# Chapter 1
## From legacy to breakthrough

**On the afternoon before the first day at his new job, Ron heard the forecast on the radio—50 percent chance of** high winds and lightning. A storm might be brewing. He felt both concern for and curiosity about his new employer, AnyTown Energy. How would this utility company handle it? He was to start work the next morning as their GIS manager, to implement a software system particularly adept at crisis management. So he wondered what processes were already in place for decision making around an impending storm, one of a utility's biggest challenges. A storm could do the kind of damage that fells trees, downs power lines, and blacks out whole neighborhoods. With just a skeleton crew, it would take forever to get the power back on. Yet, what if the storm didn't come, and the company was left with the costs of keeping a full crew on overtime?

Just to observe, he drove to the outlying area where the utility's service center was located and parked outside the gate, out of the way of the line trucks rolling by yet close enough to witness the chaos around a long platform. One man was standing on it, clearly the leader, still as a stone while all around him swirled. Then suddenly his voice boomed out an order, causing the bustling workers to stop dead in their tracks.

The boss began directing one group after another, and steadily parts of the throng peeled off and headed back to their trucks and then out of the gate in various directions. Obviously, everybody out there looked to the boss for their instructions, but where was this man getting *his* information from? On what was he basing his decisions? It seemed obvious to Ron that he was directing many of his workers to be prepared to work an extra shift. Knowing whether to keep crews on overtime or to send them home was one thing, but how did he know *where* to send the crews? For that, you have to know what part of the electric network is particularly vulnerable and likely to fail if hit hard by heavy winds. These must be important moments for a utility company, Ron thought. Whether it's overtime pay or the utilitys reputation at stake, such judgment calls on emergencies such as extreme weather conditions can make or break you as a foreman. The tough leader wasn't looking at a cell phone but appeared as if he were going by gut feeling. But the right thing to do doesn't just come out of thin air, does it?

That night, the news reported power outages from the storm, which meant that the boss on the platform was spot on. He'd made the right choice to keep his workers on hand to help in case the power failed. But did he send his people to the right places, equipped for the right repairs? How long would it take to get the electricity restored? On whose desk would the stack of public complaints be found at the corporate offices in the morning? Ron resolved to get a reading on all this as soon as possible, and to find a way to talk with that man who was directing from the platform.

## Orientation

The next morning, while riding the elevator up to the corporate offices for his orientation meeting as the company's new GIS manager, Ron reviewed in his mind what he'd already researched. For years, AnyTown Energy had been content to be a middle-of-the-pack utility in the region, neither outstanding nor poorly rated. The company earned investors a stable return, and its stock price kept pace with the industry average. However, energy prices and customer demands for service were increasing, the infrastructure was deteriorating, and a flurry of skilled workers were coming due for retirement (one of them, Ron found out later, was the man directing crews during the previous day's storm, Stanley, an operations manager). In addition, AnyTown Energy's customer satisfaction ratings had tanked. Several embarrassing safety audits, an increase in motor vehicle accidents, and lower reliability had attracted unwelcome media attention.

AnyTown Energy was below average in nearly every category of a utility's benchmarks. Ron figured that, like most companies, it had probably retained tried-and-true processes that had served it in the past but that were too cumbersome for today's challenging environment. He knew the CEO must be worried—the board of directors was demanding improvements. After assessing operations, a top management consultant had recommended an enterprise GIS, an information system that turns data into knowledge throughout an organization. A geographic information system for the enterprise meant a GIS integrated for use by a large number of people, sharing and using spatial data and related information to perform analyses and to address many and various needs.

By successfully implementing the GIS in electric distribution, its largest division, along with other recommendations, AnyTown Energy expected its benchmark ratings to be positive once again within two years and trending toward its best-ever performance. It was up to Ron, building on the consultant's strong business case for it, to model an enterprise GIS that would improve the utility's most important workflows and functions. AnyTown Energy's enterprise GIS would be integrated with the company's other new information systems, such as its new enterprise asset management (EAM) system, which tracks all the distribution equipment characteristics; its supervisory control and data acquisition (SCADA) system, which provides for real-time control of the power system; and anything else that came along, to make the best of all the data and functions these systems had or were linked to.

