1 Modeling with ArcGIS Electric Distribution

ArcGIS Electric Distribution contains ready-to-use data models that can be configured and customized for use at electric utilities. A keystone of this new data model is superior modeling of electric devices and circuits that capture the behavior of real-world objects such as transformers and feeders.

These are the topics in this chapter:

- *Introduction*
- *Modeling concepts*
- *Modeling electric distribution systems*

Electricity is an essential part of our everyday lives. Yet it is so easy for most of us to obtain and use it that we often take it for granted. We take it for granted, that is, until we have to do without power for one reason or another. We don't often actually see them, but behind the scenes many people are working to ensure that we have a clean, safe, reliable source of power; that we don't have unpredictable or inappropriate current to power the infinite variety of devices we use; that the supply is there when we need it; and that it is, more or less, reasonably priced.

ArcGIS Electric Distribution is designed for electric utilities to help them manage distribution systems that deliver electric power to our service drops. By providing a geographically oriented view of electric distribution devices, structures, circuits, and even customer information, ArcGIS Electric Distribution helps utility managers and administrators visualize, analyze, and understand real-world engineering and business problems and, more importantly, find solutions. Built using object–component technology, ArcGIS Electric Distribution provides a powerful new platform for utility solutions. The goal of this system is to provide operational efficiencies and business benefits that transcend traditional geographic information system (GIS) and mapping boundaries.

Today's electric utilities are realizing the benefits of GIS technology in the management of facilities for engineering, construction, and operation purposes. The typical requirements of these utilities reflect business needs to:

- Update GIS databases with design and as-built data.
- Produce standard and custom map products.
- Integrate computer-aided design (CAD) drawings with the GIS network.
- Integrate with other enterprise systems such as work. management systems, outage management systems, document management systems, materials management systems, and customer information systems.
- Analyze installed network for capacity planning and capital improvement projects.
- Manage feeder system, conduit systems, and inspection operations.

The ArcGIS Electric Distribution Model supports these typical business needs by providing an implementation that focuses on operations and maintenance portions of the facility life cycle and provides a crucial visual component.

WHO SHOULD READ THIS BOOK

ArcGIS Electric Distribution Model is intended for users who implement the ArcGIS Electric Distribution Object Models. These users include database designers, data builders, database administrators, analysts, and developers. This book serves as a companion to the ArcGIS electric distribution (UML) object model and details the model components and provides information for developing custom applications.

The following topics are discussed in this book:

- Introduction to the ArcGIS Electric Distribution Model.
- Definition of distribution networks and devices and the design considerations of these systems as they are applied in ArcGIS Electric Distribution.
- Descriptions of the ArcGIS Electric Distribution Model structures and organization including modeling techniques and component notation in UML.
- Component reference of the ArcGIS Electric Distribution Model presented by subsystem and described in narrative form at the class level. Each component contains a description of usage and application within the model.
- Resources and guidelines for implementing instances of ArcGIS Electric Distribution.
- Deployment scenarios and task-based instruction for evaluating model requirements and implementing a custom geodatabase in the ESRI® ArcInfo™ 8 environment.

This book is written assuming that the reader is knowledgeable about electric distribution and has a functional understanding of ArcInfo 8. Additional resources are provided in the bibliography to assist you with developing a basic understanding of Component Object Model (COM), Unified Modeling Language (UML), and object-oriented database design.

The sample data contained on the ArcGIS Electric Distribution CD–ROM is provided courtesy of the Town of Greeley, Colorado. The data has been modified by Miner & Miner to suit the needs of this book and to highlight ArcGIS functionality. The Town of Greeley and Miner & Miner cannot guarantee the reliability or suitability of this information, as it is provided as an example. Original data was compiled and manipulated from various sources and may not accurately represent the electric distribution systems as maintained by Greeley. The sample data may be updated, corrected, or otherwise modified without notification.

Modeling electric distribution systems

The object technology at the core of ArcInfo 8 combines data and application behavior modeling. As a result, the ArcGIS model not only includes an essential set of electric device, structure, circuit segment, and customer information feature classes and properties, but it also includes rules and relationships that define object behaviors. The core object technology and applied ArcGIS electric distribution model result in significantly less configuration and customization effort for overall implementation per site.

ELECTRIC DISTRIBUTION

The power delivered by electric utilities is transmitted from generating plants to industrial sites and the substations that distribute power to residential and commercial users; the utility business is thus divided into these two areas: transmission and distribution. Transmission networks connect generators to substations through transmission networks. The distribution system delivers power from substations to residential and commercial users. This book covers the aspects of the electric utility business dealing with distribution.

Distribution represents about 35 percent to 50 percent of a utility's investment. The mission of the utility is to provide power to consumers at an appropriate voltage with a certain degree of reliability. Distribution components typically include:

- Subtransmission circuits with voltage ratings that range between 12.47 and 345 kV
- Distribution substations that convert energy from transmission network levels to lower primary system voltages
- Feeders, or primary circuits, that operate between 4.16 and 34.5 kV and supply load to specific geographic areas
- Distribution transformer typically rated from 10 to 2,500 kVA that transform primary voltage to utilization voltage
- Secondary circuits that carry current from the transformer along the street
- Service drops that carry current from transformers to customer point of utilization

Electric distribution system components

Typical primary overhead distribution systems are operated as radial circuits from the substation outward. In overhead systems, structures such as poles and H-frames support the primary and secondary conductors. Surface structures such as pads enclose and protect electric devices on the ground.

