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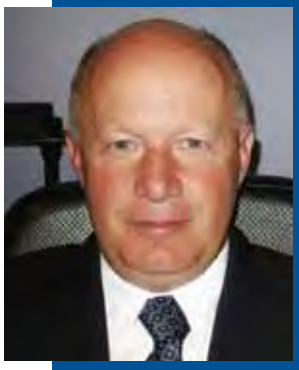

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Mr. Macaluso has more than 20 years experience in the electricity industry. As the CEO of the EDA, Mr. Macaluso spearheaded the reform of the EDA to meet the emerging competitive electricity marketplace, and positioned the EDA as the voice of Ontario's local electricity distributors, the publicly and privately owned companies that safely and reliably deliver electricity to over four million Ontario homes, businesses, and public institutions.

SCOTT ROUSE, Managing Partner, Energy @ Work

Scott Rouse is a strong advocate for proactive energy solutions. He has achieved North American recognition for developing an energy efficiency program that won Canadian and US EPA Climate Protection Awards through practical and proven solutions. As a published author, Scott has been called to be a keynote speaker across the continent for numerous organizations including the ACEEE, IEEE, EPRI, and Combustion Canada. Scott is a founding chair of Canada's Energy Manager network and is a professional engineer, holds an M.B.A. and is also a Certified Energy Manager.

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David W. Moncur has 29 years of electrical maintenance experience ranging from high voltage installations to CNC computer applications, and has conducted an analysis of more than 60,000 various electrical failures involving all types and manner of equipment. Mr. Moncur has chaired a Canadian Standards Association committee and the EASA Ontario Chapter CSA Liaison Committee, and is a Past President of the Windsor Construction Association.

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Mr. McDonald, P.E., is Senior Principal Consultant and Director of Automation, Reliability and Asset Management for KEMA, Inc. He is President-Elect of the IEEE Power Engineering Society (PES), Immediate Past Chair of the IEEE PES Substations Committee, and an IEEE Fellow.

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Dearest Friends and Utility Family: Thank you for all the flowers, phone calls, prayers and support. You are a true reflection of what Butch lived, loved and believed in. He treated people as the most important thing. He valued relationships more than money, recognition or accolades. Butch was passionate about teaching, faithful to family and devoted to God. He lived a life full of laughter, generosity and love.

We will always remember – and smile.

In loving memory: CZAR Inc. Staff, Family and Friends

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UNINTERRUPTIBLE POWER DOWN TO THE MILLISECOND

By Don Horne

The need to maintain a steady flow of power throughout the grid to industrial, commercial and residential consumers is a basic tenet for every utility.

This holds especially true for the industrial and commercial sectors, where a loss of power can quickly mean thousands and hundreds of thousands of dollars down the drain due to disrupted production lines and spoilage.

The recent spate of heat waves coupled with highly destructive storms has placed incredible pressures on grids from the Pacific to the Atlantic, creating brownouts, blackouts and repeated appeals for conservation from North American energy distributors.

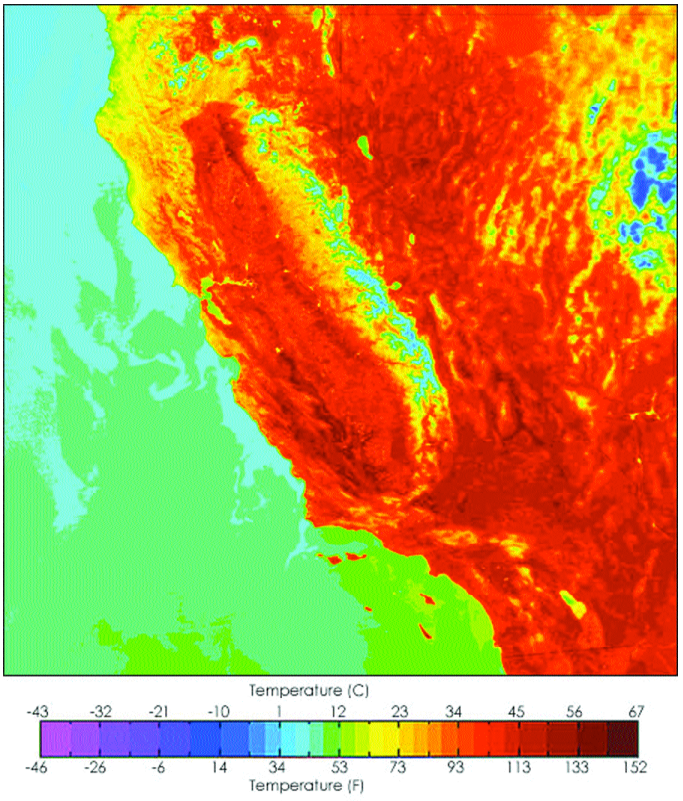
The summer of 2006 has even spawned some innovative thinking to ease pressure on the grid, like Anaheim's Public Utility efforts to back a program encouraging people to add on a device that makes ice during off-peak hours at night to help HVAC systems keep cool during the day.

The $21,000 rebate plus reduced electricity rates are the carrot to keep California's skyrocketing cooling costs within the realm of reality.

And for California's Silicon Valley, a steady flow of electricity is mandatory.

The definition of what constitutes a disruption of power can be razor thin for high-tech companies whose lifespan can be literally measured in milliseconds.

A microchip fabricator cannot go without power for more than 100 milliseconds, and it is precisely just that type of industry every municipality is striving to attract.



NASA satellite images of the heatwave that hit California

Silicon chip industries draw a well-educated, affluent workforce – precisely what local governments look for in their residents come tax time. A highly paid, well-educated citizenry usually translates into less crime, and that means smaller police forces and, in turn, smaller budgets.

For upstate New York, eight years of lobbying and relentless planning has paid off in the form of computer chip manufacturer Advanced Micro Devices Inc. (AMD) agreeing to locate in Saratoga County. Great news, considering that area of the state had been witness to a loss in manufacturing jobs totaling 33 per cent in just the last decade.

The deal was predicated on the local utility, National Grid, guaranteeing an uninterrupted, stable flow of power to the company – 100 megawatts to be precise – necessitating the construction of a new substation and four new transmission lines.

Aging infrastructure is the Achilles' heel of North American utilities. With every leap in technology, it has been built on the back of a transmission and distribution network constructed (in many cases) 30 years ago. The leading edge robotics, computers and engineering systems are all shackled by their thirst for power, and that power must come from systems designed many generations before.

For Niagara Mohawk and National Grid, it was an eight-year journey to bring AMD to upstate New York. Many other regions and municipalities could take a page from their book and understand that the way to prosperity is paved with power – guaranteed, stable electrical power.

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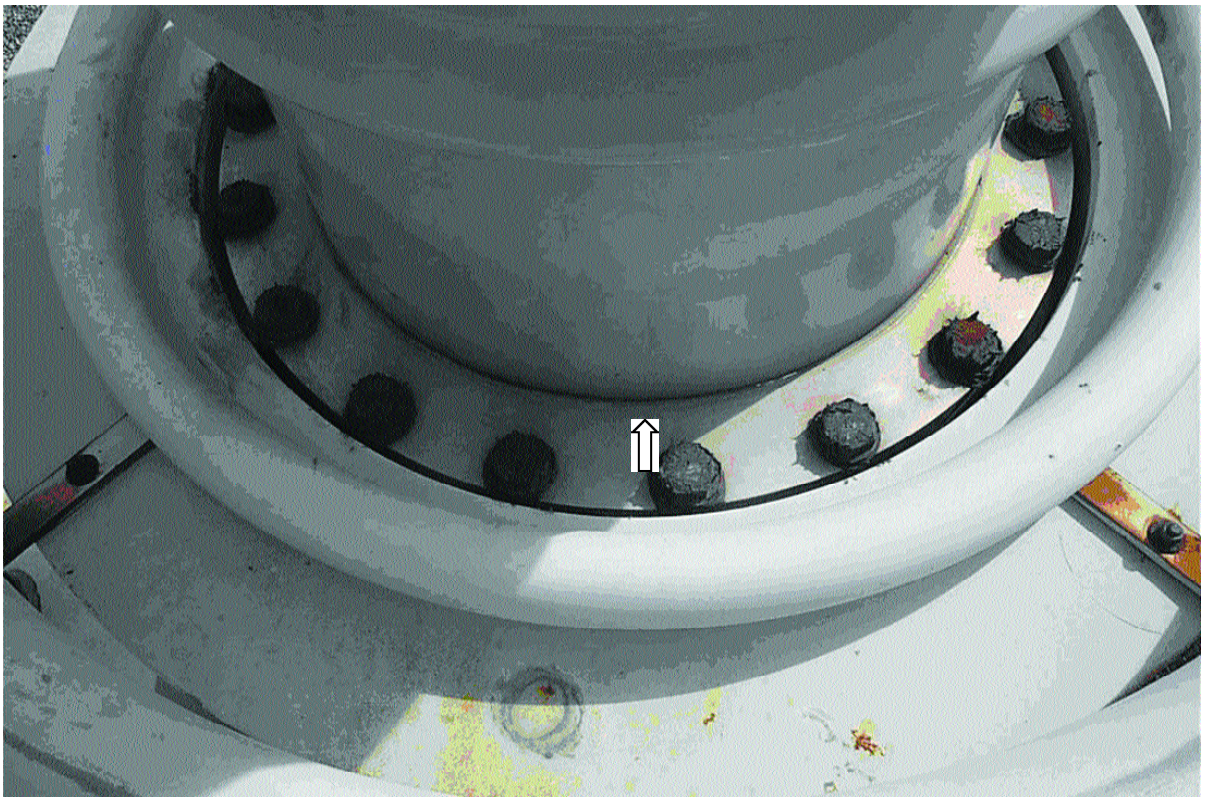
WORKING UNDER PRESSURE! REPAIRING SF6 GAS AND TRANSFORMER OIL LEAKS

By Jim Hackett



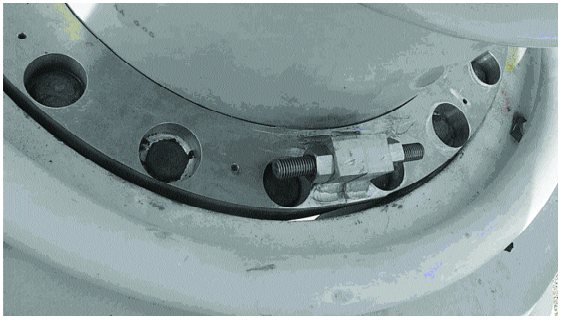
The arrow is showing the leak point.

The problem, a 345kv gas insulated bushing had developed a leak between the aluminum flange and the porcelain. Conventional repairs would require an extended outage and high cost.

In this situation, a call is placed to Colt Atlantic Services, Inc., Power Services Division. When the technician arrives, the breaker is taken out of service for approximately two hours to allow the technician to obtain precise measurements around the leaking area. These measurements are transferred to the Colt engineering department where a custom repair clamp is designed within hours.

The engineering department sends the design data to the machine shop and in a period of twenty-four to thirty-six hours the custom made clamp is on-site and ready to be installed.

The Power Services Division of Colt is dedicated to the repair of SF6 Gas, Transformer Oil and Nitrogen leaks on electrical equipment. Having success-



Here the repair clamp has been installed around the leaking area and S-22 sealant injected to stop the leak.

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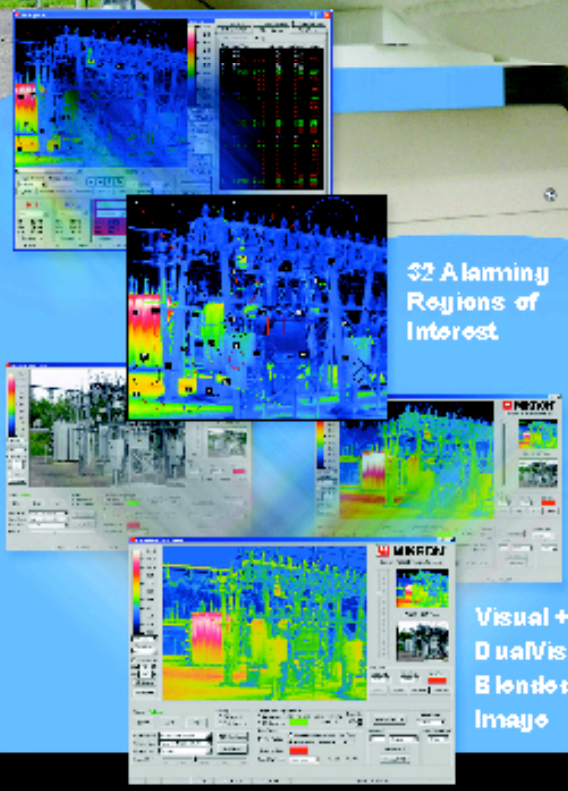

Mikron Infrared's ThermalSpection Systems allow remote monitoring of temperatures in real-time through image data obtained from one or more cameras and transmitted wirelessly or by ethernet to a single PC. The information easily integrates with a SCADA system.

Designed with advanced maintenance-free electronics and industrial NEMA-4 packaging, the *DualVision* model adds a visual camera to its IR-monitoring capabilities. Mikron's software blends the visual and IR camera feeds into a single image. The composite image can be viewed in any blended percentage of visual/IR, simply by moving a slider bar. In addition, DualVision easily helps spot intruders—without supplementary lighting.

The *DualVision Ultra* model adds ultrasound detection to the IR and visual monitoring capabilities, providing a three-in-one, 24/7 monitoring solution for the electrical industry.

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The arrow is pointing to the leaking weld. The leak is located between the six-inch pipe and the support gusset. A two-inch long section of the weld had failed.

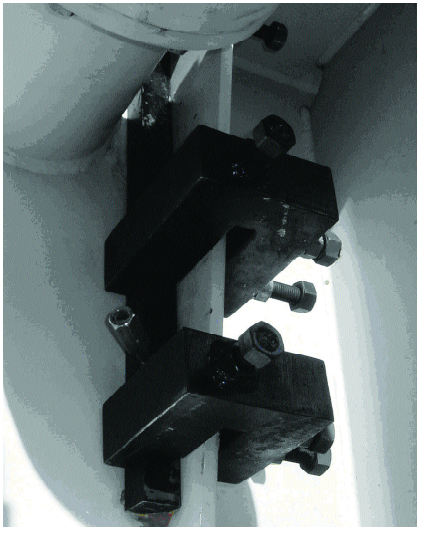
Under Pressure

continued from page 8

fully repaired and documented over five thousand various leaks, Colt is second to none when it comes to making electrical equipment leak repairs, on line.

The scenario above is just one example of the type of leaks that can be repaired without de-pressurizing or draining the equipment. Valve packings, threads, flanges, cover plates, welds, level gauges and more are repaired by Colt technicians every day. The proven process involves the hydraulic injection of a two-part sealant (S-22) to seal the leak. The S-22 sealant has excellent dielectric properties and has had dissolved gas

Continued on Page 13



The picture here shows the completed repair.

