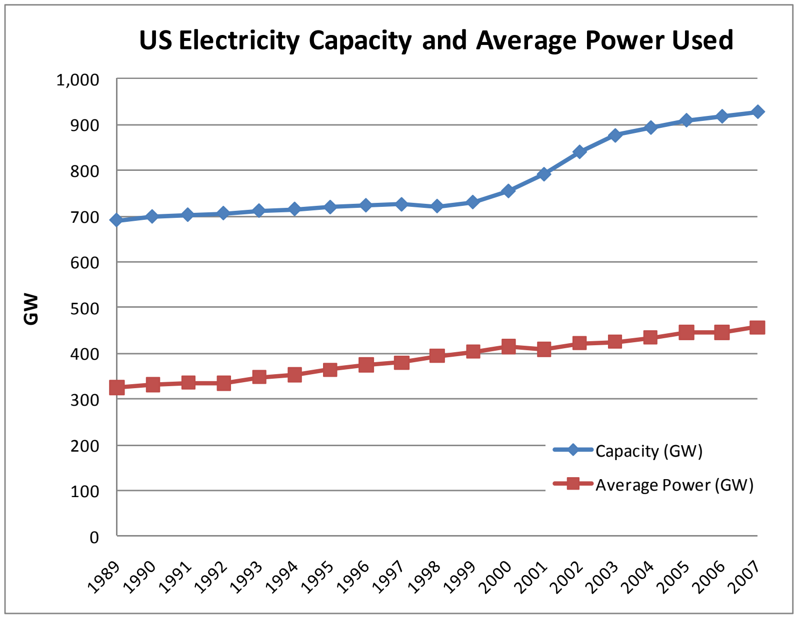

Figure 2: U.S. Electricity Capacity and Average Power Used

So in retrospect, it seems a program that instead employed existing BUGS might have better filled this role in the past and should certainly be considered going forward. And, utilizing BUGS to address peak load does not detract from their primary duties of emergency and standby generation. It simply enables the owner and utility to make better use of an existing capital intensive resource, thereby saving money and reducing emissions.

Are BUGS a significant United States resource?

The annual investment by U.S. businesses in BUG's is more than $5 billion. The DOE Energy Information Administration (EIA) data shows that the installed base of more than 220 GW is increasing. Emergency and standby applications represent an installed capacity of 170 GW, currently providing about 3.5 TWh per year which is 20 hours of operation per year on the average.

If the nation were to expand the use of this resource to 200 hours per year, BUGS would address 22% of the peak demand across the nation. This makes BUGS a viable partner that can complement demand response (DR) in addressing peak load. The 200 hours per year is not an operational challenge for BUGS, in fact, the increase hours of operation actually improves reliability over the typical hour test run per month currently experienced with emergency backup applications.

Can BUGS be dispatched at peak?

There are several utilities currently dispatching BUGS at peak load. Portland General Electric (PGE) is perhaps the best example. PGE has a dispatchable standby generation program popular with local businesses who own BUGS. PGE has about 50 MW of dispatchable peak generation capacity in the program which represents a significant portion of its peak load. The PGE agreements with businesses who own BUGS are for up to 400 hours per year, making this dispatchable peak resource available for many peaks during the year.

What about the emissions issue?

The NETL analysis yielded reductions in CO_2, NO_x, and SO_x for a national program in which half the BUGS fleet was used to address peak load for 200 hours per year. With additions of scrubbers on the output of BUGS, and by employing rapid startup and shutdown sequences and controls, the BUGS give a resulting reduction in emissions for the same peak load served, when compared to using central-station peakers. It is important to remember that a central-station peaker needs to produce up to 10% more power to serve a peak load than the local BUGS due to transmission and distribution losses because it is some distance away from the peak load location.

With the above example of using half the BUGS fleet, the reduction in CO_2 emissions would be more than 935,000 tons per year. The economic value of such an emissions savings certainly helps to make the case for BUGS as a main peak resource.

How would BUGS compare to the existing peak resource paradigm?

Let's consider three factors: (1) asset utilization, (2) capital expense, and (3) operations / maintenance (O&M) expense. First, the EIA data shows that traditional central-station peakers operate (on average) at an 11% capacity factor, while this EIA data also shows that DG operated as peakers have a capacity factor of 30%. This is a multi-year trend that suggests addressing the peak load with localized resources is more effective.

Second, up-converting a BUG to a peaking application is more capital cost effective than permitting and constructing a new central-station peaker, as well as more quickly deployed, for the same peak load. The average cost of new central-station gas turbine generation including any associated transmission build and new siting is roughly $1,000/kW. The up-conversion of BUGS to address peak load at a northwestern utility averages $175/kW, including the cost of scrubbers. Plus the transmission and distribution losses must be accommodated from a central-station peaker by adding capacity (capital cost) to offset the losses.

Finally, considering the operational viewpoint, the northwestern utility again provides a good example. At this utility, the average all-in operating cost is about $0.17 per kWh for peak load offset. By comparison, while $0.17 per kWh is expensive, it is less expensive than the wholesale peak price (primarily supplied by central-station gas turbine peakers), which is often $0.25 per kWh or above, depending on the region.

Thus, the economic and environmental benefits strongly suggest a peak resource paradigm different from the traditional central-station peaker paradigm prevalent over the last 15 years.

