Environmental Benefits of Distributed Generation

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Summary

Distributed generation (DG) has been identified by some as a new paradigm in power generation, providing new solutions to changing customer needs for electricity. A huge potential market is forecast for a variety of DG technologies in different end use markets. One of the claimed advantages of DG is superior environmental performance. That claim has recently been challenged by some analysts and the rapid projected growth of DG has raised concerns among some environmental regulators.

There is no question that most new DG technologies have emissions characteristics significantly superior to the existing electric generation system. However, some analysts and some regulatory proposals have compared DG only to the newest, cleanest central station generators, thereby projecting a negative impact for increased use of DG.

In the context of a competitive electric market, this is an incorrect approach that leads to erroneous results and counterproductive public policies. This article explores the environmental impact of DG and the appropriate ways in which it should be evaluated. It concludes that DG should more correctly be compared to average environmental performance of the existing fossil generation mix. The analysis shows that current DG technologies have significant environmental value in many applications and should be strongly encouraged. It also discusses appropriate approaches for regulating DG.

Background

The exact definition of distributed generation varies somewhat between sources, however it is generally agreed to mean electric generation that takes place at or near the point of use rather than at a central station power plant. Although this could include larger on-site generating facilities, the major focus of interest is systems of 20 to 30 MW or less. Some but not all of these include the use of combined heat and power (CHP) designs. The new interest in DG has been driven largely by technologies, customer needs and structural change.

- New small-scale, efficient power generation technologies are promising to provide generating performance that previously was available only from large central station plants.
- Changes in electric customer needs for power reliability are creating an increased value for high quality power.
- Electric utility restructuring is creating new opportunities for self-generation as well as concerns over the future cost and/or reliability of the central power generating system.

The definition of DG includes the on-site diesel emergency generators that have been in place for many years. One manifestation of DG is to create an opportunity to use these generators in new and expanded ways. Since these are very high emitters, this aspect of DG has created a concern for environmental regulators that dominates much of the discussion of DG. From the perspective of the "DG industry" however, the primary R&D and business focus involves the application of new and advanced natural gas-based generating technologies with much lower emissions. One of the challenges in this discussion is to separate the potential value of new technology from the concerns over increased use of old, high emitting equipment. In order to address all of these issues, it is useful to begin with an overview of DG applications and technologies.

Applications of DG

Compared to large utility base load generating technologies, distributed generation technologies have higher capital costs, higher operating costs, or both. Thus there are relatively few applications or markets today in which DG is economically competitive on a pure base load energy basis[1]. Instead, DG applications tend to fill some special requirement that justifies the additional cost. Most DG applications fit one of three categories:

Emergency Generation - This application has been around for many years and predates the broader concept of "distributed generation." There have always been some facilities and some loads at some facilities that could not tolerate any interruption in electric service. Medical facilities with critical life support equipment are one example. With the increasing importance of computers in U.S. industry and commerce, intolerance for even short interruptions has become more common. In these applications, an automatic system monitors electric supply and automatically starts a back-up generator in case of a failure. Automatic switches connect the back-up generator to the critical loads.

Reciprocating engines are the only generating technology that can provide the immediate start-up required for these applications. Also, some life safety rules require the use of fuel stored onsite, rather than natural gas, which could be subject to interruption during an emergency. Diesel engines have historically been the lowest cost, fastest starting and most common option. Although they have very high NO_x emissions, the actual hours of operation due to grid interruption in any year are very low. The regulatory solution to limiting emissions has been to limit the hours of operation to 100 to 500 hours per year, including periodic testing.

It is worth noting that the timing of emergency operation hours is generally not correlated to the time of major air quality concern (ozone exceedances). Grid interruptions tend to be during periods of bad weather (thunderstorm or ice storm) which are not high ozone times, or related to mechanical interruptions (construction or traffic accident) that are not correlated to air quality issues.

Historically, emergency generators have operated significantly less than their permitted hours. One of the major regulatory concerns with DG today is the potential or the reality for emergency generators to evolve into the next category of DG.

Peaking/Load Shaving - This application is the use of on-site generation on a periodic basis during periods of high electric system demand to:

- Reduce peak electric costs to the end user.
- Avoid electric reliability/power quality problems with grid power.

[1] Combined heat and power (CHP) applications and other applications using byproduct fuel are primary exceptions, as discussed below.

- Generate peak electricity to sell back to the grid.

One slightly different application is the use of utility-owned DG systems to provide peak electricity near load centers in areas where transmission and distribution facilities are constrained.

The use of on-site generators, especially emergency back-up generators, to provide peaking power has also been common for many years. Its use was limited however due to electricity rate structures that limited the economic value or actively discouraged it. The potential for onsite peak/load shaving has increased for a variety of reasons related to electric industry restructuring:

- More transparent rate structures may provide a stronger economic incentive for electric customers to reduce peak loads.
- Increasingly sensitive electric loads and increasing reliability/power quality problems with central power supply have created a demand for on-site generation. Many of the power quality/interruption problems are related to inadequate peak generation capability or transmission and distribution constraints on the central grid. The economic value of electric supply disruption is large for an increasing number of customers who can therefore increasingly afford on-site generation.
- In some cases, the grid is actively looking to on-site generators as a source of peak generating capacity. In some cases, the ISO will pay very high market rates to on-site generators for peak power. This can be a strong driver for installation of peak/load shaving generation.

The duration of peak/load shaving operation varies regionally but is likely to be higher than emergency back-up use – several hundred to possibly thousands of hours. In many places, some of the peak/load shaving operation will be correlated with ozone problem days. Many demand peaks are correlated with hot summer days that are ozone problem days. Peak/load shaving related to winter demand peaks (common in many areas) will of course not contribute to ozone exceedances except in a few southern areas.

