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Keeping your transformers fit

Pages 8, 12 and 22

SPECIAL FEATURE
Energy Security: a North American Concern

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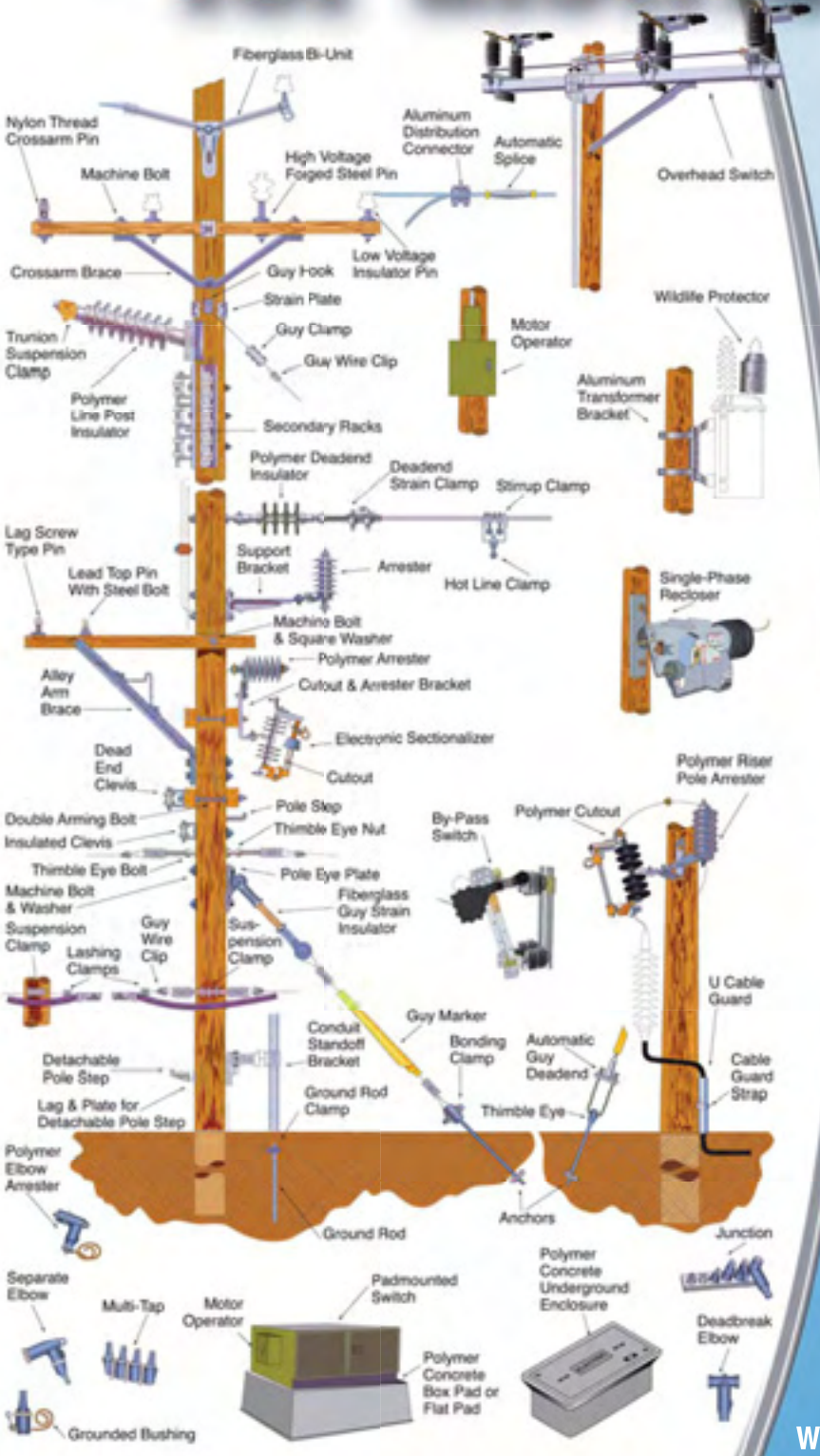

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ELECTRICITY TODAY

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LOOKING AT THE BIG PICTURE THROUGH SMALL TECHNOLOGY

By Don Horne

You can sum up most of the industry seminars on transformers this way: Getting the most for the longest time possible. At the recent DistribuTECH Conference in Tampa Bay, Florida, it was evident that a crucial part of any automation system is the ability to monitor, diagnose and troubleshoot transformers before a failure occurs.

And much more.

We've come a long way from the simple thermal imaging of transformers to see if they are running too hot. Now, system-wide monitoring of transformers for peak performance throughout the distribution grid is what the future holds.

Power is at a premium, and transformers have to do more than just perform. They are expected to perform at top efficiency, squeezing every last volt out to the customer. The days of old transformers operating at 10 to 20 per cent below optimal are rapidly disappearing.

With politicians scrutinizing every new fossil-fuel based generation plant being constructed, utilities are looking to save waste anywhere they can.

The current massive upgrades to the distribution systems in North America are an excellent opportunity to replace old, low-efficiency transformers with energy-efficient ones. In concert with the new SCADA networks, the utility can monitor and minimize transformer losses that were once the accepted norm.

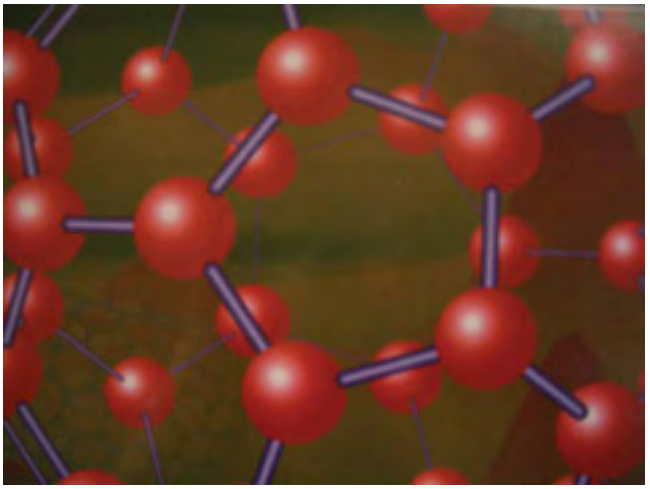
Although power and distribution transformers have service lives ranging from 25 to 50 years, there are many electrical transformers that were built and installed shortly after the Second World War that still remain in service.

The life cycles of these transformers are dictated by the internal insulation system and the maintenance of that system.

Through reliability-centered maintenance (RCM) programs, utilities have achieved a high level of dependability; however, they require near-continuous monitoring and diagnoses to show individual and aggregate equipment status and trends.

By thinking in big terms, one company went small to address this need through nanotechnology.

The life of the electrical transformer actually depends on the life of the internal insulation system. It can be shortened by a number of events - exposure to extreme conditions, aging and wear and tear. Many conditional items can be replaced in a timely manner to extend the life of the transformer. However, the oil-cellulose insulation system is one component of the transformer that cannot be replaced. Due to the omnipresence of oxygen and water, insulating oil deterioration is normal.



A reliable method for predicting transformer failure before it reaches an extreme condition (explosion, for example), is crucial. A high hydrogen level in electrical insulating oils can indicate an imminent explosion, and closely monitoring hydrogen can be an effective tool in predicting and preventing transformer failure.

One of the future technologies included in the monitoring mix is the emergence of nanotechnology.

One company created a palladium alloy nanoparticle-based sensor for the detection of hydrogen gas dissolved in power transformer oil. The absorption of hydrogen by the palladium alloy nanoparticles results in changes in the oil's physical, electrical and optical properties.

It is based on a phase transition of these alloys in the presence of hydrogen whereby the nanoparticles expand by as much as 5 percent to 10 percent. This means that the volume increases in the presence of hydrogen. The company (Applied Nanotech) developed certain semiconductor processes whereby palladium alloy nanoparticles are isolated from each other when hydrogen is not present. In the presence of hydrogen, because of the volume growth due to the phase transition, the particles touch each other and considerably change the electrical characteristics of the device.

Because the sensor acts like an open circuit, it uses low to no power in the absence of hydrogen.

As it is nanotechnology, the sensor can be as small as one square millimetre and can be easily incorporated inside the transformer oil for continuous real-time sensing.

Traditionally, transformer oil is analyzed using gas chromatography, which is expensive and time-consuming (and not to mention cannot be performed remotely and continuously).

Applied Nanotech plans to integrate the hydrogen sensor with recently developed wireless transmission chips so that the status of all transformers in a simple network can be monitored remotely and simultaneously.

That is just one example of one company thinking big by going small.

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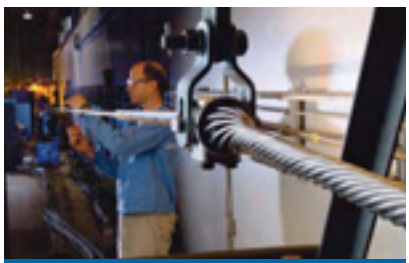

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REALTIME ANALYSIS OF SF6 DECOMPOSITION PRODUCTS

By Keith C. Lee and Ian G. N. Wylie, Powertech Labs Inc.

Developed under a joint B.C. Hydro and EPRI research program, the Powertech SF6DPD provides a quick and accurate measurement of SF6 decomposition products in field situations. Testing SF6 directly from the equipment eliminates the sampling and delay associated with lab analysis.

Low-level decomposition products are extremely unstable and their concentrations may be significantly reduced in the time between sampling and analysis. Using this detector, rapid screening of a SF6 filled electrical equipment is possible. Developing problems can be easily identified and outages minimized.

The SF6DPD is a first step in isolating and identifying incipient problems such as arcing, partial discharge or corona in SF6. The high sensitivity and rapid response time identifies the gas zone where a problem is occurring and with further examination using other analytical techniques such as UHF, the exact location and nature of the problem can be identified. The detector is able to handle sampling from energized equipment at system pressure. Personnel safety can also be rapidly assessed before maintenance begins so that appropriate procedures and precautions can be implemented.

The interpretation of the results from using the SF6DPD depends on the equipment. In non-switching equipment such as bus runs, the presence of any decomposition products should be of concern. In compartments where switching is involved, decomposition products may be formed under normal conditions. In the case of circuit breakers with an internal absorbent, the presence of decomposition products may indicate normal operation. The levels will vary depending on the equipment and each situation. The concentration should decrease over a period of a few days as the absorbent removes these decomposition products. If the levels do not decrease and there is no further switching, this may indicate that the absorbent is spent or that there is an ongoing problem. This is certainly the case if there is a continual increase in the concentration of decomposition products in the absence of any switching operations.

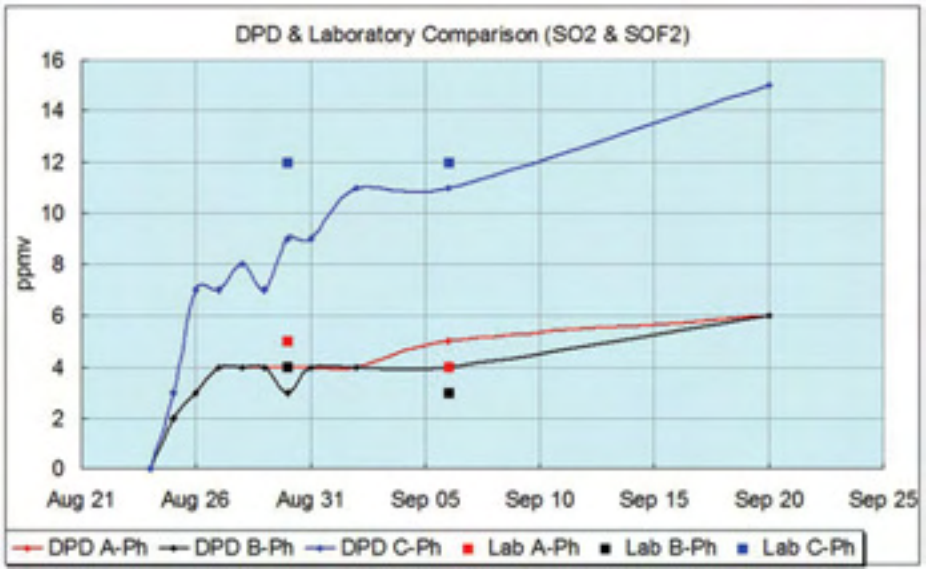

Figure 1 Monitoring of decomposition product levels in a bus

The SF6DPD detects and displays the total concentration of SF4, SOF2 and SO2. SF4 is one of the initial products formed from the decomposition of SF6. However, due to its high reactivity, it is rarely present in significant levels. SOF2 is the most predominant SF6 decomposition products and the primary decomposition path for SOF2 produces the more stable SO2 (and HF). Detection of low ppm levels of SOF2 enable incipient faults to be identified earlier, an obvious advantage over instruments that are only sensitive to SO2 or HF.

Using a 3 m long 1/4" stainless steel braided PTFE sampling line, a measurement can be typically taken with the release of less than 2 g of SF6. A vent gas recovery kit may also be used to further reduce the release of SF6 during sampling.

The following examples demonstrate how the SF6DPD has been used successfully in the field.

FIELD TEST RESULTS

Field tests were carried out at a 2,000 MW generating station. All 53 gas zones were tested on site by using both the SF6DPD and a customized portable micro gas chromatograph (GC). Samples were also taken and sent to a laboratory for analysis using a laboratory GC. Using the SF6DPD and GC, all on-site tests were completed in less than 10 hours. If gas detector tubes were used, 53 detector tubes would have been required and there would not have been any saving in time. Two of the tested zones gave positive responses from the SF6DPD and confirmatory tests. Samples from the zones that tested positive using the SF6DPD were also sent to the laboratory. The SF6DPD gives results that are comparable to those obtained by the more sophisticated, more time-consuming and more expensive laboratory tests.

PARTIAL DISCHARGE AT A BUS

UHF analysis showed signs of the presence of loose particles in A-phase of a 230 kV bus. The bus was de-energized

Continued on Page 10

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Continued from Page 8

for other maintenance work and analyzed with the SF6DPD two weeks later. The delay in analysis was not planned and all three phases showed almost identical readings of about 5 ppmv. Since all three phases are normally connected through a common filling line, the decomposition products would have diffused through the common filling lines to the other phases.

The bus was put back on line and a subsequent analysis by the SF6DPD identified A-phase contained more than 50 ppmv of decomposition product. A lab sample was taken and it was analyzed to have 650 ppmv SOF2 and 50 ppmv SO2. This unusually high level of decomposition products indicated a problem with that phase. Using time of flight measurements with the UHF monitor, the source was pinpointed to an insulator.

In this example, the SF6DPD was used as a preliminary diagnostic tool to focus on the suspected problem area.

MONITORING OF ARCING IN 230 KV BUS ZONES

Another 230 kV bus with a common fill point was analyzed with the SF6DPD and found to contain about 1 ppmv of decomposition product in all 3 phases. A monitoring program was initiated on each of the three phases. The level of decomposition products in C-phase eventually increased to beyond 50 ppmv and laboratory analysis of the gas confirmed levels of between 230 and 370 ppmv. As shown in Figure 1, the high sensitivity of the SF6DPD allows an early detection of the problem phase. The portability of the SF6DPD allows samples to be analyzed frequently. The immediate availability of results is crucial in rapid diagnosis of the problem.

When the bus was opened for examination and servicing, it appeared that a spring in C-phase had broken from the insulator assembly inside the bus and was causing arcing that eventfully produced a hole through the conductor.

Figure 2 Damage caused by arcing

INVESTIGATION OF PARTIAL DISCHARGE IN A BUS

A 500 kV bus of about 25 metres in length showed a concentration of one ppmv with the SF6DPD. Due to the large volume of gas in the bus, even such a low level may indicate a significant problem. Further investigations using a UHF analyzer located the problem to partial discharge activity in one area. This diagnosis was made possible only because of the high sensitivity of the SF6DPD. Again, the SF6DPD was used as the initial diagnostic tool and other techniques were used to pinpoint the source of the problem.

ACCEPTABLE LEVEL OF DECOMPOSITION PRODUCTS

The following may be used as a guideline when using the SF6DPD:

Bus – Since a bus has no switching activity, the SF6DPD should show no reading (less than 1 ppmv). If a low-level reading is observed, a monitoring program should be initiated. If the reading continues to rise, then another tool, e.g., UHF, should be brought in to isolate the source of the decomposition product. As shown in the above examples, isolating the different phases or compartments of a bus will further narrow down the source.

Switchgear – Decomposition products are usually produced during switching operations. The absorbent used in most switchgear will reduce the level of decomposition products with time. If a consistently high level (e.g., greater than 20 ppmv) is detected with no reduction with time, then perhaps the absorbent package needs to be replaced or replenished. It is also possible that a problem exists inside the switchgear that causes partial discharge when the switch is idle. The SF6DPD can be used to monitor the level of decomposition products in real time (as long as the level is less than 50 ppmv) to help with the diagnostic process.

Figure 3 Powertech SF6DPD

CONCLUSION

The Powertech SF6DPD is an accurate, easy to use and inexpensive instrument for field personnel to measure SF6 decomposition products from in-service equipment. The real time display of results at the ppm level saves maintenance staff time and money by diagnosing an incipient fault well before it manifests itself into a catastrophic outage.

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TRANSFORMER THERMAL BEHAVIOR AND AGING IN DISTRIBUTION DELIVERY SYSTEMS

By Reigh Walling, GE Energy; G. Bruce Shattuck, Alabama Power Company

INTRODUCTION

In the "local delivery" concept of distribution used throughout North America, medium-voltage feeders reach within a few hundred meters of the individual customer loads. Distribution transformers are widely dispersed with each transformer serving relatively few customers; typically one to twelve residential customers, or often a single commercial customer, per transformer. Thus, the transformer loads are not very diversified and can vary widely in magnitude over a relatively short period of time.

Distribution transformer application practices in local delivery distribution systems are inherently an engineering art more than a rigorous science. Load demand characteristics are not well defined, nor are the acceptable loading levels on transformers precisely defined thresholds.

Conventional distribution transformer application practices tend to base kVA rating selection solely on the expected peak load demand. Distribution transformers in North America are routinely applied so that the peak estimated load is above the rated transformer capacity. A fixed overload factor, typically 100% to 140% of rating, is commonly used. However, experience suggests that the typical overload factors are conservative as premature distribution transformer failures due to insulation thermal degradation are relatively infrequent.

Transformer rating selections based solely on peak load do not adequately account for the true relationships between transformer loading, ambient temperature, and expected insulation lifespan. Transformer insulation thermal degradation is a cumulative function of winding temperature, and winding temperature is a dynamic function of loading plus ambient temperature. Overloading leads to accelerated insulation aging, but operation of the transformer at less than rated load, or in reduced ambient temperatures, causes aging to progress at less than the nominal rate. Short periods of excess temperature due to overloading can be balanced with longer periods of underloading such that the net transformer life is acceptable.

Distribution transformers comprise a very large segment of a power delivery utility's assets, and effective management of these assets is critical to the utility's financial success.

The Distribution Systems Testing, Application, and Research consortium (DSTAR) commissioned a research project to investigate transformer thermal behavior and insulation aging in actual applications, thus yielding information crucial to improving transformer asset management by its member utilities. In this investigation, actual transformer hourly loadings and ambient temperature conditions have been applied to transformer thermal and aging models. This paper summarizes key results of the investigation.

