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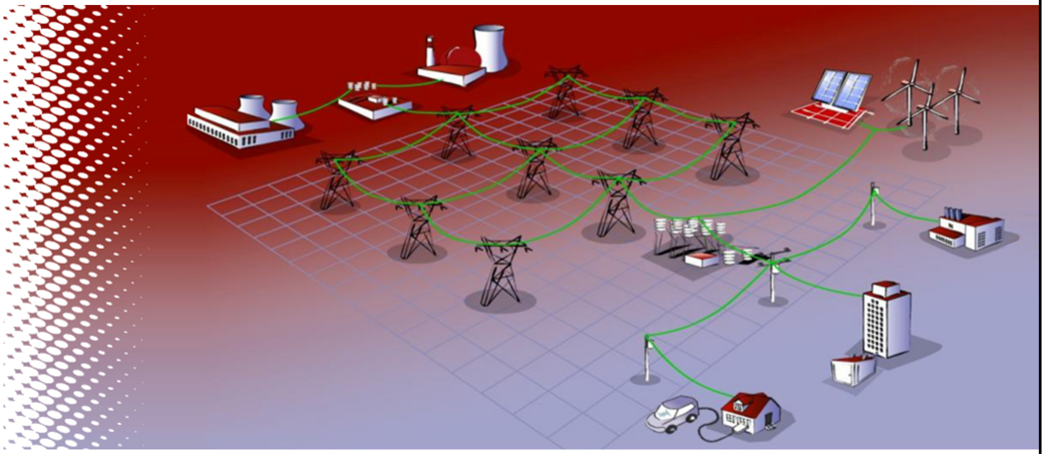

Backup Generators (BUGS):
The Next Smart Grid Peak Resource

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ACRONYMS

BUGS	Backup Generators
CHP	Combined Heat and Power
DG	Distributed Generation
EIA	Energy Information Administration
GW	Gigawatts
GWh	Gigawatt Hours
IEEE	Institute of Electrical and Electronic Engineers
kW	Kilowatt
MW	Megawatt
PGE	Portland General Electric
RTOs	Regional Transmission organizations
SAIC	Science Applications International Corporation
TWh	Terawatt Hours

BUGS: THE NEXT SMART GRID PEAK RESOURCE

EXECUTIVE SUMMARY

Tomorrow's smart grid will accommodate and enable a wide variety of generation and storage options. Today, there is a large untapped resource on the consumer side of the meter at many commercial and industrial customer facilities. Consumer backup generators (BUGS), which are distributed generation (DG) units for either emergency or standby applications, are plentiful and well distributed. BUGS can play a significant role in flattening the utility load profile to the economic and environmental benefit of utilities, consumers, and society. Properly integrated, BUGS can have an environmental as well as economic benefit because they are well distributed, quick to startup and shutdown, close to the point of consumption, and more responsive than large, traditional power sources.

The low asset utilization of standby and emergency applications represents 170 GW of untapped capacity suggesting they could potentially serve larger loads, certainly at peak. This 170 GW of BUGS capacity represents about 22 percent of the peak and 36 percent of the average load in 2009 and could be available to address the peak demand. This could be a significant benefit to consumers and utilities. A Portland General Electric (PGE) demonstration showed a significantly lower conversion cost per kW as well as a 30% or more reduction cost per KW over simple cycle gas turbine costs. The key to increasing the capacity factor of BUGS is interconnecting them to the grid and using them to serve larger loads.

The generators within the emergency power are predominately diesel fueled reciprocal engines. At first glance the environmental benefit of this resource may not be apparent. However, preliminary calculations indicate there is a reduction in CO_2, NO_X, and SO_X compared to gas turbine peaking units.

The Science Applications International Corporation (SAIC) Pollution Reduction Estimator (v1.0) shows that a national program to engage half of the BUGS for peak reduction during 200 hours a year results in emission reduction compared to natural gas peaking units. Specifically,

- More than 935,000 tons a year reduction in CO_2 emissions.
- More than 54,000 tons a year reduction in NO_X emissions.
- More than 33,000 tons a year reduction in SO_X emissions.

The Smart Grid as described in the Modern Grid Strategy Seven Principal Characteristics envisions the accommodation of all generation resources and optimizes the efficiency of the available assets. Enabling BUGS as a peak resource is one option that builds on the enablement provided by the Smart Grid.

This report addresses the following broad issues that will shape the role of BUGS in the smart grid:

- Size and topology of today's generation fleet.
- Critiquing the current peak load paradigm.
- Breaking the paradigm: enabling BUGS as a DG resources.
- Potential uses for integrated BUGS.
- Dealing with barriers to greater BUGS utilization.
- Economics.
- Environmental Metrics.
- Reliability.

INTRODUCTION

Challenges to the Traditional Model of Generation

With construction costs high, lengthy regulatory lag times, and public opposition to most types of central power plants (Not-In-My-Back-Yard concerns), significant barriers exist for new generation and transmission today. Yet with high growth projected in electricity demand, public concern about greenhouse gases and global climate change, and a digital economy requiring higher power quality, the need for some new generation seems unavoidable.

For the past 70 years, the utility system has dealt with growing demand for electricity by building more of everything. The philosophy was to provide whatever power the customer wanted whenever it was wanted. Much of this generation, transmission, and distribution capacity was added to compensate for a lack of built-in intelligent controls within the power system and a lack of cost awareness at the point of consumption.

The national paradigm of overbuilding to meet the peak has resulted in a low capacity factor of only 47 percent (see Figure 1). The traditional model for building generation is not economically sustainable. However, with tools like the smart grid, backup generators (BUGS), and energy storage, the peak can be addressed more efficiently, allowing new central-station generation to be deferred or cancelled.

Growing Interest in Distributed Generation

Distributed generation (DG) has begun to play a larger role in generation investment over the past few decades. The International Energy Association lists five major factors that have contributed to an increase in DG around the world (International Energy Agency, 2002).

- Developments in DG technology.
- Constraints on the construction of new transmission lines.
- Increased customer demand for highly reliable electricity.
- The liberalization of electricity markets.
- Concerns about climate change.

These factors have driven private power consumers and utilities alike to purchase greater levels of distributed generation at a pace of about $5 billion per year (International Energy Agency, 2002). Generators purchased by private consumers are generally chartered as backup power for a specific load, to provide a higher level of reliability for a specific operation than the grid can offer. A handful of these generators have achieved a greater level of integration; however, the vast majority of these generators are not connected to the grid and operate infrequently in a backup mode only.