DATA SHEET

QUICK-TRIP™

ARC FLASH REDUCTION SWITCH

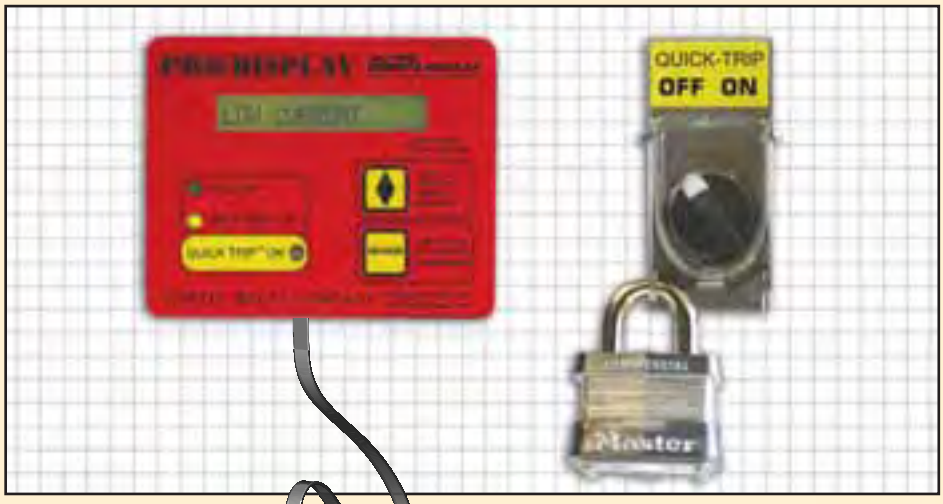
Providing a safer working environment for people working on energized electrical equipment

Since arcflash potential is directly related to breaker clearing time, the QUICK-TRIP system provides an easy and safe method to reduce fault-clearing time without opening a cubicle door to reprogram the trip unit.

The QUICK-TRIP system is activated by means of a padlockable selector switch. When enabled, two additional settings are activated in the AC-PRO trip unit to provide enhanced protection:

- ❑ QT Instantaneous
- ❑ QT Ground Fault

These two individually programmable settings are designed to provide faster clearing times in the event of a fault.



System Features

The QUICK-TRIP system is as easy to use as it is to install, with the additional personnel safety features:

- ❑ Installation uses standard punches.
- ❑ Wires in minutes without cutting into existing wiring harness.
- ❑ QT settings are only active when the selector switch is in the ON position (during maintenance).
- ❑ Reduction in arc flash incident energy levels may permit lower PPE clothing for maintenance personnel.
- ❑ Padlocking switch can be incorporated into a lock-out tag-out procedure.
- ❑ QUICK-TRIP ON LED confirms operation.
- ❑ SELF-TEST LED verifies trip unit operation.
- ❑ PICK-UP LED indicates overcurrent situations.
- ❑ QUICK-TRIP settings can be reviewed on the external PRO-DISPLAY.
- ❑ Last Trip Data and all settings can be reviewed on the PRO-DISPLAY.
- ❑ 3-phase currents are displayed continuously on the PRO-DISPLAY.
- ❑ The system is fully powered by the trip unit's CTs. No aux power or batteries.
- ❑ Extra contacts on the selector switch are available for external annunciation.

Practical Example

A technician needs to rack out a feeder breaker for maintenance. In so doing, he is the minimum 18" away from any potential arc flash source in the cubicle. As the breaker is being racked out, a 12,000 amp arcing fault occurs inside the cubicle. The 2000A main breaker sees the fault and trips, subsequently clearing the fault in the feeder breaker cubicle.

The two graphs below illustrate the dramatic impact that arc-clearing time has on incident energy levels.

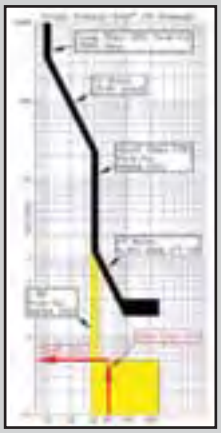
Given that: **F = 12kA** and **D = 18 in.**

Graph 1:
QUICK-TRIP: **OFF** shows the trip time characteristics of the main breaker.

- ❑ The AC-PRO will cause the main breaker to clear the 12kA fault in .556 seconds (based on a Short-Time Delay of .20 seconds with I^2t ON). The resulting arc duration will be: **t = .556**
- ❑ The resulting incident energy is: **E_I = 25.8022**
- ❑ The Hazard Risk Category is: **4**

Graph 2:
QUICK-TRIP: **ON** shows the trip time characteristics of the main breaker.

- ❑ The AC-PRO will now cause the main breaker to clear the 12kA fault .05 seconds (based on the Instantaneous QT or I QT Pick-Up setting of 8000 amps). The resulting arc duration will be: **t = .05**
- ❑ The resulting incident energy is: **E_I = 2.3203**
- ❑ Hazard Risk Category reduced to: **1**



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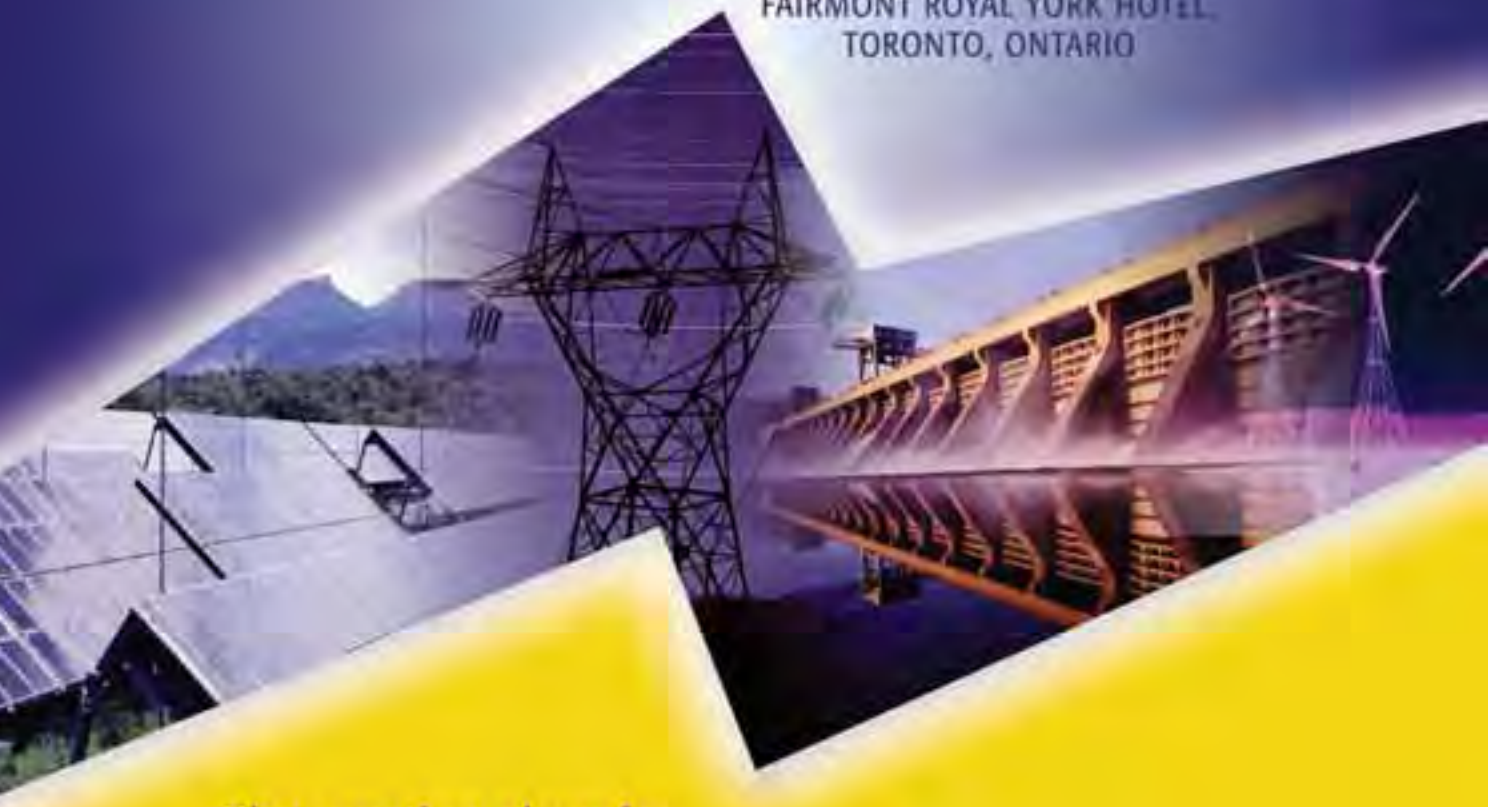

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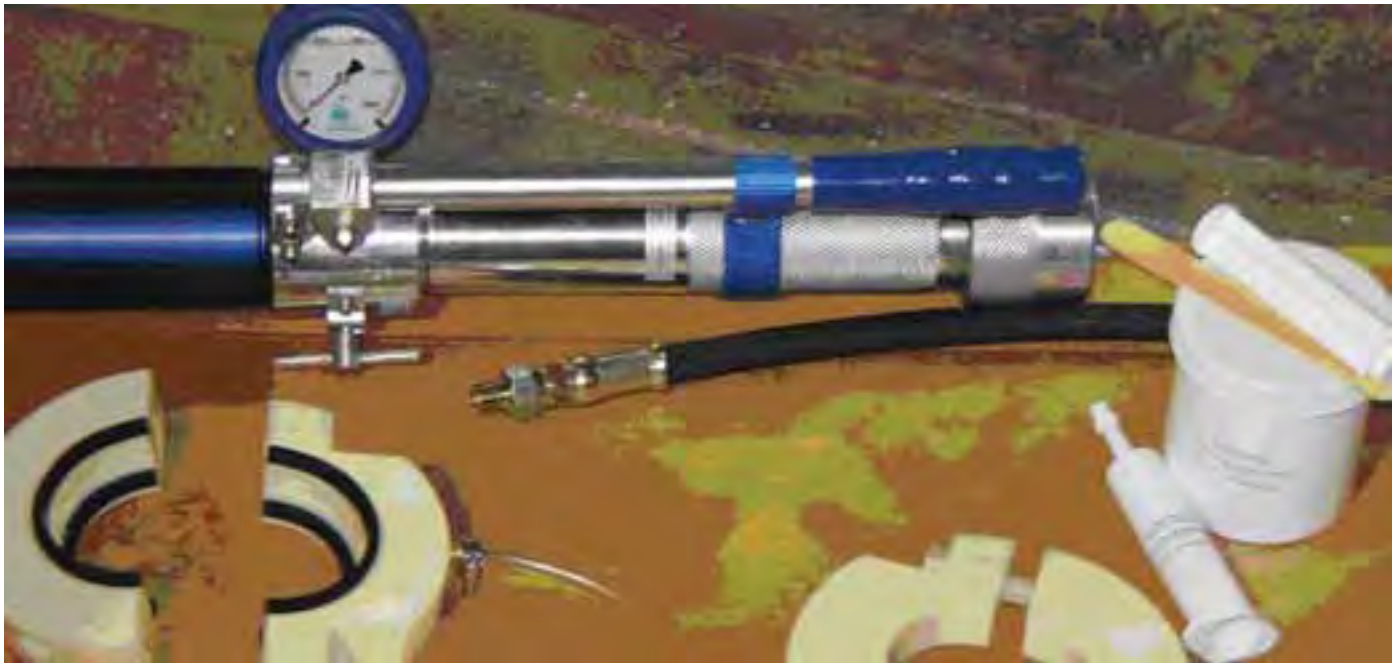

Here you can see the injection equipment that is used; the gauge is just one means of reducing or eliminating the sealant from mainlining. The split-ring clamp is custom manufactured from a low absorbent, non-magnetic material. This clamp was installed on the lead end of a bushing.

Under Pressure

continued from page 10

analysis completed.

This sealant will not bond to the flange and maintains a "memory" that allows for expansion and contraction caused by temperature changes and vibration.

In another scenario, an East Coast generating station transformer has developed a leak in a welded seam resulting in a loss of 1.5 gallons of oil per hour. Colt's Power Services Division technicians arrived on-site, evaluated the situation and determined a course of action.

A custom clamp would be designed, manufactured and installed; special C-clamps would be incorporated to hold the repair clamp in place. It was decided to use a charter service to expedite the clamp delivery. Fourteen hours after arriving on-site the leak was sealed and the job completed.

In many cases, the repairs described above start off with the customer emailing pictures of the leaking component, allowing Colt to make repair recommendations and to develop lump-sum quotes.

A four bolt flapper valve that has been prepared for S-22 sealant injection. 1/16″ NPT ports and injection valves have been installed in the flange gasket and stem packing. After injection of S-22 sealant, all injection valves will be removed and Teflon coated pipe plugs installed. The valve remains operable and is guaranteed for two years with an extended lifetime guarantee.

Jim Hackett is the Power Services Division Manager for Colt Atlantic Services, Inc.

IT'S ALL A MATTER OF TIMING: CIRCUIT BREAKER MOTION TESTS - PART I

By Fouad Brikci, Ph.D., Zensol Automation Inc.; Emile Nasrallah, P.Eng., Circuit Breaker Specialist

1 THE DISPLACEMENT CURVE

1.1 Description

During circuit breaker timing tests, the measurement of the operation times from the first appearance of the order on the command coil to the switching of the main contact, is recorded with a timing instrument, such as the ZENSOL CBA32-P.

This measurement offers precious information on the state of the circuit breaker and allows, in most cases, the precise verification of the presence or absence of anomalies. But this information does not reveal all the secrets of the circuit breaker. Other important information remains hidden from view.

Whenever it is possible, a point-by-point measurement of the movement of the internal components of the circuit breaker, from the beginning of the movement until it comes to a complete stop, traces a curve called a DISPLACEMENT CURVE.

While the main contact timing curve gives the moment when the movement starts and the moment when the contact switches over, the information contained in the displacement curve is interesting because it allows us to follow the entire movement from beginning to end.

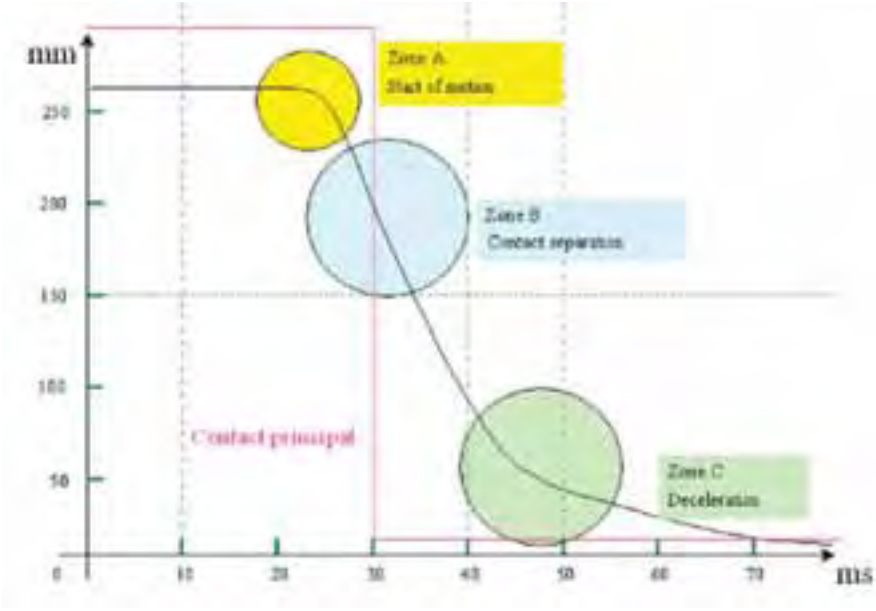

Fig 1.2 Displacement curve on Open operation

1.2 Operation on opening

An example of a displacement curve for an Open operation is shown in Fig. 1.2, superimposed on an opening timing curve for the main contact (in red).