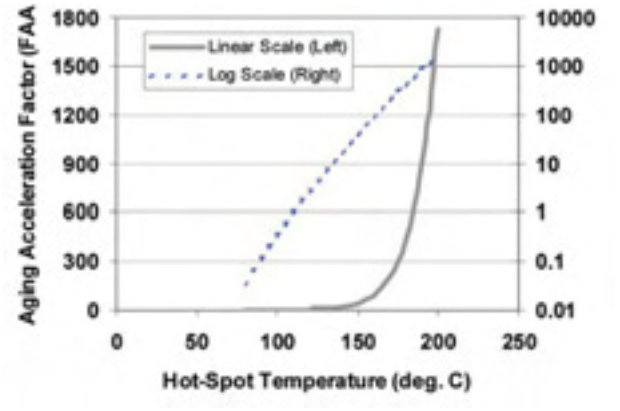

Figure 1 – Relationship between transformer insulation aging acceleration factor and winding hot-spot temperature.

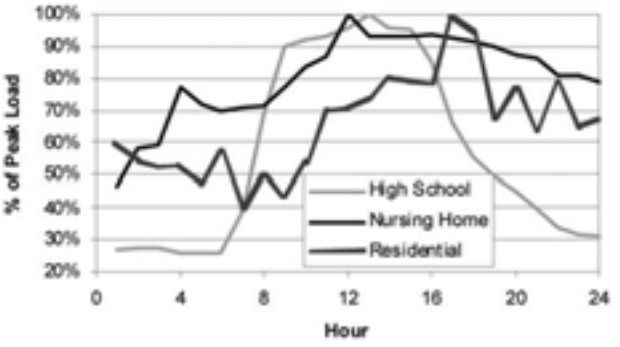

Figure 2 – Peak day load profiles.

TRANSFORMER THERMAL BEHAVIOR

The relationship between acceleration of aging and temperature, as specified in [1], is plotted in Figure 1.

When the hottest spot on the transformer winding is at 110°C, the aging acceleration factor (FAA) is 1.0, meaning that the transformer ages at a rate yielding a useful insulation life of 180,000 hours of continuous exposure to this temperature. Every 7°C increase in temperature yields a doubling of the rate at which the insulation deteriorates.

Conversely, a decrease in temperature decreases the aging rate.

A change in loading does not result in an instantaneous change in winding temperature because it takes an accumulation of thermal energy to heat the transformer's windings, core, and oil. Reference [1] provides a simplified thermal dynamic response model having two effective time constants: the hot-spot time constant and the top-oil time constant. The hot-spot time constant relates to the rise of the winding hot-spot above the temperature of the transformer's oil, and is typically a few minutes. The top-

oil time constant relates to the rise of the transformer's oil above the ambient temperature. This time constant is several hours long for a typical distribution transformer, and has a large role in "smoothing" the effects of loading spikes on the transformer temperature.

The total temperature rise of the winding hot-spot, above ambient, is due to the load placed on the transformer. The absolute temperature upon which insulation aging is dependent is the sum of the load-caused temperature rise plus the ambient temperature. This means that when the ambient temperature is less than the prescribed value (30°C) on which nameplate rating is based, a greater amount of transformer loading can be tolerated.

Most loads have some correlation between kVA load and the ambient temperature, primarily due to the heating and cooling loads served. A positive correlation, such as where electric cooling load is dominant, provides more severe transformer duty than a load dominated by space heating demand that is negatively correlated with ambient temperature. A transformer serving a load peaking in winter, with a lesser secondary summer peak, may actually have its most severe thermal duty at the smaller summer peak.

Using the thermal model and the relationships between winding hottest-spot temperature and insulation aging acceleration, the cumulative aging per year can be calculated given the loading and concurrent ambient temperature histories. Transformer kVA rating can then be iteratively adjusted until the calculated insulation life exceeds a desired value. There is a firm limit, however, to the peak transformer overload. In addition to accelerating aging, very high winding temperatures can lead to gas evolution, which can result in immediate failure. For this reason, [1] recommends that, independent of accumulated aging considerations, loading of distribution transformers with 65°C rated winding rise insulation should observe the following maximum limits:

· 300% of rated nameplate load
· 120°C top oil temperature
· 200°C winding hot-spot temperature.

In addition to these thermal considerations, voltage drop considerations can be an important practical limit to distribution transformer kVA rating selection.

LOAD CHARACTERIZATION

Commercial and residential loads have substantially different characteristics. Within the commercial category, load patterns differ widely depending on the nature of the enterprise served. Distribution transformer application practices also differ. Commercial loads typically have a dedicated transformer, but multiple residences are served by a single transformer except in rural areas. For these reasons, the characterizations of commercial and residential loads were considered separately. Figure 2 compares peakday load cycles for two commercial loads, a school and a health-care facility, with a four-customer residential load.

Commercial and residential loads have substantially different characteristics. Within the commercial category, load patterns differ widely depending on the nature of the enterprise served.

Commercial and Institutional Loads

Hourly integrated demand measurements were made on a total of twelve loads in six categories and four locations with reasonably diverse climates in the southeastern U.S. (Atlanta, Rome, and Savannah, Georgia, and Panama City, Florida).

Table 1 lists the loads along with their respective peak demands and annual load factors. Each of these load histories, along with concurrent hourly ambient temperatures for each location, were applied to a thermal model. The model yielded hour-by-hour transformer internal temperatures and the cumulative transformer insulation aging. Figure 3 shows the dynamic response of transformer temperatures to loading and ambient temperature for the Savannah high school load for the peak load day, as well as the resulting aging acceleration factor.

Type	Atlanta	Rome	Savannah	Panama City
Nursing Home	484 kW_{pk} 0.59 LF			
Large Office	973 kW_{pk} 0.69 LF	1583 kW_{pk} 0.57 LF	387 kW_{pk} 0.49 LF	
Small Office	17 kW_{pk} 0.32 LF			
High School	513 kW_{pk} 0.26 LF	1343 kW_{pk} 0.27 LF	1509 kW_{pk} 0.33 LF	
Retail	509 kW_{pk} 0.48 LF			
Grocery	485 kW_{pk} 0.69 LF	474 kW_{pk} 0.63 LF		642 kW_{pk} 0.68 LF

Table 1 – Peak demands and load factors of commercial loads in study.

The kVA rating of the transformer was varied until the cumulative aging in the one year modeled was equal to the aging the transformer would sustain if continuously loaded to nameplate rating at a standard (30°C) ambient temperature for the one year (i.e., mean FAA = 1.0). For the purpose of this analysis, transformer kVA ratings were not limited to standard values.

This thermal analysis yielded interesting results. One of the most significant findings is that, for most loads, almost all of the insulation aging occurs during a relatively few days of the year. Figure 4 plots the aging hours per day over one year, along with the ambient temperature and loading, for the Atlanta nursing home load. (Normal aging is equal to 24 aging hours per day.) For this same load, Figure 5 shows histograms of cumulative transformer aging plotted versus days, ranked by decreasing average ambient temperature, for two different loads. For the summer-peaking nursing home load, over half of the aging sustained by the transformer occurs in the thirty hottest days of the year. In the cooler half of the year, almost no thermal aging takes place. The other aging histogram plotted in Figure 5 is for the large office building load. This load is less ambient-temperature-dependent, and transformer aging is somewhat more evenly distributed through the year.

The ratio of peak load to transformer nameplate kVA yielding normal insulation aging (8760 aging hours per year), was found to vary with the load profile. If summer and winter peaking loads are separated, it was found that the allowable peak transformer overload is well correlated with the load factor. This is clearly shown in Figure 6. A key conclusion reached in this research is that a fixed maximum transformer overload factor does not yield best management of transformer assets; sizing must also consider the characteristics of the load profile including the shape of the load profile and correlation between peak load and ambient temperature.

RESIDENTIAL LOADS

Hourly load and ambient temperature recordings for twenty individual residences, ten with electric heat and ten without.

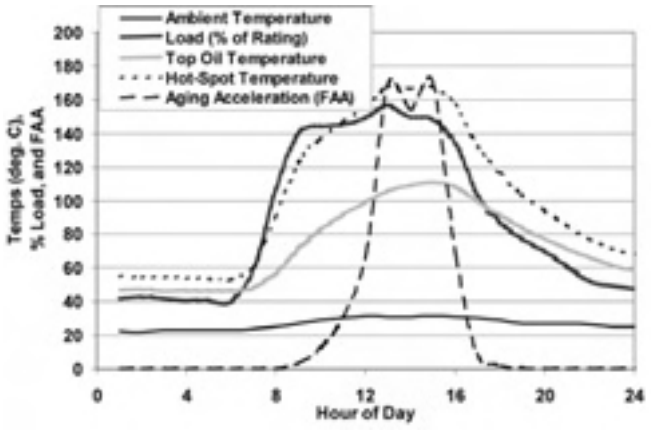

Figure 3 – Loading, thermal behavior, and resulting aging for peak day, Savannah high school load.

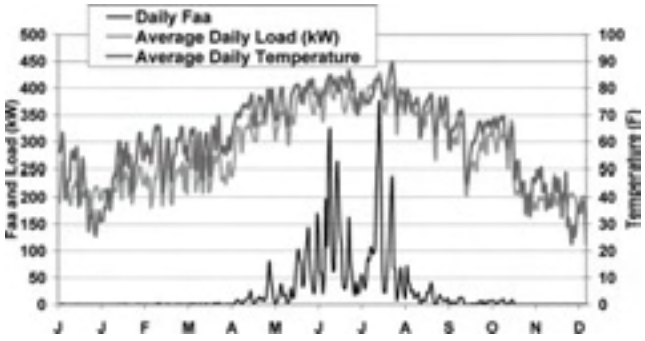

Figure 4 – Daily aging hours for Atlanta nursing home load

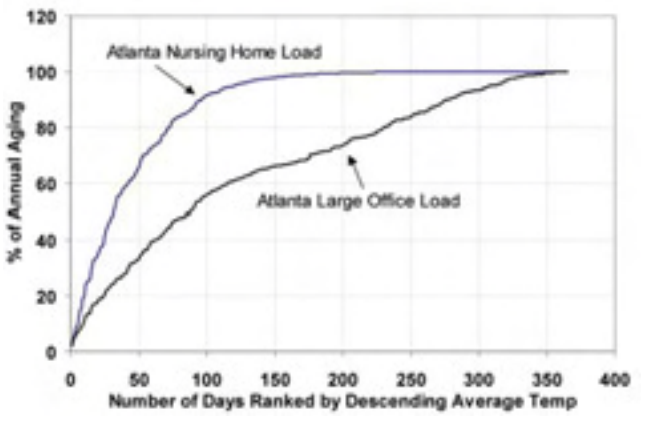

Figure 5 – Comparison of transformer aging histograms

The load factors of the individual all-electric loads ranged from 0.09 to 0.26, with an average of 0.185. For the non-all-electric loads, the load factors ranged from 0.13 to 0.31, with an average of 0.20. These load factors are substantially less than those of the commercial loads studied in this project.

Although these residential loads are not physically adjacent, they were combined in this research to investigate the impacts of load coincidence on transformer insulation aging. A

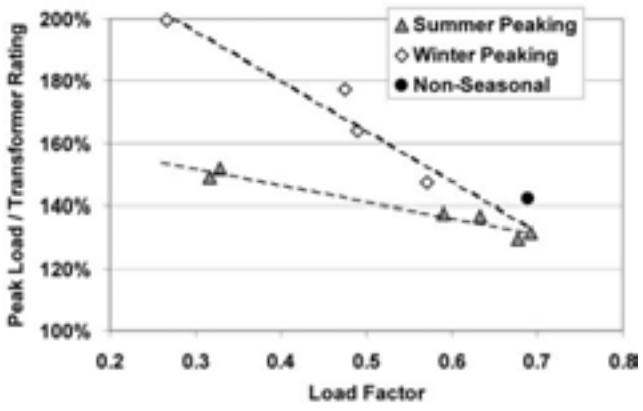

Figure 6 – Relationship of peak transformer overload factor, yielding nominal insulation life, to load factor for commercial loads.

number of different groupings of two, four, six, and eight services were studied as if each grouping was served by one distribution transformer. Each grouping was applied to a transformer thermal model having typical residential distribution transformer parameters. Figure 7 shows insulation aging histograms for typical non-all-electric and all-electric groupings of four load services. It can be seen that a transformer serving the composite load without electric heat sustains over half of its annual aging in only about the fifteen hottest days of the year. A transformer serving the composite load with electric heat sustains aging in both the summer and winter. For the

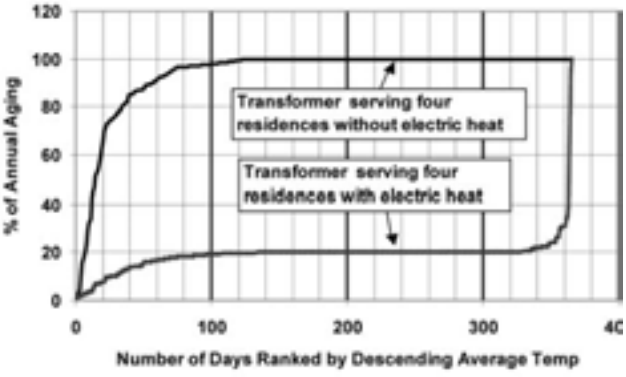

Figure 7 –Aging histograms transformers serving typical four-residence loads, with and without electric space heating

example shown, about 20% of the annual aging occurs spread over about two months, but about 60% of the aging occurs in the coldest few days of the winter. It should be noted that heat pumps with electric resistance heat backup for very cold periods are common in the area where these load data were acquired.

A very significant difference between commercial and residential loads was observed in the transformer thermal analysis. When the residential transformer kVA rating was selected so that the overall insulation aging was normal (8,760 aging hours per year), the peak winding hot-spot temperature exceeded 200°C for many of the load groupings. Because residential load factors are so low, transformer rating on an accumulated aging basis tends to lead to very high short-term overloads. This risk of failure from gas evolution during these short-time high-temperature events becomes the dominant factor in transformer size selection. In contrast, the critical 200°C threshold was not approached when transformer ratings for commercial loads were based on accumulated aging.

The residential transformer ratings in the study were based on the larger of the sizes in order to meet the criteria of nominal average aging, and peak transformer temperatures were limited to the values recommended by [1]. For the loads without electric heat, peak overload factors of 200% for transformers serving one customer were deemed acceptable, decreasing to 160% overload for transformers serving eight customers. For the loads with electric heat, acceptable peak overloads were on the order of 230% for transformers serving one customer, and 200% of rating for transformers serving eight customer loads.

Residential transformer rating selection, however, is not as simple as applying a fixed overload limit because maximum hot-spot temperature is a function of the shape of the load curve, as well as the ambient temperature, on the peak day.

The peak coincidence factor of a multi-customer load grouping is the ratio of the peak coincident load divided by the sum of the peak loads of the individual customers.

Similarly, a transformer thermal coincidence factor can also be defined as the rating of the transformer needed to serve the composite load, divided by the sum of the transformer ratings needed to serve the customers individually. Figure 8 plots the peak and transformer thermal coincidence factors for different numbers of loads served by a common distribution

transformer. For both the all-electric and non-all-electric loads, the thermal coincidence factor is substantially greater than the peak coincidence factor.

Utilities typically use coincidence factors based on peak loads for various design calculations, including distribution transformer application. The results of this research imply that the benefits of load diversity, from the standpoint of distribution transformer application, are not as great as is commonly assumed.

CONCLUSIONS

The research described in this paper has shown that distribution transformers can be applied to loads substantially exceeding the transformers' nameplate rating.

While the optimized rating of distribution transformers serving commercial loads tends to be constrained by accumulated insulation aging, residential transformers are more likely to be constrained by peak temperature considerations during very-high short-term loads. Best management of commercial and residential transformer assets, however, cannot be achieved using fixed maximum transformer overload factors. Optimal sizing must also consider the characteristics of the application including the shape of the load profile, recurrence of peak periods, and correlation between peak load and ambient temperature.

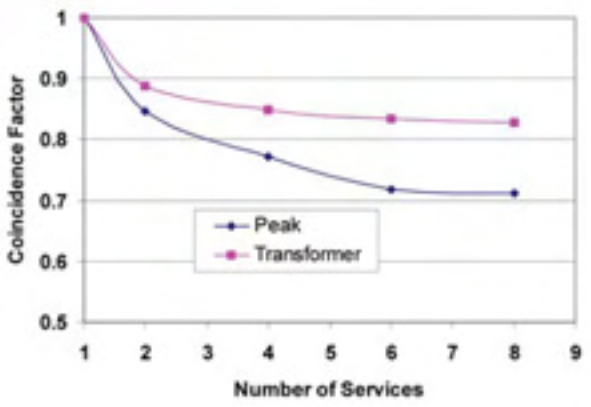

Figure 8 – Comparison of peak and transformer thermal coincidence factors for residential loads without electric space heat.

ACKNOWLEDGMENTS

The support of the DSTAR (Distribution Systems Testing, Application, and Research) consortium of utilities, and the direct participation of Gulf Power Company and Mississippi Power Company, operating companies of the Southern Company, are gratefully acknowledged.

REFERENCE

[1] IEEE Standard C57.91-1995, IEEE Guide for Loading Mineral-Oil-Immersed Transformers, Institution of Electrical and Electronic Engineers, Piscataway, NJ, USA.

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20,000 MILE SURVEY LAYS FOUNDATION FOR THE NEXT 100,000

I. ABOUT THE 20,000 MILE RELIABILITY SURVEY

From January of 2007 through December of 2007, Exacter, Inc. conducted reliability surveys of electrical distribution systems for more than 19 U.S. utilities in 15 states. The surveys identified and located failing equipment across more than 20,000 miles of distribution overhead.

This is the single largest measurement of U.S. electrical distribution systems ever conducted, covering more miles, identifying more problem locations, and delivering more field data on failing equipment than any other survey of its kind.

This is the first attempt to characterize the second largest reliability issue next to weather – the first attempt to proactively reduce SAIFI through preventive maintenance.

II. METHODOLOGY

Using our proprietary signal measurement technology, the EXACTER Outage-Avoidance System, Exacter, Inc. was commissioned by multiple utilities. The sensor technology element of the system was deployed in various utility vehicles and non-utility vehicles for periods of one to six months. While the vehicles drove their daily routes, failure emissions were detected, identified, and located with GPS coordinates. Maps were generated with the locations of any failing electrical equipment for the participating utilities to take corrective measures.

All survey data was stored, analyzed, and distributed by Exacter, Inc. to their customers and made available through an interactive Web Information Portal. The cumulative data gathered across 19 different utilities is the basis of the 20,000 Mile Reliability Survey and proves the opportunity to deploy technology to reduce SAIFI.

III. MEASURING TECHNOLOGY

The EXACTER Outage-Avoidance System was the primary source of data for this survey.

The proprietary EXACTER Outage-Avoidance System monitors the sources of distribution line emissions and coordinates date, time, GPS location, and maintenance priority. The system uses an advanced sensor array to locate predictive conditions that precede hardware failure. EXACTER collects distribution feeder information from any vehicle as it travels throughout an electrical distribution system. There is no operator interaction required. The measurement unit transmits feeder information to a Knowledge Database where it is analyzed for known failure-prediction signatures. Using a web portal, mapped locations and processed information are returned to the utility for review, analysis, and preventive maintenance scheduling.

During the survey, utilities used complementary IR camera and RF sensor technology to verify and pinpoint disturbances located by EXACTER validating the accuracy and the ability of this new technology to automatically locate failing electrical equipment before outages result.

IV. GEOGRAPHIC COVERAGE

Surveys were conducted in the following states: Florida, Kansas, New Jersey, South Carolina, Georgia, Maryland, New York, Pennsylvania, Indiana, Michigan, Ohio, Mississippi, Illinois, Kentucky and West Virginia.