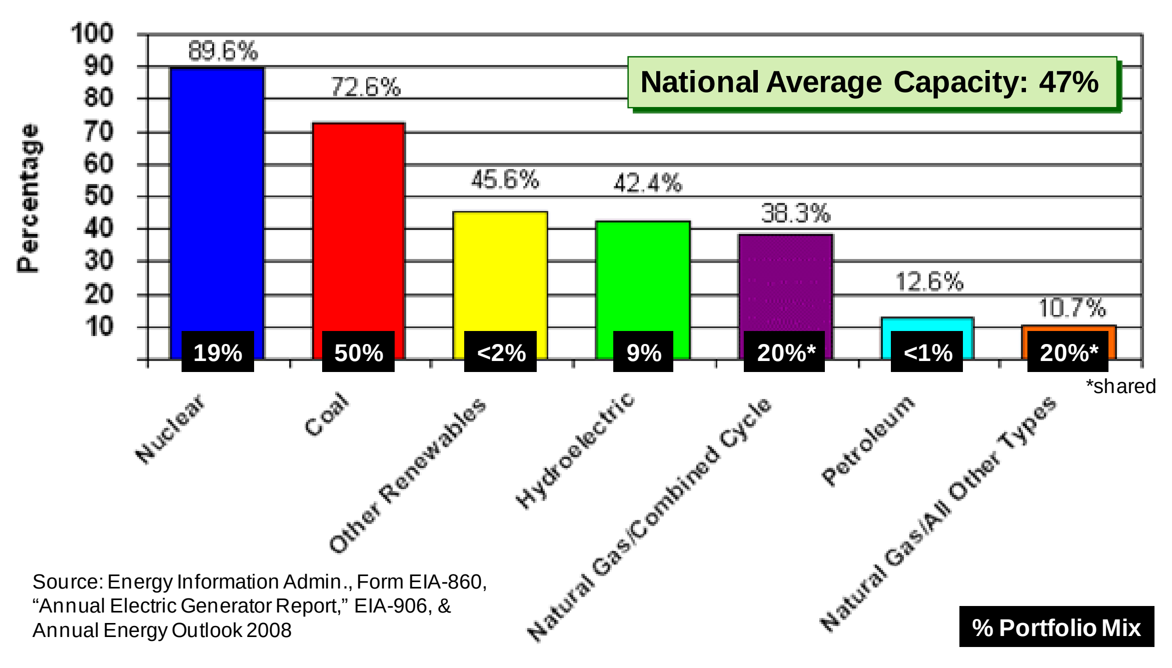
SIZE AND TOPOLOGY OF TODAY'S GENERATION FLEET

Conventional Generation

In 2009, the U.S. peak demand was 764 gigawatts (GW), and the corresponding system generation capacity was about 1,013 GW. (Energy Information Administration, 2009). This generation base is primarily composed of large, centralized, fossil-fuel-based generators. Figure 1 shows the relative electric generation mix of the 1,013 GW in capacity delivering energy totaling 4.16 million gigawatt hours (GWh) in 2007.

However, from an energy perspective, the 4.16 million GWh divided by the total hours in a year (8,760 hours), reveals that we only used the capacity equivalent of 475 GW of central-station generation. Hence, the percent utilization of fleet nameplate capacity was only 47 percent.

Annual plant maintenance is required, unexpected outages occur, and reserves are needed, so a 100 percent capacity factor for the fleet is virtually impossible. In addition, some technologies and sources lend themselves to higher capacity factors than others due to the nature of their operating principles. However, the national average of 47 percent remains a useful benchmark when comparing new technologies to the status quo. Figure 1 shows the capacity factor of various kinds of generators based on their primary fuel.



Source: Energy Information Admin., Form EIA-860, "Annual Electric Generator Report," EIA-906, & Annual Energy Outlook 2008

Figure 1: National Average Capacity Factor of U.S. Generation Mix (Energy Information Administration, 2009)

Since the late 1990s, the nation has focused on building generation and transmission capacity to serve the peak. Figure 2 shows how the grid-connected generation capacity (blue) has increased significantly (greater than 200 GW) since 1998 while the average delivered (red curve) has not increased as much (about 50 GW equivalent).

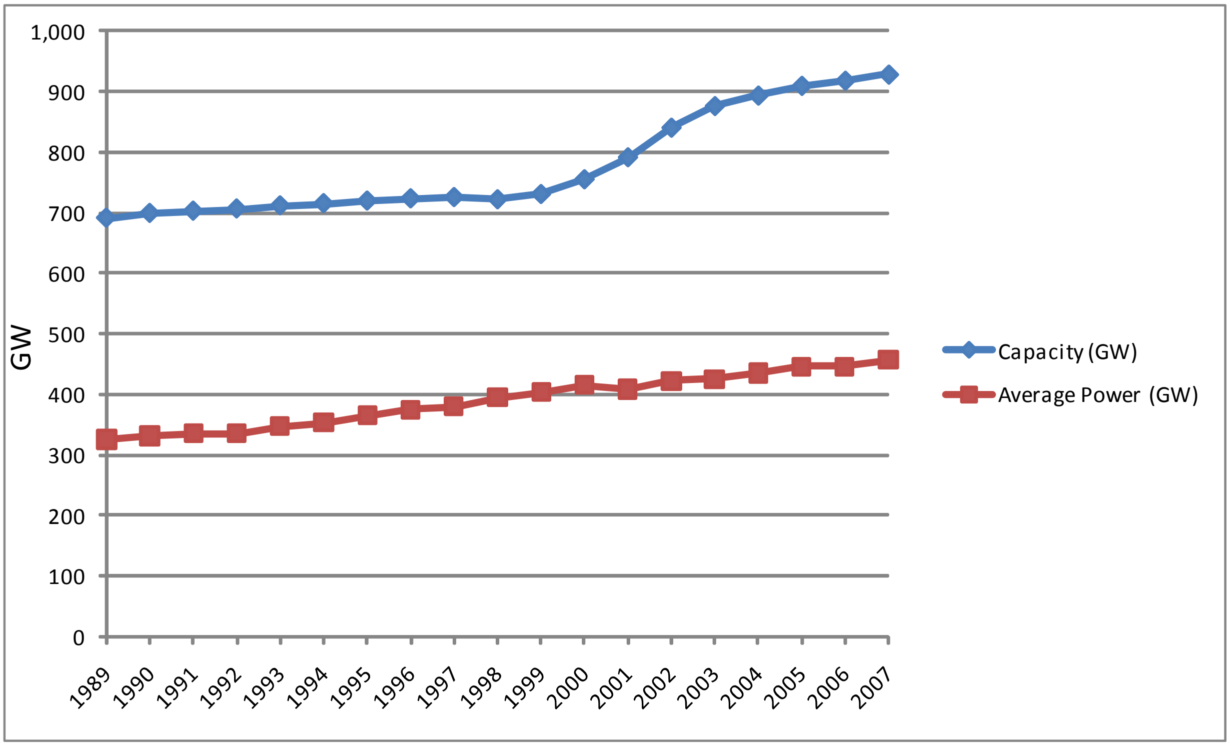


Figure 2: U.S. Power Capacity versus Actual Average Power (Energy Information Administration, 2009)