Even if the general shape of the curve is the first characteristic to check, three Zones (circled in Fig. 1.2) merit particular attention.

1. Zone A: the beginning of the movement.
2. Zone B: contact separation.
3. Zone C: from the beginning of the deceleration to the final resting position.

1.2.1 Zone A: the beginning of the movement

This is where the movement starts. It is extremely important to know if the movement has begun at the right moment. For example, a delay with respect to the reference specification means an electrical problem exists, if the coil is not excited on time, or a mechanical problem may exist between the command mechanism where the movement is triggered and the mobile contact of the breaker itself.

1.2.2 Zone B: contact separation

This is where the main contacts separate from each other. At this exact instant, the arc begins to form and the breaker implements its measures to extinguish it. The separation speed becomes an important and primordial factor in order to succeed in breaking the circuit.

The method for calculating the average velocity in this zone depends on the breaker designer. Only the designer may determine the calculation method and establish the reference specification.

1.2.3 Zone C: deceleration

This is where the movement decelerates until the circuit breaker's mobile contact comes to a complete stop.

The amount of energy required in the breaking process is proportional to the intensity of the current being interrupted. Once the current has been interrupted and the arc has been extinguished, the energy developed is quite excessive.

Effective means of damping are put into action to absorb this excess energy and thus reduce the risk of damaging the internal components of the circuit breaker. The analysis of this zone makes it possible to determine if the damping is optimal, which means the movement is stopped gradually.

Insufficient damping, or underdamping, allows the moving parts to undergo shocks, which causes severe damage.

A sudden damping, where the kinetic energy developed by the moving parts of the breaker is absorbed over very little time, causes damage similar to underdamping. This phenomenon is called overdamping.

1.3 Operation on closing

An example of a displacement curve for a Close operation is shown in Fig. 1.3, superimposed on a timing curve for the main contact (in red).

Even if the general shape of the curve is the first characteristic to check, three Zones (circled in Fig. 1.3) merit particular attention.

Zone A: the beginning of the movement.

Zone B: contact closing

Zone C: from the beginning of the deceleration to the final resting position.

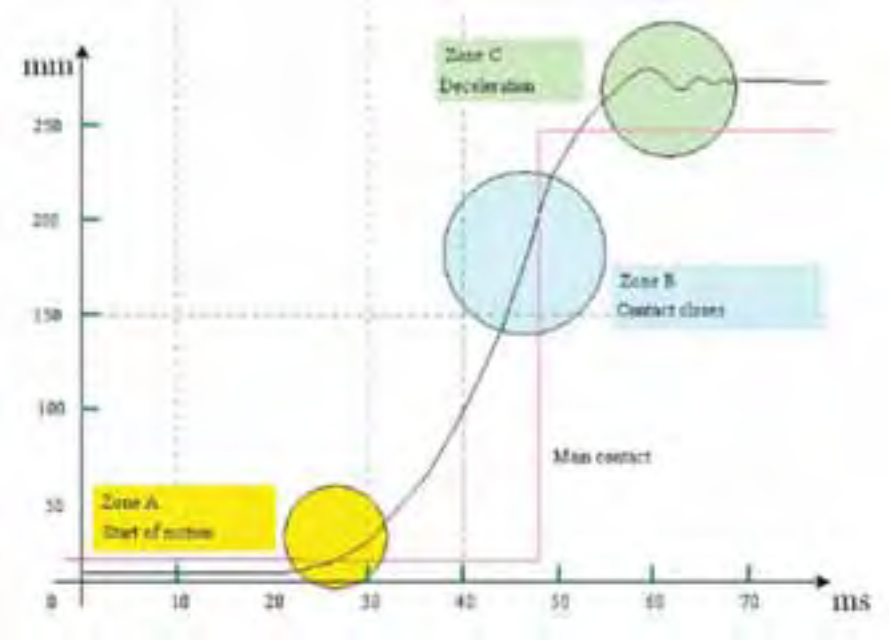

Fig 1.3 Displacement curve for Close operation

1.3.1 Zone A: the beginning of the movement

As is the case for the opening displacement curve, this is where the movement starts, and it is very important to know if the movement started at the right place.

1.3.2 Zone B: contact closing

This is where the main contacts come into contact. In this zone, also called the pre-arc zone, as the contacts come closer to each other, the dielectric, as a function of the separation distance, becomes insufficient and a pre-arc current forms within an arc, the duration of which is a function of the speed of the contacts.

Thus, contact velocity is an important factor in limiting premature wear of the contacts.

As is the case for the opening operation, the method for calculating the average speed in this zone is also determined by the designer of the breaker. Only the designer may determine this calculation method and establish the reference specification.

1.3.3 Zone C: deceleration

This is where the movement slows down to a complete stop of the breaker's mobile contacts.

The energy involved in the closing process is less than that developed in the breaking process, but it is nonetheless quite considerable.

Excess energy is translated into an overtravel which, if it exceeds tolerances, may cause severe damage to the device.

1.4 Velocity curve

A velocity curve is calculated by the derivative of the displacement curve, using, for example, the CBA Win analysis software. The velocity curves gives the speed as a function of time, which gains new information on the dynamic behavior of the circuit breaker.

1.5 Acceleration curve

In the same manner, an acceleration curve can be traced, as the derivative of the velocity curve, again using the CBA Win analysis software, which gives additional useful data.

2 PERFORMING THE MEASUREMENT

To record the displacement curve, some type of assembly is needed between the ZENSOL CBA-32P and the breaker. A displacement transducer is used to sense the movement of the mobile contact. The CBA Win software processes the data, traces the displacement curve and performs the various veloc-

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ity calculations. To understand the process, a summary description of the transducer, the breaker and the CBA-32P follows.

2.1 Displacement transducer

2.1.1 Description

The displacement transducer, in its most elementary form, consists of a fixed part and a mobile part. The mobile part is attached to the mobile contact of the breaker under test, and moves with the contacts, while the fixed part acts as a reference.

Several types of transducers are available on the market. Their differences reside in the method used to identify the relative value against the reference value. Some examples of transducers are:

· Magnetic transducer
· Optical transducer
· Resistive transducer
· Etc.

The resistive transducer, which is the most popular, will be described in detail. This type of transducer is composed of a resistor and a cursor that moves along the length of this resistor. There are two types of resistive transducers:

· Linear displacement transducer, or linear transducer (fig. 2.11a)

· Rotary displacement transducer, or rotary transducer (fig.2.11b)

The difference lies in the physical layout of the reference resistor and in the way the cursor moves.

For the linear transducer, the displacement of the cursor is linear, in a straight line whereas, for the rotary transducer, the displacement is a rotation around an axis.

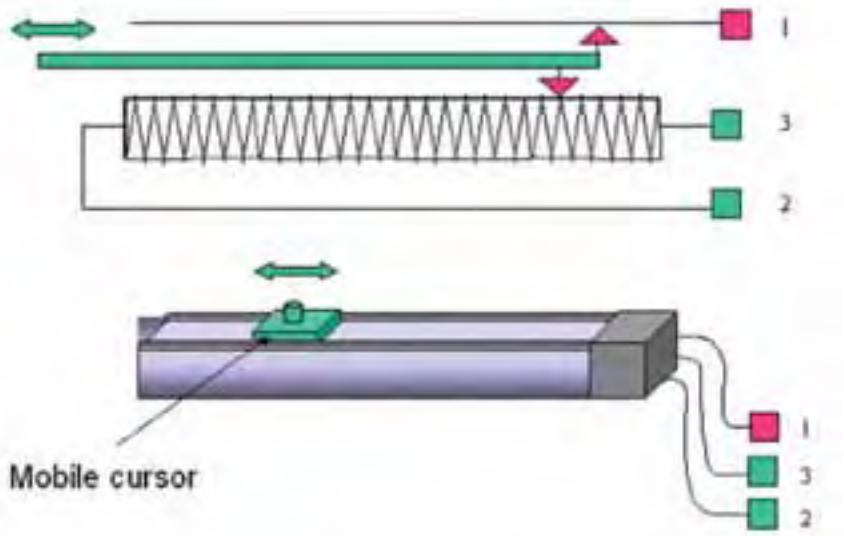

Fig 2.11a - Linear displacement transducer

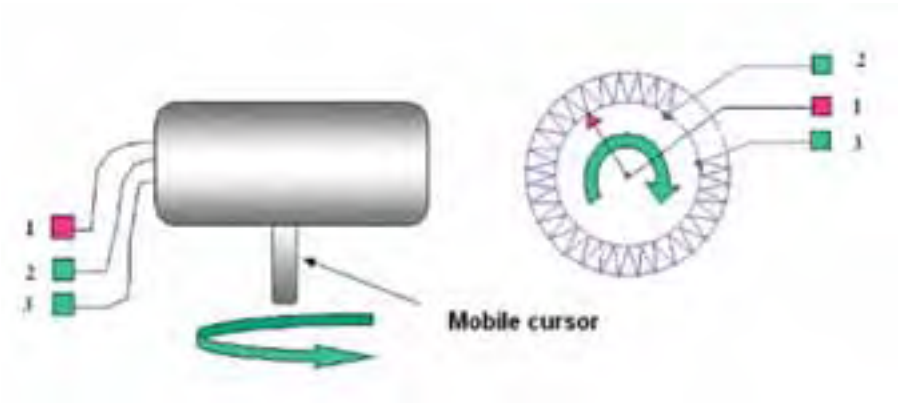

Fig 2.11b - Rotary displacement transducer

2.1.2 Operation

The transducer is solidly attached to the breaker support, while the mobile cursor is solidly attached to the control arm of the mobile contact.

A known, fixed voltage source (E) is connected to terminals (1) and (3). When the breaker is in the CLOSED position, the voltage read between terminals (2) and (3) is (V1). As the mobile contact moves toward the OPEN position, the measured voltage (Vt) between terminals (2) and (3) decreased as a function of time, down to value (V2), which is less than (V1), when the breaker has completely stopped.

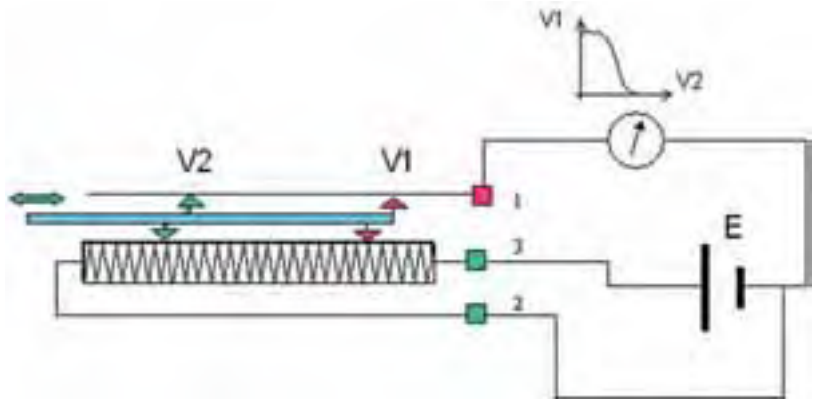

Fig. 2.12 Operation of a displacement transducer

2.2 Circuit Breaker

2.2.1 Description

A high-voltage circuit breaker consists of two main parts:

1. Active section (electrical power)
2. Command section

The active section must make or break the power current in the high-voltage circuit where the breaker is installed. The command section must develop the necessary energy to perform these operations.

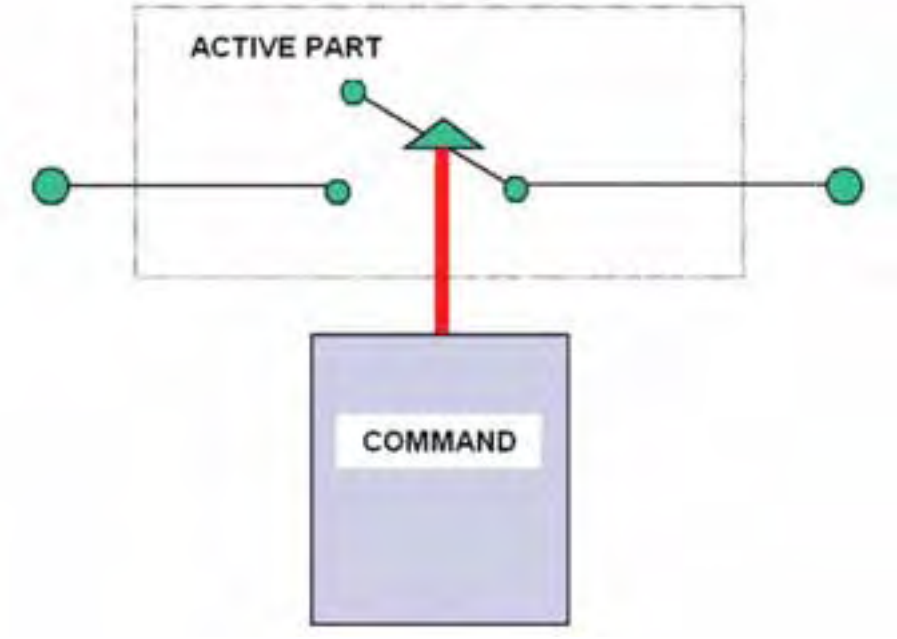

Fig. 2.21 Circuit breaker principle

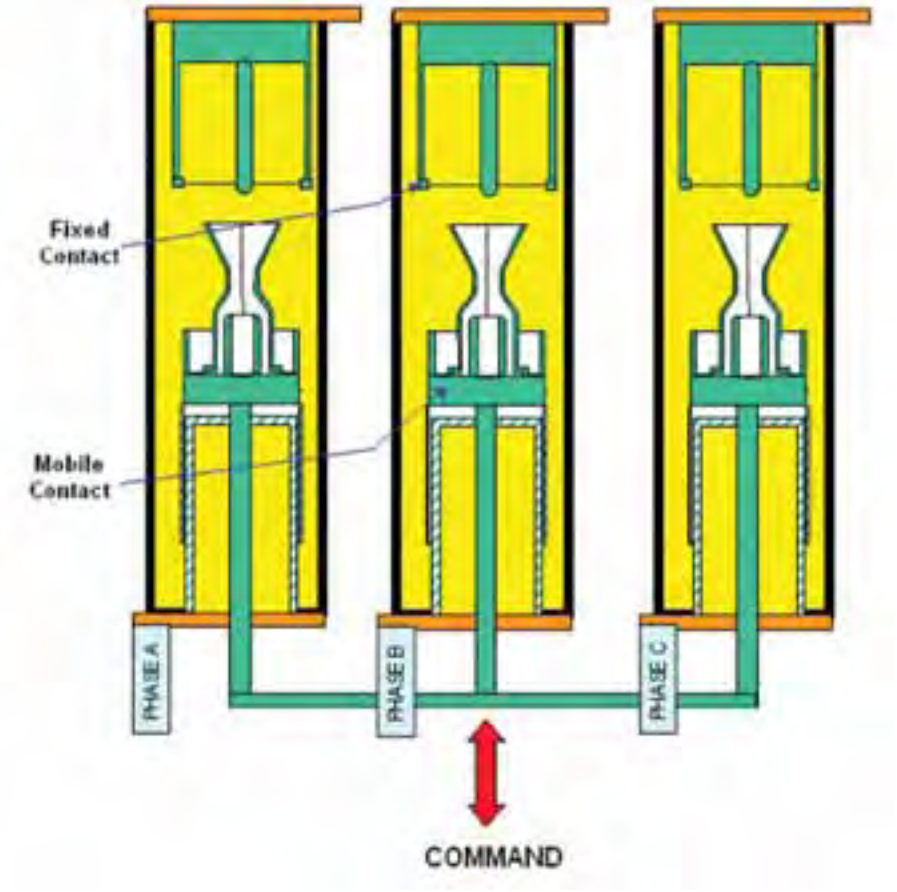

Fig 2.22 - Power section of the circuit breaker

The link between the command and active sections is usually an insulating rod, shown in red in the schematic in Fig. 2.21.