The electric utility infrastructure is also composed of devices such as transformers and fuses and circuit segments such as overhead and underground conductors. These components fall into four general logical categories: circuit segments, structures, devices, and customer and service.

Circuit Segments

This subsystem contains classes and properties that describe the conductors that transmit and distribute electric current. Circuit segments can be categorized as simple or complex edges and objects. The inherent behavior of complex edges is very different in ArcGIS Electric Distribution than the traditional ArcInfo topology model. The ArcGIS Electric Distribution system automatically maintains the relationships between complex edges, any attached devices, and other edges so you can choose how you want to physically segment your network. For instance, it makes sense to physically segment electric lines between fuses and switches since, among other things, it is important to keep circuit data on lines, depending on which side of the fuse they are on.

For example, if you place a fuse on an overhead primary that originally was associated with CircuitID 001, it may be that the overhead primary west of the fuse is part of CircuitID 001, but the overhead primary east of the fuse is now associated with CircuitID 005. At the same time, it is not necessary to physically segment electric line segments at splices.

Once your network is in place and you move an electric line segment, any attached switches, fuses, transformers, and other portions of the network automatically move with it. ArcFM™ determines whether a complex edge should be split based on the type of junction (device) being added. As with most of the subsystems discussed in this document, a common set of properties is defined in a top-level abstract class. All subclasses beneath the abstract class *ElectricComplexEdge* inherit these properties.

Structures

Structure is the abstract class that contains common characteristics, or attributes, for all electric structures involved in the distribution or transmission of electricity. The *Structure* class was created as a general top-level class for any type of facility structure. The subsystem structure contains nonnetwork (nonspatial) features and related objects. You can create associations between a support structure and the Inspection object class to capture information about maintenance, for example. The subsystem structure also includes objects to manage information about the life cycle of a structure.

Devices

Electric devices help ensure consistent service within the distribution network. The device subsystem contains simple junction features and object classes. Device features participate in the network, and objects are the units and controls associated with those devices.

Customer and Service

Residential, commercial, and industrial customers and resellers, as well as special devices such as streetlights, constitute the loads on the electrical system. Simple junction features are the electric locations (for example, primary meters and service points). Objects contain customer information and information about generators of alternate sources of electricity. Primary meters, delivery points, and generators may be associated with a structure.

Design discussion

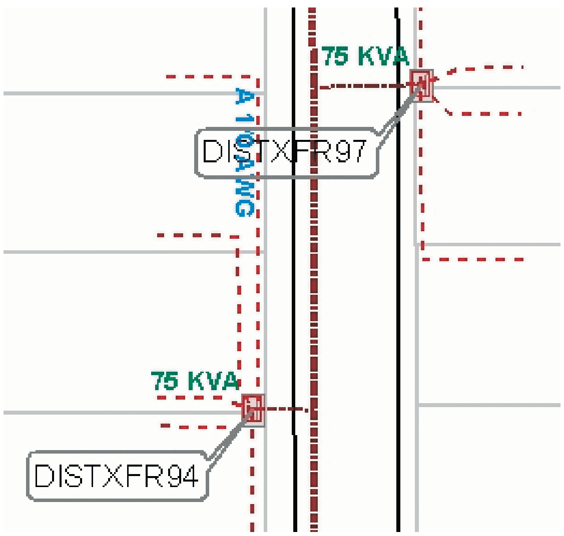
Electric distribution modeling requires considering facilities as assets

One benefit of GIS technology is that utilities can track their assets by geographic location. Network assets, like most other infrastructure owned by businesses, can be depreciated for tax accounting purposes. The specific amount of depreciation allowed depends on the original value of the equipment, how long the facilities have been in place, and the tax boundary area that facilities are located in. Having an accurate record of facilities managed with a GIS provides a more accurate inventory of existing facilities and an automated way to maintain these records as a by-product of map maintenance activities. From a GIS system design standpoint, it is important to understand how the location of physical equipment (i.e., a conduit) can be considered differently from an asset management standpoint, depending on how many ducts, conductors, or cables it may contain. You should consider asset management for your geodatabase design and any special rules that your utility may have for asset management.

Design discussion

Devices are often moved to different locations during their life span.

During the lifetime of a particular transformer or switch, the individual piece of network equipment may be installed in one location, only to be removed and stored in a truck or warehouse for a period of time. This process can be repeated for the same piece of equipment several times during its useful lifetime. From an asset management standpoint, an accurate accounting for depreciation purposes is important. It is also important to continue to link historical maintenance, repair, and inspection data to understand when the equipment has reached the end of its reliability curve.



Section of transformer placement job sketch (source: map sketch created for Arizona Public Service Co. by Miner & Miner, Consulting Engineers, Inc.)