During this period, the company was also to embark on implementing a smart grid, allowing for greater automation, control, and monitoring of and by the electric utility. Ron knew from past experience that an enterprise GIS was not only critical for improving overall effectiveness throughout an organization, but also essential for a successful smart grid implementation.

The company saw the need for a GIS, justifying it based on sound economics and operating metrics. Now it was time for Ron to figure out exactly how to lay the groundwork for a real return on the company's investment. He had about two months to devise a plan, which would take about two years to implement. He had done this before, but in county government, not for a utility. The question on his mind was, What are the practical ways to build a GIS for electric distribution? The endeavor he would be investigating intensely in the weeks ahead was how to do this for AnyTown Energy.

*The first step before action is to create a model in your head*, Ron thought as he stepped off the elevator at the highest floor, the corporate offices. To set the stage for implementation, Ron's first deliverable as AnyTown Energy's new GIS manager would be a design for a GIS model that would connect every department with accurate information. He knew what a GIS could do: it could help integrate processes and workflows, even in the most diverse of business landscapes. But he did not know whether even the chief information officer (CIO), his new boss, really understood all that a GIS could do. Many CIOs don't. *Well, I'll educate them*, Ron thought, *but maybe not on the first day.* His mind kept returning to the scene he had witnessed yesterday, with the warehouse and the trucks and the smell of oil and diesel fuel amidst the bustling strangers inside a chain-link fence. It appeared to be nothing but confusion, but somehow it worked. *But how?* It made Ron realize that before educating them, he would need to educate himself on the complexities of an electric distribution utility.

## Current perceptions

At Ron's orientation meeting with middle managers, the vice president of electric operations was there to represent upper management in emphasizing that the company was fully behind the implementation of an enterprise GIS. Ron could tell that not everyone around the conference table really believed anything would change all that much. After all, things were working just fine, most were thinking, and they were making progress in nearly all areas of the company. Oh sure, there were problems, but nothing they couldn't handle. The general opinion was, regardless of the new GIS, we will handle the big things, as we've always done.

Ron posed a simple question: "What is the single most important challenge facing AnyTown Energy?" The responses of those in the room fit into one or more of the following five categories:

- Senior management is out of touch with how things really work in the trenches.
- Data is out of date, and senior management doesn't want to spend the money to keep it up to date.
- Senior management keeps reducing the staff, but they don't know what's falling through the cracks.
- There is too much interference from outside parties, such as environmental agencies and the public utilities commission.
- Senior management doesn't appreciate the progress we've made—they are never satisfied.

Ron felt uneasy. None of them had cited any of the problems facing the electric distribution industry as a whole, such as how to meet a demand that might double in a decade, or how to increase customer service while reducing costs, or how to replace a workforce that will be retiring in droves. A lot of institutional knowledge could be lost with the exodus of so much hands-on experience, Ron thought to himself, knowing that accurate, up-to-date information would be crucial to the database underlying the GIS he envisioned.

As proof that the company was really making progress, one manager at the table used the example of her department's work in redefining the new customer connection process. They had shortened the time from when customers called for a new service to when they got service from 12 weeks on average to eight weeks. To do that, they'd substituted faxes for mail deliveries, cut out several approval steps, did cost estimating in the field, and scanned in the subdivision plans from the developer instead of redrawing them in their digital mapping system. There was a little round of applause in the room for this new, shortened customer connection process.

"I apologize for not knowing the business well enough yet to answer this question myself," said Ron, "but, may I ask, why can't you put the new service in the same day as the customer requests it? Why does it take eight weeks?" The answer he got was essentially, *You are just like senior management—you don't know how things are in the trenches*.

## Progress or quantum leap?

After the meeting, the vice president of electric operations offered some advice: "I've got just the person to help you get up to speed—my assistant, Flo. She could give you a real orientation to what this business is all about. She knows something about everything around here *and* in the trenches." And with that, Ron was introduced to Flo.