2.2.2 Electrical power section

This part generally constitutes three phases of equal size. Each phase, in turn, is composed of a fixed contact assembly and a mobile contact assembly. When the two assemblies are in contact, it is said that the breaker is CLOSED, so current flows through the power circuit.

To interrupt the flow of current in the power circuit, the mobile contact assembly is mechanically moved away from the fixed contact assembly and stopped at a distance that is sufficient to ensure electrical isolation.

2.2.3 Command section

This section has the task of creating the energy required to perform the mechanical operation of the breaker, for both Open and Close operations.

Three types of commands are often used in high-voltage circuit breakers:

- Pneumatic
- Hydraulic
- Mechanical spring

2.2.3.1 Pneumatic command

Usually found on compressed air circuit breakers. This type uses compressed air as a dielectric medium and uses piston-type mobile contacts.

A series of valves activated in a precise sequence allows the application of air pressure on one side of the piston, which causes the latter to move through the action of the pressure difference between the opposing sides of the piston. The movement of the mobile contacts is generally not accessible in this type of circuit breaker, making the use of conventional transducers almost impossible.

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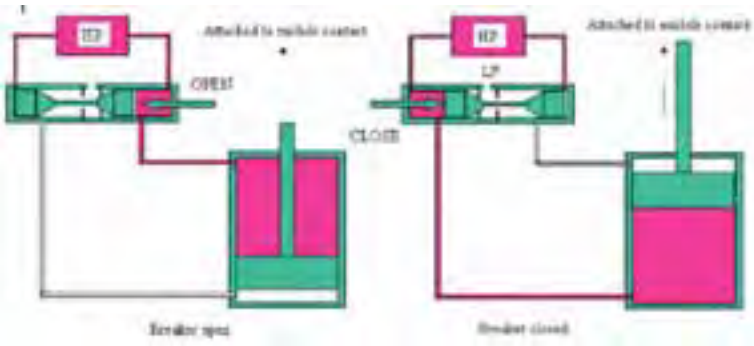

Fig 2.2.32 - Hydraulic command

2.2.3.2 Hydraulic command

This type of command has an energy reservoir, or accumulator, either compressed nitrogen or springs compressed by hydraulic fluid and a pump. The moving contact of the circuit breaker is attached to the piston by an insulating rod.

A set of hydraulic valves allows the application of the previously accumulated pressure to one side or the other of the hydraulic ram, which moves it and the contact in the desired direction.

2.2.3.3 Spring-loaded mechanical command

This type is most in demand because of its proven reliability and also because of its very low frequency of periodic maintenance.

It usually consists of two compressed springs, one used to accumulate the energy necessary to close the breaker and the other to store energy to open the breaker.

The closing spring (E) is compressed manually, using a crank, or electrically, using a motor. A locking mechanism holds and controls the energy accumulated in the closing spring.

When this energy is released, by the release of the closing spring, the mobile contact is moved toward the fixed contact, through the connecting rods, while simultaneously charging the opening spring which maintains the energy accumulated with its own locking mechanism, ready to be released on the next opening order.

2.3 Choice of tranducers

The goal is to reproduce the exact movement of the moving contact in the breaking chamber of the circuit breaker, which is usually inaccessible because the entire assembly is inside a closed container. While the final displacement of this mobile contact is always linear, the initial movement generated by the command mechanism is not always so.

The movement generated by the command mechanism may be rotary, which is translated into a linear motion by a set of levers and connecting rods.

When the linear movement of the contact is accessible indirectly, for example through the connecting rod, a linear transducer may accurately reproduce this movement by attaching it to the rod in question. In figure 2.3a, you will

continued on page 20

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MAKING NORTH AMERICAN NETWORKS SMARTER, MORE EFFICIENT

By Don Horne

During the middle of the heat wave at a recent meeting of the European Energy Commission in Paris, France, one of the members wryly observed that when nature is providing the earth with the most energy, utilities are generating the most to keep customers cool.

Klaus Heimann, Senior Vice President of Industry Business Unit Utilities SAP AG, is bringing the future of transmission and distribution to utilities around the globe, through automation, next-generation technologies and smarter networks.

And, the movement towards deregulation in the United States is spurring this. But Mr. Heimann would prefer a different word than deregulation.

"I don't like the term 'deregulation', I prefer 'new market methods'," he says. "By taking it (utilities) out of public hands and placing them into private, entrepreneurial, creative hands, you see much more efficiency."

Klaus Heimann

Based out of Germany, Mr. Heimann checks in with his U.S. SAP clients on a quarterly basis.

"We never lose the view of what is happening here in the United States. Deregulation is a big business driver, and there is a thirst for more intelligent networks; more efficiency, more from each kilowatt hour."

But North America has been more concerned with reliability and safety, especially following the series of blackouts and after the terrorist attacks of 9/11.

"After September 11, the focus became safety and reliability for at least two years. And certainly the troubles with Enron and California's experiment with deregulation didn't help, as both cost taxpayer money."

Europe has the jump on smart networks, and it is SAP that hopes to bring that experience and technological advice here.

"We're extending our expertise to North America, but they want to see it in

Continued on page 38

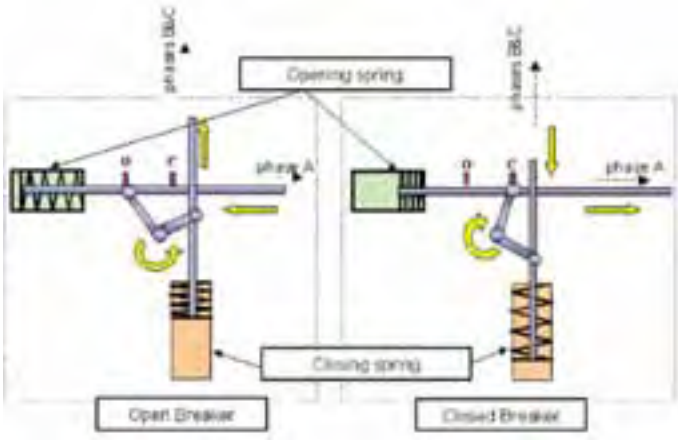


Fig 2.2.33 - Mechanical spring command

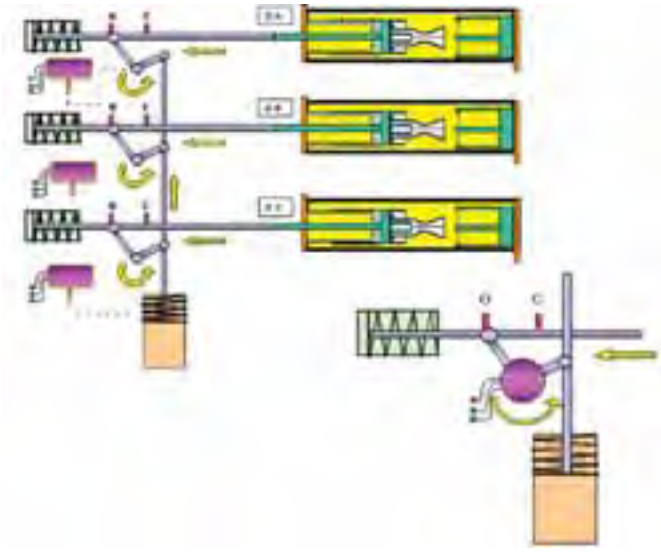
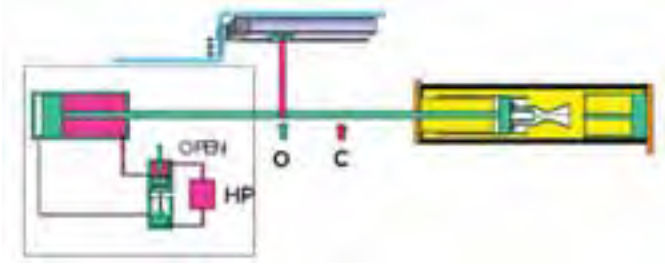
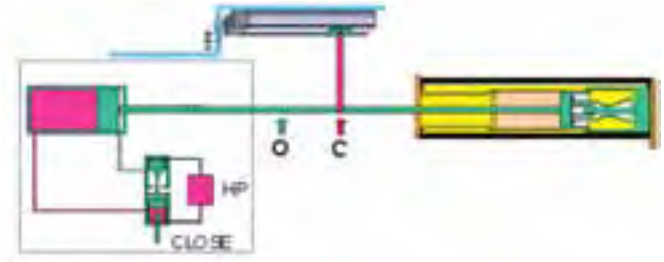


Fig. 2.3b Example using rotary transducers



Linear transducer with breaker in open position



Linear transducer with breaker in closed position
Fig 2.3a Linear transducer examples

Fig. 2.4a Zensol CBA-32P instrument

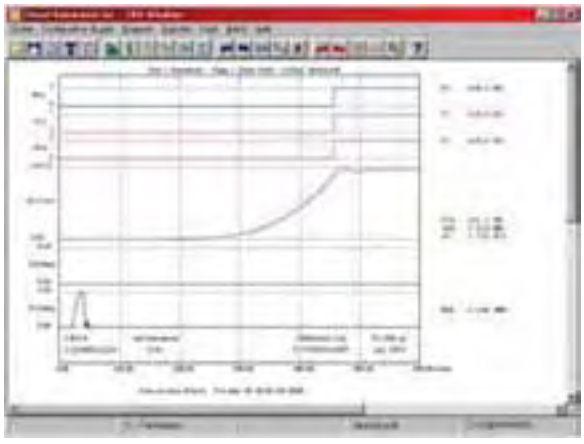


Fig 2.4b CBA Win graphic report as seen on the computer screen

Motion Tests

continued from page 18

find an example of a linear motion sensed by a linear transducer (in the case of an accessible motion).

In the case where only the command motion is accessible, and if this motion is rotary, the final motion of the mobile contact is measured by transforming this rotary motion using various levers and connecting rods of different sizes.

The sizes of the levers add multiplying factors that influence the desired curve, whereas the angular motion of these levers is always the same. In this case, using rotary transducers will give better results.

One condition must be observed, however. A translation curve must be drawn, point-by-point, to convert the angular motion into a linear one.

An example of the use of a rotary transducer is shown in figure 2.3b.

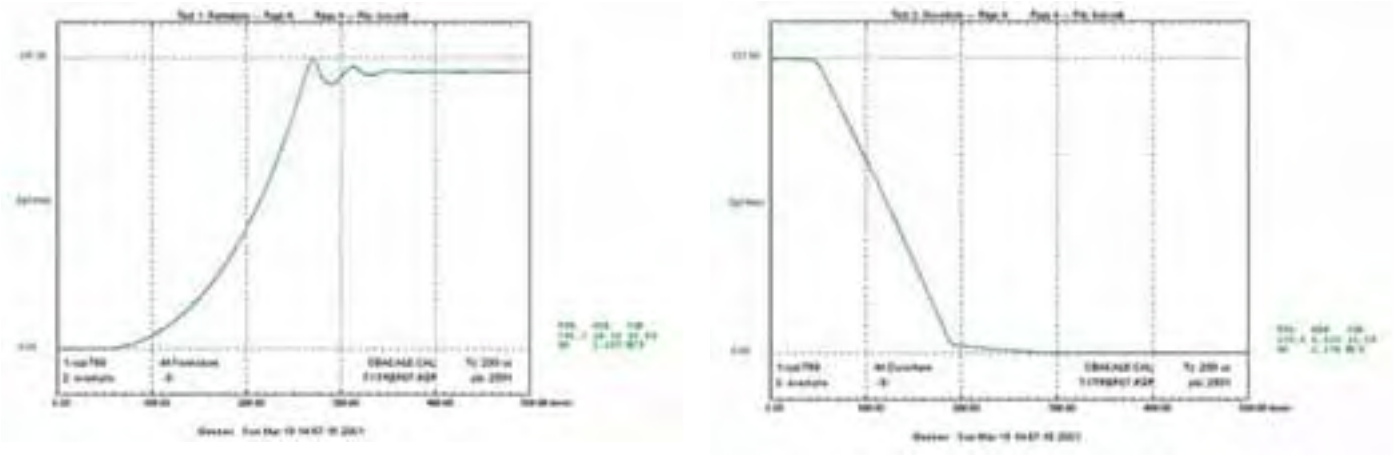


Fig. 2.5 Examples of displacement curves for Close and Open operations

2.4 Acquisition and display of results

The acquisition and the display of the results is performed by the analog input channels of ZENSOL's CBA32P (see Fig. 2.4a)

Each analog channel has three leads numbered (1), (2), and (3) on the corresponding plug.

Between leads (1) and (3), a 10 volt DC signal is generated during the test. The signal collected from the displacement transducer is measured between (2) and (3), and transmitted to the CBA Win analysis software which draws the curve on the computer screen. Fig. 2.4b shows an example of CBA Win's graphic report, as it is shown on the computer screen.

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ELECTRICITY COSTS IN THE NEW ENGLAND MARKET

Wholesale electricity prices in New England are directly linked to the costs of the fuels used by generating units to produce electricity. Since many of the region's power plants are fueled by natural gas and these plants often set the wholesale electricity price, the increase in electricity prices in fall 2005 was a reflection of the increase in the price of natural gas during that period. Similarly, in late fall/winter 2005/2006, wholesale electricity prices decreased with the decrease in natural gas prices.

In turn, some New England utility companies have begun to reduce retail electricity rates.

Wholesale electricity prices are also linked to the amount of electricity consumers use at peak times, primarily during the summer. Power consumption on the hottest summer days has been growing at about 2% each year, which is higher than the growth in average consumption. This consumption trend drives the requirement to build additional resources (e.g. peaking units), increasing the capacity costs of the region. It also is creating an underutilized power system where resources are built to satisfy demand for only a few days of the year.

> Giving customers the opportunity to respond to real-time prices can potentially reduce peak loads, such as through traditional price-based demand-response programs, energy-efficiency measures, and conservation efforts.

This article discusses the results of an ISO New England (ISO) analysis that evaluated the drivers of electricity costs in terms of their fixed and variable components, with projections through 2015. To indicate electricity-price trends, the analysis projected total electricity costs for the region in 2010 and 2015, based on the region taking no actions to change its mix of capacity resources or decrease demand (i.e., a "business-as-usual" scenario). These costs were compared to the 2006 expected costs for electricity.

The analysis also used actual electricity usage and bidding data for 2005 to estimate the potential impact that various options to control electricity costs, such as policy actions that alter the "business-as-usual" scenario, can have on the electricity market. These options broadly include building low-cost baseload generation (e.g., renewables, clean coal, and perhaps nuclear power) and reducing peak usage. Giving customers the opportunity to respond to real-time prices can potentially reduce peak loads, such as through traditional price-based demand-response programs, energy-efficiency measures, and conservation efforts. Reducing demand in response to high prices during peak periods could also reduce the need to add electricity infrastructure.