Figure 2 shows that the total generation capacity over the past few years has increased significantly, as indicated by the upward sloping blue line. Instead of increasing capacity, however, an alternative is to make smarter use of existing energy resources by increasing the capacity factor (on the graph this would reduce the gap between the red and blue lines). The gap between the lines represents the amount of capacity that is, on average, overbuilt.

The traditional model of generation building of chasing the peak is no longer the best economic choice for the U.S. consumer because of its high cost and low efficiency. Better options are becoming available through technology advances and the smart grid. The U.S. economy needs new peak load solutions like demand response, storage, and DG—including BUGS.

Distributed Generation

In addition to centralized generation, a significant amount of DG exists throughout the United States. Estimates of the amount of DG in the United States vary, depending on how it is defined. A common definition of DG is the generation of electricity by generators of less than 60 MW for consumption near the DG unit. Using this definition, the U.S. DG fleet as of 2003 was composed of about 12.3 million units, had 222 GW of generation capacity, and produced about 232,000 GWh of energy annually (*DG Monitor*, 2005).

The U.S. DG fleet has been growing slowly throughout recent decades. As of 2004, about 68 percent of the total U.S. DG capacity was installed between 1990 and 2003 (*DG Monitor*, 2005). Carnegie Mellon's Electricity Industry Center reports that there are 12 million DG units in the United States with over 200 GW of generating capacity, growing at about 5 GW a year (Gilmore, 2007).

Figure 3 shows the increase in DG installations over the past few years, delineated by technology type and seems to be an extension of the DG trend observed in 2000–2003. It is also clear that internal combustion engines remain the dominant technology in DG, and that many of the recent DG deployments use this technology. Other technologies appear to be holding steady, with the exception of wind and other nonconventional sources, which have been growing rapidly in the past few years.

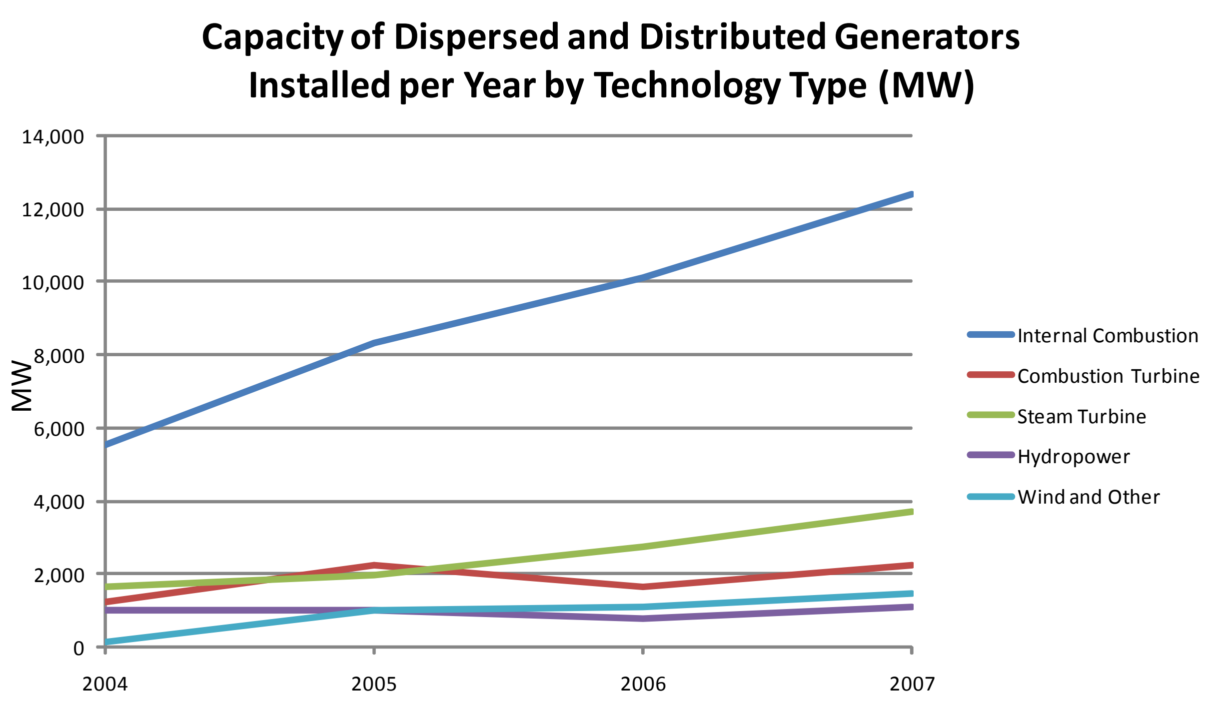


Figure 3: Capacity of Dispersed and Distributed Generators Installed per Year by Technology Type (Energy Information Administration, 2009).

Distributed Generation Technologies

The current fleet of DG can be classified based on their technology and their application type. The technology types are presented in Figure 4 below:

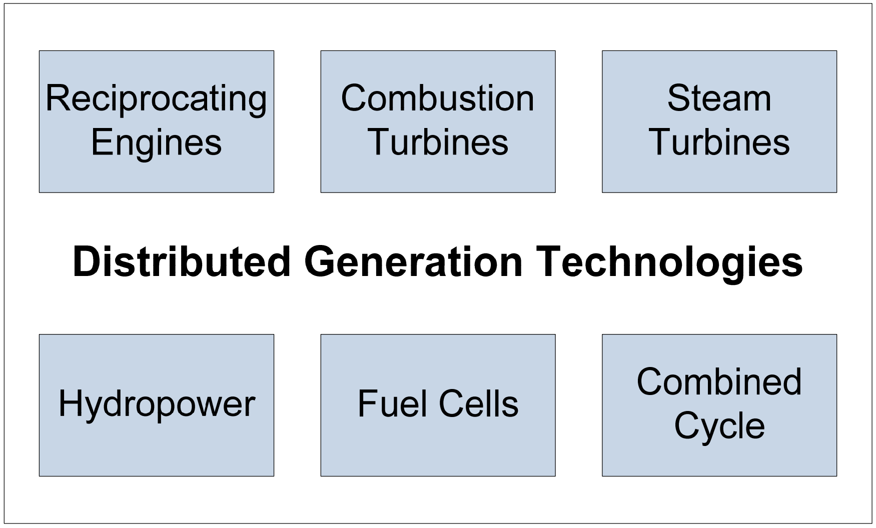


Figure 4: Distributed Generation Technologies (DG Monitor, 2005)

