01 Jan 1997

The New--But Is It Improved?--Power System

Mariesa Crow
Missouri University of Science and Technology, crow@mst.edu

Recommended Citation

M. Crow, "The New--But Is It Improved?--Power System," *IEEE Potentials*, vol. 16, no. 5, pp. 9-10, Institute of Electrical and Electronics Engineers (IEEE), Jan 1997.
The definitive version is available at https://doi.org/10.1109/45.645822

The new—but is it improved?—power system

Mariesa L. Crow

Many US industries have felt the heavy hand of deregulation over the past twenty years; telephones, airlines, trucking and natural gas to name a few. However, electric power was long felt to be too much a "natural monopoly" to face the deregulation process. Well, those days are over...

The electric power industry is undergoing major changes, both politically and technically. They are a result of the Federal Energy Regulatory Commission's (FERC) Orders 888 and 889 issued in 1996. These orders essentially deregulate the transmission network, allowing producers and customers access to the network for electricity transactions.

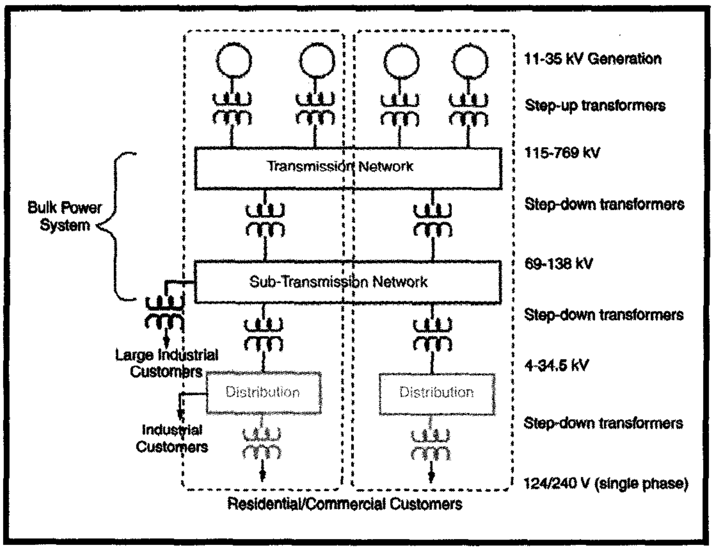

Fig. 1 Power system structure

One justification for this deregulation is to level the considerable differences in price of a kWh (kilowatt-hour) of electrical energy across the United States and Canada. Average residential costs vary from 5.0 cents per kWh in Washington state to 13.6 cents per kWh in New York. What is overlooked, however, is that this cost is not just for generating the electricity. Currently, a considerable excess of power exists in the US The cost differences primarily lie in transmitting this power from its origin to the place of demand.

How it has been working

To better understand the effect deregulation will have on the US power system, we must look at how electric utilities currently operate. A typical power system configuration is shown in Fig. 1. In current and past operations, the utilities were vertically integrated as shown by the dashed box. A single utility would own and operate all components necessary for providing service to their customers, from generation, through transmission, down to the distribution system. Customers received one bill from their utility company for the entire service. Historically, a single utility would service a geographic region. The utility was responsible for providing enough generation to meet all of their customers' needs. However, after the infamous New York City blackout of 1965, utilities began to interconnect.

Interconnection yielded many advantages. Reliability was improved since neighboring systems could act as buffer zones and provide additional power during fault conditions. Many power companies worked cooperatively together to avert power failures.

Additionally, utilities would buy and sell power across the interconnections, or tie lines. Frequently, a utility would produce excess power and sell it at a cheaper price than a neighbor could produce it. Thus, both companies profited from this arrangement. Currently, the flow of electric power through parts of the network is closely coordinated between utilities. For many decades, it was felt that having a single company own a region's transmission and distribution systems and generation, under tight regulation, was more efficient than competition.

How things will change

Deregulation will essentially turn the dashed boxes in Fig. 1 on their sides. As deregulation proceeds, these entities will no longer exist in close collaboration within a single utility. Indeed, it is forecasted that distinct industries may arise which specialize in only one of these areas: a GenCo. (generation), a TransCo. (transmission), or a DisCo. (distribution). Competition will replace cooperation. Competition, however, will spur technological growth.

How is this deregulation being accomplished? The new FERC orders have forced utilities to give "open access" to their transmission system to both suppliers of power and consumers. What this means is that, like the sidewalk in front of your house, anyone who chooses to may use it. And, secondly, consumers are no longer constrained to purchase their power from the regional utility. They can shop around for the best price. These two initiatives, taken together, will change the face of how electric power has traditionally been produced and transmitted.

The impact on the network will be that certain transmission corridors may be forced to carry more power than they were designed for. The results will be a myriad of technical difficulties such as decreased reliability (ability to serve the demand), decreased power quality (harmonics and transients), and increased wear and tear on system equipment. An excellent example are the blackouts that affected western US and Canada in July and August of 1996. Both blackouts were exacerbated by unscheduled power flows along the North-South coastal corridors.

©Steve Niedorf/Image Bank

Case in point

For example, in August 1996, California was suffering through a heat wave. Large amounts of electric power were shipped along two parallel tie lines (one AC and one DC line) from the northwest, south to the heavily populated areas of California. However, since electrical current will take the path of least impedance, not all of the current flowed through the desired corridor. As some current took a circuitous route (called a "loop flow"), the transmission lines over which the extraneous power flowed began to overload. This happened because they were not designed to carry such large amounts of current.