HIGHLIGHTS OF THE ANALYSIS

The major findings of the analysis are as follows:

- Fuel costs, primarily natural gas, are a principal determinant of electricity costs.
- The addition of low-cost baseload power plants and price-responsive demand are effective ways to control costs.
- Adding 1,000 megawatts (MW) of supply produced by low-cost plants will save New England consumers $600 million a year.
- Reducing usage by 5% during on-peak hours will lower consumer cost by $580 million a year. On-peak price signals that reveal wholesale prices and more aggressive on-peak energy-efficiency programs can bring about these reductions.
- A 500 MW increase in traditional demand-response pro-

Continued on Page 24

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Wholesale Costs

continued from page 22

gram participation will cut costs by $32 million a year.

• Assuming continued high fuel prices, taking no action (a business-as-usual scenario) will result in electricity costs rising with increases in demand and fuel prices. A 5% increase in power usage will increase costs by $700 million.

Figure 1 shows the estimated cost impacts associated with adding new low-cost plants, increasing a combination of price-responsive demand and more aggressive on-peak energy-efficiency measures, and increasing demand response compared with the costs of a business-as-usual scenario. These estimates are a combination of electricity and capacity costs. They do not include the costs to implement each measure, and no ranking of responses is implied. That is, while the cost savings of 500 MW of traditional demand response appears small, it may be that demand response is more easily implemented and less expensive to achieve than building a new baseload generator. These estimates are intended to be representative of the effects of such actions and investments. Changes in actual consumer costs could vary widely.

COMPONENTS OF ELECTRICITY RATES

The ISO estimated the following about the components of electricity rates:

• Power costs, which reflect the cost of producing electricity and vary with the global fuel markets, will make up approximately half of the average consumer's electricity bill in 2006.

Of this, fuel and capacity costs will account for roughly 95% of the total.

• Transmission and distribution costs, which will make up the remaining 50% of the bill, are regulated and reflect the cost to build, maintain, and operate the regional transmission system and local transmission (distribution) networks.

• Over the next 10 years, power costs should be expected to track natural gas prices and capacity cost trends, unless targeted action is taken to control these costs. Capacity costs are expected to increase by 75% as the region implements a new capacity market to ensure supply keeps up with growing demand. Transmission costs, while a small component of total costs, will rise by 77%, as the region builds and pays for new lines. Distribution costs are expected to remain fairly stable as they generally have in recent years.

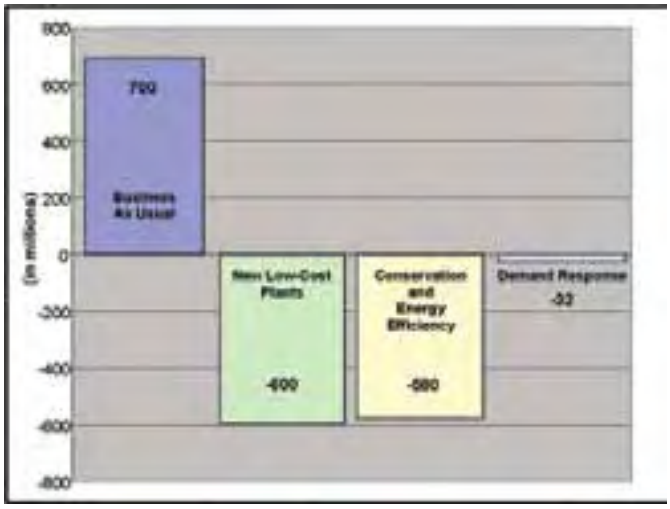

Figure 1 Impacts of various "solutions" for controlling electricity costs.

ACTION PLAN FOR MANAGING ELECTRICITY COSTS

Actions that can reduce electricity costs in New England include the following:

• Improvements in energy efficiency — stimulated by some form of dynamic pricing that indicates to consumers when prices are highest and creates an incentive to reduce electricity use at peak times — to lessen the need to add new plants

• The development of power plants using low-cost fuels, such as wind, nuclear, and clean coal, which can lower power costs by displacing the operation of higher-cost power plants

• The facilitation of these responses by state officials, who can increase the control of electricity prices in the region through the following measures:

- Adopting retail-rate policies that reveal real-time electricity prices to businesses and residential consumers and provide incentives for managing the use of electricity during these high-price peak-use periods

- Enabling the siting of new supply resources that use wind, clean coal, nuclear, and other alternative energy sources

- Implementing additional programs to promote greater energy efficiency and use of customer-operated resources, such as load management and distributed generation to reduce

on-peak load

ELECTRICITY COST DRIVERS

End-user electricity costs are based on three components of electricity production and delivery — power generation, transmission, and distribution. Each component is part of both the regulated and competitive environments. However, the mechanisms for ensuring the efficient production and delivery of electricity and for investing in these components differ between the two environments. In a regulated environment, state and federal regulatory bodies manage costs. In a competitive environment, market mechanisms drive some costs and investment decisions (power generation, capacity, ancillary services), while other costs (transmission and distribution) continue to be governed by regulatory review.

Figure 2 shows the approximate expected average 2006 costs of the three main electricity cost components in New England. Transmission costs are small relative to the total costs, with electricity and distribution costs at similar levels. Each cost category can be further segregated into variable and fixed costs. Variable costs are generally associated with power production, with fuel costs the dominant component. Fixed costs include the capital costs for required infrastructure (transmission and distribution systems, power plants) and the personnel and organizational costs for maintaining and operating the power system, which do not vary significantly with demand.

Wholesale electricity costs can be separated into fuel costs, Variable Operation and Maintenance (VOM) costs, capacity costs, and ancillary service costs. Figure 3 shows a sample breakdown of these costs. Fuel costs are the majority of wholesale electricity costs. The figure assumes that a moderately efficient combined-cycle gas-fired power plant is the marginal unit, that natural gas costs are $7.50/million British Thermal Units (MMBtu), and that the capacity market pays $3/kilowatt (kW)-Month. In the example, the major components of wholesale electricity market costs are capacity and fuel costs, comprising approximately 95% of total costs.

Figure 4 shows a projection of the typical wholesale electricity costs shown in Figure 3. Figure 4 uses EIA forecast data for natural gas prices to calculate projected fuel-operating costs. The EIA forecast is that the average natural gas price in 2006 will be $7.24/MMBtu, with a steady decline to a low of $5.08/MMBtu in 2015. These numbers are in real dollars and are adjusted slightly to reflect higher costs when delivered to New England. The projected fuel costs are used to calculate projected wholesale electricity costs over the next 10 years. The projected market capacity costs are based on transition payments prior to the implementation of the Forward Capacity Market. After 2009, the costs are based on an expected Forward Capacity Auction (FCA) clearing price of $7.50/kW-Month.

Figure 2 Components of the average forecast New England retail consumer cost of $156/megawatt-hour (MWh) in 2006.
Note: The electricity cost of $83.80/MWh assumes that the average Locational Marginal Price (LMP) in New England for 2006 will be $74, calculated by adjusting the 2005 average LMP for changing natural gas costs. Gas costs are based on U.S. Department of Energy, Energy Information Administration (EIA) forecasts. Capacity costs are assumed to be approximately $3/kW-Month, the expected value at the end of 2006. These costs are estimates of average New England costs and represent actual costs; they may not match those of any particular consumer.

After deducting assumed peak-energy rents of $2.50/kW-Month, the net capacity cost is $5.00/kW-Month.

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Market capacity costs also increase after 2010 due to the decreased use of capacity or declining load factors (i.e., when capacity requirements increase at a faster rate than the overall growth in electricity consumption). Other costs, which include unit VOM costs, ISO administrative costs, and ancillary service costs, are held constant over the period.

Transmission system costs are a combination of the cost to build the transmission system, amortized over the expected useful life of each component, and the costs of operating and maintaining the system. Figure 5 shows projected New England transmission costs by year per megawatt-hour of New England electricity demand. These calculations assume that projected transmission upgrades are completed, that their costs are recovered from consumers, and that total electricity demand increases as forecast in the ISO's 2005 Regional System Plan (RSP05). Total costs are broken down into carrying charges, depreciation of assets, property taxes, and other operations and maintenance expenses. Transmission costs increase as costs for new transmission projects are moved into rate base and are recovered from consumers. Figure 5 assumes that major planned transmission projects are completed on schedule. It does not include costs for the Southern New England Transmission Reinforcement (SNETR) Project.

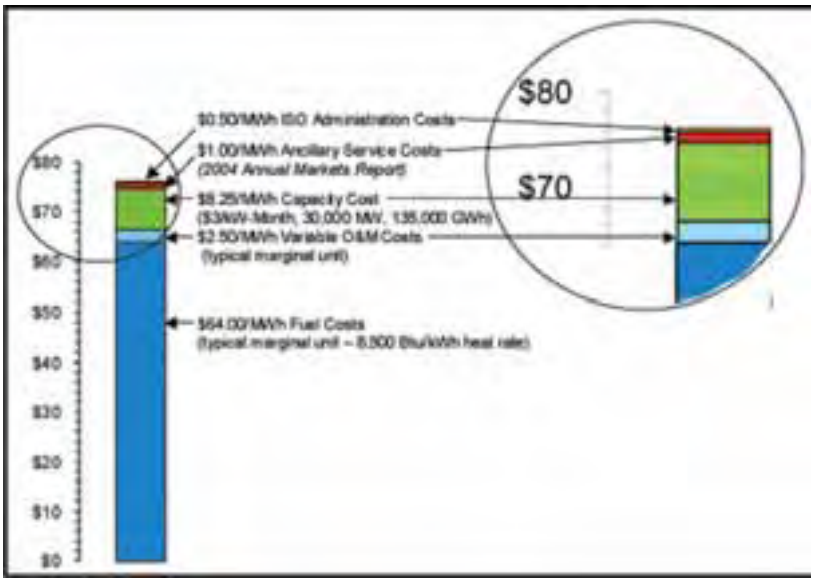

Figure 3 Components of the wholesale electricity cost for a typical hour with a gas unit on the margin, Total $76.25/MWh (2005).

Note: The typical hourly cost shown in Figure 3 differs from the average price shown in Figure 2 to allow the cost components to be more clearly disaggregated. The typical hourly cost is not a price projection, but a snapshot of the different components that make up electricity costs.

Distribution system costs are a combination of the cost to build the distribution system, amortized over the expected useful life of each component, and the costs of operating and maintaining the distribution system. Figure 6 shows these projected costs. These costs are not broken out the same way as transmission costs because detailed cost data are not readily available. Relative to electricity and transmission costs, these costs are expected to be stable.

Electricity costs are comprised largely of fuel and capacity costs, with natural gas costs expected to decrease and capacity costs expected to increase in the future. Transmission costs, while a small component of total costs, are expected to nearly double over the next 10 years. Distribution costs, while large, are very stable relative to electricity and transmission costs. These costs are largely under the jurisdiction of state regulators.

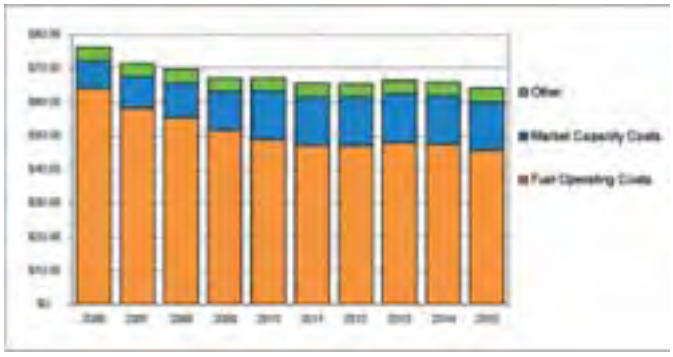

Figure 4 Projected New England wholesale electricity costs for a typical hour ($/MWh in 2005 $).

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FUTURE COSTS OF TAKING NO ACTION

Accurate electricity price forecasts are difficult, if not impossible, to develop due to their strong dependence on fuel prices. To provide some indication of the drivers and trends in electricity prices, this analysis projected the all-in costs of electricity in 2010 and 2015, compared with the expected costs in 2006 shown in Figure 2. These projections are labeled "Business as Usual" and combine the separate electricity, transmission, and distribution projections presented above. Three business-as-usual projections (scenarios) are provided: the first based on EIA forecast natural gas prices, which decline over the next 10 years; the second assuming flat natural gas prices; and the third assuming that natural gas prices increase by 5% per year between 2006 and 2015.

These costs were computed assuming that peak loads grow as projected in RSP05, that the large transmission projects discussed in RSP05 are built, and that natural gas continues to be the incremental source of most new generation in New England. Prices are in constant 2005 dollars.

Natural gas price forecasts in the first scenario, shown in Table 1, are from the EIA.

(a) Calculated by adjusting 2005 prices for projected gas prices and adding ancillary service costs ($1/MWh) and ISO costs ($0.50/MWh)

(b) The capacity costs for 2006 are assumed to be $3/kW-Month. The capacity costs for 2010 and 2015 are expected to be the estimated cost of new entry ($7.50/kW-Month) minus assumed peak-energy rents of $2.50/kW-Month, for a net cost of $5/kW-Month. These costs are only expected to be in the range of possible costs, not to forecast actual prices. Annual energy consumption data are from RSP05 forecasts.

The projected costs shown in Table 1 are driven primarily by increased capacity costs, falling natural gas prices, and additional transmission investment. The capacity costs are driven by peak loads that are increasing faster than average electricity consumption and a redesigned capacity market expected to spur new investment.

Table 2 uses the same assumptions as Table 1, but holds natural gas prices constant at expected 2006 levels. This results in higher all-in prices than shown in Table 1.

Table 3 assumes that natural gas prices increase at 5% per year in real dollars. This results in the highest prices of the three scenarios.

Wholesale electricity prices vary by 78% between the projections using EIA natural gas price forecasts and those assuming that natural gas prices increase by 5% per year. Total consumer costs per megawatt-hour vary by 31%.

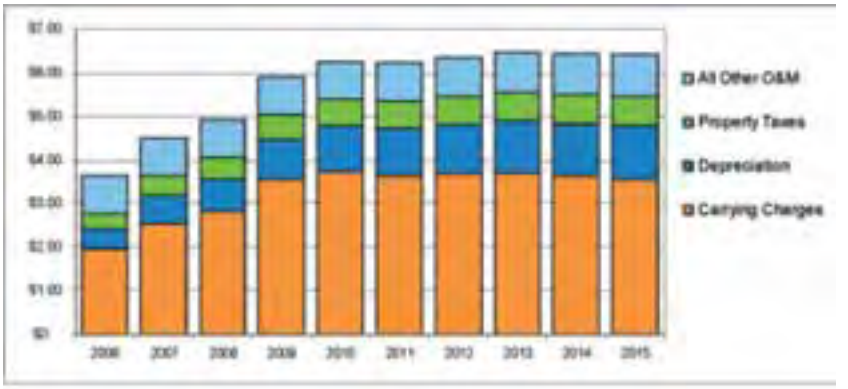

Figure 5 Projected New England transmission costs ($/MWh in 2005 $).