These surveys included a variety of system configurations and design standards. Within the 19 participating utilities and the data from over forty technology demonstrations more than 1,000 electrical components were prioritized and the removed components meant more than 1,000 avoided outages. The study included seven IOUs covering 11,353 miles, five REAs covering 7,947 miles, and seven Municipal utilities covering 3,406 miles. The areas covered included urban systems (38%), suburban systems (24%), and rural systems (35%). Two international countries were included in the survey to confirm the effectiveness of the technology in 50 Hz systems.

V. SURVEY DATA

The 20,000 miles of survey resulted in a number of interesting findings:

1. Equipment on the aging distribution infrastructure is almost always replaced rather than maintained;

2. New replacement components are inferior in quality to the original components being replaced;

Table 1 Base Survey Data	
Miles Surveyed	22,706
Sites Analyzed	600,723
Failing Equipment	
Sources Located	26,450
Outages Avoided	1,122

3. Well-maintained systems do not exhibit failure signatures;

4. Results indicate that this technology applied to preventive maintenance provides an effective methodology for outage avoidance and SAIFI improvement.

Survey Data Compared to the DOE National Study

In 2003, the DOE commissioned a study to analyze the cost of reliability to the U.S. economy. In this study, the economic cost to our economy was defined as $79 billion annually. This was costs associated with the failure of the infrastructure and did not include catastrophic events like the 2003 Northeast blackout. Startling in this study was the definition of the problem: Six million outages in the United States each year, and 30% of these outages were related to electrical equipment failures.

When the nation is faced with an outage resulting from failing equipment every 2 miles of circuit, a way to survey

Continued on Page 20

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Survey results

Continued from Page 18

and prioritize the removal of this equipment becomes mandatory. In the table below a comparison of findings from the EXACTER survey and the DOE report is shown. A linear interpolation was completed to demonstrate how the two analyses relate. The EXACTER Survey demonstrates that the problem of failing electrical equipment is much worse than the predictions of the DOE study by a factor of nearly 2 to 1.

	EXACTER Survey	DOE Interpolated	DOE Outage Report
Miles	22,706	22,706	3,000,000
Sites Analyzed	600,723	- -	- -
Failing Equipment Sites Located	26,450	13,624	1,800,000
Outages Avoided	1,122	0	0

Definition of Terms

Miles surveyed - The miles of distribution line surveyed by EXACTER or studied in the DOE commissioned study. The DOE interpolated mileage is a linear estimation for comparison to the EXACTER study.

Sites Analyzed – This is the total number of failing equipment identifiable emission signature that was recognized and analyzed by EXACTER.

Failing Equipment Sources Located - These are emission sites that have appeared consistently in the same location over the course of the survey. They represent failure signatures indicating areas of concern.

Outages Avoided – Final analysis of EXACTER intelligence results in prioritized urgent maintenance issues. This prioritization results from EXACTER proprietary Group analysis method. These are the locations that represent significant likelihood for imminent power outages, and ones that provide a 100% correlation to failing equipment and the ability to apply technology to avoid outages.

VI. SURVEY SUMMARY

In addition to calculating survey data, Exacter Team Members had the opportunity to spend significant amounts of time in the field and in conversation with various utility maintenance and management personnel responsible for improving distribution system reliability. The comments below reflect some of their findings and observations.

• Department of Energy studies indicate that 30% of all power outages are due to failing equipment. This estimate has been confirmed by the utilities we worked with (estimated varied from 28% to 35%) and in publications and presentations by EEI, NRECA, APPA. and IEEE.

• EXACTER measurements indicate that early indications of equipment failure are detectable on twice the estimated number of devices. These failing devices can be detected, located and prioritized for replacement allowing predictive, preventive maintenance.

• Using DOE estimates of the avoidable costs through outage prevention ($6,700 per outage), this group of surveys produced an opportunity for cost savings of $7.5 Million by avoiding 1,122 outages. The study proved that these outages can be detected, located, and prevented using predictive, preventive-maintenance strategies.

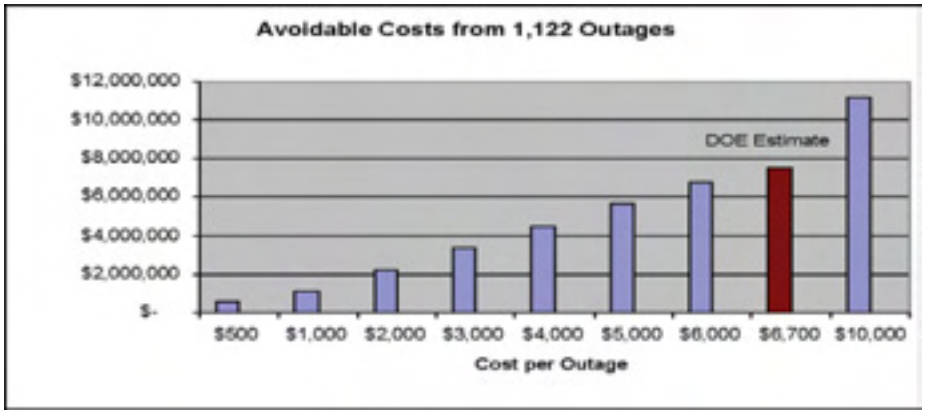
• Over the 22,706 miles, DOE indicates 13,624 equipment failures over the course of the year. EXACTER measurements over its one-to-three month measurement period identified 26,450 or about twice the DOE annual statistic.

• The majority of reliability improvement efforts are “REACTIVE” affecting SAIDI, or after the outage has occurred – not “PROACTIVE” which would affect SAIFI.

• Utilities have made significant progress and investment in Asset Management, but have not yet found a means to measure Asset Health which corresponds to reliability and SAIFI improvement.

• There is no clear problem ownership regarding reliability. Different departments take on aspects of the problem. There is no integrated solution empowering change.

• With regard to reliability, there are few RESULTS-BASED SOLUTIONS being offered by utility suppliers or sought after by utility management.



VII. UTILITY RESPONSES

The utility response to the data generated by the EXACTER System was initially one of skepticism. However, using their existing IR Camera and RF technology, EXACTER failure locations were investigated and validated. As part of the collaboration process, new analysis methods were created that resulted in 100% equipment failure identification rates. Below are some of the results and utility responses to the data generated by this survey.

• More than 100 communities in Ohio HAVE ALREADY banded together to address the issue of electric reliability at the cooperative and municipal level. These communities are using EXACTER technology and data to drive their efforts.

• One large northeast utility is CURRENTLY USING EXACTER technology and data as a reliability strategy in their 3-Year rate-base request to the PUCO. In the first year of EXACTER use, a 30% improvement in the SAIFI objective from 1.30 to 1.02 was achieved.

• An Automatic Meter Reading user was able to find a disturbance they had not been able to locate that had interrupted AMR data flow for 6 months.

• One municipal utility identified a ceramic cutout that was literally cracked in half. It was at a strategic point that would have eventually shut down about 30% of the city's distribution system.

• An IOU has been suffering fused cutout failures that result in $30 Million to $50 Million per year. EXACTER is now part of their targeted strategic reliability initiative to eliminate these devices.

• A municipality has received an APPA grant to study the problem of failing lightning arrestors using EXACTER as the locating and discriminating technology.

• A major provider of BPL technology to utilities has selected EXACTER for pre-installation surveys and post installation maintenance surveys as a way to locate and have replaced failing electrical equipment that inhibits broadband communication of power lines.

• A cooperative located and replaced a failing ceramic cutout that would have led to a power failure at a large rural high school.

VIII. RECOMMENDATIONS

In 2008, EXACTER will be recruiting 50 electric utilities from across the country to participate in a 100,000 mile distribution survey to draw attention to the need for intelligence-based preventive maintenance. This survey will be designed to include all regions and climates of the country. The data will provide a valuable benchmark to the national problem of maintaining the aging distribution overhead infrastructure.

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HIGH PERFORMANCE TRANSFORMER OIL PUMPS: WORTH THE INVESTMENT

By Greg Stem, Engineering Services & Rep. Channel Manager, Cardinal Pumps and Exchangers

Transformer oil pumps have evolved dramatically over the past several decades. Once considered to be merely a replaceable routine maintenance item, comparable to say, a valve, pumps are now almost universally recognized as a critical component of "forced oil cooled" transformers – a component that requires sophisticated engineering, high quality construction and systematic preventative maintenance.

When a transformer oil pump performs properly, it ensures maximum cooling to maintain the transformer's peak load capacity. However, impairments to a pump can result in costly breakdowns and potentially catastrophic damage to the transformer.

Unfortunately, such impairments are notoriously difficult to detect and prevent in pumps that are designed and/or constructed inadequately.

Transformer oil pump manufacturers in the United States have provided worldwide leadership in addressing these problems by introducing design improvements and innovations such as ultrasonic sensors that monitor the condition of bearings. Major North American utility companies have also driven the development of high performance transformer oil pumps by requiring thermal, mechanical, sealing, electrical and fluid systems that provide dependable operation.

THE CHALLENGE

Pumping transformer oil is a demanding application. The pump must operate continuously, year after year, pumping high temperature oil and remain hermetically sealed, in harsh outdoor environments.

One of the most challenging aspects of transformer oil pump design is the fact that the transformer oil also functions as the pump's lubricant. The problem is that transformer oil is selected – not for its lubricating performance – but rather for its ability to function as an insulator to suppress corona and arcing within the transformer and for its ability to maintain stability and good dielectric properties at high temperature. Highly refined mineral oil works well inside the transformer, but it is a poor lubricant for the ball bearing systems in many types of transformer oil pumps.

THE RISK

Wear of the bearing system and impeller can lead to the release of metal particles into the oil circulating through the pump, cooler and ultimately, the transformer. As a result, the dielectric properties of the oil and insulation can degrade, potentially causing hazardous arcing.

Degradation of the bearing system and impellers, as well as impairments of motor windings, can also cause a reduction in pump flow and discharge pressure which causes reduced cooling capacity.

Leaking electrical connectors and gasketed surfaces can impair pump performance and allow the ingress of moisture into the oil, as well as oil leaks into the environment.

State-of-the-art pumps mitigate these risks in a number of ways, including improvements to bearing design, ultrasonic monitoring of bearing condition, and high quality construction. Properly designed new or remanufactured pumps can take advantage of many of these advancements in transformer oil pump technology.

BEARING DESIGN

Of all the design improvements in transformer oil pumps over the past several decades, the single most important one is the replacement of ball bearing systems with bronze sleeve bearings.

As mentioned above, transformer oil provides a poor lubricant for ball bearings. In fact, ball bearings are a viable solution only when lubricated by heavier oil or grease. They fail prematurely when lubricated by lightweight, low-viscosity transformer oil.

Additionally, ball bearing pumps that are not operated continuously will commonly fail as a result of false brinelling of the bearings caused by transformer vibration or slight flow caused by convection. False brinelling occurs when vibration pushes the lubricant away from a region that it is intended to protect. In a situation when a mostly stationary bearing is subjected only to oscillating or vibrating load, the lubricant may be pushed out of the loaded area. However, since the bearing is rolling only small distances, there is no action or movement that replaces the displaced lubricant. The resulting wear debris oxidizes to form an abrasive compound which further accelerates wear.

All U.S. manufacturers, and some foreign suppliers, have discontinued using ball bearings in transformer pump designs. North America's largest manufacturer and remanufacturer of transformer oil pumps, Cardinal Pumps & Exchangers in Salem, Ohio, a division of Unifin Int'l, retrofits all ball bearing pumps with pump-specific bronze sleeve type radial/thrust bearings and hardened steel thrust collars.

The key to the design of thrust and radial bearings for transformer oil applications is large thrust face sleeve bearings for long life and minimum wear. The bearings need to have proper surface finish, and precisely positioned grooves to pass the oil and maintain an adequate lubricant film under all conditions.

MONITORING BEARING WEAR

Reliable long-term performance of transformer oil pumps depends not only on the bearing and hydraulic design systems but also on the ability to pro-actively detect wear, to ensure effective and energy-efficient cooling performance and to protect the pump and transformer from damage and breakdowns.

A patented ultrasonic bearing wear monitoring system was developed in 1984 by J.W. Harley / TecSonics Inc. (a recent acquisition of Cardinal Pumps and Exchangers, Inc.) to overcome the shortcomings of conventional transformer

pump bearing wear detection methods based on sound, vibration, and oil contamination. Such methods proved inconsistent and unreliable, and they were useful only after the pump was in an abnormal operating state or on the verge of catastrophic failure.

The ultrasonic bearing wear system, TecSonics, provides advance warning. By tracking data over time, the monitoring system provides rate-of-wear information that enables informed decisions about selective, preventive maintenance to protect equipment, avoid breakdowns, and optimize maintenance effort and expense.

The principle of operation of the ultrasonic monitoring system is not complicated. Six precision ultrasonic sensors are mounted in both thrust and radial bearings at strategic points, on new pumps or on remanufactured pumps from various manufacturers. A permanently mounted piezoelectric transducer emits a high-frequency sound wave, and precisely measures the echo time to determine the distance between the sensor and the bearing surface, to an accuracy of 0.0002 inches. Measurements are compared to baseline readings to determine if any bearing wear has occurred.

The temperature-compensated readings can be taken while the pump is under any operating condition, without disassembling the pump, whether the pump is operating or not. The sensors do not affect the performance of the pump.

In addition to the ultrasonic system for monitoring bearing wear, it is also useful to have a shaft rotation sight plug to facilitate checking for proper shaft/impeller rotation.

QUALITY CONSTRUCTION

A third consideration, beyond the design and monitoring of the bearing system is the overall quality of construction, both in terms of the quality of materials and the quality of manufacturing.

Pumps should be constructed of rugged cast iron material for the pump castings (casings, motor enclosures, and impellers) to provide long life in the field. To protect the exterior surfaces from corrosion, high performance/high quality coatings (primer and top coats) should be applied.

All sleeve bearing pumps should have the bearing journals and thrust surfaces ground between centers to ensure alignment and surface finish. All pump shaft, impeller and motor assemblies should be dynamically balanced to assure long-term vibration-free operation.

Durable electric supply power cords also help to ensure reliable transformer pump performance. They should be capable of withstanding ultraviolet rays, oil, water and extreme weather conditions.

THE ECONOMICS OF TRANSFORMER OIL PUMP INVESTMENT

Investment in high quality new and remanufactured transformer oil pumps has a high economic return. A good pump will typically cost much less than one percent of the cost of the transformer that it supports, and yet it provides long-term insurance against breakdown, damage or failure of the transformer. And as all owners of large critical transformers will attest, a failure or major outage of this equipment can cause severe upheaval to the wellbeing of their electrical power distribution system.

LIGHTHOUSE DISTRIBUTION GRID MONITORING LAUNCHED AT DISTRIBUTECH

A new centralized remote monitoring system, called LightHouse, allows utilities to deploy technology to provide real-time grid intelligence, immediately detect faults, help to minimize the impact of outages and optimize utilization of assets, with a goal to improve overall efficiency of energy delivery.

A LightHouse sensor, mounted directly on the electrical conductor, continuously monitors key circuit parameters and transmits data over a wireless network to a central location, reducing time of detecting a problem on the grid, identifying its location and restoring service.

The new LightHouse system was introduced at the DistribuTECH Conference & Exhibition, in Tampa, Florida, recently.

"Today, utilities face unprecedented challenges from regulators and customers to improve reliability and quality, and to increase efficiency," said Joseph Ferrara, Tollgrade's President and CEO. "Our core competency and expertise in centralized test and measurement is a real solution for new markets, such as the power distribution industry, to better drive operational efficiency and improve customer satisfaction," added Ferrara.

"For many years, the distribution grid relied on visual observation from field crews or calls from customers to alert the power company to a problem," said Steven Day, Tollgrade's Executive Director of Marketing. "We recognized a compelling need for robust and flexible sensor technology in a marketplace that requires continuous performance and in an industry that is seeking ways to optimize the performance of distribution grids," added Day.

"Advanced sensors are an essential element for the intelligent grid. Sensor technology provides utilities with a snapshot of the grid's current status for fault and equipment problem location and historical data to enable better economic decisions about asset operations and maintenance, plus more accurate load research and forecasting," said H. Christine Richards, Senior Research Analyst of Intelligent Grid Strategies at Energy Insights (an IDC Company).

The new LightHouse product line is a system of components that includes a wireless sensor, an aggregator device that collects data, and software that will enable viewing, maintenance and reporting functions in real-time. Several LightHouse pilot deployments are already underway or planned for 2008. The product line has been in development for more than a year and is now available as a beta product for utility evaluation pilot programs, and will be commercially available before the end of 2008.

Tollgrade Communications, Inc. designs, engineers, markets and supports centralized test systems, test access and status monitoring products, and next generation network assurance technologies for the broadband marketplace. Tollgrade's customers range from the top RBOCs (Regional Bell Operating Companies) and Cable providers, to numerous independent telecom, cable and broadband providers around the world.

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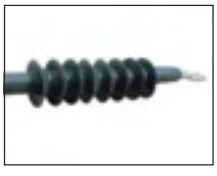

3M

A NEW FUSE-SAVING PHILOSOPHY

By Christopher McCarthy, Ray O'Leary, and Doug Staszesky, S&C Electric Company

Utilities generally apply one of two fuse coordination philosophies on a given distribution feeder – fuse-blowing or fuse-saving. When fuse-saving works, it benefits both the utility company and its customers.

Service is automatically restored to all customers and a utility line crew does not have to travel to the fuse location to replace a blown fuse.

However, fuse-saving practices have coordination limitations at higher current levels – it is common for the upline device to trip and the fuse to operate at the same time. The result is frequent momentary outages for many customers and blown fuses, even for temporary faults. These challenges have led some utilities to abandon the practice of fuse-saving and instead migrate to a fuse-blowing philosophy.

The conventional fuse-saving practice has an inherent tradeoff of sustained outage improvement at the expense of increased momentary activity. Ratings under the reliability indices SAIFI and SAIDI are improved, but the gains are offset by an increase in momentary events, reported as MAIFIE. When the fuse blowing practice is employed, the tradeoff is reversed – reduced momentary activity comes at the expense of more frequent sustained outages.

The new fuse-saving philosophy described in this paper offers several improvements over conventional practices by extending the range of coordination, minimizing miscoordination with downline devices, and eliminating unnecessary tripping. An optimized composite phase and ground fuse-saving TCC curve is developed for the smallest downline fuse that is to be saved. Tripping on this curve only occurs when it can actually clear the fault before the fuse begins to melt. If the fuse cannot be saved, the initial tripping operation of the upline device shifts to a more delayed curve to allows the fuse to operate.

While most utilities use a mix of fuse-blowing and fuse-saving on different feeders, this new fuse saving philosophy achieves an intelligent mix of both practices on the same device. The full SAIFI and SAIDI benefits of fuse-saving are achieved while avoiding excessive momentary operations similar to a fuse-blowing philosophy.

I. FUSE COORDINATION PHILOSOPHIES

Utilities generally apply one of two approaches for coordinating breakers and reclosers with downline fuses.

Some use a "fuse-blowing" philosophy: The substation feeder breaker or recloser is coordinated with downline lateral fuses so that the fuses will clear any downline faults within their ratings. The breaker or recloser does not trip for faults beyond a fuse. But customers located downline of a fuse experience a sustained interruption for every fault, even faults that would have been temporary had they been given a chance to be cleared. And the utility must deal with the high cost of service calls to replace blown fuses.