The six technologies primarily found in DG include the following (*DG Monitor,* 2005):

- Reciprocating Engines
  - 192 GW capacity and 113 terawatt hours (TWh) generated in 2003.
  - Low capital cost.
  - Fast startup (20 seconds).
  - High reliability and efficiency.
  - Combust gasoline or fuel gases.
  - Uses the same operating principle as conventional vehicles.
  - \$300–\$600 per kilowatt (kW) capital costs and \$0.09–\$0.20 per kWh operating costs.
- Combustion Turbines
  - 14.8 GW capacity and 4.9 TWh generated in 2003.
  - Air is compressed in order to turn a series of blades that turn a generator (like a jet engine).
  - Generally these use a gaseous fuel like natural gas, or a liquid fuel.
  - Low emissions.
  - \$800–\$1200 per kW capital cost.
- Steam Turbines
  - 12.7 GW capacity per 53.6 TWh generated in 2003.
  - Use high pressure steam to turn a series of blades to generate power.
  - Generally only suitable for large, industrial applications.
- Hydropower
  - 1.27 GW capacity per 6.55 TWh generated in 2003.
  - Can store power by pumping water back up for use later.
  - High efficiency.
  - Low emissions.
- Fuel Cells
  - 0.07 GW capacity per 0.55 TWh generated in 2003.
  - Use a chemical reaction to generate electricity.
  - Use a variety of gases to operate.
  - Generates considerable waste heat.
- Combined Cycle
  - 9.37 GW capacity per 4.99 GWh generated in 2003.
  - A combination of a combustion turbine and a steam turbine.
  - Exhaust heat from the combustion turbine is used to generate steam for the steam turbine.

Wind, photovoltaics, and plug-in electric vehicles could also be included in the DG list. However, they still comprise a relatively small portion of DG and are generally not useful for addressing peak load.

The following data is taken from the *DG Monitor*'s 2005 edition of the report "The Installed Base of U.S. Distributed Generation," published by Resource Dynamics Corporation (*DG Monitor*, 2005).

The U.S. DG landscape is dominated in terms of quantity by reciprocating engines, primarily running on gasoline or fuel oil. Most of the U.S. DG fleet (97.9 percent) is composed of reciprocating engines smaller than 100 kW in size. Figure 5 also shows a significant growth in DG that took place during 2000–2003, concurrent with the growth of the central-station natural gas peaker fleet.

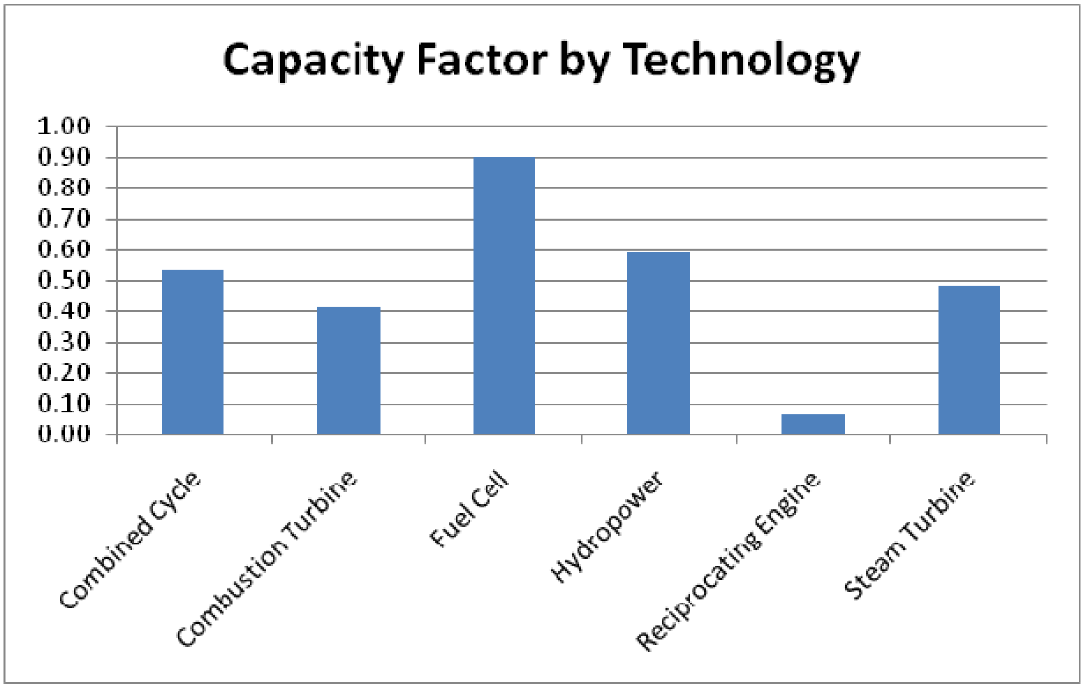


Figure 5: Capacity Factor by DG Technology

Comparing Figure 5 to Figure 1, the small combined cycle, combustion turbine and hydropower have higher capacity factors than their larger counterparts. This is because the smaller "distributed generators" are tailored to specific needs or matched with specific loads. This is a good lesson for the future; tailoring DG applications to yield more effective use of capital.

Distributed Generation Applications

DG technologies can be used in a variety of applications. The five primary applications are shown in Figure 6.