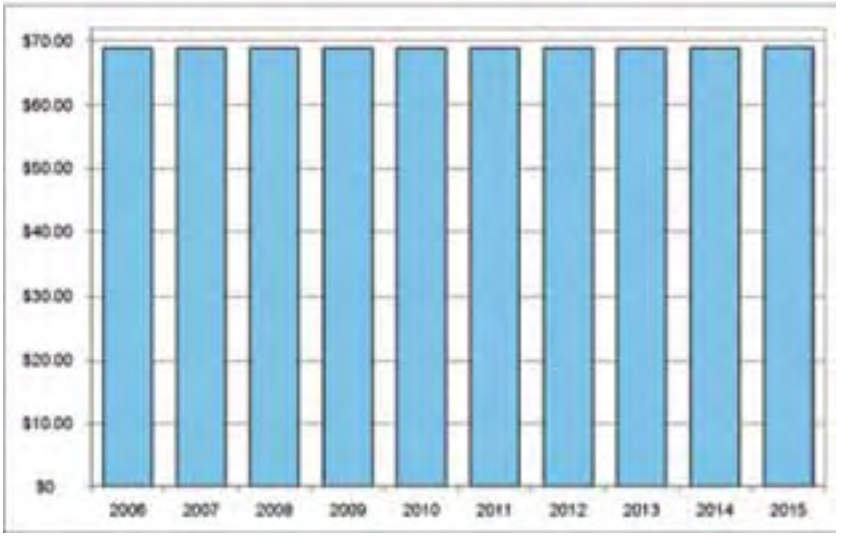

Figure 6 Projected New England distribution costs ($/MWh in 2005 $).

RESPONSES TO COST PROJECTIONS

The projected costs under the business-as-usual scenarios and the risk associated with volatile natural gas prices may be reduced in a number of ways.

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These fall into two broad categories. One category is to build low-cost generation, and the other is to reduce peak loads to avoid incremental infrastructure investment. Electricity costs would be reduced by displacing high-cost resources with low-cost resources, by reducing the need to build and pay for additional infrastructure, or a combination of both.

Current market signals appear to provide a strong incentive for building low-cost generation using available technology. While natural gas once looked like a low-cost alternative with which to displace existing oil resources, currently, renewables, coal, and possibly even nuclear power look cost-effective.

While the increased incentive to build is clear, less recognized is the impact that adding baseload resources could have on market prices. Because the lowest-priced resources are selected first for commitment and dispatch, adding an inexpensive resource necessarily displaces the otherwise marginal units, lowering prices throughout the region. This effect can be significant.

Reducing peak loads reduces the need to add generation and transmission infrastructure, which lowers costs. Current load profiles require substantial investments for serving load during only a handful of hours each year. Reducing demand in that handful of hours can have a disproportionate impact on infrastructure needs. Giving customers the opportunity to respond to accurate wholesale price signals can provide market incentives for them to reduce demand during these times, such as through energy efficiency, load management, distributed generation, and real-time demand-response.

	2006	2010	2015
Wholesale electricity[a]	$75.50	$62.00	$59.10
Capacity[b]	$8.30	$14.30	$14.50
Transmission	$3.60	$6.30	$6.40
Distribution	$68.90	$69.00	$69.00
Total	$156.30	$151.60	$149.00

Table 1
Business-as-Usual Electricity Prices: EIA Gas Prices ($/MWh)

	2006	2010	2015
Wholesale electricity	$75.50	$75.50	$75.50
Capacity	$8.30	$14.30	$14.50
Transmission	$3.00	$6.30	$6.40
Distribution	$68.90	$69.00	$69.00
Total	$156.30	$165.10	$165.40

Table 2
Business-as-Usual Electricity Prices: Flat Natural Gas Prices ($/MWh)

State-sponsored programs that assist consumers in better utilizing resources on the customer side of the meter would enable such consumers to respond to price signals and lower their electricity bills.

This analysis estimated the electricity market impact of each of these actions, using market loads and offer data for 2005. For each hour of the year, a modeled market price was calculated by stacking the supply offers in order and identifying where supply and demand intersects. This intersection point determined the hourly price. Separate model runs were then executed, with a single change to the input data corresponding to a change in either resources or demand. For example, a baseload resource was added to the supply curve each hour, or a certain amount of energy efficiency was assumed. The prices from these runs were compared with the baseline-calculated prices to estimate the market effect of the various modeled actions, conditional on 2005 fuel prices, actual 2005 resources and availability, and 2005 hourly loads.

Giving customers the opportunity to respond to accurate wholesale price signals can provide market incentives for them to reduce demand during these times, such as through energy efficiency, load management, distributed generation, and real-time demand-response.

Capacity-market impacts were calculated from the total capacity cost for New England, assuming that the Forward Capacity Market is in place. The net cost of capacity was assumed to be $5/kW-Month ($7.50/kW-Month in the FCA net of peak-energy rents, as assumed earlier). Capacity requirements in the business-as-usual case were estimated to grow linearly with peak-load growth. Reductions in peak-load

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growth through demand response, energy efficiency, and other measures reduced costs by $5/kW-Month because of reduced capacity needs.

Thus, the scenarios used 2005 power market data and results as indicators for future years. It was assumed that, in the future, the capacity market will clear at the cost of new entry. Because the future capacity market is still under development, using 2005 capacity-market results is not appropriate.

The following scenarios were modeled:

1) Addition of a 1,000 MW price-taking baseload resource

2) Addition of a 1,000 MW clean-coal generator, assuming that only clean coal can be permitted and sited

3) Assumption of 5% load growth without generation addition

4) Assumption of 5% reduced on-peak consumption

5) Addition of 500 MW of load response

Table 4 provides model estimates of the change in the wholesale electricity price, the change in electricity production costs, and the change in capacity costs under each scenario. The table shows these changes as follows:

• The changes in the wholesale electricity price are shown as percentages and as changes in total consumer electricity costs.

• The changes in production costs are shown as percentages and changes in total electricity production costs.

• The capacity cost changes are shown as percentages and changes in total capacity payments to capacity resources.

These estimates are intended to be representative of the effects of such actions and investments.

Changes in actual consumer costs could vary widely from these estimates. For example, 2005, the base year in the modeling analysis, experienced relatively few high-priced hours. An increased number of high-priced hours in future years would increase the calculated savings from load-response programs.

The modeling results suggest that substantial reductions in consumer and production costs can be achieved through market investment in low-cost baseload resources and reductions in consumer demand. Reduced consumer costs can occur both because of decreased electricity prices and because of decreased capacity requirements. It is assumed that market signals are sufficiently strong for investment in low-cost baseload resources such that investments would be made without any additional market incentives or costs. Thus, capacity costs are unchanged as new baseload resources displace existing, higher-cost resources.

	2006	2010	2015
Wholesale electricity	$75.50	$87.00	$105.00
Capacity	$8.30	$14.30	$14.50
Transmission	$3.60	$6.30	$6.40
Distribution	$68.90	$69.00	$69.00
Total	$156.30	$176.60	$194.90

Table 3
Business-as-Usual Electricity Prices: Natural Gas Prices Increasing 5% per Year ($/MWh)

	% Change in Wholesale Electricity Price	Change in Total Consumer Costs[a]	% Change in Production Costs	Change in Total Production Costs	% Change in Total Capacity Costs	Change in Total Capacity Costs[b]
1) Add baseload	-5.70%	-$600 million	-19%	-$470 million	-	-
2) Add coal	-5.60%	-$590 million	-11%	-$300 million	-	-
3) 5% growth	5.80%	$600 million	16%	$420 million	5.00%	$90 million
4) 5% reduction	-4.70%	-$490 million	-14%	-$360 million	-5.00%	-$90 million
5) Load response	-0.02%	-$2 million	-0.01%	-$0.5 million	-1.70%	-$30 million

Table 4
Summary of Scenario Results (2005 $)
(a) Assumed total wholesale electricity consumer costs in 2005 of approximately $10.4 billion.
(b) Installed Capacity Requirement of 30,000 MW in 2005, at $5/kW-Month net capacity cost, results in a base capacity cost of $1.8 billion/year.

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NATIONAL GRID PLAYS KEY ROLE IN ATTRACTING AMD PLANT

By Don Horne

Marilyn Higgins, VP of Economic Development for National Grid.

A project started almost a decade ago has borne fruit for Saratoga County, New York in the form of a semiconductor company agreeing to build a $3.2 billion computer chip manufacturing plant there.

National Grid, the major utility provider for the area, played a leading role in laying the groundwork to make such a move possible.

"Eight years ago we began targeting this type of industry, which came about from another unsuccessful bid," says Marilyn Higgins, VP of Economic Development for National Grid. "Computer chip manufacturers are very, very specific in their power reliability requirements. Reliability and capacity are a big part of their decision-making when it comes to choosing location."

The company, Advanced Micro Designs Inc. (AMD), is expected to employ 1,200 people in their factory, and create more than 1,500 construction jobs as well. Construction is expected to begin in the fall of 2007, taking anywhere from 18 months to 2 years to complete.

For National Grid, it means the construction of one new substation and four new transmission lines, with an expected capacity of 100 megawatts.

"There is the capacity to expand," Ms. Higgins points out. "AMD is expected to draw other similar industries."

The groundwork laid to attract AMD is considerable, and an excellent lesson in that you have to spend money to make money.

"It's been a long-term process, started by Niagara Mohawk, which National Grid bought out," she says. "Actually, after the purchase, National Grid not only maintained the budget for this project, but increased the money."

What followed were exhaustive searches for an appropriate site (the Luther Forest Technology Campus was chosen and upgraded), and countless trade shows, meetings and sales junkets - $1 million in total spent on attracting industry to the state.

Saratoga Economic Development Corp., the developer of Luther Forest, received nearly $750,000 for site preparation, including engineering, aerial mapping, and environmental and vibration studies from National Grid.

The utility also worked closely with groups like the Center for Economic Growth, an Albany-based economic development group, and Albany NanoTech, the University at Albany's $3 billion nanotechnology research and development center.

National Grid is an international energy delivery business based in the UK with principal activities in the regulated electricity and natural gas industries. In the U.S., National Grid delivers electricity to approximately 3.3 million customers across 29,000 square miles of Massachusetts, New Hampshire, upstate New York and Rhode Island. The company also distributes natural gas to 565,000 upstate New York customers.

But for upstate New York, the AMD announcement is great news for a region that has been witness to a decade-long drain in manufacturing jobs – a whopping 33 per cent.

"We lost about a quarter of our young people, because there just wasn't any work here," says Ms. Higgins. "So for a semiconductor company to locate in upstate New York, it is really encouraging."

MAKE IT A (FINE) POINT TO GO TO THE CIRCUIT BREAKER CONFERENCE

Finepoint inaugurated the annual Circuit Breaker Test & Maintenance Conference, the electric power industry's premier event for substation/switchgear maintenance people.

Participants receive practical training from users' perspectives, learn factory authorized test and maintenance procedures, network with their peers, and view cutting-edge products at the supplier exhibits each evening in the hospitality room. More than 350 electric utility and testing company delegates attended the 2005 conference, representing 158 different companies. The conference provides attendees, speakers, and exhibitors with a high quality, low key opportunity to exchange information with their peers and learn from the experts.

Many conference topics focus on low - medium - and high-voltage circuit breakers. However, related substation and switchgear topics such as power transformer maintenance, oil testing and filtration, SF6 gas handling, safe work practices, and asset management issues are also covered. Finepoint's objective is to provide useful and unbiased information that can be immediately applied to substation and switchgear maintenance work.

What makes the conference unique is that most speakers are the electric utility and testing company delegates themselves, not suppliers.

The full day at a circuit breaker manufacturing plant has been another unique feature of the conference since 1996. Participating manufacturers are ABB (Greensburg/Mt. Pleasant PA in 1996, 2000, and 2005), AREVA (Charleroi PA in 1997, 2001, and 2006), HVB AE Power Systems (Suwanee GA in 2004), Mitsubishi (Warrendale PA in 1998 and 2002), and Siemens (Jackson MS in 1999 and 2003).

The AREVA T&D high voltage test lab in Charleroi, PA will be featured during Tuesday's Factory Day at the Circuit Breaker Test & Maintenance Conference in October.

The conference begins October 9 with a reception that evening. The factory day is on Tuesday. The conference presentations and training seminars are scheduled each year on Wednesday, Thursday, and Friday.

The 2006 factory day host is AREVA T&D in Charleroi PA, their worldwide competency center for dead tank high-voltage circuit breakers. Expanded in 2003 to include greater production area and state-of-the-art development and test facilities, the site has devel-

oped as a center for HV, MV, and T&D Service activities.

AREVA HV dead tank circuit breakers and live tank circuit switchers are designed, assembled and tested from 72.5 to 550 kV. In 2005, their MV circuit breaker facility was relocated to the Charleroi site to satisfy customers' supply chain preferences for full line supply. AREVA is limiting factory day participation to the first 250 people who register (you can visit their website for further information).

See pages 40-41 for floor plan layout of the show.

In association with the 2006 conference, AREVA T&D will be hosting a PKG Generator Circuit Breaker User Group meeting on Monday, October 9, from 8:30 a.m. to 4:30 p.m.

This user group will share maintenance and operation practices, expertise, and exchange ideas. It will also look at future practices regarding maintenance, parts, resources, and knowledge.

In addition to more than a dozen presentations, the 2006 conference features two half-day training seminars.

Westinghouse developed the line of AA-7, AA-10, and AA-14 circuit breaker mechanisms in the early 1950s and more than 35,000 were produced. The ABB "Maintaining AA-7/10/14 Mechanisms" seminar on Wednesday afternoon, October 11, will provide an understanding of the design, operation, maintenance, interchangeability of parts, and trouble-shooting of the mechanisms and ancillary devices. Bring the questions you have always wanted answered and challenge the experts.

On Friday morning, October 13, Reinhausen will take you inside load tap changers and demonstrate how they work, what to test and evaluate, and why. This "Load Tap Changer Testing and Evaluation" seminar will provide full knowledge of what it's like to be a Tap Changer, the order in which parts operate and, sadly, what happens to you if you operate outside the proper sequence of parameters. This seminar is fully interactive and will be one terrific learning experience.

The conference is pleased to welcome PEARL, the Professional Electrical Apparatus Recyclers League, an association made up predominately of companies that supply quality surplus and remanufactured electrical equipment and apparatus such as circuit breakers, transformers, switchgear, motor control centers, wire and cable, etc. PEARL hosts an annual conference and invites attendance by anyone interested in ensuring the quality and safety of recycled electrical equipment.

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LOOKING AT LARGE-SCALE UTILITY ASSET MANAGEMENT

By Bjørn Inge Langdal and Arnt Ove Eggen, SINTEF Energy Research; Pål Ivar Hansen, Powel ASA; Terje Pynten, NTE

The trend for grid management is towards larger utilities, with owners, authorities and customers making heavy demands in terms of return on investment, efficiency, health, the environment, safety and quality. Typical characteristics include more stringent internal quality requirements, demands by the authorities for better documentation and reporting, and an increasing need for specialist evaluation to be documented and justified to management and decision-makers.

Utilities are, therefore, faced with important choices when it comes to prioritizing grid refurbishment, replacement, maintenance, and fault correction. The need for a holistic approach and more reliable decision support is now a reality in achieving desired goals.

In the present situation, this is not easy to implement in practice. It is still common that important information is only available in manual archives or only available as "silent" knowledge in the heads of experienced employees. A typical situation is meters of shelving with ring binders containing forms covering several years of line inspections, backed up by employees who remember where there have been problems. This type of knowledge could previously be used to make decisions at the local level, without much thought being given to the overall picture and main priorities at the utility level.