The use of high-emitting diesel engines to provide peak/load shaving service is probably the biggest concern for environmental regulators. The requirements for peak/load shaving, however, are different than the requirements for emergency generation and additional technology options exist. Peak/load shaving systems do not necessarily require instant start-up and are therefore open to a wider range of technology options, including lower emitting options. Also, if on-site generators are receiving significant payments for peak generation, it may be cost-effective to apply pollution control equipment to high emitting generators. That said, peak/load shaving is still a fairly low capacity factor application.

Base Load Operation – In some cases, electricity users may install on-site generation facilities that operate essentially year-round. Remote locations with no access to central generation are one niche market for these systems. Locations with “free” byproduct fuel are another example in which base load generation may be economic. In many cases, these locations may apply combined heat and power (CHP). In CHP, the input energy is used sequentially to generate both electricity and thermal energy. This increases the total efficiency of the system and reduces the energy cost and emissions relative to conventional systems. Finally, some facilities with highly critical electric loads may find that on-site base load generation is economically justified to provide the required power quality and reliability.

For base load applications, the full range of DG technologies can be considered and the most efficient and lowest emitting technologies are often the best choices for end users.

Emissions of DG Technologies

The DG market is being driven in part by the current and imminent availability of more efficient, more cost-effective on-site generation technologies. It also continues to make use of technologies that have been available for many years but are now economic in new applications. The characteristics of these technologies affect their suitability for different DG applications.

The emissions characteristics of DG technologies are a critical aspect of an environmental assessment. For a variety of reasons, the data used in assessing the emissions impact of DG have generally been of poor quality. For this paper, a significant effort was made to assemble a consistent, well-documented set of emissions profiles. Appendix A discusses the sources and methodology used. The pollutants profiled include NO_x, SO_x, particulates and CO_2.

Table 1 and Figure 1 summarize the results. The emissions are compared on the basis of lb/MWh. This output-based format provides a consistent basis for comparison of the actual pollution produced to provide the desired product. This format also explicitly recognizes that higher efficiency reduces the amount of pollution produced per MWh. Figure 2 compares the electric generation efficiency of the various technologies.

A variety of DG technologies is shown. The technologies themselves are discussed in Appendix B. Emissions from a large gas combined cycle and large simple cycle gas turbine, actual average emissions from central generation by coal plants, all fossil plants and all central plants (including nuclear and hydro) are also shown for comparison. The central plant emissions are not adjusted to account for line losses. The avoidance of line losses is one advantage of DG. To be directly comparable, the central plant emissions should be adjusted upward by the line loss factor, which can range from 8 to 20 percent.

Potential SO_2 and CO_2 emissions are purely a function of fuel characteristics. Gas has a negligible amount of sulfur and SO_2 emissions are therefore negligible for any gas technology - less than 0.01 lb/MWh compared to 12 lb/MWh for central station fossil plants and 8 lb/MWh for all central plants. The sulfur content of diesel fuel varies. Highway diesel has very low sulfur and that level is expected to be further reduced in the near future. At current sulfur levels for highway diesel, SO_2 emissions are about 0.5 lb/MWh - still much lower than central station generation. Some diesel engines may use higher sulfur fuel but SO_2 emissions from diesel engines can be kept low through appropriate choice of fuel.

CO_2 emissions are not currently regulated in the U.S. but the U.S. is a party to the Rio Treaty limiting CO_2 emissions and is participating in international negotiations on further limits. All fossil fuels contain carbon and create CO_2 as they are burned. Oil has lower carbon per Btu than

Table 1
Emissions Comparison

		Solid Oxide Fuel Cell	Phosphoric Acid Fuel Cell	Uncontrolled Gas-Fired Lean Burn IC Engine	3-way Catalyst Gas-Fired Rich Burn IC Engine	Uncontrolled Diesel Engine	SCR Controlled Diesel Engine	Micro Turbine	Small Gas Turbine	Large Gas Combined Cycle	Large Gas Turbines	ATS Simple Cycle Gas Turbine	1998 Average Coal Boiler	1998 Average Fossil	1998 Average PowerGen
Efficiency	%	46%	41%	36%	36%	35%	35%	27%	30%	51%	34%	35%	33%	33%	47%
	Btu/kWh	7,420	8,324	9,402	9,402	9,646	9,646	12,641	11,374	6,637	10,165	9,870	10,322	10,382	7,197
NO_x	gm/hp-hr			0.70	0.20	4.28	2.00								
	ppm@15%O2	0.2	1.0	61	17	362	169	9.0	25	2.5	15.0	9.0			
	lb/MMBtu	0.0007	0.0036	0.22	0.06	1.31	0.61	0.03	0.09	0.01	0.05	0.03			
SO_2	gm/hp-hr														
	ppm@15%O2														
	lb/MMBtu	0.0006	0.0006	0.0006	0.0006	0.051	0.051	0.0006	0.0006	0.0006	0.0006	0.0006			
PM-10	gm/hp-hr			0.01	0.01	0.25	0.25								
	ppm@15%O2	0	0	1	1	21									
	lb/MMBtu	0	0	0.0	0.00	0.08	0.08	0.0066	0.0066	0.0066	0.0066	0.0066			
CO_2	gm/hp-hr														
	ppm@15%O2														
	lb/MMBtu	117	117	117	117	159	159	117	117	117	117	117			
NO_x	lb/MWh	0.01	0.03	2.07	0.59	12.65	5.91	0.41	1.03	0.06	0.55	0.32	5.60	5.06	3.43
SO_2	lb/MWh	0.004	0.005	0.006	0.006	0.49	0.49	0.008	0.007	0.004	0.006	0.006	13.4	11.6	7.9
PM-10	lb/MWh	-	-	0.03	0.03	0.74	0.74	0.08	0.08	0.04	0.07	0.07	0.30	0.27	0.19
CO_2	lb/MWh	867	973	1,099	1,099	1,537	1,537	1,477	1,329	776	1,188	1,154	2,115	2,031	1,408