Others use a "fuse saving" philosophy: The first one or two trips of a substation feeder breaker or recloser is intentionally coordinated so that the breaker or recloser operates faster than the downline fuse to attempt to clear temporary faults that occur beyond the fuse. The subsequent trips of the breaker or recloser are slower so that if the fault is still present, the downline fuse will operate to clear it. The downside of this scheme is that all customers downline of the breaker or recloser experience a momentary interruption for every fault.

Fuse-saving improves SAIFI and SAIDI. However, these gains are offset by an increase in MAIFIE. This increased number of momentary outages can be very large since there are typically a large number of customers served by a breaker or recloser. Fuse-saving also has coordination limitations at higher current levels; fault currents above a certain level will result in the breaker or recloser tripping coincidentally with the operation of the fuse.

This results in a blown fuse and a momentary outage for all customers downline of the breaker or recloser, which is undesirable.

A 1996 survey on the usage of fuse saving reported a mix

of coordination practices. 40% of the surveyed utilities used fuse-saving, 27% used fuse-blowing, and 33% reported using a mixture on a case-by-case basis because fuse-saving had often resulted in too many customer complaints for momentary interruptions. A separate survey reported a steady decline of fuse-saving usage from 91% in 1988 to 71% in 1994 and finally to 66% in 2000.

This article introduces a new fuse-saving philosophy called "Intelligent Fuse-Saving." This innovative approach extends the range of coordination, eliminates unnecessary tripping, and minimizes interference with downline devices. A custom time-current characteristic (TCC) curve is constructed to optimize coordination with the downline fuse. It allows fuse-saving to be applied in situations that have proven troublesome in the past.

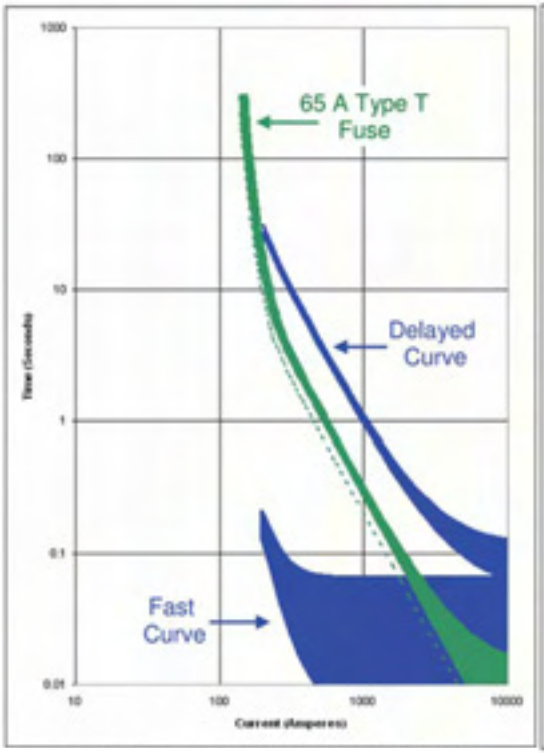

Figure 1. Conventional Fuse-Saving using a common fast TCC curve.

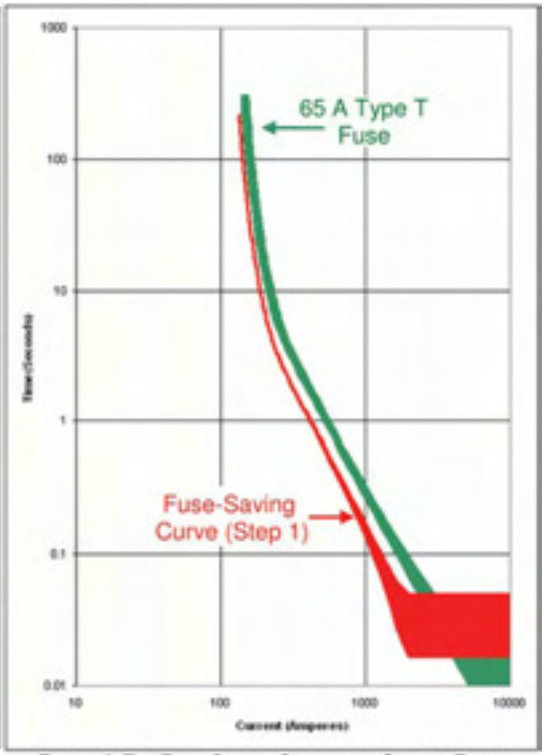

Figure 2. The first step in creating a custom fuse-saving TCC curve.

II. THE IMPORTANCE OF PROPER OVERCURRENT COORDINATION

Properly coordinated protective devices are essential to a reliable distribution system. Without proper coordination, other commonly implemented reliability enhancements such as feeder automation or fault prevention methods will have a lesser impact on SAIFI, SAIDI, MAIFIE, and other reliability indices.

Improper coordination results in the wrong device tripping and/or locking out for a fault event, which always increases the number of customers that experience an outage. Feeder automation automatically reconfigures the system after a fault has been cleared to restore as much of the feeder as possible, but the automation system typically depends on properly coordinated devices to determine the location of the fault.

The most common equipment pair that needs to be coordinated on a typical distribution feeder is a substation or midline recloser and a downline lateral fuse. Optimizing recloser-fuse coordination is very important because miscoordination results in excessive recloser tripping, causing outages for the large number of downline customers. The new fuse coordination approach described in this paper results in the best possible recloser-fuse coordination.

III. A NEW PHILOSOPHY - FOUR IMPROVEMENTS OVER CONVENTIONAL FUSE-SAVING

Four changes to the conventional fuse-saving method are proposed:

1. Develop optimized fuse-saving TCC curve

A unique fuse-saving TCC curve is developed specifically for each of the downline fuse sizes and types that are commonly used on distribution systems, such as Type T, K, QR, KSR, Coordinating Speed, and others. This custom TCC curve is placed just below the fuse's minimum-melting curve, with appropriate allowances for such items as the control response and mechanical interrupting time with tolerances, fuse pre-loading, ambient temperature, and fault current asymmetry.

The shape of the fuse-saving curve is designed to conform to the specified fuse curve as closely as possible, thus minimizing interference with smaller downline transformer fuses. Conventional recloser fast curves are typically much faster than necessary at lower currents, as shown in Figure 1. This miscoordination leads to recloser tripping even when it is not possible, nor desirable, to save transformer fuses.

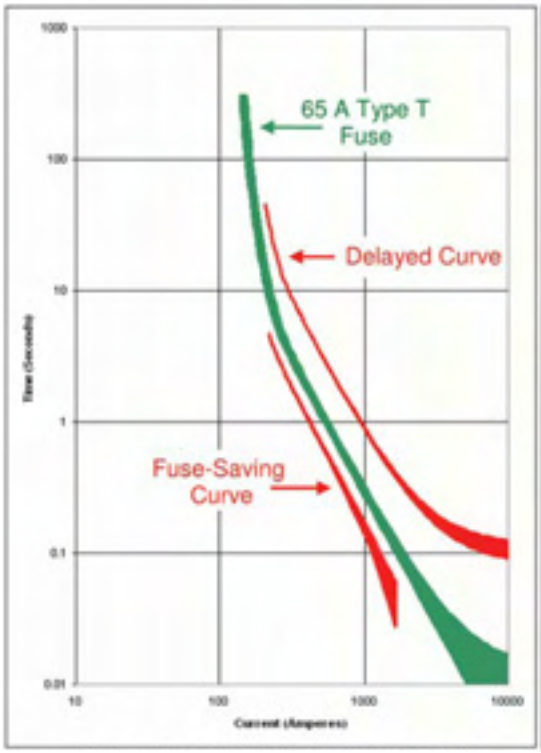

Figure 3. Partial range fuse-saving curve is implemented from the delayed curve minimum trip through the maximum coordinating current.

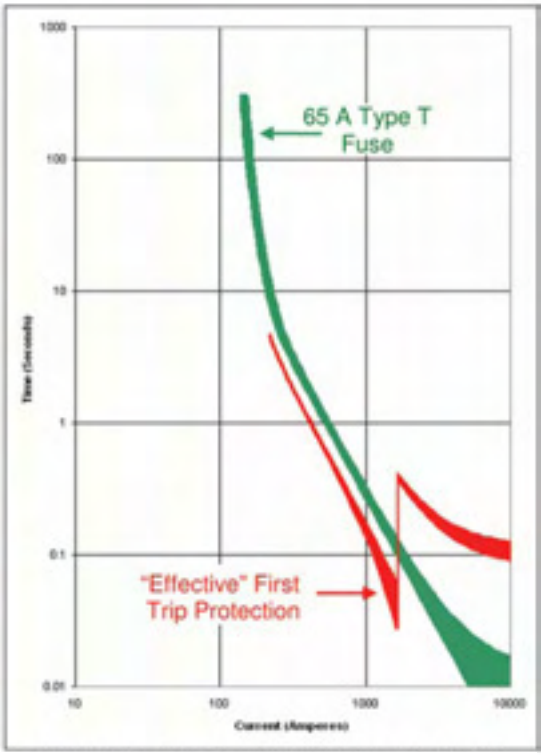

Figure 4. Effective first trip protection combining the fuse-saving curve and part of the delayed curve.

In Figure 2, the first step of developing an optimized fuse-saving curve is plotted as a band consisting of the minimum response and maximum clear curves with all tolerances accounted for. Since the fuse-saving curve is created based on the fuse minimum-melting characteristic of the fuse with which it is intended to coordinate, the same curve shape applies for both ground and phase applications.

Another benefit of pre-engineered optimized fuse-saving curves is that configuring an upline protective device control for fuse-saving applications is simplified. Enabling the fuse-saving element and selecting the downline fuse size and type is all that is required.

2. Partial range fuse-saving curve

Ideally, a "fast" fuse-saving trip should only occur when the fault can actually be cleared before the downline fuse begins to melt. If the fuse cannot be saved, fast tripping should be skipped and timing should occur using a delayed curve that allows the fuse to operate before the recloser trips. This technique garners all the benefits of successful fuse-saving without the nuisance trips resulting from miscoordination at higher fault currents.

As shown in Figure 3, the fuse-saving curve starts at the lowest phase or ground minimum trip current setting specified for the "delayed" curves. The custom curve is also truncated at the maximum coordination current, which is defined as the

current where it can no longer be guaranteed that the breaker or recloser will interrupt and clear the fault before the fuse begins to melt. Therefore, low current faults will cause a trip on the fuse-saving curve and high current faults may only result in a trip on the delayed curve. The effective first trip protection curve is shown in Figure 4. This maximizes the range of possible fuse-saving coordination currents and prevents the fuse-saving element from tripping for fault currents that will result in a blown fuse anyway.

If both phase and ground delayed curves have been specified, the ground fuse-saving curve will be implemented over the range of currents from the minimum trip value of the delayed ground curve through the maximum coordinating current. This is shown in Figure 5. The phase fuse-saving curve, which has the same exact shape as the ground fuse-saving curve, will be implemented over the range of currents from the minimum trip value of the delayed phase curve through the maximum coordinating current. The ground fuse-saving curve and the phase fuse-saving curve are driven by the residual ground current and the phase current, respectively.

During steady-state operation, both the fuse-saving curve and the delayed curve are active and will time in parallel. The effective composite curve of first trip overcurrent protection is shown in Figure 6. The fuse-saving curve is faster for a limited range of fault currents. Fuse-saving trips only occur for relatively low magnitude faults. For the 65T downline fuse shown in Figure 6 and a selected minimum trip of 200 A on the upline protective device, the effective fuse-saving range is from 200 A through 1700 A. Faults greater than 1700 A exceed the maximum coordinating current of the fuse-saving curve, so timing only occurs on the delayed curve.

A fault beyond the fuse will cause the fuse to operate without ever causing a trip on either the fuse-save curve or the delayed curve. If the high-magnitude fault is actually on the main line and not beyond a fuse, then a trip will be triggered according to the delayed TCC curve.

Note that if the maximum available fault current at the fuse location is 5200 A, the effective fuse saving range is only 30% of the total available protection range. This fact is often overlooked due to the visual nature of a loglog plot. Even disregarding the fact that most fault currents tend to be closer to the maximum available fault current rather than the minimum, it can be assumed that fuse-saving has a chance to work for approx-

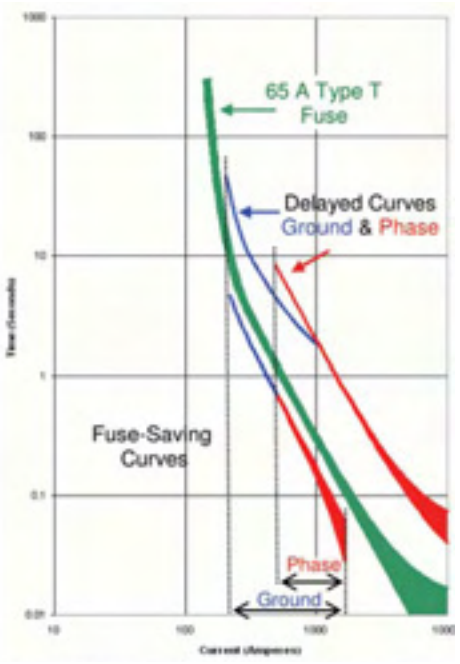

Figure 5. Full implementation of phase and ground elements with fuse-saving and delayed curves.

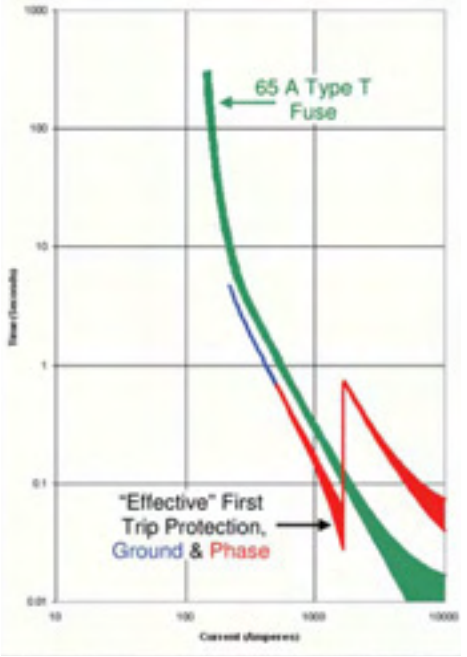

Figure 6. Effective first trip protection of both phase and ground elements.

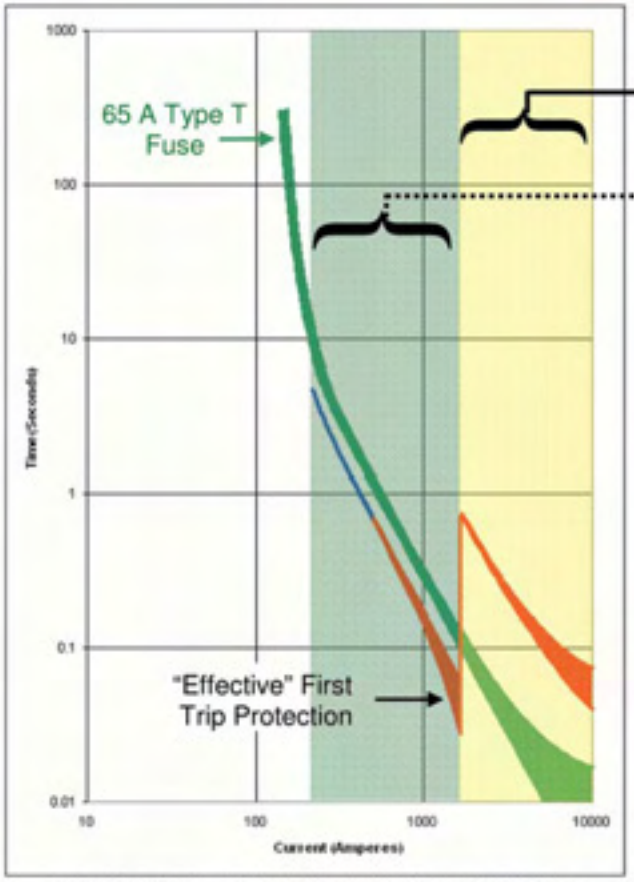

Figure 7. The left shaded area (green) represents the range of effective fuse-saving.

Fault Current Range	200 - 1700 A	> 1700 A
Initial Trip Operation	Fuse-Saving Curves	Delayed Curves
Test #1	Pulseclose	Pulseclose
Test #2	Pulseclose	Pulseclose
Test #3	CLOSE	Pulseclose
Test #4	Pulseclose	Pulseclose

Table 1. Two operating sequences based on the fault current ranges in Figure 7

imately 30% of all faults that occur beyond the downline fuse. Therefore, the fuse-saving approach described in this article prevents a momentary outage to a relatively large number of customers for 70% of the faults that occur beyond the fuse due to the fuse-saving TCC curve only being instantiated over a partial range of the available fault currents.

3. Separate fuse-saving operating sequence

Fuse-saving requires both a "fast" curve and a "delayed" curve. The fast curve, or fuse-saving curve, trips the device before the downline lateral fuse begins to melt to try to clear temporary faults. But if the fault is permanent, the recloser must close and begin timing on a curve that is more delayed than the fuse in order for the fuse to melt and clear the fault.

A distinction needs to be made regarding the difference between reclosing and pulseclosing. After the initial trip, a device capable of pulseclosing can be used to determine if the line is still faulted without actually "reclosing" into the fault. Pulseclosing is a very fast close-open of the switchgear contacts that results in a minor loop of asymmetrical fault current lasting approximately 5 ms. This pulse of current provides enough information for an algorithm to determine if the line is faulted or not. [2]

A device configured for pulseclosing operations does not actually close in to the faulted line, so the dual timing characteristic is accomplished using a separate operating sequence that includes a "forced close" when the initial trip occurs on the fuse-saving curve. If the fault is higher in magnitude and the initial trip occurs on the delayed curve, then the regular overcurrent operating sequence will be followed. This may consist of only pulseclosing operations or may include one or more "forced" closes.

Consider the example in Figure 7 and Table 1. For a 1000-ampere fault, the device trips on the fuse-saving curve. The operating sequence might be configured to subsequently perform two pulseclosings which would allow adequate time for the fault byproducts to dissipate. The third test might be configured as a close operation which would allow the fuse to operate if there is indeed a permanent fault downline of a fuse. The final test might be configured as a pulseclose which would test the line once more to determine if the fault is actually a permanent fault on the main line that the fuse will not clear.

One of the main goals of pulseclosing is to relieve system and equipment stresses caused by the repeated occurrence of high magnitude fault currents that result from a conventional reclosing sequence that has three or four operations. Due to the implementation of a partial range fuse-saving curve, the only faults that will result in fuse-saving attempts, including the associated forced close to initiate timing on the delayed curve, will occur only at relatively low magnitude faults. Therefore, the full benefits of pulseclosing and intelligent fuse-saving can both be achieved on the same fault interrupting device.

4. Single-phase tripping for fuse-saving

The concept of a separate fuse-saving operating sequence can be taken one

Continued on Page 33

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ENERGY SECURITY: A NORTH AMERICAN CONCERN

North American Transmission Grid
Lines shown are 345kV and above. There are numerous interconnections between Canada and the U.S. under 345kV that do not appear on this map.

By the Canadian Electricity Association

Energy security is a concern both for the United States and for Canada. The lack of adequate investment in energy assets, volatility in both oil and natural gas prices, and political instability in key energy markets around the world have resulted in a growing sense of unease about our respective abilities to meet future energy needs. The economic health of both our countries requires a secure and sustainable source of energy in the future.