The challenge now is to use this type of information as a basis for making decisions taking into account the overall picture for the whole utility. Replacement of a line will not be appropriate if there are other needs which should be given higher priority. Furthermore, other changes are underway, with a new generation of employees

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replacing those with long years of service and extensive local grid knowledge. Younger project managers and technical personnel will be much more dependent on formalized information, as they do not have a corresponding background and local knowledge.

This article describes a concept to deal with the challenges described above. Currently, utilities should benefit from investments in key information systems, such as Network Information Systems (NIS), systems for Enterprise Resource Planning (ERP) and Customer Information Systems (CIS). Such systems have been available for many years and much effort has been put into data collection and data conversion from self-developed proprietary data systems. The situation today is characterized by key systems offering high performance functionality and vast amounts of information. The challenge is now to utilize the available information.

APPLICATION AREAS THAT REQUIRE COMPREHENSIVE GRID EVALUATION

Decision makers will need to rely upon different kinds of information, depending on what kind of decision is to be made. Typical situations are:

– Development of long-term maintenance plans
– Short-term plans for corrective maintenance
– Plans for refurbishment and replacements
– Dealing with current technical problems
– Grid dimensioning based on different prognoses
– Ensuring proper security level for employees and public
– Dealing with environmental issues
– Meeting requirements from authorities
– Satisfying needs and demands from customers

These different situations require different kinds of information, which might be found in different kinds of data systems. Furthermore, decision-makers will definitely need to differentiate the importance of the data involved. There is no single answer to such questions, and each of the utilities will have to establish rules based upon utility philosophy, preferences, and availability and quality of information.

Maintenance and renewal

Decisions regarding maintenance and renewal play an important role for most utilities due to the fact that the average age of assets has become considerably high. Furthermore, the need for short-term cost reductions will often dictate strategies and solutions where little attention is paid to long-term consequences. A considerable amount of information needs to be taken into account when making such decisions. Typical needs for information are:

• Asset state and failures from condition monitoring and inspections
• Component age
• Component types
• Results from technical calculations
• Economic data such as historical maintenance costs
• Results from LCC analysis
• Cost benefit from different actions to be taken

Authority requirements

There are several authority requirements that must be met, such as annual inspections of components in the distribution network. Information from such inspections is often important when making decisions. Other authority requirements are upgrading or replacement of different technical solutions that are motivated by safety reasons. The time frame and importance of different authority requirements might be differentiated and the number of actions to be taken will often be extensive. This means that prioritizations must be made, involving complex decisions.

Technical requirements

Technical calculations are necessary to verify that current grid complies with existing regulations and to ensure optimum operation of the grid system. This includes load flow analysis to determine voltage drop, thermal load limits of cables and lines, transformer loads, etc. Further calculations must be performed for a period of time, normally 30 years, where future development of energy and power demand is estimated. Assumptions regarding demographic development, industry developments, etc, must be defined and taken into account.

Customer satisfaction

Customer vulnerability is very diversified with respect to interruptions, voltage fluctuations, etc.

For example, customer satisfaction based on complaints should be recorded and related to the occurrence of undesirable events. Availability of historical data for customer satisfaction could be useful for understanding trends in frequency and duration of both notified and non-notified interruptions.

Further, it may be of interest to analyze fault statistics, such as weather conditions and technical causes, to find out more about problem causes.

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Personnel safety

An immediate menace to life, health, environment and safety should initiate immediate action.

However, not all observations call for immediate action as this could easily cause suboptimization.

It is, therefore, important to record such information and coordinate with other relevant information and use this to make the right decisions. Component information, such as age and type, will often be used to identify areas where safety needs to be improved.

Economic issues

Economic data is needed to understand how investments should be differentiated in the different components of the grid system. Both data describing labor expenses, asset investments, cost of losses and interruption costs must be taken into account. Furthermore, data describing planned investments and planned maintenance will be needed.

Environment/esthetics

It is necessary to evaluate environmental consequences. This implies both potential pollution problems and esthetic aspects. Public fear and uncertainty surrounding areas such as electromagnetic influence should be represented. This could, for example, determine the use of cable instead of line when crossing residential areas. Esthetic aspects could also motivate a similar conclusion.

METHODOLOGY

Low-voltage network structuring

A low-voltage cable network usually consists of the following components: LV distribution busbar, feeders, distribution pillars and service lines. In our model, the substation itself, the MV switchgear and the distribution transformers are also regarded as components of the "low-voltage" network.

It's important to note that not every single item is analyzed. In the model, all similar items, e.g. all service lines, are analyzed as one average "component".

Low-level indicators

For each component "i" in the low-voltage network, a set of low-level indicators is defined.

– Technical indicators comprise technical solution, age, technical condition (percentage value based on condition monitoring), degree of utilization, etc.

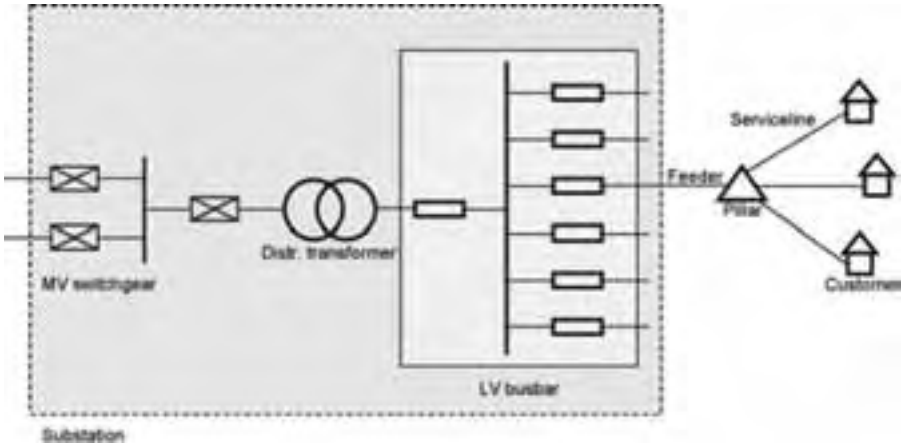

Figure 1 Example of a low-voltage cable network

– Economical indicators comprise historical investment costs, operational costs, maintenance costs, etc.

Most of the input parameters come from load flow analyses, short-circuit calculations and reliability calculations in the Network Information System (NIS). In addition, information like type, age, etc, and parameters for the technical condition, recorded failures and their consequences coming from the computerized maintenance management system (CMMS) are important parts of the analysis.

One of the main practical problems is to compare quantitative parameters (with different scales) with qualitative parameters. On way to overcome this obstacle is to transform each selected parameter into 1 out of 3 possible states by comparing the parameter value to a pre-defined set of criteria. It is important that these criteria are strongly related to the utility's philosophy and strategy. The 3 states are based on a traffic light analogy (Red, Yellow, Green), with a 4th White state added for inadequate input data. By following such a methodology the decision-maker may have a uniform and consistent analysis of all components in the entire network.

Table 1 Categorization of low-level indicators in one out of 4 possible states

State		Description	Criteria	Weighting
WHITE	-	Inadequate input data		α_{White}
GREEN	OK	No actions necessary	U > 218	α_{Green}
YELLOW	Warning	Fulfills functional requirements, but actions may be necessary	U < 218	α_{Yellow}
RED	Alarm	Does not fulfill functional requirements, actions required	U < 207	α_{Red}

U = Lowest measured (or calculated) voltage in the low-voltage network [V] (230 V system)

Table 2 Examples of low-level indicators for a transformer

Low-level indicator	Value	Red	Yellow	Green	Weight
1. Technical solution	Orient. cast		Non-ort. cast	Orient. cast	$w_{i,1}$
2. Age	30 years	[illegible]	≥ 35 years	< 35 years	$w_{i,2}$
3. Technical condition	40	[illegible]	≤ 50 %	> 50 %	$w_{i,3}$
4. Degree of utilization	92	[illegible]	> 90 %	< 90 %	$w_{i,4}$

Component indicators

Each component in the network has several low-level indicators, and to be able to make a total assessment of each component, the indicators have to be aggregated to one component indicator.

The indicator for component "i" can be calculated based on all its low-level indicators "j" by the following formula:

$$PI_{Comp,i} = \frac{\alpha_{Green} \sum_{j \in Green} w_{i,j} + \alpha_{Yellow} \sum_{j \in Yellow} w_{i,j} + \alpha_{Red} \sum_{j \in Red} w_{i,j}}{\sum_{j \in Green} w_{i,j} + \sum_{j \in Yellow} w_{i,j} + \sum_{j \in Red} w_{i,j}}$$

Relative weighting of the low-level indicators

These different low-level indicators may have varying importance (weight) when assessing the actual component. The weighting can be based on a subjective assessment. Another, more formal, weighting principle may be based on e.g. the Analytical Hierarchy Process (AHP) method. The type of customers connected to the network may also influence the weighting of the indicators, e.g. the availability or outage time is much more important in an industrial/service area than in a residential/farming area.

Network Name	Network	White	Green	Yellow	Red	Network	Sub-station	MV Switchgear	Trans-former	LV busbar	Feeders	Pillars	Service lines
<Average>	0,1	9	72	5	14	0,1	0,0	0,0	0,0	0,0	1,0	0,0	0,0
<Worst case>	14	9	72	5	14	13	100	100	100	100	13	100	100

Table 3 Results presentation examples from the prototype

Relative weighting of the four possible states

Based on an intuitive assumption that "red" indicators are more important that "yellow" and "green", the four states have been given different relative weight (white indicators are not included, and have ?White = 0).

The main purpose of aggregating low-level indicators to the component level before they are aggregated to the low-voltage network level is the possibility to separately assess similar components throughout the system, e.g. to compare component indicators for all the distribution transformers in the entire network, and to analyze whether the same components most often cause the "bad" indicators.

Low-voltage network indicators

The low-voltage network indicator is, in addition to the component indicators, calculated based on a set of indicators with aggregated values for the LV network:

– Technical indicators comprise network losses, lowest voltage, number of outages per year, annual outage time, annual outage cost, etc.

– Health, environment and safety indicators comprise safety, noise problems, esthetics, etc.

– Other indicators comprise demographic information, customer categories, etc.

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- Unidad 6, Turbina de Vapor Mca. Mitsubishi tipo Tandem Compound TAP-TBR: cap. 84000 kw, opera con combustóleo o gas, cuenta con equipo auxiliar y refacciones, entró en operación el 25 de abril de 1971, con valor de venta de $ 105'478,390.00 pesos mexicanos ($9,650,000.00 USdlls) y
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The low-voltage network indicators can be calculated using a formula similar to that on page 35. As with the weighting of low-level indicators, different components may have different importance (weight) in the network. The weighting principle can be based on the replacement cost for each component. This can be justified by the fact that the alternative to overall renewal of the LV network is replacement of faulty or overloaded components. Also, for the low-voltage network, the weighting principle may be based on the Analytical Hierarchy Process method. Table 3 presents examples of result presentation from the prototype.

<Average>

The result from the <Average> calculations gives a "Green" indicator for this LV-network. In addition to the overall indicator, a weighted percentage value for each of the states White, Green, Yellow and Red is calculated. By inspecting these values, the decision-maker can find that an overall "green" network still may have potential "red" problems. For this particular network, the result shows that 9% of the indicators are "White" (data missing), 72% are "Green", 5% are "Yellow" and 14% are "Red". The detailed results for the different components show that it is only the feeders that are not "Green".

<Worst case>

In addition to the overall weighted average, the prototype also gives the possibility to calculate and present aggregated indicators where information about the worst low-level indicators is maintained. The result from the <Worst case> calculation shows that 33% of the low-level indicators (1 out of 3 indicators with equal weight) for the feeders are "Red", which results in the 14% "Red" for the whole low-voltage network. Notice that in this case the color of the worst-case indicator is presented as the network indicator.

In this example the results are presented for only one low-voltage network. However, the prototype can simultaneously calculate indicators for all low-voltage networks the user selects.

Presentation of low-voltage network indicators in NIS/GIS

The one single weighted indicator representing the state of the entire low-voltage network indicators can be presented in the NIS/GIS (Graphical Information System). Figure 2 shows the results from an analysis in the prototype. The lines represent the medium-voltage network, while each dot (located at the geographical position of the sub-station) represents the low-voltage network indicators. In this grey-scale figure dark grey = Red, grey = Green, light grey = Yellow and white = White. This kind of graphical presentation may give the decision-maker an indication on geographical areas with several "bad" low-voltage networks.

Figure 2 Example of visualization of indicators in a network

It is impossible to have an exact and perfect large-scale utility asset management model. The real challenge is, therefore, to establish a model that is not so complex that it cannot be implemented, but still complex enough to present results that are "good enough", although not "optimized".

Maynard Keynes once stated: "It is better to be roughly right than precisely wrong". Using high-precision values in the result presentation only gives the impression that the calculations also are very precise, which they are not.

It is therefore emphasized, as the name implies, that the indicators only give an indication of current problem areas, or areas where future problems are most likely to occur. For the "Red" and "Yellow" low-voltage networks more detailed analyses must be carried out in order to identify the actual problems and the proper solutions.

INFORMATION AVAILABILITY

Currently, most utilities have established systems for documentation of assets, including geographical information. In a modern NIS (Network Information System), asset information is integrated with geographical information, network topology, maintenance information, making considerable amounts of information available for users within various levels of the organization.

The trend seems to move from integration between several stand-alone applications towards fewer integrated solutions where NIS (Network Information System), ERP (Enterprise Resource Planning), CIS (Customer Information System) and SCADA are the core systems. The advantage of few core systems in this context is that information is made easily available to those who need data to make decisions. Stand-alone applications may seem advantageous when just looking at the need for information for specific tasks, e.g. applications for recording data when doing line or substation inspections. However, such information is far more valuable if it is possible to relate this information to other relevant grid data such as results from network calculations and historical maintenance costs.

CONCLUSION

Traditionally, most of the maintenance and renewal planning and decision-making have been carried out in local departments, where in-depth knowledge about the condition of the network was background for many important decisions. Due to centralization, more of the planning and decision-making is transferred to central offices where the planners do not have a similar local knowledge about the network condition. Furthermore, decisions now have to be made upon a broader set of information, including economical data, technical analysis, environmental and safety data. Therefore, making decisions now has to be based on "formal knowledge" stored in different information systems.

Distribution networks are characterized by a large number of geographically dispersed components, and the opportunities for decision-makers to get detailed information about the network is limited. This fact calls for a methodology to help decision-makers in screening the entire network to decide what is likely to be the most cost-effective solution for maintenance and renewal.

Smarter networks

continued from page 19

action; and the ocean is wide," he points out.

"It is easier to use a Canadian example of smarter networks, something the Americans can see as being viable."

The Ontario electricity market has been deregulated since 2002 (Alberta deregulated its market in 2001), and is currently undergoing an extensive smart meter upgrade for all of its residential customers.

In what Mr. Heimann describes as a "staggering effect" of deregulation across North America, he stresses that intelligent utility platforms are effective – if not more profitable – for smaller utilities.

"We have basically the same demographic in Germany as in the United States, many large communities with many mid-size utility providers. The smaller 'munis' are attractive as customers, as profitability is a strong incentive for them to make the move to automation."

