AN ECONOMIC EVALUATION OF DISTRIBUTED ELECTRICITY GENERATION TECHNOLOGIES

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ABSTRACT

Distributed generation, the small-scale production of electricity at or near customers' homes and businesses, has the potential to improve the reliability of the power supply, reduce the cost of electricity, and lower emissions of air pollutants. The high price of electricity in certain regions and problems with emissions from older power plants have stimulated interest in alternatives to traditional utility-supplied power. Distributed generation could provide benefits in all of those areas. Energy legislation will encourage wider use of distributed generation. This paper explores the context in which policymakers may be addressing distributed generation issues in the near future.

1. INTRODUCTION

Distributed generation can come from conventional technologies, such as motors powered by natural gas or diesel fuel, or from renewable technologies, such as solar photovoltaic cells. Over the past two decades, declines in the costs of small-scale electricity generation, increases in the reliability needs of many customers, and the partial deregulation of electricity markets have made distributed generation more attractive to businesses and households as a supplement to utility-supplied power. Some policymakers believe, however, that various rules, restrictions, and prices set by utilities, regulators, or administrative bodies do not reflect the net economic benefits of distributed generation and act as barriers to its cost-effective adoption and operation. Those barriers could be lowered significantly by clarifying and standardizing the rules for connecting distributed generators to the electricity supply network (the grid) and by setting prices for basic electricity services (access to the grid, the electric power itself, and the transportation of that power) that reflect their costs.

If the new rules and prices are well designed, the cost of providing highly reliable electricity service to customers who desire it and the total cost of serving all customers will probably fall as distributed generation becomes more widely used. But initiatives to reduce barriers to widespread adoption have costs and risks, which will pose a challenge to electric utilities, regulatory bodies, and other public agencies that must develop and enforce the rules governing interconnection and establish prices for electricity from those new sources of power. If customers are allowed to connect their distributed generators to the grid without adequate safeguards, the overall performance of the electric system can be impaired. Changes that can promote cost-effective distributed generation, such as the adoption of economically sound pricing, may increase rates for customers who currently pay prices that are below the utilities' costs for providing service. If the new rules and prices are poorly designed, the changes that benefit distributed generators will raise the overall cost of electricity and increase rates to most other customers. Aside from those risks, separate technological and regulatory changes that would significantly lower the future cost of utility-supplied electricity (for example, additional cost reductions in large-generation

technologies and extensive competition in wholesale markets) could lessen the attractiveness of some new investments in distributed generation.

To investigate those issues, this paper addresses four questions. What are the current status of and prospects for distributed generation technologies, particularly in terms of their costs as compared with those of utility-supplied power? What are the benefits and risks of a wider adoption of distributed generation in restructured electricity markets? What specific utility practices, local government regulations, and electricity pricing methods may be acting as barriers to adoption? And what types of policy changes could help reduce those barriers while limiting the downside risks of greater reliance on distributed generation? Although many of those policy changes could be the concern of state and local authorities, this paper highlights the federal role--particularly those aspects that might receive legislative attention.

2. THE CURRENT STATUS OF AND PROSPECTS FOR DISTRIBUTED GENERATION

Distributed generation is an important, although small, component of the nation's electricity supply. The principal source of electricity today continues to be large central facilities that generate electricity from steam plants (fueled by coal, natural gas, or nuclear power) and hydroelectric power. Historically, most steam plants were operated by large investor-owned utilities that were responsible for generating electricity, transmitting it from the central generating facilities to communities, and, in many regions, distributing it to retail customers within those communities.

Among distributed generation technologies, the most important in terms of their capacity to generate electricity are customer-owned generators that produce both electricity and steam for on-site use (called combined heat and power, or cogeneration) and emergency backup generators. Together, those two sources account for more than 95 percent of the customer-owned generation capacity. For the most part, the cogeneration plants that have been built to date are large facilities that sell the majority of their output to utilities.

Natural gas fuels most of those plants, but coal and biomass also power a significant percentage of the total capacity. Most backup generators are internal combustion engines fueled by diesel oil or gasoline. Diesel-fired backup generators are commonly used in high-rise buildings for safety reasons (as required by local building codes), in hospitals, and in manufacturing facilities that depend on a highly reliable supply of power.