Figure 1 - Emissions Comparison

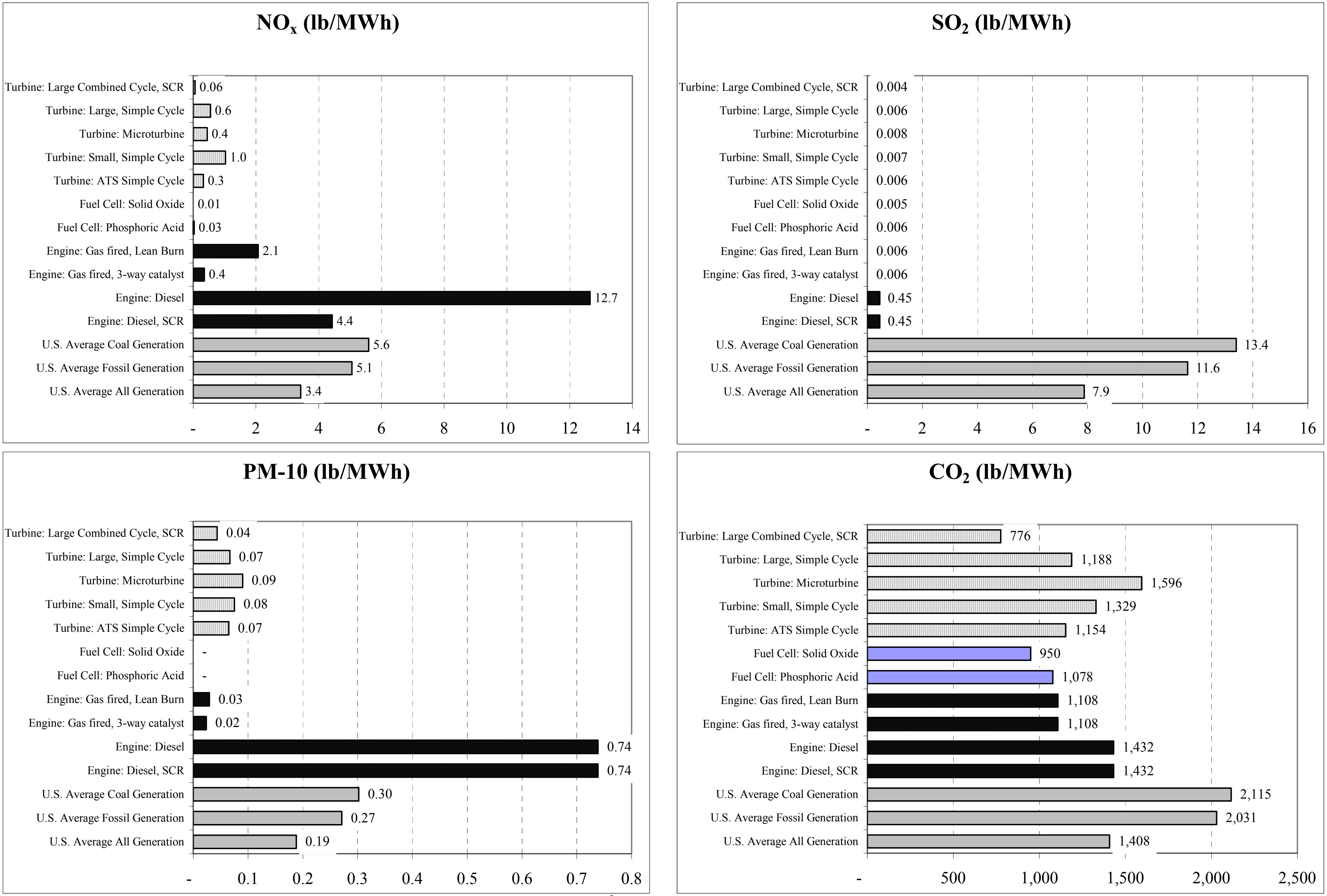
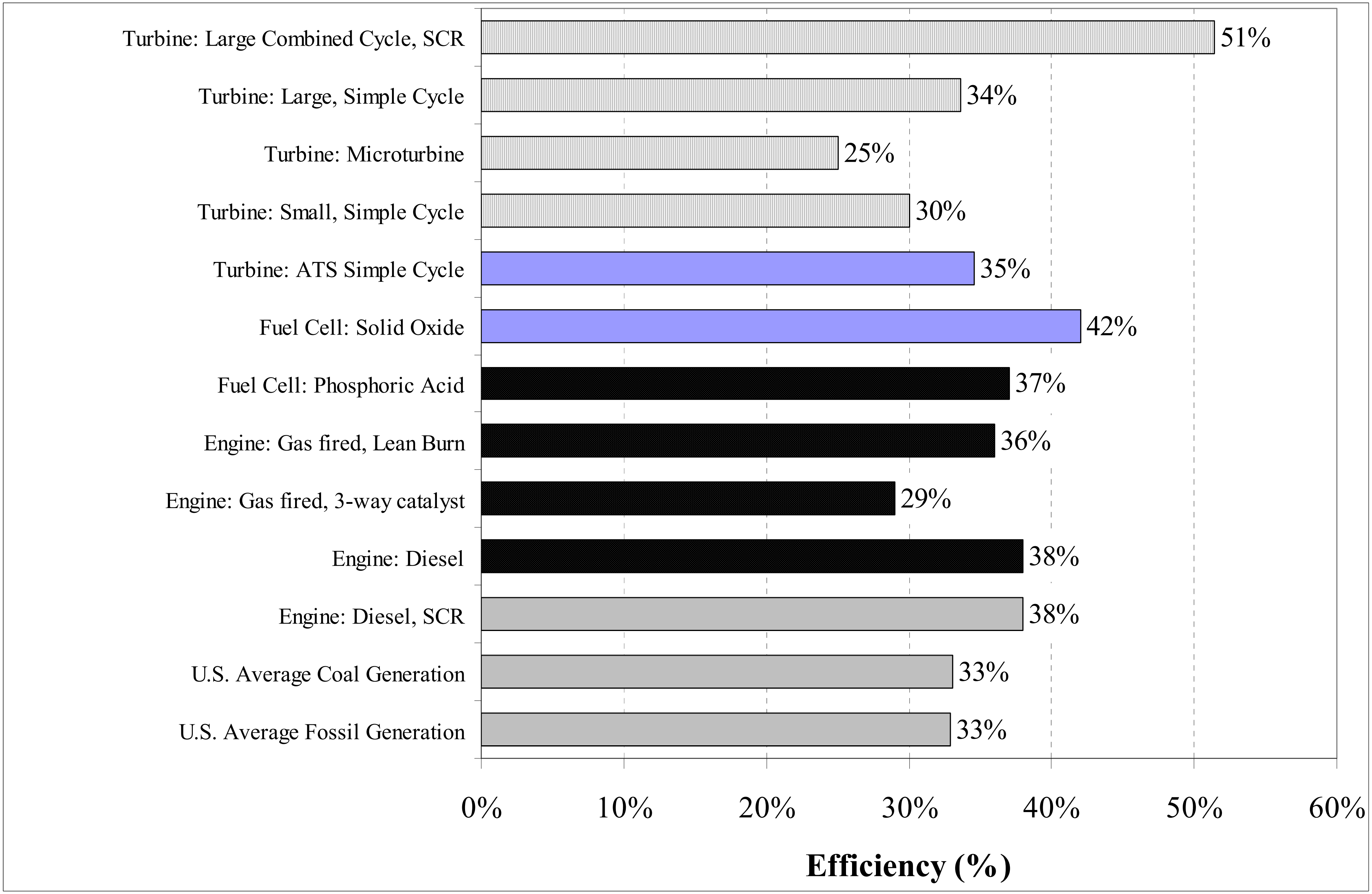