The SAP road map for utilities takes into account market trends and challenges, targeting pending deregulation requirements such as "unbundling", which will affect sweeping changes across utilities' organizational structures, business processes and IT systems. As early as 2007, utilities in the European Union and other countries around the world must meet regulatory requirements to separate their previously "bundled" generation, distribution and retail operations.

Mr. Heimann, affectionately called the "Grandfather of Utilities", expects his children will see a new way in how power is generated and distributed in the coming years.

"The majority of people who switch do it because of how that power is generated. It makes a difference to them; or they will produce it themselves.

"In my neighbourhood, there are two soccer-field sized solar generation plants, generating four megawatts. These and other creative combinations are the future."

Although the North American market hasn't fully embraced deregulation, Mr. Heimann points to the Lone Star state as a prime example of what the future holds for the continent.

"Texas is very similar to Europe, insofar as deregulation.

"With TXU (citing the major Texas utility), we can roll out our product to its full scope."

In the U.S. southwest, SAP recently introduced their Safe Passage program to the Arizona Electric Power Cooperative, Inc. (AEPCO), a tailored package of applications, technology and incentives to consolidate approximately 100 disparate legacy systems onto a single, integrated platform, streamlining business processes for improved usability across its three cooperative organizations.

The move will aid in the modernization of internal systems and help AEPCO preserve its intellectual property.

"We realized the need to modernize our business processes and move to a more streamlined and integrated approach in order to increase enterprise visibility in our internal operations," said Lee Anne Wilfert, CIO of Sierra, the energy services and human resources arm of AEPCO. "SAP was the natural choice — it offered a complete, flexible, enterprise-wide, integrated solution and the reassurance of knowing we were partnering with a stable vendor that could support us for the long term."

By standardizing business processes on a single, integrated, enterprise platform, AEPCO is able to preserve the valuable working knowledge, trade secrets, networking contacts and customer information that resides in each employee's head. By transferring this knowledge to a place where it can be stored, shared and accessed by the entire company — from employees at the electric generation plant site to the boardroom — AEPCO will be able to save time and money on training new employees, decrease the drain on company knowledge resources and increase productivity among workers.

METER DATA MANAGEMENT: A KEY TO THE UTILITY OF THE FUTURE

By Wendy Lohkamp, Director, Meter Data Management Solutions, Itron, Inc.

As your utility has added customers over the years, you've probably looked for ways to gather meter data more efficiently. If you distribute multiple products — electricity, water, natural gas — or serve a diverse service area, you may have installed multiple types of meter reading solutions. Today, your utility may have tens or even hundreds of thousands or millions of meters from multiple manufacturers generating data that's gathered in multiple ways. Your large investment in gathering meter data has helped your billing department keep pace with change and growth, but now other groups within your utility are asking for more data. Or, perhaps you are looking for ways to share the operational costs of deploying AMR across the multiple groups that can all gain some advantage with this data. Ideally, you need one simple way to collate and analyze all your meter data for forecasting, planning, energy delivery, maintenance, and more to help keep your system reliable, profitable, and competitive.

Properly managed meter data enables utilities to predict system load and usage to avoid imbalances and reduce off-network purchases.

Properly managed meter data enables utilities to predict system load and usage to avoid imbalances and reduce off-network purchases. Data analysis can help pinpoint over- or under-utilized infrastructure, improve system throughput, speed service restoration after outages, and more. Properly managed data means your utility can deliver more value to customers and shareholders for less overall cost. Data itself becomes an asset. Although this may sound like technology from a hi-tech future, meter data management really just supports the basic and sound operation of energy delivery. It enables operational efficiency, cost reduction, and meeting current and future goals with fewer resources. Meter data helps utility leaders make good decisions, deploy new supporting technologies and get the most return out of their existing base of assets.

This article will examine strategies for implementing a centralized meter data management system, how such a system interacts with multiple metering technologies and data applications, and the benefits that meter data management can supply to employees, customers, and shareholders.

THE CASE FOR METER DATA MANAGEMENT

Typically, organizations that are considering installing meter data management systems have some or all of these traits in common.

- They have multiple users or groups (internal and external) that need access to meter data.
- They have silos of data and systems that add support cost and make combining data for analysis nearly impossible.
- They have spent copious resources on patching, integrating and manipulating multiple source systems and do not want to maintain this integration or these systems in the future.
- They read multiple makes of meters by multiple systems such as MV-90, mobile collection, fixed network, and handheld.
- They have experienced issues with data quality and want a solution where data can be cleaned, maintained, and audited in one central location.
- They have users demanding ad-hoc access to data to perform analysis but no mechanism available to supply that data.
- They have struggled through large enterprise-wide software implementations in the past and do not want to build another system from scratch.
- They have outsourced IT departments and do not want to maintain applications.
- They have individual departments seeking their own cost-

Continued on Page 42

E. Patrick Carroll, P.Eng., President of Tiltran Services, Tillsonburg, Ontario, is pleased to announce the hiring of **Charles (Chuck) Sparks**, CET, as Manager of Engineering.

Chuck has for many years been well known and respected in the Ontario electrical industry, as a contractor and in various positions with Ontario Hydro and the Electrical Safety Authority (ESA).

Chuck looks forward to joining the Tiltran team, which over the years has developed into one of the most respected high voltage construction and maintenance companies in the province. Tiltran, in association with Lizco Sales, has access to Canada's largest privately owned inventory of high voltage transformers and switchgear, giving Chuck and the rest of the Engineering team the resources they need to design and complete projects well within current equipment deliveries.

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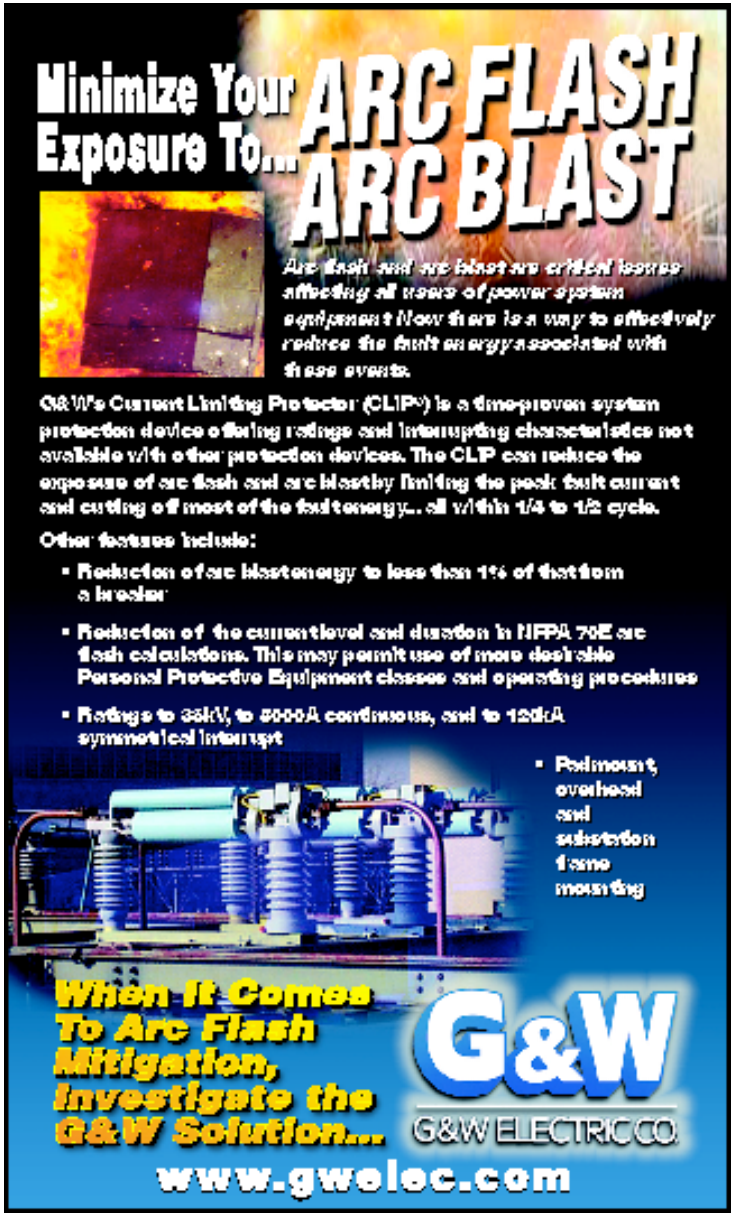

Metering

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ly solutions after realizing that they cannot get what they need from existing applications.

• They have decided not to outsource key strategic information, because they do not want an ASP/hosting model where they pay for access to their own data.

• They have realized their current system's potential for errors and confusion, especially as the frequency of data collection and intervals increase.

What do these characteristics mean in the real world of energy delivery? Here are three scenarios.

IMPLEMENTING AUTOMATED METER READING

Advances in metering and communication technologies continue to provide a wide range of options for automated meter reading (AMR). Today, no single vendor can offer a solution that covers all terrains, territories and meter reading issues. Utilities may have multiple AMR solutions within the same territory.

Adding a new AMR technology may fix a meter-reading problem, but it can also affect existing systems and processes and create a separate silo of data within the organization.

AMR can provide a much higher frequency of data as meter reading moves from monthly to daily or even hourly. While the data is valuable in many ways, the shear growth in data introduces concerns about the volume, scalability, and processing power of existing systems. In particular, many current residential billing systems are not structured to handle more than one reading per billing cycle. Billing is structured around routes, but with the introduction of fixed network AMR, routes may no longer be necessary or meaningful.

How can utilities interface these best-of-breed collection systems to existing collection, billing, and IT systems?

MANAGING MULTIPLE TECHNOLOGIES

Mergers and acquisitions have left utilities with multiple technologies that do the same thing. Newly formed utilities may have multiple collection systems from multiple vendors. Data from different vendors and organizations is stored separately, thus requiring synchronization, manipulation and maintenance of multiple systems. The different streams of data may be incompatible, requiring that EBCDIC data be transformed to ASCII (or vice verse). Or XML, flat files and delimited files must be parsed to find the common data elements. Each solution must exchange data with multiple other solutions, creating an unmanageable web of interfaces between billing departments, meter shops, field service organizations, outage management teams, and more.

How can an organization undergoing transformation tame all this technology?

REGULATORY COMPLIANCE

Recent corporate accounting and securities scandals have brought additional regulatory requirements to an energy sector already familiar with compli-

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Metering

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ance issues. In particular, the Sarbanes-Oxley Act mandates an unprecedented level of financial auditing and transparency. Under the act, public companies have new requirements governing whether financial statements are accurate, controls are adequate, disclosures are timely, and that documents and data supporting the financial assertions are controlled.

How can an energy supplier who sells multiple products at multiple rates to multiple customer classes, and collects the sales information through multiple systems, make sure that their accounting and financial reporting is accurate, controlled, and timely?

These three scenarios point to impending — or ongoing — technological chaos for energy providers.

HOW TO TAME THE CHAOS?

Characteristics of a Meter Data Management Solution

Meter data management solutions provide a single data repository, can gather data from multiple metering systems and then supply that data to multiple applications such as billing, forecasting, customer service, system operation and maintenance. Mapping multiple metering systems to multiple business applications through a single repository organizes your meter data to help you run your business more efficiently.

Good meter data management solutions adapt to your situation, accommodating your unique combination of meters, meter reading technologies, billing systems, and analytic needs. They also help you find ways to reduce costs, increase revenues, and deliver more value to your customers.

The core of meter data management is a single database or repository of customer, meter, and reading data. Data exports and application programming interfaces (APIs) push or pull data between the repository and the multiple destinations that rely on meter data. This helps ensure that consistent processes are applied to a single set of data. Such processes include calculation services (aggregations and calculations on interval data performed in a controlled and consistent fashion); validation, estimation and editing (confirmation that collection systems and meters are functioning properly); best read rules; and more. Audit logs record all changes and corrections to data, including who, how, and why edits were made. Import logs track if any data was not captured successfully. All versions of, and changes to, data are retained for as long as needed for historical perspective or regulatory compliance. The data is safeguarded by both data- and role-based security.

How would such meter data management systems, which exist today, respond to the three scenarios posed earlier?

• AMR implementation featuring meter data management

When an energy provider using meter data management adds a new AMR system, that system needs to be interfaced only with the meter data management system. The meter data management system then handles interfacing the AMR system to other functions throughout the organization. This greatly simplifies the introduction or expansion of AMR systems.

• Multiple technology integration featuring meter data management

When a merged utility must integrate multiple technologies, meter data management can serve as the focal point. Instead of requiring that every system communicate with every other system, all systems need only communicate with the meter data management system, which then handles all the data interfaces.

• Regulatory compliance featuring meter data management

Because all sales data is stored in a single, auditable repository that logs all changes and who made them, corporate auditors and regulators can have a high degree of transparency and confidence with financial statements based upon that sales data.

• In the end, meter data management systems create a common view of energy data and decrease data integration complexity

As a result, data managers can focus more on meeting the strategic needs in their organization, thereby providing value-added services while making end users more self-sufficient.

STRATEGIES FOR IMPLEMENTING METER DATA MANAGEMENT

While each case will be slightly different because each organization's collection of disparate meters, meter reading, and data processing systems is different, implementation of meter data management solutions usually includes these steps.

1. Generate enterprise-wide buy-in for a meter data management solution. The new system will have enterprise-wide ramifications, so the entire enterprise needs to support the implementation. As seen from just the three scenarios already presented, for nearly every department in the utility a business case can be made that accessible, accurate meter data can improve operations, reduce costs, and create new services.
2. Identify all sources, destinations and formats for meter data. Interview people in every corner of the enterprise. There will probably be more data sources and needs than you imagined.
3. Identify the specific meter data management vendor or solution that will fit the enterprise's needs.
4. Once the meter data management solution is initially installed, get data from disparate collection systems to flow into the new, single data repository.
5. Once meter data can flow into the repository, get data to flow from the repository to a data-dependent application such as billing or forecasting.
6. Phase-in support for other users of meter data such as outage management, distribution planning, revenue assurance, and forecasting.

BENEFITS OF METER DATA MANAGEMENT

In addition to the three scenarios discussed earlier, meter data management enables a whole host of other services that are beneficial to energy providers and their customers.

CONCLUSION

Organizations that undergo the transformative process of adopting meter data management solutions start to realize efficiencies and savings as soon as the solutions come on-line. Many of them continue to find ways to earn a return on their investment in meter data management through new and innovative ways to apply meter data throughout the organization. At that point, meter data is truly shaping the utility of the future.

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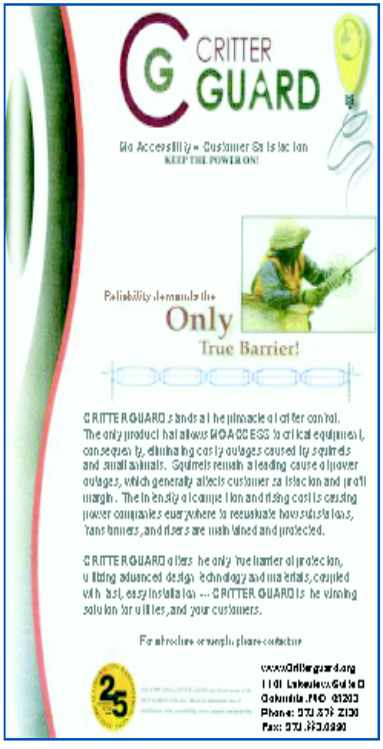

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