Making either country energy independent, however, is neither a realistic goal, nor does it make sense from an economic perspective. Given the close and extensive relationship between the U.S. and Canada, energy security for these two countries should be defined in the context of a secure North American energy market. The North American electricity system, which interconnects Canadian and U.S. electricity markets, is among the most integrated and reliable in the world and combines a diversity of fuel sources, extensive transmission interconnects and two-way trading that benefits both countries.

The integration between these two countries provides the framework for greater trade, greater market opportunities and ultimately, greater energy security between our countries.

Increased integration of the U.S./Canadian marketplace will reduce the uncertainty regarding energy supply in North

American energy markets. CEA believes that the following measures would enhance electrical energy security across the North American market:

• Working cooperatively to increase generation supply, including both conventional and emerging technologies;

• Enhancing the cross-border transmission grid by increasing transmission capacity, implementing bi-national transmission reliability rules, and ensuring critical infrastructure protection;

Continued on Page 34

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step farther by implementing single-phase tripping for the fuse-saving trips. Even in locations where single-phase tripping is not acceptable for any extended duration, it may be allowable to have just the first trip occur on the faulted phase in an attempt to clear a temporary fault in fuse-saving situations. If the fault current is higher than the maximum fuse-saving possibility, the first trip would occur on the delayed curve, and this could be specified to be a three-phase trip.After the initial single-phase trip for fuse-saving, all subsequent operations can be single-phase or three-phase as desired.

The control and hardware can minimize any single-phasing concerns by accommodating a mix of single-phase and three-phase tripping. This includes the ability to turn off ground and negative sequence protection elements only for the duration of the single-phase open interval and allowing a setting range for the first open inverval to be very short.

The advantage of a single-phase trip is a further reduction of the MAIFIE index by approximately two-thirds since customers served by the non-faulted phase will not experience a momentary outage. As described for the 65T fuse above, implementing a partial range fuse-saving curve can reduce MAIFIE by approximately 70% of what it would be for conventional fuse-saving. Single-phase tripping further reduces MAIFIE by a factor of 3, resulting in momentary relibability indices that are reduced in total by a factor of 10 compared to the conventional fuse-saving technique. The expected level of MAIFIE improvement can be calculated for different fuse-saving applications using the fuse size and type, the minimum trip current setting, and the range of available fault currents.

IV. CONCLUSION

With the limited coordination that can be achieved using conventional recloser fuse-saving, customers experience frequent momentary outages for faults on other parts of the system as the breaker or recloser trips in a futile attempt to save fuses. When a fuse-blowing strategy is employed instead, any fault on a lateral - even a temporary fault due to conductor slapping or animal contact - will cause fuses to operate and results in frequent and lengthy customer outages.

The new fuse-saving technique described in this paper bridges the gap between the two conventional fuse coordination philosophies. By using custom-generated fuse-saving curves and only tripping when the fuse may actually be saved, the best combination of reliability and overcurrent protection is achieved. Using a separate operating sequence for fuse-saving trips allows the full use of pulseclosing and fuse-saving together.

Additionally, tripping only the faulted phase(s) for the fuse-saving trip greatly reduces MAIFIE and can likely be used even in locations where extended single-phasing conditions are not acceptable.

• Avoiding barriers to cross-border electricity trade;

• Promoting demand-side measures and energy efficiency; and

• Coordinating strategies to address concerns about greenhouse gases.

As major players in the global energy market whose economies turn on a robust and secure energy sector, both Canada and the U.S. must ensure a secure energy supply in the future. Such energy security can be built on the existing energy trading relationship and the opportunities for enhanced trade between the countries. The continued emphasis on the integrated U.S. and Canadian energy markets provides an excellent means to ensure energy security for both countries. Making energy security a North American concern makes sense from both an economic and a political perspective.

Major Transmission Interconnections between Canada and the U.S.
Note: The numbers indicate the voltage of the power lines from each province to the states. If there is more than one line with a given voltage, the number of lines is indicated in parentheses.
Source: NEB, Canadian Electricity Association and Natural Resources Canada.

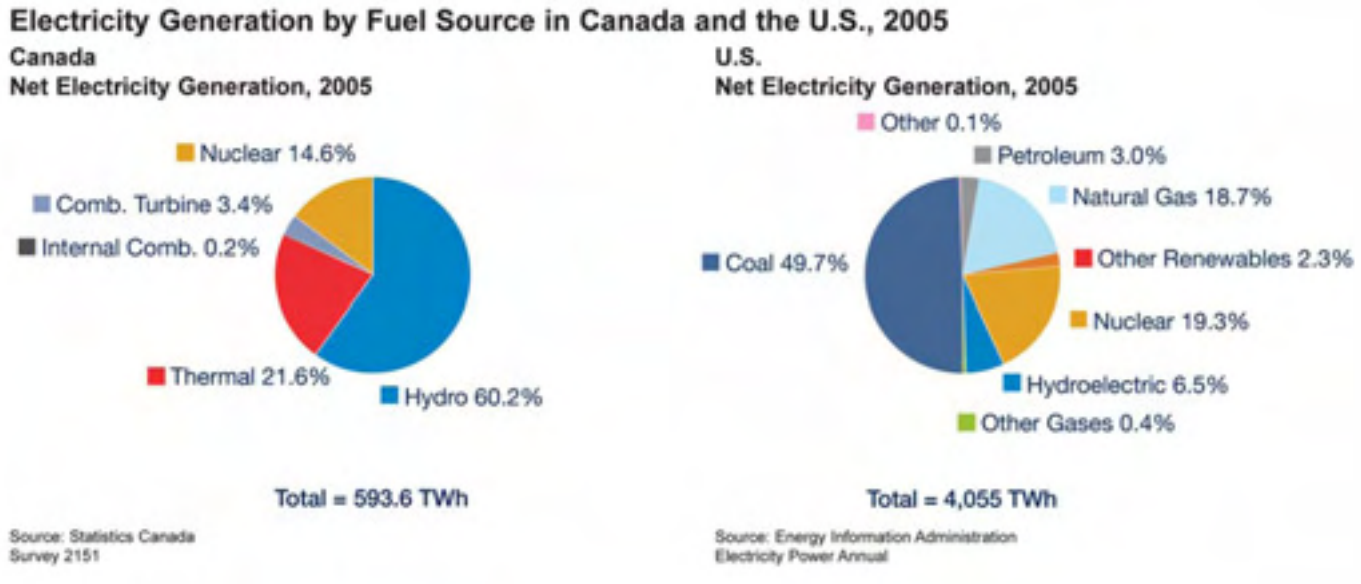
I. MARKET OVERVIEW: THE INTEGRATED U.S./CANADIAN ELECTRICITY MARKET

The diversity of the Canadian and U.S. electricity systems, the different balances of conventional and emerging technologies in our various regional generation mixes, and the differing market demands region by region over days, weeks, and seasons, have prompted a level of trade that benefits electricity consumers in every region across the continent. When linked across the international border, our diverse systems have created opportunities for efficiencies in regional systems management, reduced environmental impact, and improved reliability; these are vital achievements for all concerned.

A. Details of the Integrated Market

The map of the North American Transmission Grid offers a clear visual indicator of the extent of current integration. Electricity trade occurs at a range of points across the Canada-U.S. border, reflecting the largely north-south nature of the Canadian grid, as it is integrated with the more dense web of transmission infrastructure in the U.S.

Cross-border trade enables market participants to take advantage of diversity between the Canadian and U.S. electricity systems. The diversity and complementary nature of our systems are first demonstrated by the different balances of various conventional and emerging technologies in our generation mixes. These differences primarily reflect availability of resources, as different geographic regions have access to different input



Electricity Generation by Fuel Source in Canada and the U.S., 2005

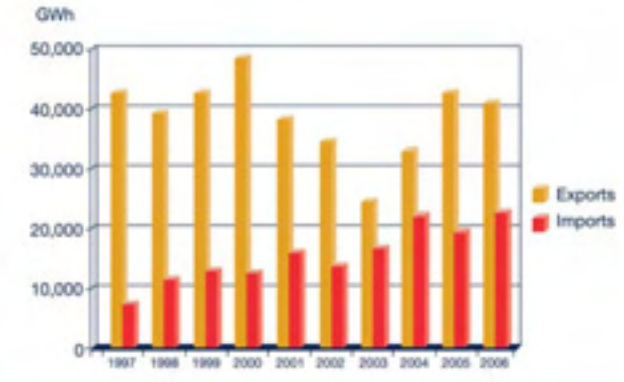
resources. The pie charts below show the generation mixes for Canada and the U.S.

Electricity is now established as a key and growing part of the larger energy trade between the two countries, and it is increasingly two-way. Electricity trade between Canada and the U.S. stems primarily from two sources. First, generators in Canada are key suppliers to particular U.S. markets. In addition, generators in both countries take advantage of the trading relationship to optimize the performance of their respective asset portfolios, which contributes to lower electricity costs and higher overall system efficiency and reliability. The bar graph to the right demonstrates the extent of this two-way trading relationship.

The quantity of electricity exported from Canada has typically been 6 to 10 percent of production. At the same time, electricity imports to Canada have increased. The fundamental point is that the market is a borderless one, and supply meets demand north to south or south to north as that market requires, to the advantage of consumers across the continent. Robust competitive wholesale markets in both the U.S. and Canada rely on integrated U.S./Canadian markets.

As the markets continue to open, the importance of crossborder trade will only increase.

Restructuring of the electricity industry has followed a similar pace in both Canada and the U.S., although the drive to open markets in both countries appears to have stopped. Currently, approximately 50 percent of Canadian retail customers are in open markets (although regulated rates remain available to retail customers in both Ontario and Alberta). The map below describes market restructuring in Canada.



Electricity Exports from Canada and Imports from the U.S., 1997-2006

II. SETTING THE STAGE: ENERGY SECURITY IN A NORTH AMERICAN ELECTRICITY CONTEXT

A number of factors have led to concerns about energy security in North America. First, and particularly for the electricity sector (in generation and transmission), there are growing concerns about the need for more investment in energy assets. This is particularly the case with respect to new generation

(which has lower greenhouse gas and air pollutant emissions) and investment in transmission (both east-west and north-south), to alleviate congestion and provide access to new generation for growing load centres. Second, recent years have witnessed significant volatility in both oil and natural gas prices. Third, political instability in other key energy markets around the world has prompted many to question the prudence of reliance on these regions for supply. The response in North America has been a growing sense of unease. In the U.S., some members of Congress have called for energy independence for the United States. In Canada, a new cabinet committee on environment and energy security was recently created by Prime Minister Harper. Both countries are appropriately concerned, as both countries are major players in the global energy market, whose economies turn on a robust and secure energy sector.

What is sometimes lost though, is an appreciation of how critical a close working relationship between our two countries is to address our respective energy security concerns. As explained in the following, energy security for the U.S. and Canada would be better defined in the context of a secure North American energy market.

Exports and Imports between Canada and the U.S., 2005
Source: NEB Electricity Exports and Imports, January 2005 to December 2005.

A. Factors Driving Energy Security Concerns

The most visible issue driving energy security concerns for the electricity sector is the need for new investment.

Key markets across the continent are facing significant shortfalls in generation supply in the next 10-15 years due to replacement, refurbishments, and new build requirements. The transmission grid across the continent has not seen significant new build for decades. The system, as robust as it is, requires major additions to meet the growing demands of the last and next several decades for electrical energy, due to population growth and the expanding uses for this form of energy.

For the public, an even more visible energy security concern is the price of oil and gas. Between 2001 and 2006, oil prices more than tripled from an average of US$21.84 a barrel in 2001 to a record high of US$78.40 in July of 2006. The U.S. Energy Information Administration ("EIA") predicts that oil prices will remain at approximately the 2006 average price of US$66 a barrel for 2007. Natural gas prices have also risen dramatically, from approximately US$3 per thousand cubic feet in 2003 to just over US$7 per thousand cubic feet in 2006. EIA predicts that natural gas prices will remain above US$7 per thousand cubic feet for 2007.

Related to the concern about price volatility is the concern about source of supply. The public perception is that a vast majority of North American oil, for example, comes from the Middle East. While that is not the case – America's largest single supplier of petroleum and petroleum products remains Canada – it is true that relying on energy from politically unstable regions in the world could impact energy security. Such concerns have encouraged some U.S. policy makers to promote measures to assure U.S. energy independence in the future.

Finally, measures to address environmental issues can raise concerns regarding energy security, particularly where such measures advocate – directly or indirectly – the reduced use of conventional generation, such as coal, hydro, or nuclear. For example, the Kyoto Protocol, to which Canada is a signatory, requires significant emissions reductions beginning in 2008. While the U.S. is not a signatory, aggressive measures to address climate change are being pursued in jurisdictions across the country. In either country, the climate change debate tends to focus attention on emerging technologies, sometimes at the expense of conventional ones, despite the necessary reliance of both countries on the latter. In particular, at least in the short to medium term, we must rely on existing technologies for emissions reductions. While diversifying the generation portfolio is good for energy security, limiting the options available is not. Conventional technologies are essential to meet demand and, used effectively, they can contribute to emission reduction targets.

B. The Importance of Making Energy Security a North American Concern

Canada and the United States enjoy the most significant trading relationship in the world. On a daily basis, that trading relationship amounts to $1.3 billion. A key element of that trading relationship is energy. Canada is America's largest supplier of energy, accounting for 94% of natural gas imports, nearly 100% of electricity imports, and more crude and refined oil products than any other foreign supplier. And in terms of electricity trade, in 2005, the U.S. imported 44.5 million megawatt hours from Canada and exported 19.8 million megawatt hours to Canada. More important to the U.S./Canada relationship, such trade enhances the reliability of each country's transmission system, allows for efficient use of resources particularly where seasonal peak demands are complementary, allows for the sale of inexpensive surplus power, and mitigates risk by providing for power during times of emergency outages or periods of high electricity demand.

Continued on Page 38

TBEA Transformer

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TBEA produces power transformers up to 1000kV, reactors up to 1000kV, HVDC converter transformers Up to 800kV, railway traction transformers up to 220kV, and drytype, special type transformers, rectifier transformers, and a large variety of transformation systems.

POWER TRANSFORMERS

Power transformers are commonly used as generator step-up and intertie power transformers. TBEA produces generator step-up transformers up to 840MVA for system voltages of up to 500kV and intertie power transformers up to 1000MVA for system voltages of up to 1000kV. The technical features of the TBEA power transformers include low losses, low noise, safe and reliable resulting in economical ownership.

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TBEA produces HVDC converter transformers up to 350MVA for long distance power transmission and mass capacity transformation systems for system voltages of ±220kV, ±500kV and up to ±800kV.

OIL-FILLED DISTRIBUTION TRANSFORMERS

TBEA produces oil-filled distribution transformers up to 30MVA (with on-load tap changer), 75MVA (with off-circuit tap changer) for system voltages of 0.4 to 35kV and up to 90MVA (with on-load tap changer), 240MVA (with off-circuit tap changer) for system voltages of 66kV and up to 110kV. Our distribution transformers are characterized by high reliability, high impedance, low losses, low noise, lower temperature rise, low partial discharge and require no maintenance.

840MVA/500kV Generator Step-UP Transformers for Three Gorges Dam Project, China. 2002

900MVA/220kV Three-Phase Auto-Transformer for the City of Los Angeles, USA. 2004

REACTORS

Reactors produced by TBEA include shunt, controllable, smoothing, grounding, current-limiting and dry type reactors. Shunt reactors are supplied up to 60MVA for system voltages of up to 1000kV. Controllable reactors are supplied with adjustable scope of 5% to 100% for system voltages of up to 550kV and unit ratings of up to 340,000kVA. Smoothing reactors are supplied for system voltages of up to ±800kV. Dry type reactors include current-limiting, shunt, filter and series reactors up to 20,000kVar for system voltages of up to 35kV.

COMBINED TYPE SUBSTATION (COMPARTMENTAL TRANSFORMER)

Combined type substation is composed of HV electrical equipment, power transformer, LV electrical equipment and auxiliary equipment. The combined type substation provides high reliability and easy maintenance resulting in shorter construction cycles and lower costs. Combined type substation is available in European and American types with unit ratings of up to 20,000kVA for system voltages of 35/10kV, 10/0.4kV or 6/0.4kV.

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Making the U.S. energy independent is neither a realistic goal, nor does it make sense from an economic perspective. EIA projects that energy consumption in the U.S. as a whole will increase by 24 percent by the year 2025, and already in the oil market alone net imports account for 66% of total U.S. oil consumption. Reasonably priced U.S. supplies – while significant – cannot meet that growing demand. This is a key reason why the focus should be on energy security, not energy independence.

If independence is not sensible, then the relationships you have need to be the most secure possible.

Continued emphasis on the integrated U.S. and Canadian energy markets provide an excellent means to build that energy security – for both countries. The electric transmission systems in Canada and the U.S. are interconnected at key points along the Canada/U.S. border.

Natural gas and oil pipelines also do not stop at the border, but instead provide a vast network for the movement of natural gas in the North American market. Such integration provides the framework for greater trade and greater market opportunities between our two countries. Making energy security a North American concern makes sense from both an economic and a political perspective.

III. ENHANCING ENERGY SECURITY IN THE NORTH AMERICAN ELECTRICITY MARKET

The current energy trading relationship between the United States and Canada contains a framework for expanding cross-border trade, stimulating infrastructure investment, and developing efficient and sustainable technologies.

Such integration provides the foundation for greater trade and greater market opportunities between our two countries. Increased integration of the U.S./Canadian marketplace will help to reduce the current uncertainty regarding energy supply in North American energy markets, thereby providing increased energy security. In the following sections, the Canadian Electricity Association reviews a number of measures that we believe would enhance electrical energy security across the North American market.

A. Increasing Generation Supply

The first step in assuring a secure energy market is to work together to increase generation supply in the North American market and to adopt policies that encourage/facilitate long-term capital intensive investment in the electricity sector. Growth in electricity demand in Canada and the U.S., as well as the retirement of aging or environmentally underperforming facilities, will require increases in generation capacity in our respective countries. Both the U.S. and Canada project the need to increase current generation capacity by approximately 25 percent by 2025 to satisfy increases in demand and the retirement of aging generation facilities.

In terms of future generation investment, solutions will necessarily reflect the availability of resources and to a lesser extent the availability of government incentives.

Currently, in the U.S., coal is the predominant fuel source.

In Canada, hydroelectric power is the dominant generation technology. We anticipate that more coal and nuclear power plants will be constructed in the U.S. to take advantage of the incentives in the Energy Policy Act of 2005 and that new capacity in a range of technologies – but especially hydroelectricity and nuclear – will be added in the Canadian marketplace.

In fact, such differing fuel opportunities in our respective countries allow for a diversity of supply that enhances the U.S./Canada bilateral trading relationship. In the United States, 51% of electricity generation needs are met by coal-fired generation facilities, 20% by nuclear, and 20% by natural gas, with hydroelectric capacity and other renewables accounting for the remaining 9% of generation capacity. In contrast almost 60% of Canadian electricity generation capacity is hydropower, 25% is conventional thermal power, and 15% is nuclear, with emerging renewables accounting for approximately 1%.

The availability and utilization of a range of supply options – different fuels, different technologies – will be fundamental to a cost-effective, reliable, and secure North American electricity system.

1. Conventional Generation

Notwithstanding the recent fluctuations in prices of fossil fuels and concerns regarding climate change, conventional fuel sources will continue to remain important in order to maintain a secure supply of electricity. The challenge is to address both the need for conventional generation and the related environmental concerns.