Figure 2
Efficiency Comparison



coal and gas has less still. Beyond the choice of fuel, efficiency is the only determinant of CO_2 emissions. CO_2 emissions from gas technologies range from about 800 lb/MWh to 1500 lb/MWh depending on system efficiency. CO_2 emissions from diesel engines are typically around 1500 lb/MWh. CO_2 emissions from central station fossil plants average around 2000 lb/MWh. Adding nuclear and hydro generation drops the central station average to about 1400 lb/MWh.

NO_x emissions have been among the primary concerns for DG. NO_x emissons are determined by combustion characteristics as well as fuel content. Combustion characteristics are the primary determinant of NO_x emissions from gas technologies. Unlike the other profiles, the information in Table 1 and Figure 1 includes information for add-on control technologies. The emission factor for large combined cycle includes the use of selective catalytic reduction to achieve NO_x emissions of 3 ppm, the lowest emission rate for any available conventional technology. This low emission rate combined with the high efficiency of the combined cycle system results in an output-based emission factor of 0.06 lb/MWh that cannot be matched by any other conventional electric generation technology. The NO_x emission rates for other gas turbine options ranges from 0.3 to 1.0 lb/MWh. That said, the NO_x emission rate for small turbines may soon be dropping to the 0.6 lb/MWh range. Also the Advanced Turbine System (ATS) is still in development and may be able to achieve NO_x levels below 0.3 lb/MWh.

Lean burn gas reciprocating engines have NO_x emissions around 2.1 lb/MWh. Rich burn gas engines with a 3-way catalyst system (similar to the system used on automobile engines) have emissions around 0.45 lb/MWh. The issue with diesel engines is clear from the 12 lb/MWh emission rate for new diesel engines. NO_x emissions from older engines can be significantly higher. Application of SCR to diesel engines has been shown to achieve a 50 percent reduction. Further reductions may be possible. NO_x emissions from fuel cells are very low.

In comparison to this performance, current NO_x emissions from central station fossil generation are around 5 lb/MWh. NO_x emissions for total generation are around 3.5 lb/MWh. New NO_x control requirements are under development that will limit fossil-fired generation in the Northeast U.S. to a NO_x level of around 1.5 lb/MWh.

In summary, all gas-fired technologies have NO_x emissions that are lower than those of central station fossil units. The use of add-on control and the high efficiency of the combined cycle plant make its NO_x emissions significantly lower than those of other conventional gas technologies. The NO_x emissions of the large simple cycle peaking turbine, which does not typically use add-on controls and is not as efficient, are more comparable to those of the DG technologies. For the other pollutants, the DG technologies are significantly cleaner than the central station units. The combined cycle is somewhat cleaner due to its higher efficiency.

Emissions Impacts of DG

Although it is relatively simple to characterize the emissions from an individual DG or central station unit, the fundamental issue in calculating the real emissions impact of DG is what emissions are displaced by the application of DG. For example, if DG displaces coal-fired generation then the environmental outcome could be very positive. If it displaces only gas combined cycle generation then the outcome could be negative.

Many analysts and now some regulators have based their assessment and policies on the assumption that DG will displace only gas combined cycle units. This is an incorrect assumption that results in erroneous conclusions and flawed public policy. There are a number of reasons that this assumption is incorrect.

The simplest reasoning that would lead one to conclude that DG competes directly with gas combined cycle plants is the thought there is a certain amount growth in electric demand and it will be met either by DG or gas combined cycles. If there is more of one than there will be less of the other. This assumption is based in part on the fact that almost all new central station plants currently under development are gas-fired.

The first fallacy is that the current construction profile will continue. There is no guarantee that gas plants will continue to dominate new plant construction and some evidence to think otherwise. Due to a variety of market factors, including higher gas prices, we are already starting to see proposals for new coal plants. The long-term outcome is anyone's guess, but the continued preference for gas plants is not certain.

Beyond the specific mix, however, it is incorrect to assume that there is a direct tradeoff in the construction of DG and large combined cycle plants. There is no central planning authority governing the construction of new plants. Entrepreneurs are building plants wherever they believe there is an opportunity for profit, based on different interpretations of market conditions. In addition, the entities building DG facilities are mostly different from the entities building central station plants. Each will build whatever seems profitable.