Ron described to her the meeting he'd just had and the exchange they'd had about the new customer connection process. "What I was getting at was that with GIS you can actually achieve a breakthrough, not just progress," Ron explained. "Some of the folks thought improving a process from 12 to eight weeks was fine, but how about going from 12 weeks to an hour? Now that would be a breakthrough." He was already imagining his role as not just implementing GIS, but of pulling their heads out of the trenches and actually transforming the way the company looked at its work. The GIS would be a fully integrated information system that would be an integral part of nearly every process in the company. An enterprise GIS would not only make the company's processes work better, but it would also prepare the company for the future.

Flo listened patiently, finding his idealism refreshing. "Progress is improving on past accomplishments. A breakthrough is busting away from them," Ron said. "Progress is gradual; breakthroughs are quantum leaps, like going from 12-weeks to one-hour turnaround time. Breakthroughs require new knowledge, seeing things in a different way and visualizing a new paradigm. Progress improves a process—a breakthrough revolutionizes the business.

"There is nothing wrong with progress," Ron continued. "All businesses must improve their current operations, gradually tweaking processes and building new tools and facilities. Occasionally, new technology arrives that has the potential to significantly alter how a business operates. GIS is one of those technologies. With its main output in the form of a map that, with GIS analysis functions, can virtually be asked questions, GIS enables almost instantaneous visualization of problems and their solutions. So why not discover what this company can do out from under the confines of outmoded data and old thinking? The challenge for utilities is first to recognize that GIS can enable breakthrough improvement, and second, to set aside the legacy that limits breakthroughs to just progress."

But Flo was one step ahead of him, or maybe two steps back. "Do you know why it is so tough to shed legacy processes and thinking?" she asked. "Legacy processes are the ones that worked well once and now are so entrenched in the business that few can even see that they are obsolete," she said. "Middle managers at AnyTown Energy think that senior management doesn't understand their problems, yet they themselves are so comfortable with a system that's worked so well for so long that it's inconceivable that anything so radically different could work."

"Exactly. That's why it takes a *breakthrough* technology like GIS. In fact, GIS allows utilities to see patterns that no other technology can provide." Ron pulled something out of a folder in his briefcase to show her—a diagram illustrating the vision of using GIS at a utility. It was the diagram he had used in the interview that had gotten him the job ( figure 1.1). "A GIS should be a fully integrated information system used as an integral part of nearly every process in the company," Ron said. "GIS can both develop and identify patterns, and the decisions that result are fresh and reflect the latest situations."


**Figure 1.1** An enterprise GIS is an integrated information system. Esri.

"I'll take your word for it for now," she said finally. "But before you can expect anyone else to, I've got something for you to do."

Flo took him into her office, going straight to the bookshelves against the wall. “Look, it’s great that you’re turned toward the future and not the past,” she said. “Underneath all the attitude you might see around here, we all know that although tough today, the challenges ahead for utilities will be much tougher tomorrow. Your challenge now, however, is to get to know the business as well as you know GIS.”

With a background in GIS, Ron came from a local government that managed millions of pieces of spatial information, so he was fully aware of how to deal with volumes of spatial data. He knew how to use GIS for spatial analysis, how to collect spatially referenced data in the field, and how to create great web maps. He thought he could tackle Flo’s books on the electric business just fine.

The company’s plan was to eventually implement GIS in all divisions but to first roll out the enterprise GIS for electric distribution only. Ron wanted to get it up and running so he could demonstrate its benefits. Then he would focus on the other parts of the business. The payoff would be greatest in electric distribution, and because the new smart grid initiative was focused most heavily there, this decision made sense. But before he could implement the GIS, Flo was right: he needed to know a lot more about the electric distribution network—how it works, its challenges, and the opportunities for improvement.

## What the future holds for electric utilities

Hitting the books Flo loaned him and surfing the web over the next few days, Ron discovered that the challenge for him in learning about the electric distribution network was nothing compared with the challenges confronting electric distribution itself. In 2010, US consumers used nearly four trillion kilowatt-hours (kWh) of electricity (see Ron’s notes on measuring electricity). Worldwide electric demand stands at around 16 trillion kWh. It may top 30 trillion kWh by 2025. That energy cost an average of eight to 12 cents per kilowatt-hour in 2010. This means that Americans spend about half a trillion dollars on electricity a year. That’s big bucks.