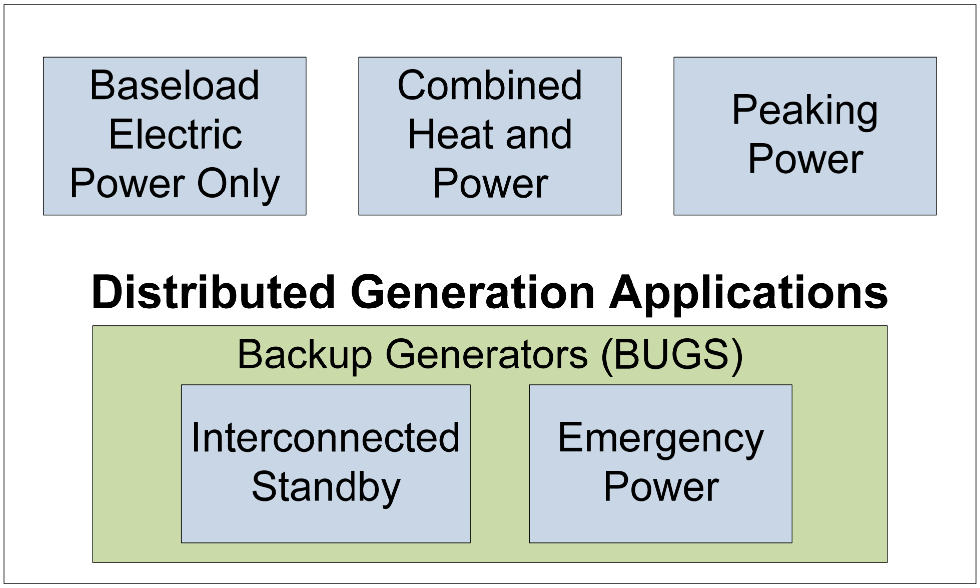


Figure 6: Distributed Generation Applications (DG Monitor, 2005)

These are the five primary applications of DG (*DG Monitor*, 2005):

- **Baseload Electric Power-Only** (10.4 GW capacity, 73.9 TWh generated in 2003)—Baseload power is where DG is operated almost continuously, primarily to generate electric power for a specific load, which is generally industrial.
- **Combined Heat and Power (CHP)** (34.7 GW capacity, 136 TWh generated in 2003)—CHP is operated almost continuously to generate both electricity and heat. CHP operations must have a reliable heat load nearby and are mostly used for industrial applications.
- **Peaking Power** (7.11 GW capacity, 18.6 TWh generated in 2003)—Peaking power applications are not operated continuously but rather are used to reduce overall electricity costs through reductions in peak power purchases and by offsetting electricity use during high-price periods. Utilities and a number of industrial consumers use these.
- **Interconnected Standby** (1.29 GW capacity, 1.17 TWh generated in 2003)—Interconnected standby generators include spinning reserves, which are grid-connected, but generate little energy throughout the year except to offer regulation services for utilities. Interconnected standby also includes DG operated by private companies, but these are connected to the grid to occasionally offer peaking power support. These units spend most of their time idle.
- **Emergency Power** (169 GW capacity, 2.38 TWh generated in 2003)—Emergency power systems are grid-independent systems that provide power to a limited load for a limited time frame if the normal source of power fails.
- **BUGS** —Can be considered a combination of DG used in emergency power and interconnected standby applications. These generators may or may not be grid-connected, but they share a common thread in that they are considered secondary sources of power (they only operate to replace or supplement the grid) and have very low capacity factors.

Figures 7 and 8 summarize the U.S. DG fleet's topology by application. The relative contribution of each application to the total fleet is viewed through a variety of lenses.

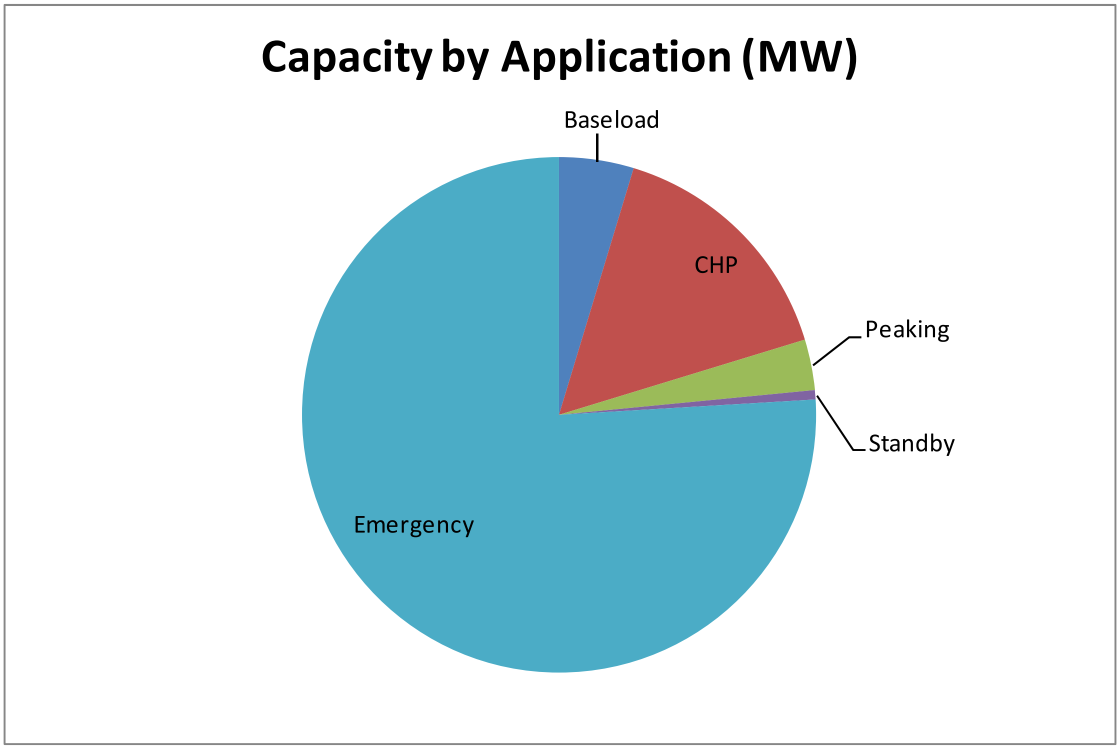


Figure 7: DG Capacity by Application

Figure 7 reveals that among the various applications, CHP and baseload applications tend to involve larger generation units. Because of the sheer size of the fleet, emergency backup generators still comprise the majority of the capacity, but they have a low capacity factor. BUGS have the greatest potential as a significant resource for addressing peak load.