Given the stage of development of the competitive power industry, there seems to be little basis to assume that either one is paying attention to the other's actions or is able to respond analytically with respect to the need for new capacity. In the long run, the development of new capacity will respond to the total capacity constructed, but the extent and efficiency of that process in the competitive market are anything but clear. In the near term, perhaps five to ten years, the construction of DG and central generation resources will be largely decoupled.

Beyond the disorder of the market, much of the DG and large combined cycle construction will not directly compete because they serve different markets. As discussed above, two of the three primary markets for DG are emergency generation and peak/load shaving. Large gas combined cycles do not and will not serve these markets. These markets are the parts of the dispatch mix that are not served by base load plants of any kind due to the economics and limitations of the central utility framework. In fact, it is precisely the inability of the central grid to meet these on-site needs that creates the opportunity for DG.

Thus, we cannot simply assume a direct tradeoff between the construction of DG and gas combined cycle units and we can be certain that there is little or no such tradeoff for two of the primary DG markets. What we will see instead is a mix of DG, new gas and new coal base load units, new central station peaking units, and the existing generating plants which will continue to represent the largest portion of generation well into the future.

The critical and most difficult question is:

How will new DG fit into the future mix of new and existing power generators and what will be the emissions impact?

To properly answer this question, one should use an electricity capacity dispatch model to see how DG operates in the dispatch mix for a given region and what generation/emissions are displaced. In one recent study of this type done by the Center for Clean Air Policy[2], the results show clearly that the on-site generation displaces a mix of other generators depending on the location and operating characteristics of the DG project. It does not displace only one technology such as gas combined cycle. Because DG displaces a mix of new and existing generators with higher average emissions, the environmental outcome for DG is always positive.

While this type of complete analysis is quite complex, we can get many of the same insights, an intuitive understanding of the issues and some useful rules of thumb through a simplified graphical approach to the analysis.

Load Curve Analysis

One of the most important determinants of electricity industry infrastructure is the fact that electricity cannot be stored and must be generated when it is needed. Demand for electricity varies widely over the year and different kinds of generating equipment are used to meet the varying load as it occurs. A common way of looking at this is with a load duration curve. The load duration curve shows the electric demand in MW for a region for each of the 8760 hours in the year. The hourly values are sorted from highest to lowest.

Figure 3 shows the load duration curve for the ECAR regional (central midwest U.S.) for a recent year. The shape of the curve is typical of electric load duration curves. The vertical axis shows demand in MW and the horizontal axis shows the hours of the year. The chart shows that the highest hourly electric demand was 93,500 MW, probably on a hot summer day. The demand for the next highest hour was about 93,000 MW, possibly on a different day. The minimum demand was 23,300 MW, perhaps in the middle of a temperate spring night. Every hour of the year had at least this much demand. The next highest hour had a demand of 35,000 MW. The demand was at least this much for all except one hour of the year.

The area under the curve is the total generation, about 524 million MWh. The total generation for the 23,300 MW base demand that exists every hour of the year is 40 percent of the total generation. The minimum demand for all but the last of hour of the year is 35,000 MW and the generation at the level for all but one hour of the year comprises 60 percent of the total generation. The units that operate for 5600 hours per year account for 90 percent of the total

[2] "Clean Power, Clean Air and Brownfield Redevelopment", Catherine Morris, Center for Clean Air Policy.