Renewable technologies that are currently used to generate electricity at homes and businesses include wind turbines and solar photovoltaic systems. Those technologies produce electricity intermittently and generally are not available to operate continuously. Fuel cells and small turbines (called microturbines) are frequently mentioned, newly emerging high-efficiency technologies. Although they account for very little of the nation's existing electricity supply, proponents believe they will contribute significantly in the future.

Four developments over the past decade have spurred interest in moving distributed power beyond the limited markets that it now serves and integrating it more fully into the nation's electricity supply. First, the costs of renewable technologies and high-efficiency technologies that are suitable for operation by households and small businesses have fallen. Typical costs of electricity from certain distributed generation systems are now within range of those of electricity from large generators, and they are below the average prices of electricity in some regions of the United States (see Fig. 1.). Second, the introduction of competition to wholesale electricity markets has increased the possibilities for sales of customer-owned distributed power. Those newly competitive markets feature prices that vary hourly and that are high during periods of peak demand (times at which distributed generators would be most profitable to operate). Third, many commercial and industrial customers place increasing importance on highly reliable electricity service, which can be provided by on-site generation. Fourth, building new transmission lines to meet growing demand has been a contentious issue for local, state,

and federal regulators and among power producers. Wider adoption of distributed generation can in some cases obviate the need for new transmission capacity.

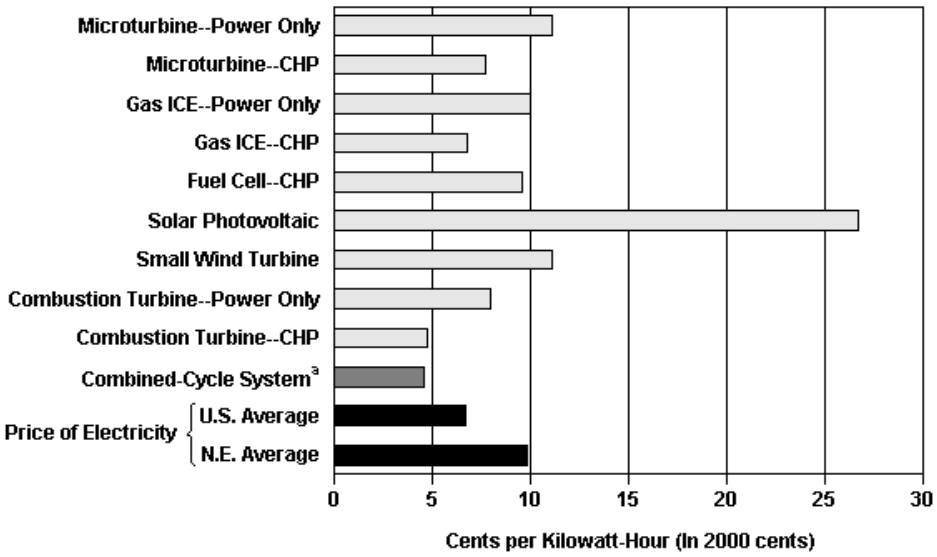

Fig. 1. Levelized Cost of Selected Technologies Suitable for Distributed Generation

Source: Congressional Budget Office using data on electricity prices from Department of Energy, Energy Information Administration, *Electric Power Annual 2000* (August 2001).

Notes: CHP = combined heat and power (also known as cogeneration); ICE = internal combustion engine; N.E. = New England.

The levelized cost is the average cost of electricity (cents per kilowatt-hour) over the operating life of the generation equipment. Future costs and output flows are discounted at 7 percent from their present values. The cost estimates assume that the systems powered by fossil fuels will be operated 90 percent of the time and that the wind and solar photovoltaic systems will run 40 percent and 27 percent of the time, respectively. Levelized cost comparisons do not include the effects of tax credits or other direct subsidies for specific technologies.

"Large wind turbine" is not included in the figure (because it is not generally considered to be well-suited to distributed generation applications (typically, it is not located near customers).

a. In a combined-cycle system, a combustion turbine is operated in tandem with a steam turbine. The system is included here as a benchmark for the cost of power from new large-scale generators. Transmission and distribution expenses would add an estimated 2.4 cents per kilowatt-hour, on average, to the marginal cost of delivered power.