Benefits of BUGS to the Industry and Consumers/Society

According to the EIA, about 75% of commercial businesses have backup generators, of an average size of 18 kW (U.S. Department of Energy, 2008). This resource is distributed and matched with appropriate loads, but utilities have held these resources at arm's length until recently. BUGS, incorporated intelligently within a smart grid, can provide a number of benefits shown in Figure 3.

Industry Benefits	Consumer/Society Benefits
Increased capacity, especially during peak hours, by interconnecting BUGS, and adding peaking power roles to their emergency and standby power roles. Increased system efficiency through greater supply-side price elasticity by incorporating a larger number and wider set of options for responding to price changes. Enhanced network security and resilience to disruptions because BUGS are geographically distributed, use a variety of fuels, and have a variety of operating principles. Deferral of major capital investments by using BUGS and energy storage, enabling utilities to defer major capital investments by temporarily increasing this local capacity in critical areas as needed. Higher power quality and reliability by using generation located closer to the load as "fine-tuning" tools for providing better power quality and reliability for customers when used in conjunction with a smart grid.	Reducing the carbon footprint by using local BUGS to address local peaks more exactly and quickly. Hedging overall energy costs by providing more alternatives to address the most costly portion of the energy supply operations. Improved emergency backup and standby generation reliability by running BUGS more often in controlled ways. Also adds capability to self-heal. Increase downward electricity price pressure by deferring some major capital investments related to chasing the peak load, and by reducing the peak which reduces the marginal cost of the next MW giving short term savings. Higher power quality and reliability by using BUGS as "fine-tuning" tools to providing better power quality and reliability for customers.

Figure 3: Benefits of Incorporating BUGS into the Operating Paradigm

Overcoming Barriers to BUGS

Incorporating a large fleet of BUGS into a new operating paradigm is not without barriers. There are regulatory, programmatic, and technical barriers to overcome. Figure 4 provides a summary:

Programmatic and Technical Barriers	Policy / Regulatory Barriers
Maintaining adequate voltage regulation through the use of voltage regulators is an important first step. Voltage support must be sufficient to maintain voltage when the BUG disconnects or connects. Installing appropriately rated fuses and reclosers to detect faults will prevent unnecessary fuse	Provide incentives for more efficient forms of DG. The development of more efficient and cost-effective DG technologies has been one of the major drivers behind the increase of DG use. Encourage DG owners to pursue applications with higher asset utilization. Some states have already begun providing incentives to pursue more

burnouts. Fuses and reclosers must be rated correctly and coordinated in order to resolve issues that could arise from the addition of BUGS.

Limiting and filtering harmonics introduced by BUGS are important for maintaining power quality. Grid-connected BUGS can introduce harmonics into the system, potentially increasing harmonic distortion above acceptable levels.

Avoiding unexpected islanding is an important safety factor. Maintaining fuses and installing important safety equipment protects both utility work crews and the public from danger.

Providing appropriate visualization and decision support both to the utility and to customers must be accomplished. As more backup generation is incorporated into the grid, effective dispatch and management will become more commonplace.

Adding adequate energy storage will be important if backup generators are expected to play a larger role in managing grid strain. Specifically, replacing spinning reserves with quick-starting BUGS will require significant investments in energy storage to help manage transients.

Enabling two-way power flow is a critical pre-requisite to higher utilization of BUGS, since this allows BUGS to serve local peak loads larger than the locally connected peak load.

integrated DG applications, such as CHP. Creating these incentives and removing barriers to interconnection will result in the necessary shift of BUGS to higher value DG applications. This also includes addressing metering needs as the BUGS supply energy to the grid.

Implement real-time pricing schemes. By using real-time pricing, time-of-use pricing, critical-peak pricing, or other similar methods of pricing electricity and ancillary services, regulators and regional transmission organizations (RTOs) create a natural incentive for DG owners to operate their resources in a way that is more in tune with the needs of the grid.

Reduce regulatory red tape. Creating standard classes for DG interconnection—or using other methods to reduce the lead time for interconnecting DG—can greatly increase the number of BUGS serving higher value roles. Currently, the interconnection standards do not support seamless operation of DG, including BUGS. Simple and safe interconnection standards and interconnection agreements are needed.

Utility fear of lost load under existing profit models.

Figure 4: Overcoming Barriers to BUGS

Conclusion

The nation simply cannot afford to continue the central-station peaker paradigm. Fortunately, between demand response and using BUGS as peak resources, all enabled by the Smart Grid, the nation has an available solution already proven in the field by a few forward-thinking utilities and business customers.

Greater utilization of the BUGS fleet to address needs in the electric system has the potential to offer significant advantages to the nation:

- A more efficient and economical way to address the peak.
- A more emission-friendly approach (that would be more readily accepted by society).
- An existing installed generation base that can be rapidly enabled to offset new generation, transmission, and distribution construction.
- A more robust electrical infrastructure using a more diversified supply base.

Reference

Source for this article: “Backup Generators (BUGS): The Next Smart Grid Peak Resource,” Pullins, Zheng, Miller, National Energy Technology Laboratory, DOE/NETL-2010/1406, March 2010. It can be found on the Reference Shelf of the DOE/NETL Smart Grid website, under White Papers.