Figure 3

Load Duration Curve

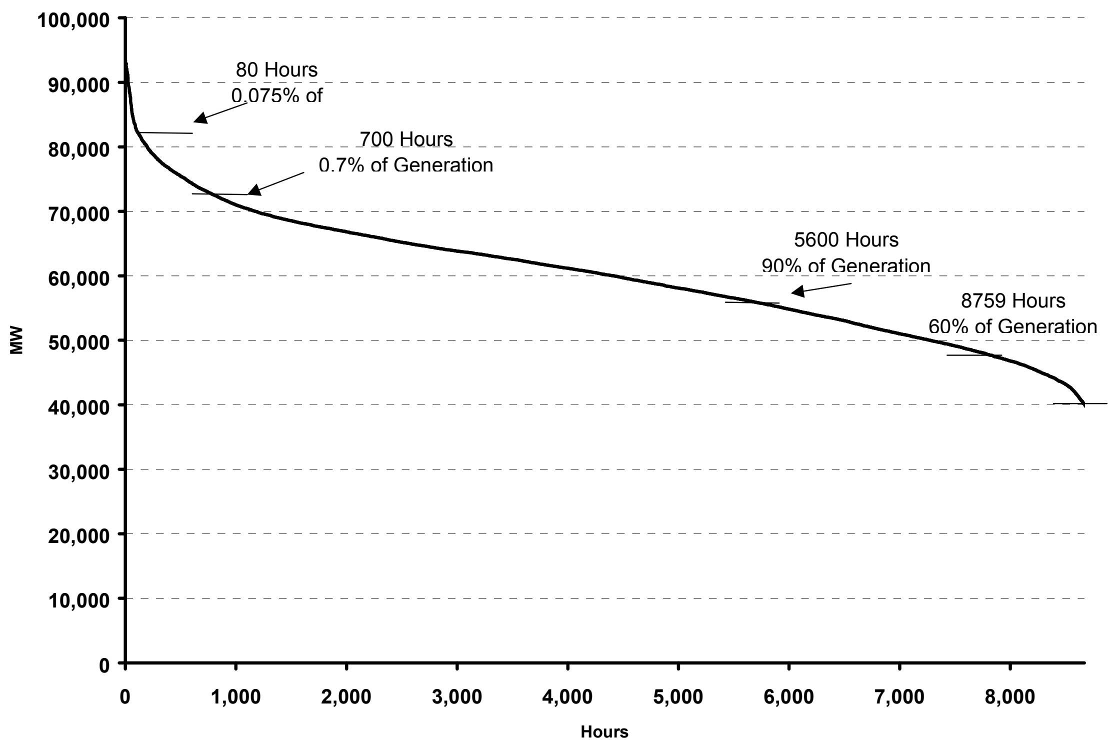
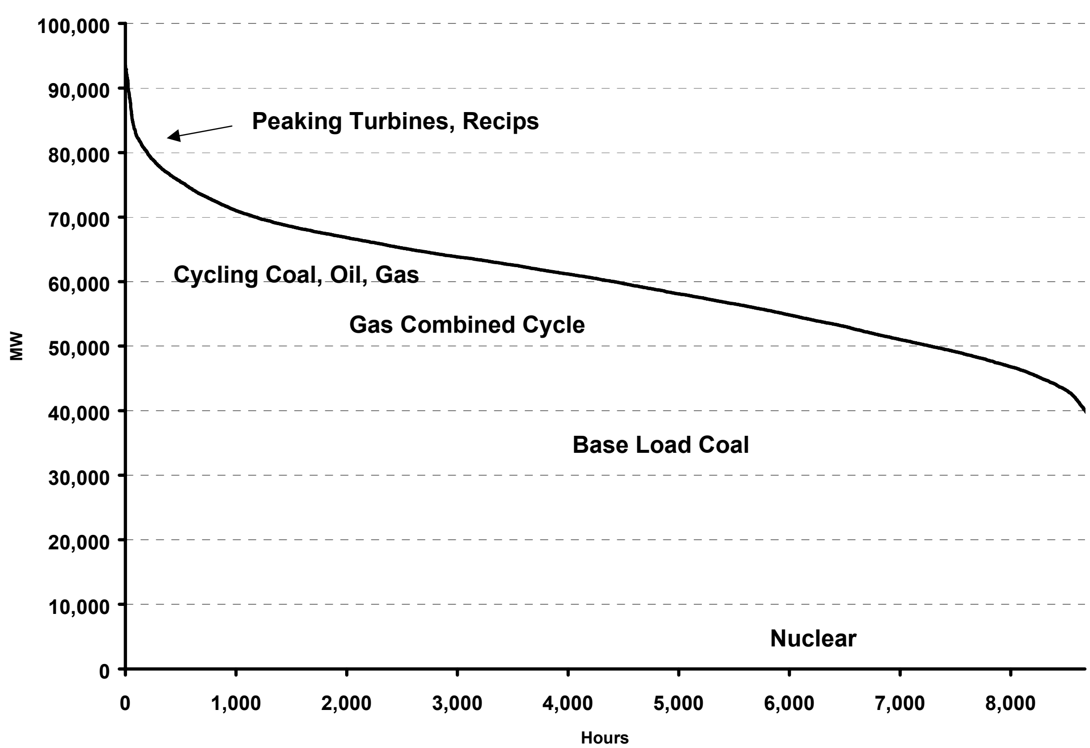


Figure 4
Basic Dispatch Mix



generation. In contrast, the peak 10,000 MW of capacity operates for 80 hours or less per year and accounts for only 0.075 percent of generation. The peak 20,000 MW operates less than 700 hours per year and accounts for only 0.7 percent of generation.

This varying electric load is met with a large number of different types and sizes of generating units. Figure 4 shows a typical generating mix. In a competitive electric market, the units are dispatched based on their variable cost – the cost of fuel, consumable items, and operation and maintenance costs directly related to production. The base load units need to run many hours per year as possible. They need to have low variable costs, which means some combination of low fuel cost and high efficiency. Because they will have high utilization, they can support a higher capital investment in efficiency. In the midwest, the base load is primarily met by large nuclear and coal power plants.

The peaking units may run only tens to hundreds of hours, so a high capital cost is hard to support. On the other hand, high efficiency is not critical, since these plants only run when there is no other source of capacity and electricity prices are very high. Simple cycle gas turbines are the classic peaking generator, though reciprocating engines and standby oil and gas steam plants are used for peaking in some parts of the country.

Between the very peak and the very base load, a variety of generating assets is used to meet demand. In most regions these are cycling coal, oil and gas steam units. Large hydro generators can also fit in this regime. Developers of gas combined cycle plants would like them to run 5000 hours or more, in the base load to low intermediate load ranges. Depending on the cost of gas and other factors, they may run in the middle intermediate range.

The emissions from power generation are the MWh of operation of each part of the mix times the emission rate in lb/MWh. We could multiply each unit of generation under the load curve times the associated emission factor and derive an emissions curve that would look very similar. The nuclear component would drop out. The coal component would be accentuated due to higher emission rates. It is noteworthy that even at the peak hours, the majority of the emissions are from the base load units at the bottom of the stack.