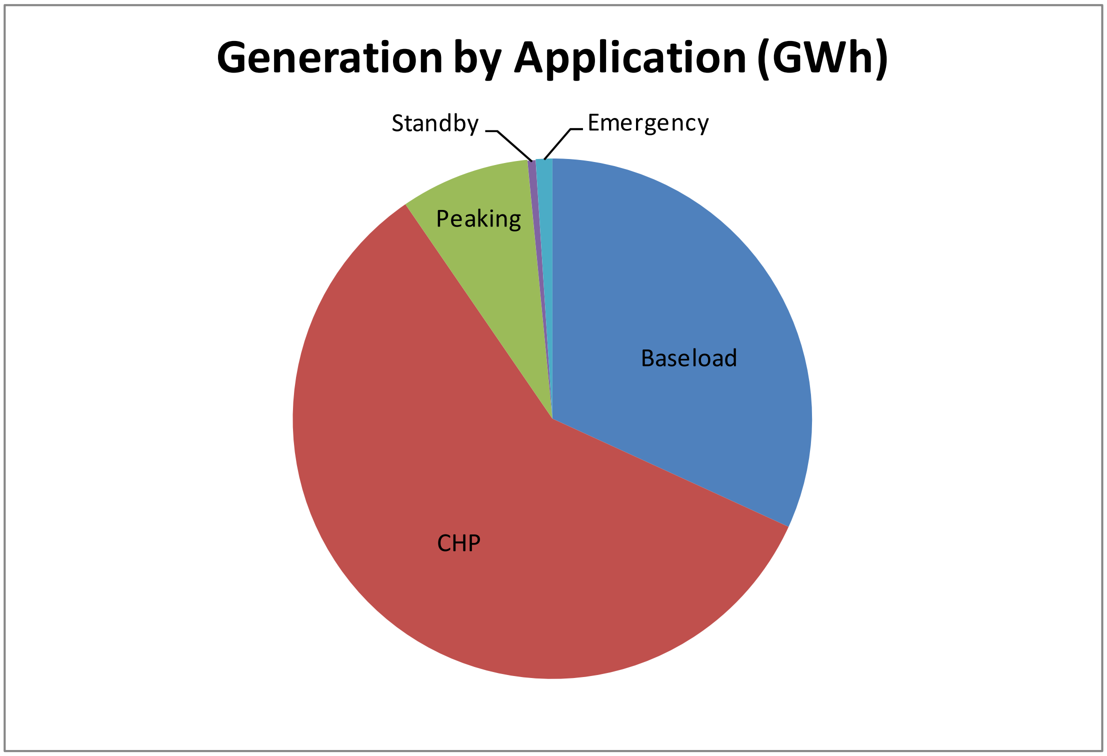


Figure 8: Energy Generated by DG Application

Figures 7 and 8 show that with the capacity factor taken into account, CHP and baseload applications have a more significant energy role in the DG fleet than peaking, standby, and emergency, as expected. Emergency and standby units have low capacity factors and are underutilized compared to DG peaking power units, which are similar in technology characteristics.

CRITIQUING THE CURRENT PEAK LOAD PARADIGM

DG Can Address the Peak Better than Centralized Peakers

The current paradigm in peak load management of overbuilding to meet the peak has increased generation capacity on both sides of the meter but without much coordination between the utility and the private consumer. This has resulted in low asset utilization levels both in utility-owned and privately-owned generators. According to the Energy Information Administration (EIA)'s "Electric Power Annual 2007," natural gas peaking plants have a capacity factor of about 11 percent (Energy Information Administration, 2009). Sector-wide surveys of DG show similarly low capacity factors (less than 10 percent), with large variations by application (*DG Monitor*, 2005). These low-usage rates represent a huge opportunity to defer additional new generation builds, if only these assets could be used more intelligently.

Integrated DG resources, which are paired with loads and are activated during the peak, can address the peak more efficiently than centralized peakers. For example, DG units used in a peaking application have on average a capacity factor of about 30 percent compared to their central-station fleet counterpart (natural gas peakers) that operate at about an 11 percent capacity factor. One likely explanation is that DG units are closer to the load, thus are better able to address local peaks and focus on optimizing economics and reliability for the end-customer rather than dealing with the aggregate peak and aggregate reliability like the utility. This suggests that up-converting a BUG into a peaking application is more cost effective than constructing a new central-station peaker to meet the same peak since the DG unit has a more appropriate size and location for meeting the local needs of the load. Assuming the DG fleet is perfectly distributed at the load, the efficiency level is also higher with a DG peaking application.

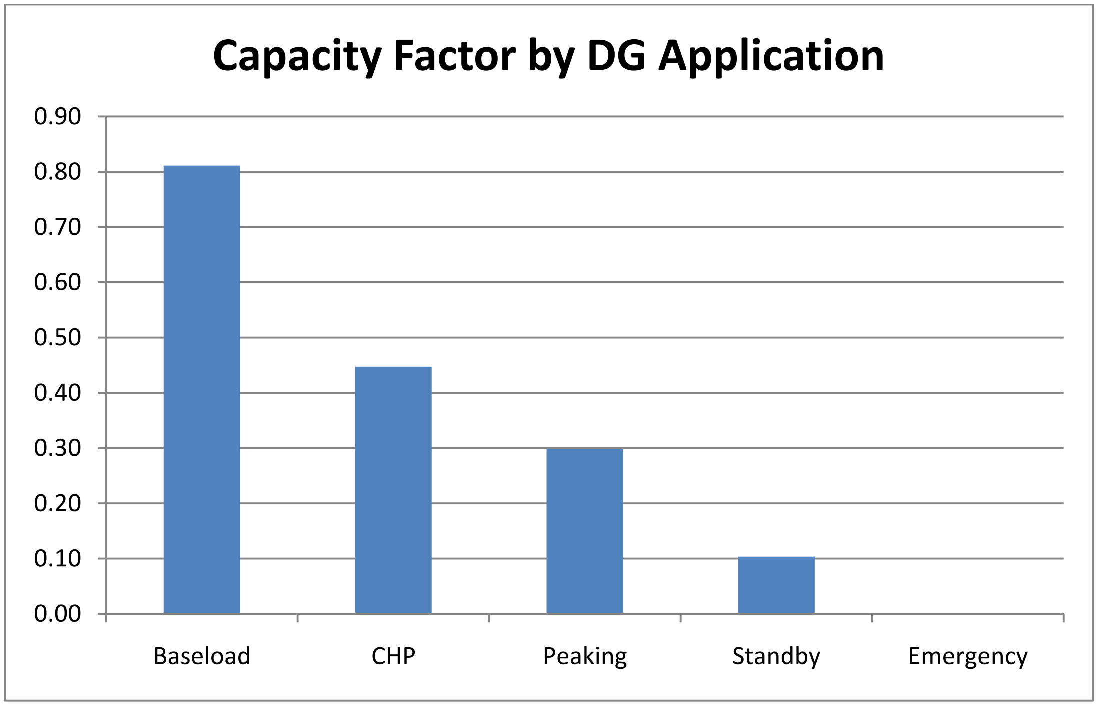


Figure 9: Capacity Factor by DG Application

Figure 9 shows there is significant potential for increasing the capacity factors of emergency and standby DG units or BUGS by changing the applications. The low asset utilization of standby and emergency applications coupled with the significant capacity they represent (170 GW) suggests that they could potentially serve larger loads, certainly at peak, displacing the otherwise necessary capacity additions. This 170 GW of BUGS capacity represents about 22 percent of the peak and 36 percent of the average load; it could be available to address the peak without adding generating capacity in the nation. This could be a significant benefit to consumers and utilities. The key to increasing the capacity factor of BUGS is the interconnection to the grid and thus serving larger loads.