Those developments have prompted discussions about using distributed generation differently from how it is typically used today. Rather than just serving as emergency backup or exploiting large commercial cogeneration opportunities, small generation systems could operate regularly. Customers could use distributed generation to meet most of their on-site requirements while relying on the grid as a source of additional power and as an outlet for excess power that they might generate. Utilities that distributed power to retail customers could use distributed generators to meet local peak loads (consumption) or to provide highly reliable electricity service to customers that required it.

Conventional fossil fuels, such as natural gas and diesel oil, power the most common distributed generation technologies, and they are likely to account for most of any growth in distributed generation that operates regularly and is connected to the grid. Renewable sources that produce electricity intermittently, especially wind and solar, will be used more if customers can rely on the traditional utility system to eliminate deficits and to absorb excesses from on-site power production.

3. THE BENEFITS AND RISKS OF DISTRIBUTED GENERATION

Nonutility owners of distributed generation units could individually benefit from structural changes that allowed their power generation activities to be integrated with those of utilities. By spreading their capital costs (the costs of acquiring and installing the generating unit) over an increased number of operating hours, they could lower their average generation costs. They could also earn revenues from their sales of electricity to

utilities or other customers, further improving the returns on their investments in distributed generation. But the economy at large might also benefit from a more widespread adoption of distributed generation technologies. Such adoption would lower the overall cost of electricity for all customers, enhance the reliability of the power supply, reduce the need for transmission and distribution investments to serve growing demand, and improve environmental quality through the increased use of renewable energy sources and fuel-efficient technologies.

If distributed generators are operated in situations in which their costs are lower than those of centrally supplied power, the overall cost of supplying electricity will fall. Those situations often occur during periods of peak electricity use (at certain times of the day or seasons of the year). At those times, relatively small reductions in demand for utility-supplied power (if the owners of distributed generators produce additional electricity for their own use) or increases in the utilities' supply (if the owners produce additional electricity for sale to the utilities) will reduce wholesale prices considerably. The availability of additional electricity during peak periods may help enhance the reliability of the power supply. A further benefit of increased supply and flexibility in demand on the part of owners of distributed generators would be a reduction in electricity price volatility (because extreme price spikes would be eliminated).

Distributed generation could also encourage efficient investments in electricity reliability by offering a cost-effective alternative in many situations to constructing new transmission and distribution power lines and transformers. Those investments might make the electric system more secure and less vulnerable to widespread service disruptions. In addition, a healthy distributed generation industry could put competitive pressure on transmission utilities to expand service and reduce congestion.

Changes that generally facilitate the integration of customer-owned distributed generation with the grid could also encourage the adoption of specific renewable energy and high-efficiency technologies, including solar photovoltaic systems, fuel cells, and microturbines. Shifting to sources of electricity that made greater use of nonfossil fuels or less-polluting forms of fossil fuels or that made more efficient use of conventional fuels might produce regional and global environmental benefits.

The widespread adoption of distributed generation technologies poses risks, however. The reliability of power to all customers might be diminished rather than bolstered if the operators of electric systems found it difficult to manage a much greater number of power sources--suppliers that were adding electricity to or drawing electricity from the grid at will. Equivalently, the retail price of electricity could rise if ratepayer-funded investments were necessary to maintain power quality. And operation of large numbers of small customer-owned generators--especially those fueled by diesel oil--could be detrimental to local air quality. Finally, poorly designed policies to encourage distributed generation might bring unexpected costs. In particular, liberalizing the rules that govern the connection of distributed generators to the grid under traditional regulatory methods of electricity pricing (whereby utilities set power rates to recover past costs and earn an allowed return on capital investments) could encourage some customers to invest in distributed generators whose power was more expensive than new, centrally supplied power. That outcome could increase the overall cost of electricity to the utilities' remaining customers (ones who did not operate distributed generators).