Ron began taking notes; in fact, he began a notebook he could take with him everywhere on the job (see sidebars throughout the book and the appendix, “Basics of electric power”).

### The prospect of overload

Ron noted that in 2010 US drivers used 400 million gallons of gasoline a day. At a price of about four dollars per gallon, Americans spent virtually the same for gasoline as they did for electricity, about half a trillion dollars, give or take a billion or two. What would happen if consumers suddenly converted from gasoline to electric or plug-in hybrid vehicles?

A gallon of gasoline has the energy content of about 36 kWh. Suppose a typical automobile has about 25 percent efficiency, as compared with 65 percent efficiency for electric vehicles. This would require 12 kWh of electric vehicle use to offset every gallon of gasoline used in a conventional vehicle. In the extreme scenario of everybody switching from gasoline to electric, the nation’s electric utilities would have to provide

Ron's notes

## Measuring electricity

A kilowatt-hour, abbreviated kWh, is the standard measure of electric energy worldwide. The *k* is the standard International System of Units (SI) unit of 1,000. The *W* is the abbreviation for "watt," again a worldwide standard for the measure of power, normally electric power. The *h* is an abbreviation for hour. Power can be thought of as the strength of an energy-producing or energy-consuming device, such as a light bulb or an automobile engine. The power rating of a light bulb determines the brightness of the light at any given moment in time. The power rating of an automobile in the United States is in horsepower, but elsewhere it is common to measure it in kilowatts. Energy is the delivery of power over a period of time. A standard 100-watt (W) light bulb running for 10 hours uses 1 kWh--1,000 watts per hour. (See the appendix for a more in-depth discussion of the fundamentals of electricity and power.)

nearly 5 billion kWh of electricity *each day* to meet the fuel needs of vehicles. That means utilities would have to deliver an additional 2 trillion kWh of electricity per year. That's half again more energy than utilities in the United States currently produce.

To put this in perspective, 2 trillion kWh of additional electricity use per year would require utilities to build maybe an additional 20,000 megawatts (MW) of generating capacity to meet this demand, assuming standard usage patterns. Alternatively, the industry could add 100,000 MW of solar energy, thought Ron. The additional solar capacity would be needed because solar-powered systems can produce only about a quarter of their capacity because of their variable nature. (When a cloud passes over the solar unit, the output can drop off rapidly.) Solar energy is extremely land intensive, too: at today's current rate of commercial photovoltaic solar technology, this generating capacity would require a solar panel surface size somewhere between the land area of Delaware and Connecticut. (That's a lot of solar panels.)

### Demands on electric distribution

Ron noted that although most people would worry about how to actually *generate* that much electricity, the *delivery* of that extra energy would put an outrageous demand on the delivery system, specifically the electric distribution network. The demands on this delivery system would be severe—the electric distribution network wasn't designed to power electric vehicles. Even if the electric vehicles were all to be charged at night, that load alone would overload most residential transformers (see Ron's notes on the next page on the impact of electric vehicles).

## Ron's notes

### Electric vehicles' impact on the distribution network

What kind of demand would an electric car actually have on the distribution network? Today's electric vehicles are powered by a large bank of batteries. The ratings of these car battery systems are in kilowatt-hours. A typical rating for an all-electric vehicle (as compared to a plug-in hybrid) battery is around 20 to 25 kWh. This produces enough storage for a driving range of about 75 to 100 miles, depending on the weight of the vehicle. The demand at any given time is equal to the rating in kilowatt-hours divided by the time it takes to fully charge. A 25 kWh battery that takes 20 hours to charge has an electric demand of 25 divided by 20, or 1.25 kW. The demand goes up as the time to charge goes down. So if it only takes five hours to charge using a higher-voltage receptacle such as a US 240-volt (V) plug, the demand jumps to 5 kW. Shorter charge times will only be possible with special charging stations, but the math is the same: the shorter the charging time, the greater the demand. To put this in perspective, 5 kW is about the demand for a 3.5- to 4-ton air conditioner, depending on its efficiency. If five or six electric cars were charged at the same time in a typical subdivision in the United States, the local electric grid could become seriously overloaded.