A Smart Grid Creates New Opportunities

The growing smart grid will enable alternative ways of managing the electric power system. Instead of building more generation a hundred miles away, utilities can tap into seldom-used BUGS to provide distributed support for a locally-strained grid. With smarter protection and control systems, sensors, and components, consumers and utilities can enable BUGS to do more than just provide emergency power: they can become a dispatchable utility resource. By properly connecting BUGS to the new smart grid, BUGS can save consumers from periods of high power cost and peak power charges, improve reliability, and provide valuable ancillary services for utilities and grid operators.

BREAKING THE PARADIGM: UP-CONVERTING BUGS TO INTEGRATED DG RESOURCES

Within the DG universe, the critical point of leverage is clearly BUGS composed of DG units in emergency and standby applications. DG units applied to BUG applications make up 99.7 percent of all DG units in the United States. At the same time, backup generation has the lowest capacity factor of any DG application, 0.2 percent. This means that more than 170 GW of capacity (already paid for) could be made available to address peak loads at or near the load. Consider the lessons from the Portland General Electric (PGE) Dispatchable Standby Generation Program (discussed in the Economics section of this report), which yielded improvements in economics and responsiveness. However, emergency backup units cannot always be readily shifted to other applications. Many emergency backup units are connected only to emergency circuits, such as emergency lighting, not to the main electrical circuit of a building. Circuit modifications and power electronics would be required to take advantage of these resources.

In order to achieve a higher level of asset utilization, BUGS must be tied into more active loads. This would allow BUGS to serve these loads during prolonged emergencies and during peak load hours. Doing so could help the owner of the backup generator recoup costs more quickly by avoiding high power costs during peak hours and by reducing peak power charges.

Greater Use through Greater Responsibility and Intelligence

While adding a grid interconnection and pairing generation to local load are necessary steps to tapping BUGS in a more useful way, they are not sufficient for achieving the larger paradigm shift away from overbuilding capacity for peaks. A shift in thinking is required, plus integrating embedded intelligence at each load center. Consider the difference between these three operating paradigms for meeting an imaginary Load A:

Old Operating Paradigm (BUGS)

- During normal operation, Load A is supplied by the grid.
- The grid controls the cost of energy for Load A and is primarily responsible for supplying it with power.
- During extreme grid events or emergencies, Load A uses its backup generator to remain partially operational.
- The DG operates “whenever the grid cannot.”

Integrated Operating Paradigm (Baseload and CHP)

- During normal operation, Load A is supplied in large part by its DG resources, which are sized to closely match its load characteristics.
- Load A’s DG resources control the cost of energy and are primarily responsible for supplying it with power.
- Load A uses the grid to supplement its DG resources, especially during emergency—or extreme—events.
- The DG operates “whenever it can.”

New Operating Paradigm (Microgrid):

- During normal and abnormal operation, Load A’s microgrid-controller is responsible for determining the optimal (in terms of cost and reliability) mix of its power suppliers.

- Load A's microgrid-controller exerts intelligent control of its cost of energy and is primarily responsible for finding an appropriate energy supply for it.
- The DG operates "whenever it is economically or technically appropriate to do so based on current conditions."

The old operating paradigm gives the grid primary responsibility for managing the load. This relegates the BUGS to the role of a contingency for the larger grid, acting only when the grid fails. This is inefficient and leads to overbuilding, as each side must build to meet the extremes of the other side. That is, the grid gets no help from BUGS when it is needed the most (during peak load), and the BUGS get no help from the grid when help is needed the most (during a blackout).

At the other end of the spectrum, certain situations lend themselves to closely integrating DG with load, for example with CHP or base load applications. These situations result in higher asset utilization for the DG, and generally higher in efficiency, but depend entirely on a good load-generation pairing. However, these cases are limited and not common in the United States, where distances between generation and load tend to be long. In addition, this kind of pairing cannot always be accomplished at a cost lower than grid-supplied power.

The ability to embed decision-intelligent devices on the customer side through smart grid technology has led to a third option. This third option allows greater control at the customer side by optimizing among whatever energy resources are available. This can include a variety of DG resources, energy storage, and the grid. Additional upfront cost is required in order to create the microgrid controller and enable various operating modes. However, on an ongoing basis this option will do a better job of meeting customer needs in terms of economics, reliability, and other objectives.

In general, the more autonomous and intelligent a DG system, the more it can understand conditions such as grid strain and respond in a way that optimizes customer objectives and helps the system as a whole. In addition, more autonomous and intelligent DG systems will have asset utilization levels that are more economical and efficient. Achieving these goals can be accomplished in part by up-converting BUGS into higher value DG applications than they have now. By converting BUGS around the country into more intelligent and autonomous DG applications, the United States can meet the peak more efficiently and economically than is possible today.

POTENTIAL USES FOR INTEGRATED BUGS

The current utility paradigm views most of the nationwide BUGS as independent, or outside the scope of the electric power system. According to the EIA, about 75 percent of commercial businesses have backup generators, of an average size of 18 kW (U.S. Department of Energy, 2008). This resource is perfectly distributed and matched with appropriate loads, but utilities have held these resources at arm's length until recently. Utilities can operate the electric power system more effectively by bringing these resources into the system and by using them in a coordinated, intelligent way.

DG, especially BUGS, incorporated intelligently within a smart grid, can provide a number of benefits to the utility:

- **Improved capacity, especially during peak hours** —By interconnecting greater amounts of BUGS, and adding standby power or peaking power roles to their emergency backup power resources, utilities will have greater system capacity and flexibility.
- **Increased system efficiency through greater supply-side price elasticity**— By incorporating a larger number of power supply options, such as multiple-fuel DG and CHP, the generation fleet as a whole will have a wider set of options for responding to price changes. This will result in greater demand-side responsiveness to price signals and a more efficient electricity market. This can result in a lower overall cost of operating the system.