As they overloaded, they began to heat up due to the large amount of I^2R (resistive) losses. As they heated up, the lines expanded and began to sag. Finally, one line sagged enough to make contact with a tree, thus causing a short circuit to ground.

As this line was removed from service, the current was then shunted in greater amounts over the remaining lines, causing more overloads. This process continued until a cascade of cause and effects caused the systems to break apart, or "island" in order to retain coverage to as many customers as possible. While this caused a catastrophic failure, there are many more similar close calls that do not receive media attention.

Cooperation vs revenues

To better visualize this phenomenon, consider Fig. 2a. This shows two systems connected via two tie lines. Under normal operation, the two generators of system A provide power to the load (all loads are denoted by→) within the system over its own lines. The same holds for system B. There is no net interchange on the tie lines between A and B. However, if system A loses one of its internal lines as shown in Fig. 2b, power will inadvertently flow over the lines of system B.

There are several ramifications here. First, system B now has the burden of the excess wear and tear on the network equipment. In addition, system B cannot make any transactions that would increase the loading on its line any more. So, from the cooperative standpoint, the reliability of the system has been increased, since system A was able to maintain service. However, from the competitive standpoint, system B has lost system capacity, and therefore potential revenues.

The FERC orders have required systems to place a dollar figure on each transmission corridor, so utilities may charge for such transgressions. Utilities are required to post these costs and their predicted available transfer capacity on a World Wide Web site called OASIS. These costs must cover not only the actual cost of transmission, but also such intangibles as wear and tear, security capacity limits, and decreased reliability of service.

What will happen

Predicting available transfer capacity is an extremely difficult task. In any given transfer of power, most of the power will flow over the predicted corridor. However, there is always a finite amount of power that will take a more circuitous route. Utilities, whose network this power flows over, will want to charge for the usage of their lines. Thus, they are working to improve their data collection and processing.

More serious, though, is that transmission lines have limits. Transfer capacity is governed by a number of factors, not just physical current carrying capacity. There are limits which are imposed by stability constraints. Too much power across a particular line could result in generators pulling out of synchronism. This is manifested by large oscillations in power. Or a phenomenon called voltage collapse can result; the voltage in the system slowly declines until it suddenly drops, with little or no warning. The power system will be pushed to the limits of its capability. Unfortunately, this limit is not usually known ahead of time.

Results that will require attention

Obviously, first off, better prediction and detection of these stability limits is going to be required under deregulation. Another cure for the woes the public is about to face is to add more transmission capacity.

This solution, however, will not typically be a viable option. Recent bids to add more transmission have met public and Environmental Protection Agency (EPA) resistance. Most of the public lives with a "not in my backyard" mentality when it comes to transmission lines. There is also the concern over deleterious effects from things such as electromagnetic fields. Many utilities will be leery about undertaking such a major capital cost endeavor as well.

The charge consumers see on their monthly bills is not only the actual cost of generation, but also the amortized cost of past investments in infrastructure. Few utilities are going to invest in new equipment when that cost will be added to the price they will have to charge. This amortized cost of equipment has left many utilities with "stranded assets." These are assets, such as nuclear power plants which cost billions of dollars to build. Those costs have been built into the rate structure the utility uses. Until these investments are paid off, the cost of electricity from that company will not drop. Even though, for example, nuclear power is one of the cheapest generation per kWh available. Many utilities fear that they will be unable to pay for these large past expenditures, since customers will abandon them for a cheaper competitor.

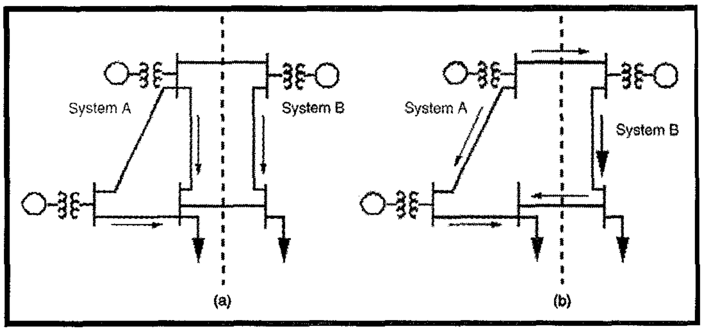

Fig. 2 **Loop flow between two systems**

A similar argument can be made about pollution. Strict clean air standards in heavily populated areas, such as the northeast and California, have forced coal-fired plants to be fitted with expensive filters, or "scrubbers." These expenditures, too, have been factored into the companies' price rates. However, under deregulation, consumers in these areas could contract with producers in the midwest, who do not have to abide by the same strict standards, to generate their power. (But shipping this power over long distances still leads to the difficulties in transmission discussed previously.)

These are all political and technical challenges yet to be solved. There is a world of opportunity out there for power engineers willing to tackle some of these problems. The US grid will certainly face growing pains, and probably a short term decrease in reliability. However, solutions to make the system more economic and reliable than before are sure to come about.

About the author

Mariesa L. Crow is an associate professor in the electrical engineering department at the University of Missouri in Rolla. She was named the IEEE Power Engineering Society's Walter Fee Outstanding Young Engineer for 1997.

Plug: ©1996 PhotoDisc, Inc.