Should a breakthrough in battery technology occur any time soon, the switch to all-electric vehicles could come very quickly. A breakthrough in electric storage technology might not even involve batteries. Some companies are looking at high-capacity capacitors, or supercapacitors, that allow for fast charging and large storage capacities. A technology may even evolve with vehicle charging-in-motion systems in which electric vehicles may not even require large batteries but rather be charged while on the road using some form of wireless electricity (such as electromagnetic induction systems). In any case, electric distribution will be challenged to the core.

The new world of the electrification of transportation will severely challenge electric distribution networks, Ron thought. Suppose electric cars were to be used to *supply* electricity to the grid, as has been suggested, and not just *consume* electricity—this, too, would complicate and tax the current distribution network considerably. The US power delivery system is already heavily loaded at the current levels of demand, despite a short-term dip because of the global financial crisis. If this additional load for transportation were to materialize quickly, every piece of electric distribution equipment would be required to deliver significantly more energy than it currently does today.

Even without this new transportation load, normal load growth is going to stress the world's current distribution networks, Ron realized. If electric alternatives were developed for diesel-powered vehicles such as trucks and buses, the trauma to the networks would be even worse. Further, there is considerable interest in the expansion of the rail system, particularly for high-speed passenger rail. High-speed rail systems are electric. Finally, the United States is completely dependent on fuel oil for its freight rail system. This system, too, could be migrated to electric and further increase the burden.

Ron put down his pencil to rub his eyes. Most people would argue that the United States won't suddenly make the switch to electric vehicles, buses, trolley cars, or freight trains. However, given the high price of gasoline and the wisdom of reducing carbon emissions, it is likely that electricity will play a larger and larger role in transportation in the future.

The upshot, if any of these situations come to pass, he realized, is that the electric system will need to deliver significantly more energy than it does today, maybe twice as much, in a relatively short period of time. Conventional electric distribution utility accounting, financing, planning, design, engineering, and operations processes will need to adjust to be able to handle it.

## A century-old network under stress

Ron knocked on Flo's office door a few days later to return some books and thank her for their glimpse into the future. "Energy is the delivery of power over time," he said proudly. It was his favorite concept, unearthed during his time poring over the books, but apparently it was not what Flo had had in mind. She looked stern. "Oh, and just to put things in perspective," he added for her benefit, "in a relatively short period of time, we could be looking at double the demand on electric utilities."

"Increased demand is not the only challenge facing electric distribution operators," said Flo. "Increased demand is an issue," she began, "but what about the infrastructure? What does it tell you that most electric equipment, wire, and cable manufacturers are reluctant to warranty their products beyond 25 years? Significant parts of the electric distribution network have been in service well over 25 years. In a recent press conference after a lengthy power outage, one major US city official held up a piece of cable stating it was more than 70 years old. No one really knows exactly how old the US electric distribution system is. Although even the older systems have performed well to date, no one knows what will happen to them under ever-increasing stress.

"Back in 2009, the US Bureau of Labor Statistics stated that the average age of the utility worker exceeds the average age of workers in general and stands at nearly 45. Within the next several years, a large percentage of staff, including our staff here at AnyTown Energy, will reach retirement age. Once these seasoned employees leave, important information about the condition, location, performance, and nuances of the electric distribution components will be lost forever. Although utilities are doing a much better job of capturing asset information digitally, that record keeping is still incomplete. One Midwestern US utility reported that it does not have a good sense of the number of poles it has. A well-respected, forward-thinking utility in South America is planning to inventory its entire electric network—because it has no confidence in the accumulated record systems it currently maintains."

Flo looked worried. "When my generation retires—or even when the younger, experienced employees leave to take other jobs—knowledge of how the network responds under stress will be lost."

**Figure 1.2** Documenting a distribution network can be difficult. Photo by Brent Jones, courtesy of Esri.

Ron found himself wondering whether anyone, retired or not, would ever be able to untangle the logic behind some of the overhead wiring configurations he'd seen ( figure 1.2.), and then said out loud, "What's going to happen when they try to build a smart grid—and they have no idea where some of their old equipment is located? They will not be able to automate a grid without precise information about where everything is, what its characteristics are, and what shape it's in. A smart grid automated system won't be very smart without good data. It is not just about the data either. It's about a system's behavior and relationship to the environment and community. These things aren't easily documented."

