

Line Design Process Requires Teamwork

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South Mississippi Electric owns and maintains more than 1,700 miles of high-voltage transmission lines – enough to stretch from Hattiesburg to beyond Phoenix, Arizona. That is a remarkable feat of engineering and construction, considering that the Association had essentially no lines at all before initiating steps toward becoming an operating G&T in 1967.

These days, the engineering department may have anywhere from 40 to 60 projects in progress, including new lines, substations, switching stations, and various transmission upgrades. Employees from various sections work together to move each project along – from planning to permitting, environmental studies, land acquisition, design, material procurement and, ultimately, construction.

Some additions to the system, of course, are in response to Member requests for new delivery points to meet consumer load growth. Other projects are a result of SME's long-range system planning, where sophisticated computer modeling is used to project how the overall system is affected by growth and load flow, thus determining where new lines are needed to ensure reliability.

The process of designing and constructing a new line may take between two to four years from start to finish. The first step is to consider the route needed to accomplish the task. In the past, possible routes or corridors for lines were first hand-drawn onto topography maps and black-and-white aerial photos; then exact routes were determined by surveys on the ground.

"Today, technology provides us with many forms of electronic data that are easier to manipulate, which is good, as there are many more regulatory considerations related to routing a line than there were 40 years ago," said Chris Roberts, transmission line design engineer. "Certainly there are more homes, churches and businesses to try to avoid. We also must take into account environmentally-sensitive areas and any aspects that will make construction and maintenance more difficult, such as river and creek crossings."

Digital aerial photography now provides extremely clear views of land under consideration and helps provide initial routing possibilities, but any proposed route is still viewed from the ground to determine where problems might exist. Like many other utilities, SME has adopted a routing process that helps identify and quantify the best options for a line, then compares those options to select the best one.

"The routing process is truly a joint effort. To be successful, we must secure input from all groups involved with the project," said Roberts. "The routes we choose must ultimately be consistent and defensible. We have to provide information to the Mississippi Public Service Commission and other regulatory agencies in order to receive permission to build and finance our projects. By considering a variety of options and documenting them, we can be sure at the end of the process that we pick the right one."

It might take up to a year or more of preliminary work to actually get to the line design stage. Roberts and design engineers Dereck Sumrall and Jeremy McAndrew then begin the task of preparing plans, which actually incorporate more mechanical and structural engineering calculations than electrical. “Basically, a transmission line is made up of straight lines and angles,” said Sumrall, “but we have to consider the topography the line will be built on, as well as other stresses the line will be subjected to.”

The lines that transmit high-voltage electricity are not particularly heavy, weighing a pound or less per foot; but when taking into account multiple conductors and long spans, the loads on the poles that suspend those lines above the ground can be significant. In addition, design codes require a line to be capable of withstanding various weather conditions such as high winds and ice buildup on the cables.

“We have various wind- and ice-loading zones across our system that we must consider during design,” said Roberts. “For example, when we design a line near the Coast, it must withstand 130-150 mile per hour winds in the event of a hurricane. In the heart of our on-system, the design wind velocities are approximately 100 miles per hour. For lines in the northern part of the state, ice loading is more of a threat. We have to consider the effects of an ice storm, which would significantly increase the load (weight) on the conductor and insulators.”

In the past, much of the line design process at SME consisted of manual drawings and calculations based on a range of engineering specifications for structures, spans, weights and pressures developed in-house over the years. Today, computers incorporate much faster and exacting design elements, creating the topography the engineer is dealing with as well as allowing for the selection of a variety of pole structures to best fit the demands of the line. McAndrew, who works primarily designing new lines, can manipulate a mouse and have the computer instantly calculate load and spans, as well as the sag of the conductor under varying conditions.

“Our software permits us to work in two or three dimensions, so we get a realistic view from virtually any angle,” said McAndrew. “The computer will also model important considerations such as the potential for a conductor to swing out or gallop (an effect where a line acts like a jump rope under certain wind and ice conditions), allowing us to select the optimal designs to reduce the likelihood of problems.

“We also model for temperature variations. When a line is energized, under heavier electrical loads and in higher ambient temperatures, the conductor will expand and increase its sag between structures. We have to allow for proper ground clearances under every scenario. In the past, designs were based on operating factors of 120 degrees F., but now we consider a conductor’s performance up to 212 degrees F.”

The kinds of structures used in new lines today also differ from the past when single wood poles and H-frame structures were used almost exclusively. Today, pre-stressed concrete and fabricated steel poles, which can reach heights of 130 feet or more, provide both structural benefits and an increased service life for the line. These poles can be designed to accommodate almost any loading condition and, when

combined with modern polymer insulators, lines that had to be designed with H-frame structures in years past can now be designed with single steel or concrete poles.

“When we are working with level terrain, we can pretty much design equal span lengths and equal support for each pole,” McAndrew said. “When we deal with elevation changes, we try to balance the weight loads and wind exposure for each structure. The design software also allows us to analyze the structure’s hardware, such as insulators, clamps, crossarms, braces and other structural elements, to make sure they are not overstressed.”

In addition to design, Sumrall’s role often focuses on working with the construction of new lines as well as assisting SME’s line crews on maintenance projects. “Once we start construction of a line, there may be a need for adjustments for problems that arise in the field,” he said.

“Sometimes poles and guys must be moved to accommodate construction needs. Our design will typically include more capacity than the computer calculations call for. This provides us with the flexibility to make those adjustments, based on the feedback we get from the crews in the field.”

Once a design is completed, an assembly summary of all the hardware, conductor and poles required for the project is compiled to allow for bidding and ordering the material. A 10-mile 69kV line may involve more than 30,000 components. Sumrall works closely with Director of Transmission Construction Jerry Pierce, who will oversee the construction crews, and Transmission Planner Tracy Stiglets, who is responsible for reserving all material associated with a project and seeing that it arrives on schedule.

“Whether a project is designed to improve the reliability of an existing line or involves construction of a new line, the only way we will do the best job is by working together,” said Sumrall. “It is common during our design process to ask for input from the construction and maintenance groups. Even with all the technology we have at our disposal, there is no substitute for experience, intuition and common sense when it comes to building and maintaining our system.”