Given our common electricity market and our common air shed, CEA supports a bi-national cooperative approach to research and development to enhance our conventional generation supply. Cooperative cross-border measures between U.S. and Canadian interests could help ensure an adequate and sustainable electricity supply in the future. This is true, for example, with regard to clean coal technologies, where companies in both the U.S. and Canada have expressed interest in siting large-scale clean coal units. Companies in both the U.S. and Canada have announced plans to invest in advanced coal generation facilities, relying on technologies such as integrated gasification combined cycle and supercritical circulating fluidized bed. Such companies will utilize applicable U.S. and Canadian incentives to overcome the relatively high capital costs of these facilities, at least in the near-term.

Hydroelectric generation will remain an important source of electricity, with significant potential for new development in several regions of Canada. Hydropower is a proven, reliable, and clean energy source, and its flexibility makes it ideal as back-up for intermittent renewable energy sources. Historically, the United States has benefited from significant imports of hydropower from Canada and can benefit from new hydro development in the future.

There are also opportunities to promote nuclear facilities on a bi-national basis. While no nuclear facility has been built in the U.S. in recent years, the Energy Policy Act of 2005 contains numerous incentives to spur investment in nuclear facilities. In fact, EIA projects that nine gigawatts of new nuclear capacity will be built as a result of the incentives in the Energy Policy Act. In Canada, although no new nuclear plants have been built in the country since 1986, there is an explicit commitment to new build nuclear in Ontario, and strong interest in Alberta and New Brunswick, and Canada – particularly Saskatchewan – is home to some of the richest concentrations of uranium in the world. While nuclear is not an option in every jurisdiction, it remains a key part of the generation portfolio across the continent – now and in the future.

2. Emerging Technologies

Concerns regarding climate change/air quality and the sustainability of fuel supply are serving to encourage the development of alternative generation technologies.

Canada and the U.S. have an opportunity to work together to foster enhanced energy security while responding to environmental and sustainability concerns. For example, Canada will continue to have most of its electricity met by hydroelectric facilities, while hydroelectric power exported from Canada will continue to serve as a critical resource in major portions of the U.S. Other renewable resources – particularly wind generation – are gaining in importance, both in recognition of their benefits in achieving fuel diversity and in improving air quality.

The U.S. EIA estimates that renewable generation, including combined heat and power generation, will grow by 1.5 percent per year, from 357 billion kilowatt hours in 2005 to 519 billion kilowatt hours in 2030. In terms of renewable generation potential in Canada, the Clean Air Renewable Energy Coalition, a group of corporate and environmental organizations and municipal governments, estimates that Canada's potential for low-impact renewable sources (defined to exclude large hydropower) is between 122 million and 398 million megawatt hours. And with respect to additional hydroelectricity production, Natural Resources Canada estimates that there is significant potential for future development by electric utilities.

Capturing this renewable potential will help to ensure a secure – and environmentally preferable – electricity supply in the North American market.

In recent years, alternative generation investment in both Canada and the U.S. has increased significantly.

For example, with respect to wind energy generation, Canada has seen a doubling of its capacity during 2006, from 684 megawatts to 1,341 megawatts. According to the American Wind Energy Association, wind energy installations in the U.S. now exceed 10,000 megawatts and produce enough electricity on a typical day to power the equivalent of 2.5 million homes. Investments in this and other technologies are expected to grow in the coming years.

Efforts to diversify our current energy supply by promoting emerging technologies are important to helping ensure reliable and environmentally sound energy. However, where technology support initiatives suggest environmental preferability without a sound scientific basis or

where the initiatives arbitrarily picks winners and losers among a range of technologies, as would be the case with recently proposed Renewable Portfolio Standards in the United States, such initiatives can result in more harm than good.

And where such technology initiatives serve to exclude certain technologies from other jurisdictions (such as defining "renewable technologies" to exclude large and existing hydropower), the benefits from cross-border trade are compromised. CEA believes that our respective markets would benefit from common definitions of environmentally preferable power choices (renewable or otherwise) and from common approaches to supporting them.

B. Enhancing the Cross-Border Transmission Grid

In its most recent reliability assessment, NERC highlights the need for increased transmission capacity. In both the U.S. and Canada, transmission investment has seriously lagged behind generation investment. In order to effectively take advantage of the diversity of the bi-national generation market, there needs to be adequate transmission capacity across the border. And that transmission must be as reliable and as safe as possible from physical and cyber attacks.

1. Increasing Transmission Capacity

In its National Transmission Grid Study, the U.S. Department of Energy concluded that the transmission system in the U.S. has become congested because growth in electricity demand and investment in new generation facilities have not been matched by investment in new transmission facilities. Similar disparities between generation and transmission investment have occurred in Canada. In fact, the North American Electric Reliability Council projects that transmission investment will continue to lag behind generation investment, resulting in still greater congestion on the North American transmission grid.

While the integrated U.S./Canadian electricity market enjoys the benefits of cross-border trade, constraints along the border and within large regional markets continue to inhibit further trading. Stronger east-west transmission return on capital invested in transmission facilities are often too low, serving to discourage investment in such facilities.

CEA believes that regulatory approaches that increase rates of return for transmission facilities would encourage greater investment in such facilities. To that end, Provincial (and State) regulators should observe FERC's lead in providing higher rates of return for investments in transmission infrastructure. In addition, measures to identify opportunities for merchant transmission facilities in our two countries could also be explored. Moreover, tax measures that would facilitate more investment in the development of new transmission infrastructure at key bottlenecks across the continental marketplace could be implemented. For example, aligning capital cost allowance rates with the useful life of the asset would encourage greater transmission investment. The U.S. Congress recognized the importance of tax incentives to encourage the construction of transmission facilities by including provisions in the Energy Policy Act that treat transmission facilities as 15-year property and provide an 8-year period for recognition of gains following the disposition of transmission property.

Opportunities for bi-national cooperation for both investment in advanced transmission technologies and transmission R&D – either through government programs, industry support, or government-industry partnerships – should also be explored to take advantage of the bi-national interest in a reliable and efficient transmission system. Advancements have been made in transmission technologies both to reinforce the grid and to improve the management of the grid. Improvements to grid management, such as the utilization of real-time data and cooperation between balancing authorities in the development of consistent scheduling protocols and sharing of reserves, have allowed for the more efficient use of the existing transmission infrastructure. Nevertheless, in the absence of higher rates of return, there may not be sufficient incentives for such improvements to the transmission grid, or for the necessary research and development to pursue advanced transmission technologies.

2. Implementing Bi-National Transmission Reliability Rules

With the highly integrated North American transmission grid in mind, the U.S. Congress developed and passed reliability legislation that allows for the creation of an Electric Reliability Organization ("ERO") that can operate on an international basis. The ERO model ensures a balance of interests that protects the organization from being unduly subject to any one stakeholder or government, while respecting the sovereign right of authorities in each country to assure themselves that the interests of their citizens are protected through oversight and remand functions. And because only the ERO – as opposed to individual regulatory or legislative bodies – can

develop reliability standards with continental application, the reliability system can be run effectively on an international basis.

The ERO's ability to operate effectively on an international basis requires close cooperation among the relevant governmental authorities. The need for this close cooperation led to the establishment of the Bilateral Electric Reliability Oversight Group ("Bilateral Group"), which is comprised of the Federal-Provincial-Territorial Working Group, the Federal Energy Regulatory Commission ("FERC" or "Commission") and the U.S. Department of Energy. The Bilateral Group developed the "Terms of Reference for Bilateral Electric Reliability Oversight Group" ("Terms of Reference"), which identified the appropriate cooperative approaches for the governments to ensure the effective operation of the ERO.

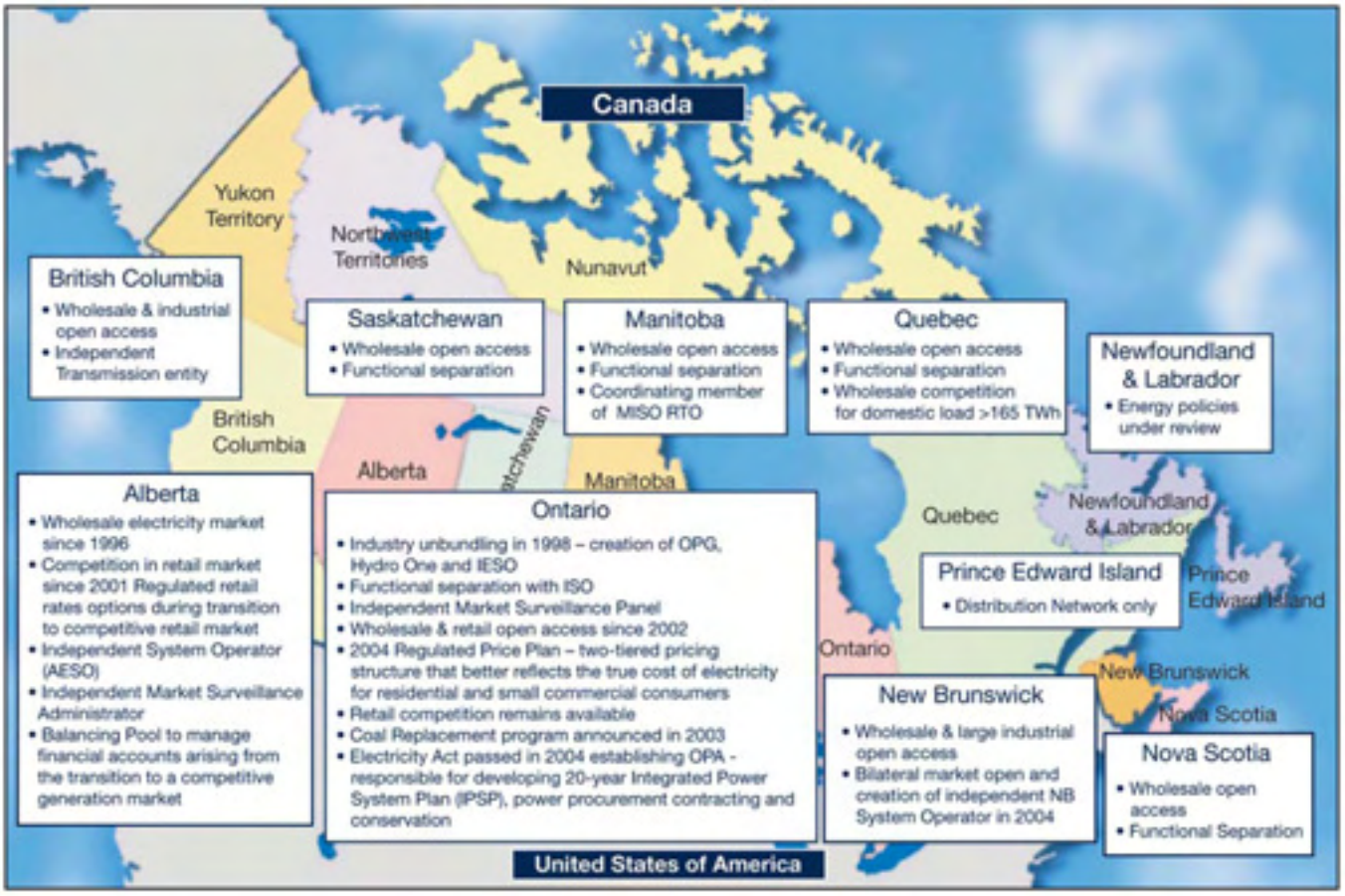
Moreover, the Bilateral Group released the "Principles for an Electric Reliability Organization That Can Function On An International Basis" ("Bilateral Principles") to assist FERC in developing rules that would allow the ERO to operate effectively on an international basis. Both the Commission's Final Rules and the NERC ERO submission ultimately approved by FERC were consistent with the Bilateral Principles, thereby ensuring that the reliability organization ultimately approved by the relevant regulatory authorities will be able to operate effectively on an international basis.

Looking ahead, in reviewing NERC's proposed Reliability Standards for approval, it is important that the relevant regulatory authorities respect the integrity of the international organization, whose responsibility is to develop standards that reflect the interests and concerns of both Canadian and U.S. entities. General guidance from governmental authorities in addressing issues of concern regarding certain standards can be useful to the ERO in revisiting certain standards. However, specific standards within and across regions will enable increased regional trade between Canada and the US. In particular, this investment will enable delivery of environmentally preferable power from more remote areas to larger centres with growing load, where options for new power developments are more limited. Several examples exist of supply potentially available to constrained regions that cannot move because of transmission congestion.

For example, the constraints in the Pacific Northwest limit the opportunities for cross-border trade between western Canada and the western U.S. Enhanced transmission capacity between Manitoba and its bordering states would allow for increased exports from Manitoba. And constraints within the Northeast region constrain economic flows across the border.

Promoting the construction of the transmission necessary to relieve existing constraints on the North American grid and to ensure available transmission capacity with respect to new generation supply will help ensure a secure supply of electricity in the North American market in the future.

A bi-national cooperative approach to encouraging the construction of such new transmission capacity would help to relieve constraints along the U.S./Canadian border, as well as help to



Market Restructuring in Canada, 2007

assure the adequacy of electricity supply in the U.S. and Canada.

Opportunities to ease transmission congestion must first be identified. The U.S. Department of Energy recently issued its National Electric Transmission Congestion Study as part of its work to designate National Interest Electric Transmission Corridors. In the Study, DOE identified as a conditional congestion area the Montana-Wyoming area.

Noting the significant potential of expanded generation in Alberta, DOE concluded that the U.S. would be unable to take advantage of such potential absent expansion of the transmission capacity in this part of the U.S. Encouraging the development of generation capacity in Alberta will require enhanced grid connections in the Montana-Wyoming area and between this area and Canada. The DOE report also identified New England as a "Congested Area of Concern", noting that the area has growing load and aging generation facilities, and that transmission will be required to bring lower-cost power to the region. This is another potential area for increased cross-border trade in electricity, particularly from new generation opportunities in Eastern Canada. However increased transmission investment will be required to fully take advantage of such opportunities for cross-border trade.

A cooperative approach between the U.S. and Canadian industries requires the identification of factors that could inhibit transmission construction, and identification of solutions to address such barriers to construction. One such barrier may be public opposition to the construction of new transmission lines, coupled with extensive regulatory processes for the approval of such lines. Transmission reinforcements may be more acceptable in regions where new construction is politically or logistically infeasible.

The solution to regulatory delays would involve the streamlining of the process for siting transmission lines.

Moreover, speeding up the process for transmission siting would allow for increased construction of beneficial transmission facilities within the North American transmission system. Regional transmission planning may also be a useful tool to help identify opportunities for linking new supplies from attractive generation sites that are relatively remote, to high load growth areas.

Such opportunities have good potential to offer regional benefits, including supply diversification and long-term security of supply.

Other measures should also be considered to promote investment in transmission infrastructure. First, action may need to be taken to ensure adequate returns. Rates of return on capital invested in transmission facilities are often too low, serving to discourage investment in such facilities.

CEA believes that regulatory approaches that increase rates of return for transmission facilities would encourage greater investment in such facilities. To that end, Provincial (and State) regulators should observe FERC's lead in providing higher rates of return for investments in transmission infrastructure. In addition, measures to identify opportunities for merchant transmission facilities in our two countries could also

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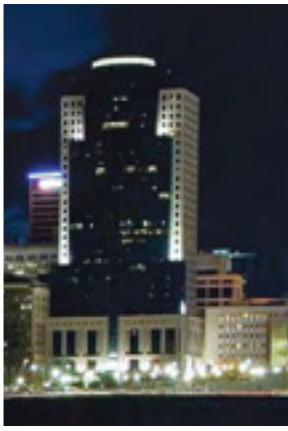

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Opportunities for bi-national cooperation for both investment in advanced transmission technologies and transmission R&D – either through government programs, industry support, or government-industry partnerships – should also be explored to take advantage of the bi-national interest in a reliable and efficient transmission system. Advancements have been made in transmission technologies both to reinforce the grid and to improve the management of the grid. Improvements to grid management, such as the utilization of real-time data and cooperation between balancing authorities in the development of consistent scheduling protocols and sharing of reserves, have allowed for the more efficient use of the existing transmission infrastructure. Nevertheless, in the absence of higher rates of return, there may not be sufficient incentives for such improvements to the transmission grid, or for the necessary research and development to pursue advanced transmission technologies.

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The ERO's ability to operate effectively on an international basis requires close cooperation among the relevant governmental authorities. The need for this close cooperation led to the establishment of the Bilateral Electric Reliability Oversight Group ("Bilateral Group"), which is comprised of the Federal-Provincial-Territorial Working Group, the Federal Energy Regulatory Commission ("FERC" or "Commission") and the U.S. Department of Energy. The Bilateral Group developed the "Terms of Reference for Bilateral Electric Reliability Oversight Group" ("Terms of Reference"), which identified the appropriate cooperative approaches for the governments to ensure the effective operation of the ERO.

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Looking ahead, in reviewing NERC's proposed Reliability Standards for approval, it is important that the relevant regulatory authorities respect the integrity of the international organization, whose responsibility is to develop standards that reflect the interests and concerns of both Canadian and U.S. entities. General guidance from governmental authorities in addressing issues of concern regarding certain standards can be useful to the ERO in revisiting certain standards. However, specific and detailed directives from a governmental authority with respect to those same standards could limit the ERO's ability to effectively balance the interests and concerns of the North American utility industry and could limit the ERO's ability to craft a revised standard that would receive approval from the other governmental authorities. An effective international ERO, recognizing the sovereignty of jurisdictions on either side of the border, turns upon cooperation across the board in the agreed-upon standard-setting process.

3. Ensuring Critical Infrastructure Protection

Since the terrorist attacks in the United States on September 11, 2001, the electricity industry has become better

prepared for both physical and cyber attacks on the electricity infrastructure. However, the frequency of cyber attacks is on the rise. Such an increase is of particular concern given the electricity industry's growing dependence on e-commerce and electronic controls.

Moreover, the potential for physical threats to the electric infrastructure remains a reality.

In January 2000, following the successful Y2K transition, CEA members formed the Critical Infrastructure Protection Working Group in order to coordinate activities, share best practices, and interface with the Canadian federal government. In its first year-and-a-half of activities, it established an effective information sharing Intranet site, implemented methods for coordinating activities with NERC and other partners, developed and implemented an Early Warning System for threats to electricity infrastructure, and worked closely with the federal government. The Early Warning System developed by the Working Group is a model being looked at by other sectors as a fast and efficient method of communicating information in times of high alert.

The North American electric power industry is currently working through NERC to develop approaches for safeguarding the North American bulk electric power system.

This work culminated in the development of cyber security standards approved by the NERC Board of Trustees and submitted to the relevant governmental authorities for approval as Reliability Standards. Such bi-national cooperation provides for an effective and cost-efficient approach to ensuring the protection of North American electricity infrastructure and, accordingly, should be encouraged.

C. Avoiding Barriers to Cross-Border Electricity Trade

CEA members are an integral component of the North American transmission grid, and the interconnected nature of our systems has allowed for the development of an important trading relationship with U.S. market participants.

Efficient and rational supply choices in our respective countries require avoiding or eliminating measures that might create seams that hinder trade within and between electricity markets. Identification and elimination of operational or business obstacles will help to ensure efficient and effective market decisions, necessary for a secure electricity system.

Seams affect electricity markets where the rules and conditions on either side of jurisdictional boundaries constrain the economic transfer capacity or flow of energy.

Differences in market rules or operating and scheduling practices that inhibit the ability to economically trade energy or capacity between regions impact market liquidity.

System operating rules, transmission access scheduling, certain pricing models, and rate pancaking are all examples of market rules and conditions that could result in inefficiencies in trade between regions. And without market liquidity,

price discovery and long-term hedging of pricing become more difficult tasks. Measures that harmonize differing market rules and transmission scheduling and pricing systems improve market liquidity and enhance cross-border trade.