This obviously hit a note with Flo. "More and more, regulators of electric utilities require us to provide documentation on our finances, service quality, safety records, employee training, operations, risks, environmental activities, carbon footprint, and who knows what else. Tolerance is extremely low for environmental mistakes, electrocuted dogs, accidents, pollution, billing errors, traffic impacts, explosions, construction delays, and other community impacts from electric equipment and utility work and whatnot. Reliability standards continue to get tougher; meanwhile, the network gets older. And if that's not a prescription for a downward spiral, I don't know what is. So we utilities will probably be spending more and more time responding to audits and monitoring of our compliance."

"GIS can do something about that," Ron ventured.

"I know that, or at least I believe you know that—why do you think I'm hammering away at you about these things?"

Ron smiled for the first time since he'd gotten there. He had an ally. "You know, looking at the future, I'm thinking that as local forms of electric generation continue to become more affordable, customers will add them at an ever-increasing rate," he said. "These private solar, wind, and small gas generators will need to be synchronized with the electric grid, complicating the management and operation of the distribution network even more."

"And keep in mind," added Flo, "although local generation might relieve parts of the distribution network, it may also lead to localized increased loading on the lines, which were really not designed to carry both load and generation."

Flo noticed the puzzled look on Ron's face. "Okay, I see you haven't gotten to that part of your self-study course yet. I think you've had enough thrown at you today, or from me anyway. Next week, why not go over and talk to Stanley to get a sense of how it is in the field? And then talk to Frank. He's in charge of our old digital mapping system, called AnyTown Map. The one you are replacing with the GIS."

## Electrical losses

Ron got his second wind after leaving Flo's office. All that week his mind kept returning to the list of problems defined by the middle managers in his first corporate meeting. The challenges were real, situational, external—even global—not just internal sour grapes and the age-old push and pull between upper and middle management. He decided to produce a list that defined the problems in a way that illuminated possible solutions. For that, he needed more perspective, and that meant more information and more research. Ron spent the weekend doing more study, highlighting utility issues that put a drain on the bottom line. He added to his notebook *Electric losses*, struck by the idea that a network that gives electricity could somehow lose it along the way. This is what he discovered in his research and in discussions with Flo:

Electric distribution networks themselves generate waste, or a loss in energy, measured in kilowatt-hours. This is especially true during times of heavy loads: as the network becomes more loaded, losses increase. These losses are called "technical losses." Losses on the distribution network can be as high as 6 percent of the total energy delivered. The other kind of loss is often called "nontechnical loss," which is a polite way of saying theft of electricity. Technical losses in the form of line losses represent a large portion of energy (and thus carbon generation, in that electricity is generated using some form of carbon generation). In some parts of the world, theft of electricity represents a significant loss to the utility and presumably unaccounted-for carbon generation, sometimes in the range of 20–30 percent, or even higher. They need to use GIS to figure out exactly where the problem is most severe, Ron concluded.

Electric distribution operators themselves rely heavily on energy to operate. Line trucks, bucket trucks, diggers, cable trucks—all kinds of heavy-duty vehicles consume a lot of diesel fuel. Utility company buildings, along with service centers (like the one Ron visited the stormy afternoon before his first day at work), require large amounts of energy. Utilities rely on big computer operations that also consume energy. A majority of the utility staff drive around the network, consuming energy. As providers of energy, utilities are also big consumers of energy. Although the amount of carbon dioxide they generate from their operations pales in comparison to the carbon they generate and release, it still represents a significant issue for utilities. The carbon footprint of an electric distribution company is worth noting.

### Change management for customers

Distribution operators, as opposed to transmission and generation operators, deal directly with consumers. Modern consumers, with their Internet surfing, online banking, text messaging, Tweeting, and blogging, are different from the consumers of 20 years ago. They are not as tolerant of estimated bills, busy signals, manual ordering, long wait times, or loss of electricity to their computers. Surges and dips that fry hard drives are unacceptable.

Sure, smart grid technology will transform the business. However, the transition from where the electric distribution network is today to the smart grid of tomorrow will take years and billions of dollars. That transition will be tough from financial, technical, and change-management perspectives, Ron thought.