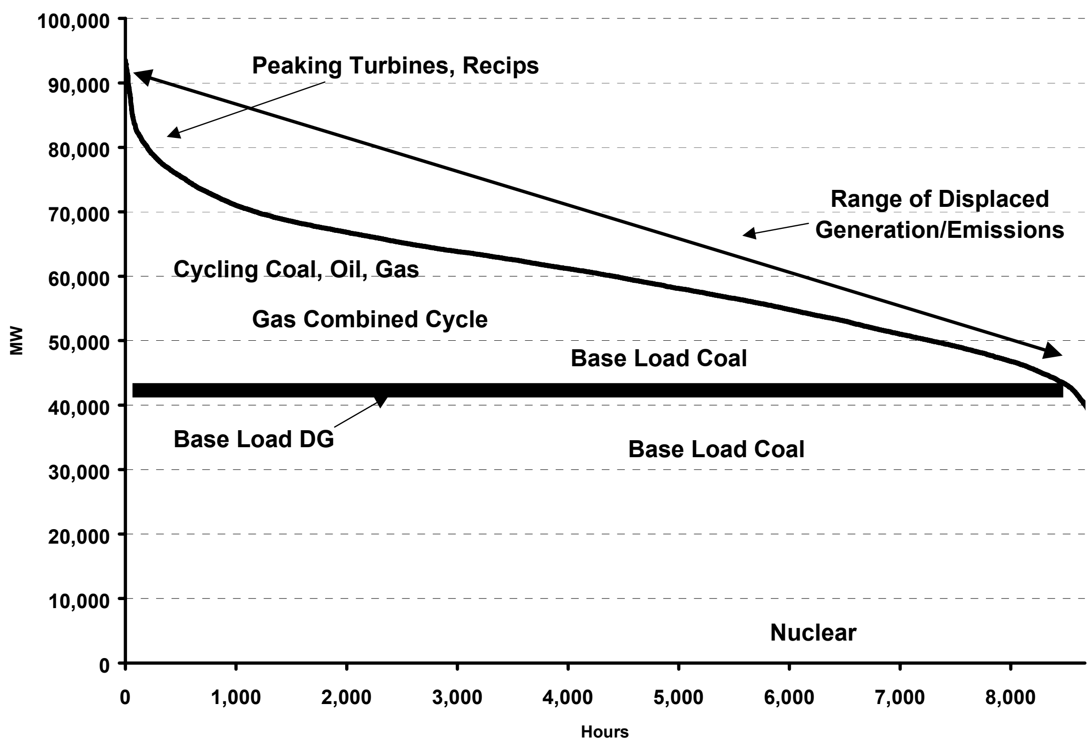
Where Does DG Fit?

With this understanding of the power generation mix, we can come back to the issue of DG's role and impact on emissions. Perhaps the simplest application to address is a base load on-site generation system. For simplicity we assume that the facility operates on-site generation for the entire year except for a two week maintenance outage. Then the generator will run for 8400 hours at its full load. This is a "must run" unit. It will run for these hours independent of what the rest of the central generating system does.

We show this on the load duration curve by inserting the appropriate amount of capacity at the 8400 hour level. This is shown in Figure 5 with the capacity of the DG unit exaggerated to make it visible. The on-site must-run generation means that some other generation is not needed in each hour that it runs. Compared to the base case, the addition of the DG unit displaces an equal amount of generation at the top of each hour that it runs. It essentially takes a "slice" off the top of the load curve for the hours that the DG unit runs. It "bumps off" the last unit of generation in each of these hours. Depending on the hour, that unit could be a cycling coal, oil or steam unit, a combined cycle unit, a central station peaking turbine or reciprocating engine unit.

The displaced emissions are the displaced generation times the specific emission rate of that unit. While the emission rates vary for each of these units, the emission rate for the displaced generation in this case is very close to the average emission rate for all fossil units in the region. This rate is significantly higher than the emission rate of a new gas combined cycle. It is also significantly higher than the emission rates for all DG technologies except diesels and some gas reciprocating engines. Thus, almost all DG technologies will provide a significant environmental benefit in a baseload application in most parts of the country.

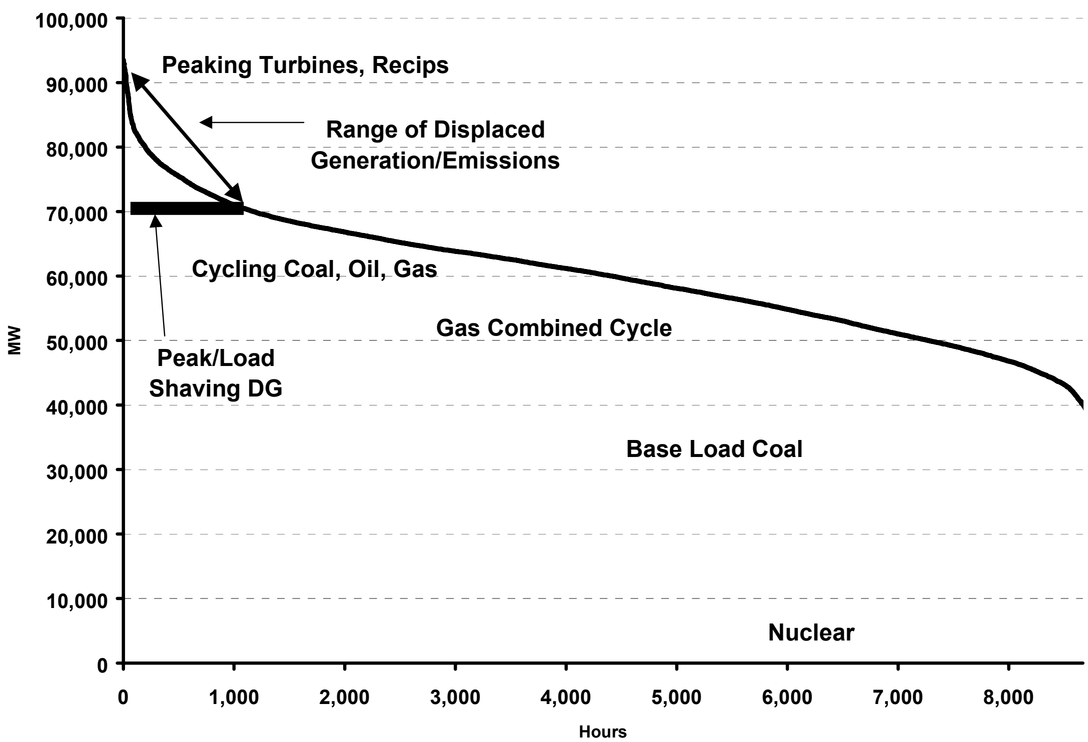
Figure 5
Dispatch Effect of Base Load DG



The process is very similar for evaluating the impact of a peak/load shaving system. In this case, we assume that the DG system operates up to 1000 hours per year. Figure 6 shows the DG capacity inserted in the load curve at that point (again exaggerated to be visible). The DG system in this case displaces peak and high intermediate generators. The emissions profile of the displaced mix will vary from one region to another. It may include some new combined cycle plants. It likely will include new and old simple cycle peaking turbines and possibly some standby steam power plants. The emissions of any new combined cycle plants will be very low. New simple cycle peaking plants have emissions very similar to many gas DG technologies, so there is little gained or lost there. Older simple cycle peaking plants can have NO_x emissions significantly higher than new ones - perhaps in the range of 5 lb/MWh. Standby/cycling oil or gas steam plants typically have very high emissions due to inefficiencies of low load operation.