Addressing such barriers to trade requires an understanding of the differing regulatory responsibilities applicable to electricity markets. In Canada, electricity is predominantly within the jurisdiction of the provinces, with a Government of Canada role in regulation of energy exports and facilities that span international borders. In contrast, in the United States, interstate electricity markets are regulated primarily by FERC. As such, different approaches to electricity markets may develop. Policymakers and regulators should work cooperatively among themselves and with industry to identify the impediments to efficient cross-border trade and to identify appropriate measures to address any barriers to trade. And governmental authorities, as well as industry, need to be mindful of the potential for additional barriers to robust electricity markets in working to address seams issues between electricity markets. Coordinated approaches to addressing seams issues will allow for greater efficiency and enhanced reliability in electricity markets.

D. Promoting Demand Side Measures and Energy Efficiency

Adequate generation and transmission capacity are critical to ensuring a secure North American electricity market.

Focusing solely on the supply side of the grid, however, misses opportunities for employing demand-side measures to address supply adequacy and energy security.

Investment in demand-side measures – particularly energy efficiency and distributed generation – can help to reduce the need for new generation facilities and reduce our reliance on fossil fuels for existing generation sources.

> In particular, the NAFTA partners could work together on a coordinated approach to GHG emissions trading. A North American GHG registry could encourage reductions in GHG emissions. First, established protocols both for reporting emissions and for reporting emissions reduction would encourage businesses in all of North America to engage in the trading of emissions reduction credits.

Demand-side measures have been implemented both in Canada and the U.S. in response to various policy directives, but are likely to increase in importance, particularly where fuel prices continue to remain volatile and concerns regarding energy security persist.

Demand-side measures can also help to relieve transmission constraints, thereby enhancing transmission reliability and energy security. In its National Transmission Grid Study, the U.S. Department of Energy concluded that targeted energy efficiency and distributed generation could reduce electricity loads on the transmission system, alleviate bottlenecks, and delay the need for construction of new transmission facilities. But measures to relieve transmission constraints can often occur in places other than where the constraint exists. For example, transmission constraints in the U.S. caused by the Lake Erie Loop Flow could be relieved through distributed generation or efficiency measures taken in Canada, or vice versa. Bi-national coordination in the planning and deployment of demand-side measures could thus prove an effective means of addressing transmission constraints on the international grid, thereby enhancing the energy security of both nations.

E. Coordinating Strategies to Manage Greenhouse Gases

Addressing the issue of climate change remains a continuing challenge for both the U.S. and Canada, but one that could benefit from cross-border dialogue. Canada and the U.S. have taken different approaches to the issue of climate change. Canada is a signatory to the Kyoto Protocol, while the U.S. is not, although initiatives to reduce emissions have been taken at the state level. Nevertheless, recent proposed approaches in Canada and the U.S. suggest opportunities for coordinated approaches to deal with climate change.

In October of 2006, the Canadian government introduced the Canada's Clean Air Act, which commits to short-term and long-term measures to address climate change and the reduction of air emissions. In the short-term, the Canadian government intends to adopt a target-setting approach based on GHG emissions intensity for the 2010-2015 period. Longer term, the Canadian government commits to achieving an absolute reduction in greenhouse gas emissions between 45 and 65% from 2003 levels by 2050. New and emerging technologies will be encouraged to help meet these targets.

Reductions in carbon intensity and measures to promote emerging technologies are currently being considered in the U.S. Congress. These measures suggest opportunities for a coordinated approach between the two countries that would recognize the unique characteristics of North American energy production, but would nevertheless encourage decisions that are environmentally sound. Our two countries should also explore opportunities to coordinate and share new technology as a means to meet sustainability goals and reduce GHG emissions, including coordination in the demonstration of such technologies.

And finally, a common approach to defining environmentally preferable power could help eliminate the often arbitrary approach of picking winners

and losers, and instead concentrate on reducing impacts of any technology application. As decision-makers begin to look at the post-2012 period in the climate change debate, all such efforts become all the more important.

In particular, the NAFTA partners could work together on a coordinated approach to GHG emissions trading. A North American GHG registry could encourage reductions in GHG emissions. First, established protocols both for reporting emissions and for reporting emissions reduction would encourage businesses in all of North America to engage in the trading of emissions reduction credits.

Second, the existence of established protocols would encourage additional investments in greenhouse gas reduction measures. Finally, eligibility for a much broader range of projects for credits could encourage more businesses to participate in the registry. As with the great success with energy trading, GHG emissions trading between Canadian and U.S. companies could offer significant benefits to both countries – building on already strong regional markets through new trading opportunities. And by providing businesses with the flexibility that trading provides, the NAFTA partners could help companies identify the most cost-effective options to reduce emissions.

CONCLUSIONS

A number of factors have led to concerns about energy security in North America, including a lack of adequate investment in energy assets, volatility in both oil and natural gas prices, and political instability in key energy markets around the world.

While the response of some has been a call for energy independence, the more sensible approach for Canada and the U.S. is to make energy security a North American concern and to focus on solutions that take advantage of our existing trading relationship and means for enhanced trade. Cooperative cross-border measures for developing increased generation supply could help to ensure a diversified, adequate and sustainable electricity supply in the future.

Adequate transmission capacity across the border would allow market players to take advantage of the diversity of the bi-national generation market – this will require an increased regional focus on transmission planning – both north-south and east-west, with a view to enhancing electricity trade that will provide regional benefits in both Canada and the U.S. The identification and elimination of operational or business obstacles will help to ensure efficient and effective market decisions, necessary for a secure electricity system. Cooperative approaches to demand-side measures and energy efficiency could help to reduce our reliance on fossil fuels and relieve constraints on the transmission grid. And coordinated approaches to addressing climate change could help to identify the most cost-effective options to reduce emissions for both countries.

The U.S./Canada integrated electricity market provides the framework for greater trade and greater market opportunities between our countries, thereby enhancing energy security for both Canada and the U.S.

ROLE OF GEOGRAPHICAL INFORMATION SYSTEMS IN DISTRIBUTION MANAGEMENT

By Vijoy Kumar and Anjuli Chandra, Central Electricity Authority, New Delhi

INTRODUCTION

Sub-Transmission (ST) and Distribution systems constitute the link between electric utilities and consumers, their revenue realization segment.

For consumers, it represents the face of the utility. Efficient functioning of this segment of the utility is essential to sustain the growth of the power sector and the economy.

However, the present situation is characterized by unacceptably high losses (both technical and commercial), poor quality and reliability of supply, billing, revenue collection, frequent interruptions in supply and resultant consumer dissatisfaction, etc. In this context, ST and segment of power sector needs immediate attention and action to achieve a turn around and self-sustenance of the power sector.

PROBLEMS IN DISTRIBUTION SYSTEMS

The main issue in distribution systems or, rather, more appropriately, the issue confronting the power sector as a whole, is the reduction in transmission & distribution (T&D) losses to acceptable minimum levels. Total India T&D losses, which were about 15% until 1966-67, increased gradually to 24.79% (1997-98). During the last few year,s some utilities estimated the losses to be in the range of 30% to 50% higher than preceding years.

T&D losses in developed countries are around 7-8%. Taking into consideration Indian conditions such as remote rural areas, nature of loads, system configuration etc., reasonable permissible (technical) energy losses should be 10%-15% in that country's states.

While losses in the extra high voltage (EHV) network are about 4%-5%, the bulk of the losses occur in the ST&D system. It is well known that these losses in Distribution systems include non-technical or commercial losses and that of power by various users with or without connivance of utility staff (theft). These constitute a large component of overall losses. There are also losses due to defective (slow) meters, stuck up/burnt meters

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Distribution management

Continued from Page 48

etc. Further, as a result of estimation involved in the agriculture sector consumption (30% of total), the absence of adequate metering at the system level, and deficiencies in consumer metering, the validity T&D loss estimates being reported becomes questionable. General conclusions are that the reported losses are under estimated and cover up large commercial losses (theft); actual figures are higher; technical losses are also high; and the bulk of the losses occurs in sub-transmission and distribution systems. Inefficiency, frequent interruptions, flickers and poor voltage also characterize distribution systems.

In addition, billing and revenue collections are very poor, leading to combined state utility financial losses of Rs. 26,0000 crores every year. If the current trend continues, in another three years, state utility financial losses will reach Rs. 45,000 crores a year.

It is, therefore, necessary to bring about improvements in the planning, implementation and operation of ST&D systems in a scientific and efficient manner. The present traditional reactive and ad-hoc approach to network development should be replaced by an approach based on technical and reliability requirements, economic considerations of costs of energy loss and expansion of system to meet the growth of prospective demand at the lowest possible cost.

STATUS OF DATA DOCUMENTATION IN POWER UTILITIES

Reliable and sufficiently detailed data is required to facilitate decision making in all activities of the distribution system management. Controlling costs, improving efficiency and reducing down time has become essential for a utility in order to succeed in today's highly competitive environment where private utilities/distribution companies are coming into distribution.

With large connected networks, number of spur lines and alternative feeds from different sources, the creation, updating and management of distribution data is a herculean task. Many studies conducted in utilities across the country have indicated that the data documentation in most utilities is very poor. The data of distribution systems is maintained through hand-drawn maps with facilities' data printed in text form on them and available with the JE/linesman in charge of the feeder. These maps are rarely updated.

Data Requirements

The data requirements for management of distribution systems are voluminous and varied. Some of them are indicated below:

Consumer data

Category wise number of consumer and connected load including the Bulk Consumer's details such as

- Contract demand
- Maximum demand
- Energy consumption
- Supply voltage

Demand data

- Peak demand MW/MVAR - simultaneous and non simultaneous

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Continued from Page 50

• Annual energy consumption data

Network data

• Geographical map (to scale) of the area depicting transmission and sub-transmission system.

• Source(s) of power supply/Grid substation(s) supplying power to the area

• Existing substation

• Existing lines

Sub-Transmission System

• Existing 66-33/11 kV substations & existing 66-33 kV lines.

• Under construction substation.

• Under construction 66/33/11 kV lines.

Distribution System

• 11kV lines

• Distribution transformers

• LT lines.

Operational parameters

• Substation equipment status

• 66/33 kV Feeder breakdowns

• Failure of distribution transformers

• Tripping on 11 KV feeders/lines

• Consumer outages

Electrical network details

• Electrical network details – single-line diagrams with conductor sizes, lengths, transformer locations, capacitors, capacitors, consumer location and load etc.

• Parameters of equipment, devices and conductors

• Load data-peak load, diversity factor, power factor etc.

LV Network

• Section length

• Conductor size of each section

• Connected load for each group of consumer

• Number of consumers in each group

• Total connected load on the transformer

EQUIPMENT PARAMETER DATA

The schematic diagram for existing substations is to be prepared with information of the power transformer rating and numbers, impedance values, bus bar scheme, isolators, circuit breakers type e.g. (minimum oil/bulk oil/SF6/Vaccum) and type of installation (indoor/outdoor), number of incoming and outgoing feeders, CTs and PTs, details of taps and normal tap position, spare bays etc.

LOAD DATA

The load data covering the monthly, daily and yearly details of energy/peak power in the electrical system as well as information as below is required:

• Peak load on each transformer/feeder and corresponding actual voltage.

• Diversity factor at various voltage levels.

• Power factor at various voltage levels

• Load factor and loss load factor at various voltage levels.

Further data on billing, revenue collection, pending applications investment, material & manpower requirements, etc are some of the other data required. As can be seen, the data requirement is considerable. These records have to be stored, retrieved and used by many different people at different locations. If manual records are used, then there is every likelihood of these records being misplaced or destroyed. The use of advanced information technology tools for maintaining a coherent database becomes essential.

ROLE OF INFORMATION TECHNOLOGY IN DISTRIBUTION SYSTEM MANAGEMENT

Initially, computers handled data only in alphanumeric form. GIS is an important tool in this area. Geographic information systems is a system of mapping a complete electrical network including low-voltage system and customer supply points with latitude and longitudes overload on satellite imaging and/or survey of India maps. Layers of information are contained in these map representations. The first layer corresponds to the distribution network coverage. The second layer corresponds to the land background containing roads, landmarks, buildings, rivers, railway crossings etc. The next layer could contain information on the equipment (utility poles), conductors, transformers etc. Most of the electrical network/equipment has a geographical location and the full benefit of any network improvement can be had only if the work is carried out in the geographical context. Business processes such as network planning, repair operations and

maintenance connection and reconnection must also be based around the network model. Even while doing something as relatively simple as adding a new service connection, it is vital to know that users of the system are not affected by this addition. GIS, in conjunction with system analysis tools, helps to do just this.

For efficient and reliable operation of a distribution system, a reliable and well-knit communication network is required to facilitate project coordination of the maintenance and fault activities of the distribution system. GIS, when integrated with real-time SCADA, can help in sending the right signals to the communication network. Outages can be isolated faster than ever before and maintenance crews dispatched with critical information, including location of the fault.

GIS can be used in distribution systems management for:

- Handling customer inquiries
- Fault Management
- Planning routine maintenance
- Network extensions and optimization
- Analysis
- Network reconfiguration
- Improved revenue management
- SCADA can be integrated with GIS
- Rights of way and compensation

A GIS environment hosts a wealth of presentation techniques that enable fast and accurate interpretation of results from power flow to short circuit analysis.

INITIATIVE BY GOVERNMENT OF INDIA

For developing sub-transmission and distribution schemes on a scientific basis with energy accounting and audit as an integral component, the Government of India has appointed a committee under the chairmanship of Member (PS), CEA to formulate guidelines/manuals on the various aspects of sub-transmission and distribution development. The committee held discussions with various utilities across the country and has formulated the several manuals/guidelines. These guidelines and manuals cover all aspects and provide guidance to the field level units to undertake ST & D development using a scientific approach to establish energy accounting and audit system, to achieve reduction in both commercial and technical losses and ensure quality and reliability of power supply to consumers.

- Guidelines for formulation of the project report on upgradation of sub-transmission and distribution system;
- Guidelines for energy accounting and audit in power systems;

GIS systems have had the reputation of being great technology for patient people.

- Guidelines for project management, performance evaluation, operations and maintenance and renovation and modernization (R&M) of sub-transmission and distribution projects;
- Manual on training of personnel deployed on sub-transmission and distribution and
- Technical specifications for equipment in ST&D: conductors, cables distribution transformers, energy meters and HT shunt capacitors and associated control equipment.

CONCLUSION

GIS integrates common database operations such as query and statistical analysis with the unique visualization and geographic analysis benefits offered by maps.

These abilities distinguish GIS from other information systems and make it valuable from explaining events, predicting outcomes and planning strategies for distribution system management. With these modern information technology tools, the power utility can be proactive rather than reactive.

GIS systems have had the reputation of being great technology for patient people. Building a database for distribution systems on geographical systems is a time-consuming and laborious task and would have to be carried out in a phased manner, but ultimately the returns would be manifold.

NEW RADIATION TECHNOLOGY REMOVES WATER, ENERGIZES BIOMASS

Utilizing biomass energy for electricity generation hinges on one major factor: the percentage of water volume.

Drier biomass yields a greater energy potential compared to wood with a higher water content. That's why a new technology that has been developed to remove all of the water from woody biomass has generated such great interest.

According to information provided by the Swiss Group of Companies in Brazil, by employing electromagnetic radiation, the technology reportedly removes the water without having to carbonize the wood, as would occur when drying biomass in a high temperature furnace. At the same time, the process energizes the biomass with higher calorific power.

A dryer using electromagnetic radiation does not need high temperature, and it acts by simple molecular agitation so that the rays only remove the water but not the inner hydrocarbons of the wood (acetic acid and greasy acids) that are extremely energetic. On preserving the hydrocarbons into the wood after taking out all of the water, its calorific power increases significantly and may attain almost 5,000 Kcal/Kg.

Drying the biomass without carbonizing it avoids the presence of residual ashes into the boilers of thermoelectric plants. The carbonization process causes high pollution because the very high temperatures cause a break of the inner hydrocarbons, pushing them out as a highly polluting gas. Also, the weight of biomass dried with electromagnetic radiation is reported to be much higher than the weight of carbonized wood. Almost 29% fewer trees thus would be needed with the technology, compared with carbonizing of the wood, Swiss Group of Companies emphasizes.

The Swiss Group of Companies are a fund-administration specialist, serving the administration and accounting needs of U.S. and offshore investment funds.

The new process decreases the hydroscopic tendency of the wood while optimizing its calorific power. By thermo-rectifying the biomass via electromagnetic radiation, the system also eliminates up to 35% of the natural toxic elements of the biomass. Under the complex process of thermo-rectification, biomass undergoes several chemical and physical alterations that benefit the environment. Several gases are drawn out, especially hydrogen, carbon, and oxygen. These elements are captured and treated for energetic use, which also can be sold in the worldwide market.


The northeast coast of Brazil

The outstanding merit is the fact that it is a pioneer in the implantation of the first industries capable of potentializing the energy of biomass products and increasing its calorific power. All the water contained in the biomass is withdrawn and makes the wood more flammable.

By electromagnetic radiation, all the water is taken out without having to carbonize the wood, just as it would occur on drying the biomass in a common furnace of high temperature. A drier using electromagnetic radiation does not need high temperature and it acts by simple molecular agitation so that the rays only remove the water, not the inner hydrocarbons of the wood (acetic acid and greasy acids) which are extremely energetic. On preserving the hydrocarbons into the wood after taking out all the water, its calorific power increases substantially and may attain almost 5,000 Kcal/Kg. On drying the biomass without carbonizing it, we avoid the presence of residual ashes in the boilers of thermoelectric plants, thus avoiding high penalty fines. The carbonization process causes high pollution because the furnaces must use a very high temperature which causes the breakdown of all the inner hydrocarbons, pushing them out as a highly polluting gas. The weight of biomass dried with electromagnetic radiation is much higher than the weight of carbonized wood. This means that the coal takes up much more volume, requiring a greater number of trucks/freight cars for transportation, pushing costs higher. Drying biomass requires less deforestation, meaning almost 29% less trees are cut down.

This process also optimizes the calorific power of the biomass while, at the same time, decreasing the hydroscopic tendency of the wood. By thermo-rectifying the biomass with electromagnetic radiation, it also eliminates up to 35% of the natural toxic elements of the biomass. Under the complex process of thermo-rectification, duly patented, our biomass undergoes several chemical and physical alterations which benefits the environment and makes the biomass substantially better in quality and in calorific power.

During the thermo-rectification

process by radiation, several gases are drawn out from the biomass, especially hydrogen, carbon and oxygen. These elements are captured and treated for energetic use. Energetic wood-chips outstrip any other wood-chips in the world because of the high calorific power obtained through a special process of electromagnetic radiation which draws out the water from the biomass but does not eliminate the hydrocarbons which are essential for combustion.

It is well known that all petroleum and gas companies have to face the new problem of supplying biomass fuels to those clients who are committed to the Kyoto Protocol. Viewing the new alternative necessities, our company has created the first Dryer functioning with electromagnetic radiation for the following important purposes:

1. To increase more than twice the energetic power of the biomass product.
2. To use significantly less quantities of biomass to generate MWh in power plants.
3. To reduce by 28% deforestation to produce electricity, compared to charcoal.
4. To use fewer agricultural products to produce electricity.
5. To decrease up to 35% the toxic elements contained naturally in the biomass: CH4, NO2, C20H12, H2CO.
6. To consume considerablt less electricity for drying biomass (208 kWh for drying 20 tons) and obtain a high yield of electricity at the power plant (116.260 MWh with the same 20 tons).
7. To decrease a moisture from 45% - 65% down to 5% - 8%.
8. To make them double the calorific power.
9. To achieve an impermeability which impedes the entrance of new moisture and parasites.
10. To slow down the deterioration process and obtain a long shelf life.