Consumers want high service quality, the ability to use as much power as they need or want, and high-tech customer service. And they want it at a reasonable cost. Utilities need to provide all this while their already old infrastructure continues to age, experienced workers leave, and the price of everything continues to rise. Utilities that are traded on the world's stock exchanges need to do it all while meeting their shareholders' expectations. Finally, they need to do it in an era of increasing regulatory oversight and control. Carbon cap-and-trade policies are starting to appear in various places around the world, which adds an additional layer of accountability, transparency, and data awareness (see Ron's notes on carbon cap and trade).

## Challenges ahead for AnyTown Energy

Reviewing in his notes the challenges facing electric utilities in general and those he discussed with Flo, Ron had no doubt that the challenges facing AnyTown Energy were huge. No wonder senior management had approved an enterprise GIS. Simply improving on their current practices would not lead them to where they needed to be. Such challenges required new thinking and informed decision making, both of which GIS spatial analysis could enable. Summarizing the challenges facing AnyTown Energy in a list, Ron found them to be the same as those for the electric distribution business as a whole. Among them:

- Significant increases in electricity usage are likely over the next decade.
- The infrastructure is already very old; replacing even a significant part of it quickly is probably not an option.
- Utility workers are aging, and when they retire will take with them their knowledge of network behavior, which amounts to much of the undocumented aspects of the network.
- Customers will demand better and better service, their expectations rising with the ease of their online web experiences.
- Utilities are squeezed for money.

Ron's notes

## Carbon cap and trade

Cap and trade is a policy system designed to gradually lower perceived bad behavior (usually environmental). Because greenhouse gases (including carbon) contribute to climate change, emitting carbon dioxide (or simply carbon) is considered bad behavior. A carbon cap-and-trade system works like this: A cap for carbon emissions is set over a particular region (e.g., the world, a country, a state). Carbon emissions are commonly measured in metric tons (1,000 kilograms [kg]) per year. The idea is to ratchet that number down over a period of years. So each year the cap is reduced by a certain percentage, and all participants in the system have to reduce their emissions by that percentage by whatever means they can--or fail and be fined.

This can be accomplished in three ways. First, participants can actually reduce emissions, such as by retiring old plants or retrofitting them with new equipment to reduce emissions. Second, they can offset the emissions by doing something else, such as planting trees to equal the amount of carbon they have not reduced. Third, they can trade; that is, buy carbon credits from someone who has reduced their emissions more than the required cap. In effect, a market is established for trading carbon credits. If a company doesn't change its bad behavior, it can buy good behavior from another company.

- Raising rates is possible, but it can be politically risky, especially during a hard economy and high unemployment.
- Security, both physical and cyber, continues to be an issue.

Of course, not even Ron believed that just implementing an enterprise GIS would make all these problems go away. However, Ron was confident that a GIS could provide a way to see things as they really are, to use metrics and information to solve problems, and to supplement gut feelings with real data. He knew that GIS was not just part of the solution, it would also help guide AnyTown Energy in approaching the challenges and understanding what they were.

### Discovering comprehensive solutions

The complexity and severity of these demands will only continue to increase, Ron knew, and it will take solutions that are out of the norm. What electric utilities like AnyTown Energy will need is more knowledge and awareness of the situation, more comprehensive approaches to the challenges they face, and solutions that consider and account for the impact of their actions to help guide them to a balanced approach to their business. Enterprise GIS integrated into the mainstream information architecture provides a comprehensive way to give utilities greater insight, Ron thought with a smile. It helps them make decisions by providing a spatial dimension to their analysis that numbers in tables lack. The electric distribution network is spatial—its assets, its workers, its communities, its carbon use, and its customers. GIS is about discovery—most notably, discovery of spatial relationships—and by providing visuals as a series of information layers, GIS can help utilities better understand their mission (figure 1.3).