In most regions, the majority of the displaced load will be older plants - either simple cycle turbines or steam plants, simply because they make up the majority of the generating mix. In rough terms, these may not be too different from the fossil average either. Compared to these, any of the gas DG technologies will show an emissions benefit. The worst case is likely to be a breakeven.

Figure 6
Dispatch Effect of Peaking/Load Shaving DG



The emergency generation case is most difficult to quantify. True emergency generation requirements can occur at any time. Thus the displaced generation is some random mix of the existing generating assets. There is certainly nothing to suggest that it is predominately new gas combined cycle plants. Without knowing the specific occurrences, the best that we can say is that the DG displaces the average emission rate.

For all three major DG applications, this graphical analysis suggests that, short of a detailed dispatch analysis, the average fossil unit emission rate is a good estimate for the displaced emissions. Based on national emission levels, this means that all gas-based DG technologies have lower NO_x and PM emissions than the displaced generation. They have much lower SO_2 emissions and CO_2 emissions that vary from 30 to 50 percent lower. These effects will vary from region to region depending on the existing (and developing) generation mix but DG is likely to present significant environmental benefits in almost if not all regions. (We will pursue further analysis to assess these differences.)

Policy Implications

These results have important implications for the development of policies and regulations that address DG. Some such current policies are based on the assumption that DG displaces only new gas combined cycle plants will therefore be detrimental to air quality. This has led to the development of regulations that attempt to hold DG technologies to the emission performance of large gas combined cycle generators - a level of performance that cannot currently be achieved by conventional DG technologies.

The analysis described above shows that gas-based DG will actually be beneficial to air quality in most applications in most locations. Based on this assessment, it is inappropriate and pointless to attempt to hold conventional DG technologies to the standard of well-controlled gas combined cycle projects. The primary result of such an approach will be that DG projects that could reduce emissions will be prevented from being installed and the environment will suffer. In light of these results, a better regulatory approach must be developed which is protective of the environment through the encouragement of beneficial DG technologies.

There are several regulatory concerns that have contributed to this counterproductive approach. One is the concern that small generators are insufficiently regulated. Although many DG facilities are too small to be affected by Federal new source permitting requirements, they are subject to state minor source review. Thus there is a readily accessible regulatory structure in place to apply appropriate requirements.

A second concern clearly is the increased use of existing or new diesel generators with high NO_x emissions. The emission characteristics of these engines are well known and have already been addressed in permitting requirements. Engines with hourly run time limits must stay within their limits or go through a repermitting process with potential new control requirements. New engine facilities that don't have run time limits must apply appropriate control equipment, like any other source. However, this concern should not reflect on gas technologies that have much lower emission rates.

The more difficult question is how to set appropriate limits for new DG projects. As pointed out above, comparing the DG technologies to large gas combined cycle plants results in a standard that cannot be met and has little practical or environmental value. Moreover, this approach is entirely out of step with the U.S. environmental regulatory practice. In this system, emission limits for new plants are based on one or both of two approaches:

- Source-specific, technology-based control requirements - the New Source Performance Standards.
- Case-by-case determinations of control requirements based on available technology, environmental benefits and cost -effectiveness (BACT/LAER).

There is no basis in U.S. regulatory practice for setting control requirements based on the performance of an entirely different technology in a very different size range. Setting requirements for DG based on large gas combined cycle plants is comparable to setting emission standards for large diesel trucks based on the performance of the latest two-seater hybrid passenger car. The result would be of little regulatory or environmental value.

Nevertheless, there needs to be a basis for regulation of emissions from DG technologies. Although the BACT/LAER process has many problems, it could be a useful starting point as the methodology for such a structure. One could start with a BACT analysis of the control options for DG technologies to identify appropriate control levels for specific technologies. At a minimum, thus would prevent the construction of very high emitters and keep DG units operating in the range where they will create environmental benefits. It is also more equitable to submit all sources to the same regulatory approach.

That said, it is likely that a proper application of BACT would allow many new gas DG technologies to be permitted at their current baseline levels. In part this is because they are relatively clean. However, it also reflects the poor cost-effectiveness of add-on control technology at these size ranges. This factor limits the ability of the new source process to produce the "technology-forcing" effect that is one of its primary effects.

Most developers and manufacturers of DG equipment have made a clear commitment to the development of environmentally superior equipment. Beyond the currently commercial offerings, the Advanced Turbine Systems program has demonstrated significant advances in increasing efficiency and reducing emissions from small turbines. The Advanced Reciprocating Engine System (ARES) program is preparing to begin a similar process for engines. With this commitment to technology improvement, it may be that there is a better approach than BACT/LAER or one-size-fits-all standards to promote the development of better technology.

One such approach that has been suggested by various parties, and most recently by the U.S. EPA in discussions of alternatives to NSR, is the development of staged technology-forcing standards for specific technologies. This approach would start from the current performance levels and set achievable future performance standards by technology that industry could work towards with a guarantee that they would be acceptable for some period of time. This would provide good performance levels, technology-forcing and simplified permitting for needed and environmentally beneficial electric generating technologies.

Conclusions

Environmental regulations that encourage the streamlined permitting of gas and well-controlled diesel DG projects at existing performance levels will be environmentally beneficial and should be pursued. It is also appropriate to provide regulatory drivers to improve DG technology over time, but those drivers should not be set so stringent as to eliminate the DG option. In the long run, a broader, flexible technology driving regulatory structure needs to be developed. In the meantime, regulations for DG need to recognize DG's value for reducing emissions in the short term and technology-specific ability to continue to improve over time.