

# The Distribution System of the Future

*Utility engineers have complained that distributed energy resources are a control and protection nightmare, but with local control agents DER will be an integral and valuable player in distribution reliability.*

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## I. Introduction

The distribution system of the future is going to be as much of a revolution to the electric energy industry as wireless telephony has been to consumer communications. An electricity market transformation will be required before the changes can take place, but this evolution is already starting to occur in many parts of the country. In this article, we discuss a vision for a future distribution system, areas that will be key for technology development, and the advantages of the new electricity market.

**P**resent-day distribution systems are, in a sense,

unintelligent. Distribution systems respond to faults, or short circuits, by sensing the abnormal fault current and then opening circuit breakers to isolate the fault. Some newer automated systems determine fault location and then close other circuit breakers to provide an alternate path for power after the fault so that the number of customers left without power is minimized, but the extent of the reconfiguration is limited. Distribution systems also have some methods to regulate voltage, but there is little real-time local response to contingencies such as loss of a transmission line or a generator.

In present-day distribution systems, there is very little control

of load, or demand response, and distributed energy resources (or DER, meaning distributed generation, storage, and responsive load) located in the distribution system are prohibited from even regulating voltage. In fact, industry standards and utility interconnection agreements typically require that when a contingency occurs on a distribution or transmission system that results in a voltage or frequency excursion, the DER is to disconnect rather than help.

There is a pressing need to evolve the distribution system model to one that can respond to contingencies sensed locally, and that has the local intelligence and autonomy to deal with contingencies such as unusual loading, transmission congestion, and line outages. Markets must be simple for customers to participate in the energy and reliability services transactions.

In the future, distribution systems will have local monitors for current, voltage, and temperature at many locations such as substations, underground cable and transformer vaults, feeders, and laterals. These monitors will input data to local agents—computers scattered throughout the distribution system constantly assessing system condition. The local agents will communicate quickly with their local sensors and with each other, and more slowly with status reports they send to the central control authority. The local agents will

review temperature, current, and voltage data and diagnose problems such as overloads, over/under-voltages, and voltage presence on circuits that are intended to be deenergized. They will also sense contingencies such as equipment outage due to faults.

The local agents will be partially independent from central control and authorized to take corrective action when they

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diagnose problems. Some of the actions that will be taken will be local dispatch of DER, local capacitor connection, voltage regulator control, local circuit switching, and provision of local reliability services, such as load response. The local agents will report up to a central agent on a periodic basis. There will be several different types of local agents that will function together.

One of the most important capabilities will be for customers to participate in the energy and reliability services markets. With only a few exceptions, these markets are now only open to

large generators and a few large loads. Reliability services, such as voltage regulation or reserve power, are much more effective when supplied locally at the load. In addition, local participation in these markets will provide demand elasticity in the load—something that is lacking now. At present, when power is scarce due to a contingency or severe weather, there is no customer response; customers continue to use the same amount because they do not see the market price. An elastic demand means that some customers would cut back during periods of shortage and high price. Elasticity in demand is essential for a healthy market system.

## II. Vision for the Future

### A. Increased safety for linesmen

Presently, linesmen rely on the central control operator to remotely open circuit breakers and clear circuits. In some instances, the linesmen will open disconnects and pull fuses themselves to isolate equipment. These precautions will also be used in the future, but there will also be a backup level of monitoring and protection provided by the local agents. The local agents will be notified of utility personnel working on a circuit, they will be involved in the de-energization of the circuit, and they will ensure that the circuit is kept de-energized to provide a secondary level

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