The Role of Distributed Generation in U.S. Energy Markets

Robert T. Eynon
U.S. Department of Energy
Washington, DC

Good Afternoon. I am Bob Eynon from the Energy Information Administration (EIA) at the United States Department of Energy. It is a pleasure to be here and present EIA's projections of energy markets with particular focus on distributed generation. EIA is an independent statistical agency in the Department of Energy with the responsibility for comprehensive data collection and dissemination. In addition EIA performs a wide variety of energy analyses for the Congress and the Executive Branch that are policy neutral. One of these analyses, the Annual Energy Outlook, is a midterm view of U.S. energy markets prepared each year for the Congress. This report contains projections of energy markets through 2020 that are based on current laws and regulations. I would like to present results from that report.

Before I begin I want to mention that EIA maintains a web site that provides extensive energy information. The site provides both data and reports that can be easily accessed (Figure 1). There is even a section for children. EIA also operates the National Energy Information Center where users can call in and speak with an energy specialist who can answer questions. These people are also knowledgeable about sources of energy information available from other Government agencies and private research organizations.

Supply and Demand Summary

To begin, energy demand is projected to grow at an annual rate of 1.4 percent between now and 2020 (Figure 2). This growth in energy services reflects an increase in population and economic activity, tempered by improved efficiency of equipment and buildings. The most rapid growth is expected to occur in the transportation sector as a result of growing personal and freight travel, slow stock turnover, and consumer preference for performance over efficiency. The overall efficiency of energy use is expected to improve reflecting a continuing trend. Over the period projected energy use per dollar of gross domestic product declines 1.5 percent per year while energy use per capita increases (Figure 3). Efficiency gains and shifts to less-energy intensive industries partly offset growth in the demand for energy services.

In order to provide for the growth in energy services, production of domestic energy is projected to grow, although not enough to meet U.S. needs (Figure 4). As a result there will be increasing levels of imports throughout the period. For example, net imports of natural gas, primarily from Canada, are projected to increase from 3.5 to 5.5 trillion cubic feet between 2000 and 2020.

One of the key factors in energy markets is the price of natural gas (Figure 5). The price for natural gas rose to record levels in 2001 due to strong demand in the winter of 2001 and tight supplies stemming from low drilling rates in 1998 and 1999. However, in the long term technology improvements will provide an offset to price increases that result from growing demand. EIA's reference case assumes that improvements in gas finding and development technology will continue at historic rates, resulting in an average annual growth rate of 1.6 percent in the wellhead price, reaching $3.26 per thousand cubic feet in real 2000 dollars by the year 2020. Between 1995 and 2000 the average wellhead price was $2.38 per thousand cubic feet (Mcf). Under higher or lower assumptions about the rate of improvement in technology for production costs, finding rates, and success rates) the wellhead price would range from $2.73 to $4.06 per Mcf.

Electricity Markets

Electricity consumption is projected to grow at 1.8 percent per year, somewhat slower than historical rates (Figure 6). The relatively low growth in electricity sales results from market saturation of electric appliances, improvements in equipment efficiency, investments in demand-side management programs, and more stringent equipment efficiency standards. The growth in electricity sales is led by the commercial sector at 2.3 percent per year followed by the residential sector at 1.7 percent. The industrial sector growth rate is 1.4 percent per year.

I'd like to focus now on projections for electricity markets and address the needs for new capacity. New generating capacity (Figure 7) will be needed to replace existing capacity that is expected to retire because it is no longer economic. New capacity will also be needed to meet the projected growth in electricity sales. From the chart (Figure 8) you can see that, currently, coal-fired steam plants have the largest share of generation in the United States, representing about one-half of total generation. Nuclear capacity provides about 20 percent of the needs followed by natural gas (13 percent) and renewable sources (10 percent) that are mainly hydroelectric. Petroleum use for electricity generation, mostly in old steam plants, is small and is expected to decline in the future as new efficient generating technologies are built to replace them.

As we look out into the future we can see very large growth in the share of generation provided by natural gas. This growth results from the construction of efficient combustion turbines and combined-cycle generators fueled by natural gas. Gas-fired technologies are expected to capture 95 percent of the market for new generation. In addition to being very efficient, these technologies are attractive because of their low capital costs when compared with other technologies and because of their short lead times for construction. These factors are especially important because of the push for competition in generation services in many States. Unlike the past, where regulated monopolies could be assured of recovering their capital investments over the life of the asset, independent generators have no such guarantees and, as a result, want to minimize their risk by making investments with shorter recovery times and lower initial capital expenditures.

The attractiveness of gas-fired technologies can be better understood by looking at this chart (Figure 9). It shows the costs for several different technologies in the years 2005 and 2020. The components of cost are capital, operations and maintenance, and fuel shown in black, red and green, respectively. While combined cycle plants have the largest fuel cost compared with coal, nuclear, and wind technologies, their relatively small capital cost makes them the least expensive alternative. This is projected to be the case even in 2020 when gas prices are higher than projected in 2005.

It is useful to look at the costs of generating technologies in more detail (Figure 10). This chart shows the cost and performance for the generating technologies used in our analysis. It shows, among other things, the overnight costs to build a plant (which is the cost without interest charges), contingency factors, and heat rates. The contingency factors are multipliers that are applied to the overnight costs. They include project contingency factors that account for unforeseen events such as weather problems or labor issues. The technological optimism factor represents cost uncertainty associated with new technologies that are entering the marketplace. For new technologies overnight costs are based on engineering analysis and, historically, underestimate the actual construction costs when the first plants are built. If you look at the heat rates for conventional and advanced gas/oil combined-cycle technologies you can see that they improve over time. This helps to offset the impacts of higher natural gas prices. Turning now to distributed technologies you can see the costs that we use for typical base load and peak load generators.