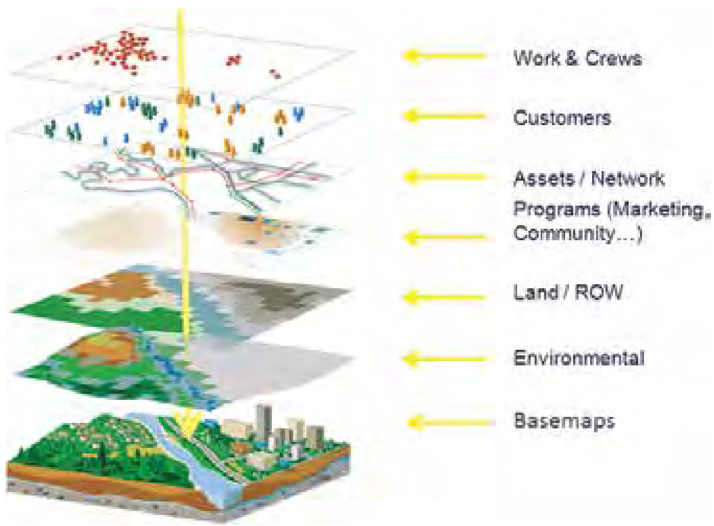


**Figure 1.3** GIS is more than just documenting the electric network. Esri.

Ron recognized that the industry faces serious challenges and that things have to change in a dramatic way. Clearly, GIS won't provide additional sources of energy, nor will it directly reduce the carbon footprint of a utility. What it will do is provide an organized framework for decision making, collaboration, and communication among people, assets, and processes. It will allow all levels of the company to understand the world around them. GIS adds the spatial dimension to decision making, so utilities know where customers are adding their solar panels and TVs, what areas of the network are at higher risk, how to prioritize replacement of assets, and how the condition of assets relates to the risks. Enterprise GIS provides the answers to such critical questions as, where are the places in my infrastructure where a single event could take the network down?

AnyTown Energy must rely more on solid data management, spatial analytics, fast processing from the field to the office, and the ability to see the big picture, Ron thought, and this will come most effectively in the form of a map. GIS provides the model of the utility network. It captures the inventory, location, and condition of all the utility assets, including the new sensor networks and smart meters. It shows the relationship of these assets to each other and to their surroundings. GIS provides a visualization of the impact of utility decisions. Because nearly every process utilities perform involves location in some way, GIS will form the foundation of the electric distribution smart grid. Even simple things such as streetlight information can have a big impact on service, and this can be shown on a map ( figure 1.4).


**Figure 1.4** Modern application of web GIS for reporting streetlight outages. Data courtesy of City of Westerville, Ohio.

Just as he did when he was first being considered for the job, Ron read through the consultant's report and senior management's recommendations for implementing an enterprise GIS, again thinking how on target it was: GIS is more than just a data repository that feeds network data into information systems such as a distribution management system (DMS), a SCADA, or the smart grid. GIS will enable utilities to discover the real patterns leading to solutions. Using GIS spatial analysis, GIS specialists like Ron, as well as forward-thinking executives, can follow the "arrows" pointing to breakthroughs for a business. All the way from corporate policy makers to distribution operators, an enterprise GIS could guide AnyTown Energy to solving the most important problems first.

Ron felt that he had solved his own most important problem first—getting a sense of the problems of the average utility so he could help transform AnyTown Energy into the utility of the future. It was going to be tough, but Ron had done this before, not for a utility but for a county government. As long as the company was prepared for the scope of an enterprise GIS project and willing to fund it, Ron was confident it would be successful.

Step by step, he would build an enterprise GIS for electric distribution that the utility could rely on to resolve the problems stemming from poor data management. Along the way to designing a GIS-based data management system, and the extensive field research it required, he would engage the help of people in the company who were interested in joining the effort and becoming part of the enterprise GIS project team. In one month, AnyTown Energy's GIS steering committee would be expecting his interim report, at which time he planned to ask for some colleagues to be assigned to his project. Already, he hoped that Flo would want to be among them.

After that, he'd have another month with their help to finish his two-year implementation plan, along with his information model. The model—the design he would eventually formulate—would need to be based on the real world of the utility. Ron knew what a GIS of the enterprise consisted of, but the one AnyTown Energy needed would not take shape in his mind until he knew a lot more about how the company worked, and that he would find out about firsthand in the weeks ahead.