- **Enhanced network security and resilience to disruptions**—Because BUG systems are geographically distributed, use a variety of fuels, and have a variety of operating principles, they are more resilient to disruptions such as price spikes, supply shortages, natural disasters, and sabotage attempts. Having a diverse fleet of generators reduces the systemic risk in the electric power system.
- **Deferral of major capital investments**—Through the use of BUGS and energy storage, utilities can defer major capital investments by temporarily increasing capacity in critical areas as needed. A number of utilities have used this approach to delay major replacements at substations and in the transmission system. This deferral of major capital investments keeps downward pressure on prices charged to consumers.
- **Higher power quality and reliability**—By making use of generation located closer to the load, utilities have a finer set of tools for providing better power quality and reliability for customers when these are used in conjunction with a smart grid.

DEALING WITH BARRIERS TO GREATER UTILIZATION OF BUGS

A number of steps need to be taken to deal with barriers to interconnecting greater numbers of BUGS to the grid. Many of these are regulatory barriers, but others are financial, programmatic, or technical. For example, utilities can take a number of measures to ensure system reliability and safety when connecting to higher levels of BUG power (Zheng, 2008), such as the following:

- **Maintaining adequate voltage regulation** through the use of voltage regulators is an important first step. Voltage support must be sufficient to maintain adequate voltage with DG disconnected. A recent paper from the Institute of Electrical and Electronic Engineers (IEEE) estimates that adding a fast responding voltage regulator to a feeder can increase the acceptable backup generator contribution from 5 percent to 10 percent of feeder capacity (Dugan, 2001).
- **Installing appropriately rated fuses and reclosers** to detect faults will prevent unnecessary fuse burnouts. Fuses and reclosers must be rated correctly and coordinated in order to resolve issues that could arise from the addition of DG units.
- **Limiting and filtering harmonics** introduced by backup generation units are important for maintaining power quality. Grid-connected DG units can introduce harmonics into the system, potentially increasing harmonic distortion above acceptable levels. As more backup generation is connected using power electronics, this problem will continue to affect the power quality of loads on the line. Efforts must be taken by utilities and/or customers to ensure that these harmonics do not exceed acceptable levels (Dugan, 2001).
- **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. Likewise, under intentional islanding schemes, indications and safety procedures must be incorporated to protect workers and the public. Revisions to protective relay schemes are also required to safely accommodate two-way power flow on the distribution network that can come from using BUGS to address peak loads.
- **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. Due to its inherent complexity, modern (21stcentury) visualization and decision-support software will be required to increase transparency and improve coordination throughout the grid.
- **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 DG will require significant investments in energy storage to help manage transients

and carry the load while the DG is being ramped up. In addition, energy storage provides an important buffer against unreliable response rates from privately-owned DG equipment.

- **Enabling two-way power flow** is a critical pre-requisite to higher utilization of BUGS, since this allows BUGS to serve loads larger than the locally connected load. This involves a number of steps at the utility side but can now be accomplished more easily, thanks to smart grid technology.

To overcome these barriers, policymakers can take a number of measures to align the interests of owners of BUGS with those of utilities:

- **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. Providing incentives or prizes for the further refinement of these technologies may result in even more innovations.
- **Encourage DG owners to pursue applications with higher asset utilization**—Historically, the asset utilization of base load and CHP applications has been higher than those of peaking, standby, and emergency backup applications. Some states have already begun providing incentives to pursue more integrated DG applications, such as CHP. Creating these incentives and removing barriers to interconnection will result in the necessary shift from BUGS to higher value DG applications.
- **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 that are converted to interconnected DG applications and decrease the burden on government agencies as well.

ECONOMICS

A few years ago, Portland General Electric (PGE) initiated a program to take advantage of the installed DG base in Portland, Oregon, to offset peaking power purchases from outside their territory. This program includes DG from 100 kW to a few MW in size with a total dispatchable capacity of more than 50 MW, which is about 7 percent of PGE's peak load. PGE gives a good business model, with a cost to integrate the technology and install emissions controls at roughly $175 per kW and an operating cost of about $0.17 per kWh for peak load offset. This capital conversion cost is significantly below the cost per kW for a simple cycle gas turbine and its associated transmission infrastructure and losses. From an operating perspective, while $0.17 per kWh is expensive, it is less than the wholesale peak price (primarily supplied by natural gas turbine units), which is often $0.25 per kWh to $0.50 per kWh, depending on the region.

While the industry needs more examples of such programs in operation to prove the economic case, the few existing programs (PGE, and PowerSecure of North Carolina) do bear out the economic savings.

With more such programs deployed across the nation, the industry could learn about regional differences, tune the economics, develop additional business models, and increase the emissions benefits.

ENVIRONMENTAL METRICS

Environmental questions arise with the use of diesel engines that comprise the majority of BUGS. This may appear to be a major issue at first glance; however, it becomes less of a concern when considering the actual annual energy delivered in a real peaking application. 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.

PowerSecure's Interactive DG system claims a 50 percent reduction in carbon emissions through optimized run-times and offsetting utility-spinning reserves. The PGE program shows that emissions controls on the diesel greatly reduces emissions and still operates at a lower cost than a traditional peaker.

The Science Applications International Corporation (SAIC) Pollution Reduction Estimator (v1.0) shows that a national program to engage half of the BUGS for peak reduction during 200 hours a year roughly yields (compared to natural gas peaking units):

- More than 935,000 tons a year reduction in CO_2 emissions.
- More than 54,000 tons a year reduction in NO_X emissions.
- More than 33,000 tons a year reduction in SO_X emissions.

Again, more such programs operating across the nation will help the industry learn about environmental pros and cons of using BUGS to address peak loads.

CONCLUSIONS

BUGS could become an important and cost-effective addition to the demand response and distributed energy resource strategy at a national and state level. A flatter load profile, achieved through an efficient use of BUGSs, will enable a more efficient (economically and environmentally) use of the entire generation fleet.

Greater utilization of the U.S. BUGS fleet to address needs in the electric system through up-converting them to more autonomous and intelligent DG applications has the potential to offer significant advantages for the nation:

1) A more efficient and economical way to address the peak.
2) A more emission-friendly approach.
3) Enabled by the Smart Grid, the existing installed generation base that can offset new generation, transmission, and distribution construction.

Taking full advantage of this underutilized resource will require a smart grid-enabled distribution network.

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