Distributed Generation- Utilities

Let's focus now on distributed technologies used in both electricity markets and in the end-use sectors. In the electricity markets we consider several distributed technologies as potential contributors to electricity supplied by electric utilities. These technologies include diesel engines, internal combustion engines, micro-turbines, fuel cells, and renewable technologies such as wind and photovoltaic generators. Distributed technologies are expected to be used when their costs are less than the combined cost of central station generation and the costs of upgrades or expansion of the transmission and distribution system that would be needed to meet additional load growth.

As mentioned earlier we use a generic representation of several technologies to represent a base load technology and a peak load technology. The reason for the limited number of technologies is that they represent the most likely technologies to be economic. The difference between the base and peak load generic technology is that the capital cost for the base load technology is 27 percent higher than the peak load technology while the operating and maintenance costs are lower. The change in costs for advanced distributed technologies including fuel cells, micro-turbines, and photovoltaics partially depends on the quantities that enter the marketplace. We assume that costs will decline by 10 percent for the first three doublings of capacity that is built. For subsequent units we assume costs continue to decline by 5 percent for the next five doublings of capacity. Beyond that costs are projected to decline by 2.5 percent for subsequent doublings.

The results of the analysis indicate that only the peak load technology is competitive (Figure 11). By 2005 about 0.9 gigawatts (GW) are built. By 2010 the distributed generation capacity that is added grows to 5.1 (GW) and reaches 19.1 GW by 2020. To put these numbers in perspective it is worth noting that between now and 2020 we project total generating capacity additions for all technologies to be 354.5 GW. The generation from distributed generators in 2020 is 8 billion kilowatt-hours which represents a capacity factor of about 5 percent.

Distributed Generation- Buildings

Distributed generation is also expected to play a role in buildings in both the residential and commercial sectors. Photovoltaic systems and fuel cells are represented in both residential and commercial sectors, while the commercial sector also includes micro-turbines and conventional combined heat and power technologies. Projections, however, focus on natural gas-fired technologies and photovoltaic devices. The costs and performance for these devices are expected to change over time due to technology improvements (Figure 12). The costs for distributed generators are expected to decline over the forecast period while the efficiency improves. For example the cost of gas micro-turbines is projected to drop by about 50 percent by 2020 while the efficiency improves by about 38 percent. The costs for advanced distributed generating technologies could drop even further if these devices penetrate the market more rapidly than projected here.

We project that natural gas-fired distributed generation in buildings will grow from about 4 billion kWh in 2000 to almost 22 billion kWh in 2020 (Figure 13). Buildings distributed generation from all fuel sources is projected to grow from 8 billion kWh in 2000 to over 27 billion kWh in 2020. Fuel cells and micro-turbines provide most of the growth while gas engines contribute modest growth and gas turbines don't grow much. Photovoltaic devices increase their contribution gradually over time as their costs are reduced.

In order to analyze the impact of increasing research efforts to bring new technologies on more quickly two additional cases were considered. (Figure 14). In the high technology case it was assumed that the costs of new distributed generation technologies (fuel cells, photovoltaic systems, and microturbines) decline more rapidly for a given level of market penetration than in the reference case. For example, fuel cell capital costs decline about 17 percent for each doubling of capacity in the buildings sectors under high technology assumptions, compared to a 13 percent decline in the reference case. In this case distributed generation increases by 11 billion kWh above the 27 billion kWh realized in the reference case. The second case considers the impacts of an even more optimistic view, with fuel cell costs assumed to decline 22 percent for each doubling of capacity in the buildings sectors.

Uncertainties and Summary

There are several uncertainties that will determine the future role of distributed generation in U.S. electricity markets (Figure 15). There is uncertainty about the future costs and performance of distributed generators. Another factor is the prices that would be paid to distributed generators in competitive markets given that rules have yet to be established in all of the markets. Another factor is the availability and price of natural gas to small generators and the reliability of supply. Because there is little experience with distributed generation in the United States, the benefits derived from planning studies could overstate or understate the case for distributed generators. Another issue is pricing and rule making policies by regulatory authorities for transmission and distribution services. For example, how the costs of hooking up distributed generators to the grid are dealt with needs to be resolved. Resolving these uncertainties will reduce the risk for investors and encourage development of distributed resources.

None-the-less distributed generation is attractive from several perspectives (Figure 16). For electric utilities these devices can provide electricity where and when they are needed. They can be connected to the distribution system to ease bottlenecks and improve supply reliability. The relatively small capital outlays combined with short lead times make them attractive compared with large central station units with long construction requirements and large costs. Distributed generation can cut costs by delaying, reducing, or eliminating investments in new transmission and distribution facilities. Distributed generation can be used to meet load requirements in slow growing areas where larger expenditures for transmission and distribution that would otherwise be made are not economic.

In end-use applications the addition of distributed generation will improve reliability by having redundant supply sources. Given that distributed resources are more costly than grid-supplied power, they may still be attractive because waste heat can be captured and used for space heating or water heating. At times of peak demand, when electricity costs are high, distributed generation can provide power that is less expensive than that provided on the grid.

I'd like to summarize the key points of this talk (Figure 17). To begin we project that there will be needs for substantial amounts of new generating capacity in the United States through 2020. Distributed generation will contribute to meeting needs for new capacity- although much less significantly than traditional central station generating sources, especially natural gas-fired turbines and combined cycle generators. These technologies will help meet the needs for peak power and are not expected to contribute to meeting base load needs because their costs are higher than other generating technologies. Over time the costs of these units are expected to decline while their performance improves.