Increased competition in wholesale electricity markets and reforms in retail electricity pricing could significantly reduce the number of situations in which distributed generation was profitable to owners. Competition in wholesale markets could lower electricity prices to the point at which many investments in distributed generation would no longer be attractive. Widespread application of real-time pricing, which could provide incentives for the operation of distributed generators, could also end up making many of them unprofitable. Real-time pricing and other tariffs (rate schedules) that encouraged retail customers to vary their demand for electricity in response to price changes could significantly lessen price volatility as well as average prices. That result would reduce the number of hours per year that many distributed generators could operate profitably.

4. BARRIERS THAT IMPEDE WIDESPREAD ADOPTION OF DISTRIBUTED GENERATION

Proponents of distributed generation argue that significant barriers impede the widespread adoption of distributed generation technologies. Most, if not all, of those barriers are related to the risks cited earlier. They include utilities' pricing and operational practices and local governments' rules about reliability and safety, cost, or environmental quality. A common theme of the complaints against those practices or rules is that they result in restricted access to the grid and protect the utilities' current investment in central generation capacity and transmission lines.

Four types of barriers are frequently cited. The first type is contractual and technical interconnection requirements for the installation of protective equipment and safety devices to protect the grid and ensure power quality; distributed generation proponents argue that those requirements are often duplicative, excessive, and time-consuming. The second type is surcharges imposed by utilities on operators of distributed generators (who are still utility customers) for standby service; proponents contend that those surcharges often do not reflect the actual cost of the service and do not give credit for the ways in which distributed generation benefits the grid. The third type is pricing of electricity that is based on the utilities' average cost rather than their marginal cost (the cost of supplying an additional unit of electricity). Proponents contend that average-cost pricing does not give owners an incentive to operate their distributed generators during periods when doing so will lower the overall cost of electricity. The fourth type is environmental and permitting requirements of local governments, which, in the proponents' view, broadly restrict the installation and operation of electricity-generating equipment or impose burdensome approval processes on applicants.

Achieving the potential cost and reliability benefits from widespread adoption of distributed generation technologies may depend on retail competition and unrestricted customer choice. The competitive positions of many utilities are already weakening with the restructuring of wholesale electricity markets and increased use of the most widespread form of distributed generation (cogeneration for customers' own use and for sale to the utilities). Broader adoption of distributed generation by customers could be an important part of what many analysts believe will be the next level of market restructuring--the introduction of retail competition. Such competition would give customers the ability not only to choose their electricity suppliers but also to elect to generate electricity on their own.

5. POLICY OPTIONS

The barriers that certain industry practices and governmental rules present to customers' potential investments in distributed generation could be lowered in two general ways. One would be to standardize and clarify the rules and procedures governing the installation and operation of distributed generators and their interconnection with the grid. That approach could streamline the approval process and help to reduce uncertainty about the requirements and costs of compliance. The second would be to set the prices that operators of distributed generators pay and receive for electric power, connection to the grid, and transmission and distribution services at levels consistent with the actual costs borne by utilities to provide those services. That change could give customers incentives to install and operate distributed generators at a level that would help to ensure the lowest cost of electricity for all customers. Specific changes would require utilities and government agencies to:

1. Grant nondiscriminatory access to the grid under a system of well-defined, uniform technical and contractual terms and cost-based interconnection fees--so that operators would know in advance what was required to run their distributed generators at the same time they were taking power from or supplying power to the grid;

2. Establish clear, explicit rates for standby electricity service that are based on the cost of the equipment utilities require to meet infrequent demand--so that operators of distributed generators would know those surcharges in advance and receive rate treatment comparable to that of regular customers;
3. Purchase excess power from operators of distributed generators at prices consistent with utilities' wholesale cost of power in real time in circumstances in which no competitive markets for distributed generation power exist--so that operators could sell their power at prices consistent with the savings to the utilities;
4. Establish real-time pricing for utilities' sales to retail customers based on the wholesale price of electricity as it varies over time and across delivery locations--so that operators of distributed generators could decide on the basis of market signals whether to purchase or generate power; and
5. Develop uniform national environmental standards for distributed generation that would allow precertification of equipment--so that manufacturers could design units to national specifications and distributed generators would not need to qualify on a case-by-case permitting basis.

This work was supported by Scientific Grant Agency of the Ministry of Education of Slovak Republic and the Slovak Academy of Sciences under the project VEGA No. 1/3141/06.

6. REFERENCES

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