In Brazil, there is a very large availability of forests (Pinus and Eucalyptus) and large agricultural extensions. The country has 8,514,877 square kilometres of extension and only 19% of agricultural lands are exploited, ie, there are still 2,600,000 square kilometres to be planted. So, from 2008 on, Brazil will produce great quantities of potentialized wood-chips and pellets. Brazil has patented a new creation of agroforestry pellet that we have named “Brazilian Tropical Pellet”. It is made up of a mixture of wood sawdust, sugar cane bagasse, tropical fruits and vegetables. Through our dryer, the Tropical Pellet achieves the highest energetic power. We could look into a new kind of pellet made with local fruits and vegetables like dates, nuts, husks and seeds, palm husk as possible alternatives.

We can also carry out the conversion of fuel systems into your thermoelectric power plants assuring your quotas of biomass supply produced in Brazil: eucalyptus wood-chips, pinus wood-chips, pellets of cane bagasse and agroforestry pellets. With regards to the Potentializer Dryers, they are built in Brazil and the buyer can secure the right of using the technology by paying a royalty fee for 5 to 10 years.

NERC CIP STANDARDS ARRIVE JUNE 2008

With the final approval of the eight NERC-CIP standards by the Federal Energy Regulatory Commission recently, bulk electric power system users, owners and operators must meet compulsory NERC-CIP standards by a looming June 2008 deadline. Thanks to a new collaborative cyber security technology offering announced by Industrial Defender and RuggedCom, these owners/operators will have an easier path to compliance with the industry's most comprehensive and integrated solution designed to meet NERC-CIP regulations.

> "Working with RuggedCom provides customers with a completely integrated and easier roadmap to NERC-CIP compliance for their critical cyber assets."
> - Brian M. Ahern, president and CEO of Industrial Defender

Industrial Defender, Inc. and RuggedCom announced they will jointly develop, market, and co-brand cyber security solutions for critical infrastructure industries, including power, oil and gas, transportation, water and chemical sectors.

As part of this new strategic partnership and technology integration, RuggedCom will benefit by tapping into Industrial Defender's comprehensive Defense in Depth approach to cyber security, which includes network security professional services, cyber security technology and managed security services. In addition, Industrial Defender can now extend its process control/SCADA network cyber security monitoring and management capabilities into harsh network environments.

"Working with RuggedCom provides customers with a completely integrated and easier roadmap to NERC-CIP compliance for their critical cyber assets," said Brian M. Ahern, president and CEO of Industrial Defender. "Joining forces with the global leader in hardened network infrastructure products extends Industrial Defender's Defense-in-Depth technology offering through the seamless integration, monitoring and management of RuggedCom devices within the Industrial Defender Security Event Management (SEM) console, while also enabling a managed security service offering for global RuggedCom products."

"Mandatory NERC-CIP compliance deadlines are forcing electric power companies to ensure the most critical elements of their systems meet stringent security requirements on an abbreviated timeframe," said Marzio Pozzuoli, president and CEO of RuggedCom. "Our partnership with Industrial Defender enables us to deliver our technology with an increased level of cyber security, providing customers with a more comprehensive and complete solution."

As part of new technology partnership program also introduced by Industrial Defender, technology providers like RuggedCom and CSE-Semaphore, a leading IP-based SCADA RTU provider, can ensure their solutions offer the industry's best cyber risk projection to better serve customers in the real time process control/SCADA market. The new Industrial Defender Enabled Partner Program allows technology providers to leverage Industrial Defender's comprehensive Defense in Depth approach to cyber security, which includes network security professional services, cyber security technology and managed security services.

The program offers two levels of participation for technology providers. As an Industrial Defender Enabled Partner, technology providers complete a comprehensive technology validation process that will enable a partner device to be monitored by the Industrial Defender Security Event Management (SEM) console, enhancing the cyber security posture of the

process control/SCADA network. Customers who purchase an Industrial Defender (SEM) console can monitor all Industrial Defender Enabled devices on the real-time process control/SCADA network. Industrial Defender Enabled partners also will benefit from opportunities to participate in co-marketing and demand-generation programs.

For a tighter level of integration, technology vendors can become an Industrial Defender Enabled Premier Partner, which delivers a more extensive technology integration of partner devices, including monitoring and management by the Industrial Defender (SEM) console, co-marketing, demand-generation and solution-selling by combining Industrial Defender's cyber security technology, network security professional services and managed security services with industry-leading premier partner technologies.

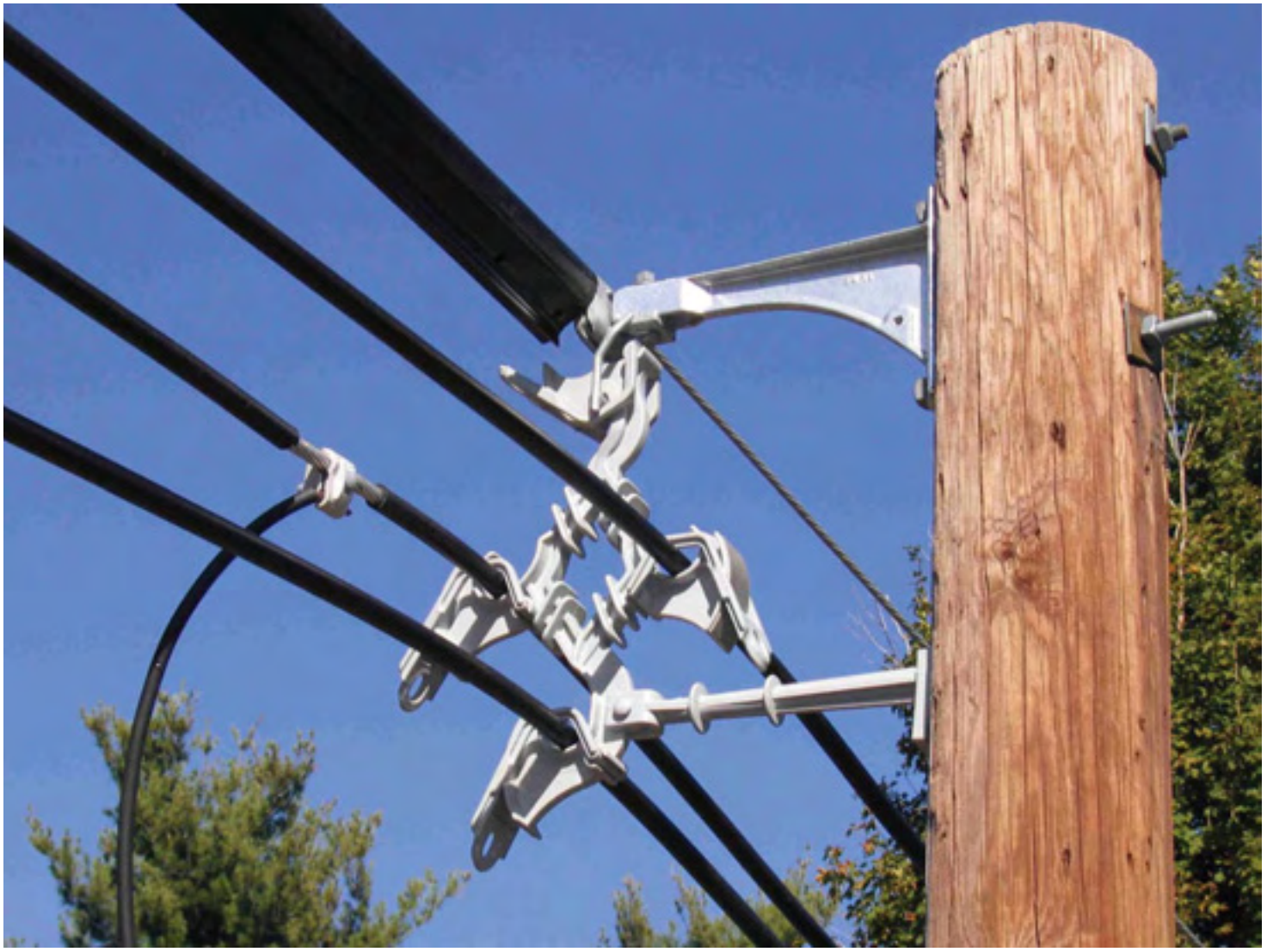
CSE-Semaphore, a leading IP-based SCADA RTU provider, is the first technology provider to join the Industrial Defender Enabled Partner Program, and has joined the Industrial Defender Enabled Premier Partner Program.

RuggedCom, a leading provider of ruggedized communications networking solutions for mission-critical applications

> "In today's world, control systems require the highest levels of security when monitoring critical infrastructure."
> - William Ketelhut, Managing Director of CSE-Semaphore

Semaphore telemetry systems are designed to leverage easy-to-use web technologies and inexpensive public networks. They offer up to 50 percent less total installed cost-per-point versus traditional SCADA/PLC systems and permit greater organizational access to data through automated reporting and browser software. Semaphore's RTU product lines include T-BOX, which offers an integral Web server and is ideal for decentralized networks, and Kingfisher, which brings open programming and advanced capabilities to SCADA systems that employ central stations. As an Industrial Defender Enabled partner, Semaphore offers the industry's first RTU line to fully support cyber security protection for process control/SCADA networks.

"In today's world, control systems require the highest levels of security when monitoring critical infrastructure," said William Ketelhut, Managing Director of CSE-Semaphore. "Our partnership with Industrial Defender has enabled us to provide uncompromised cyber security monitoring for our customers."



GIVING SOME SPACE TO ENVIRONMENTALLY SENSITIVE AREAS

Tree trimming is a major component and expense for utilities, so reducing the frequency and amount that foliage needs to be trimmed can translate into a considerable savings.

Hendrix Wire & Cable has introduced the Spacer Cable system, which allows for electrical transmission while being environmentally sensitive.

Spacer Cable conductors are designed with a covering that limits the electrical charge on the outside of the cable, cutting down on the potentially lethal electrical charges and protecting wildlife (like raptors or other large birds) that may come into contact with phase conductors and ground points.

With a conductor covering that can withstand temporary contact with tree branches and other vegetation, Spacer Cable systems from Hendrix reduce the amount of foliage that must be removed to accommodate conventional bare wire circuits by 50 to 80 percent. Hendrix Spacer Cable is available at 15kV through 69KV. Combined with the Spacer Cable system's small configuration and great strength, fewer trees need to be removed to install the system, and subsequent trimming is far less extensive than with bare wire systems. In addition, the system offers great flexibility in span length, thereby allowing the poles to be placed in areas where access is least disruptive and avoiding extensive root damage often caused by trenching to install underground systems.

The Aerial Cable & Systems is one of four operating divisions of Hendrix Wire & Cable, a provider of overhead and underground power distribution products based in Milford, New Hampshire. The division's benchmark product, Spacer Cable, formed the foundation of the company in 1951.

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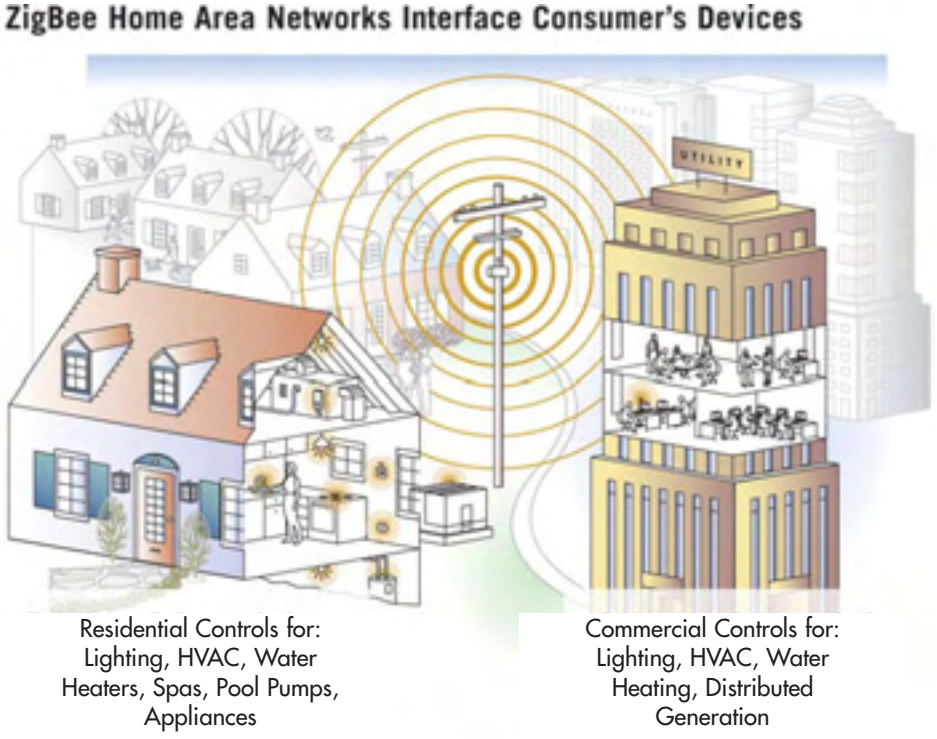
ADVANCED METERING FOR THE INTELLIGENT ELECTRIC GRID

In 2000, Californians found out the hard way what it was like to face rolling blackouts every day. In the wake of the 1996 deregulation of its utilities market, California's residents and commercial sectors endured the reality of a long, hot summer as rolling blackouts plagued the state. While not only a nuisance and an inconvenience, the blackouts temporarily slowed one of the world's largest economies and had strong political repercussions. Many individuals may think rolling blackouts are a thing of the past, but they actually give us an ominous indicator of our future if global energy efficiency programs are not implemented soon.

Blackout and brownout problems have occurred in other U.S. states and countries and could continue as energy demand increases and energy generation fails to keep up. According to a recent report from the North American Electric Reliability Corporation, "electricity demand in the U.S. is expected to grow by 141,000 megawatts in the next decade while only 57,000 megawatts of new resources have been identified, leaving a shortfall of 84,000 megawatts, an amount equivalent to 160 large power plants." With legislative and regulatory requirements in several states (e.g. California and Colorado) and countries stipulating greenhouse gas emission reductions - a requirement that does not embrace construction of new power plants - the industry faces a possible impasse. Many energy experts see the value of turning to technology to fill the gap using ZigBee wireless products and services offered by companies like Cellnet, which provides the utility industry with a data communications network and enables the reality of advanced metering infrastructure (AMI).



AMI has emerged as one of the key technologies expected by many industry experts to transform the utility market. According to the U.S. Department of Energy's Grid 2030 vision report, AMI serves as an enabler for the intelligent grid and acts as the driving force behind how utilities collect and analyze data in the future. AMI is a system that measures, collects and analyzes energy usage collected from advanced devices such as smart electricity, gas or water meters. This data can be collected through various communication channels either on request, or on a pre-defined schedule. Cellnet recognized the potential financial costs to businesses and the legal liabilities of utility companies should the electric delivery status quo remain.

In response, it created an AMI solution, UtiliNet network technology, which offers two-way communication and control - to provide key building blocks needed when creating a smart electric grid. UtiliNet puts more control and efficiency back in the hands of businesses and consumers while allowing utilities to offer new services that create more value for their customers.

THE CELLNET SOLUTION SUCCESS

Cellnet supports the single largest AMI network in the United States and its UtiliNet relies on ZigBee to communicate with ZigBee home area networks (HAN), sometimes referred to as "in-premise networks." A HAN can be comprised of ZigBee-enabled devices like appliances, thermostats, water heaters, pool pumps, to name a few. This communication and control is possible because ZigBee is a global wireless language that

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Continued from Page 60

connects dramatically different devices. Since ZigBee is a global wireless standard, it provides the scalability and reliability needed to support an infrastructure as demanding as smart energy grids created through AMI.

UtiliNet ultimately creates a wide area network linking ZigBee equipped smart meters back to the utility, allowing the utility to communicate with ZigBee-enabled devices found in HAN installed in homes and businesses.

"Our technology helps customers take charge of their energy consumption," said Mak Tarnoff, director of product marketing at Cellnet. "Now they can reduce and conserve energy based on price information. UtiliNet allows utilities to send a wireless signal to the consumer's electric meter and ZigBee technology transmits that signal to ZigBee devices in the home. This means consumers can control usage of thermostat-based equipment such as the heating ventilation and control system based on price sensitivity."

Importantly, ZigBee gives utility companies a standards based approach to new energy efficiency programs such as demand response, time-of-use pricing programs, energy monitoring, pay-as-you-use and net metering programs. Homeowners and businesses will also get the most out of their distributed generation products, like solar panels. Utility companies gain new tools and real-time data to react to emergencies. UtiliNet helps utility companies avoid dispatching a utility worker during emergencies to personally confirm a power outage. Cellnet technology immediately informs customers of an outage, accurately pinpoints the location and source of the problem allowing service to be restored faster.

WHAT IS THE ZIGBEE ALLIANCE?

ZigBee is the global wireless language connecting dramatically different devices to work together and enhance everyday life. The ZigBee Alliance (www.ZigBee.org) is a global ecosystem of companies creating wireless solutions for use in energy management and efficiency, home, commercial and industrial applications.

It is the only global wireless communications standard enabling the development of easily deployable, low-cost, low-power monitoring, and control products.

Membership: The Power of Many

ZigBee Alliance members come from a broad spectrum of industries, including electric utilities, manufacturing, technology, industrial automation and design. The member companies have come together to help shape the wireless market by defining the ZigBee specification and promote its use.

Currently, the Alliance has more than 225 member companies including the following Promoter companies that sit on its Board of Directors: Cellnet, Eaton Corporation, Ember Corporation, Freescale Semiconductor, Honeywell, Huawei Technologies, Itron, Mitsubishi Electric, Motorola, Philips, Samsung, Schneider Electric, Siemens, STMicroelectronics, Tendril Networks, and Texas Instruments.

ZigBee has strong support from leading silicon suppliers, with members representing seven out of the top 10 global semiconductor companies including: Freescale Semiconductor, NEC, NXP, Renesas, Samsung, STMicroelectronics and Texas Instruments. Major OEMs like Eaton, Honeywell, Huawei, Johnson Controls, LG, Mitsubishi, Motorola, NEC, Philips, Samsung, Schneider Electric, Siemens, Vantage/Legrand, Yokogawa are developing new products around ZigBee.

The Alliance enjoys strong endorsement of its energy management and efficiency solutions by utility industry and smart energy grid proponents. Some of the world's leading and innovative energy companies, ranging from utilities to suppliers have recently joined the Alliance and are relying on ZigBee solutions. Utilities such as CenterPoint Energy, Southern California Edison and Sempra Utilities are working alongside other member companies such as Cellnet, Eaton, Itron, Phillips, Schneider Electric, Siemens, Comverge, Control4, DCSI, Golden Power, Johnson Controls, Legrand, Nivis, Nuri Telecom, Sensus Metering, Silver Spring Networks, Site Controls, Talon Communications, Trilliant Networks, Tritech Technology and Viconics to use existing low-cost and easily installable ZigBee products and services.

Standards-Based

The ZigBee Alliance standardized its specification on top of the Physical (PHY) and Medium Access Control (MAC) layers of the IEEE 802.15.4 global standard; adding the application profile layers, security and network layers to create ZigBee.

Working with the IEEE 802.15.4 standard — which focuses on low data rate personal area networking — ZigBee capitalized on the standard's inherent reliability, long battery life and mesh network support to enable reliable, low-power, wireless data communications for monitoring and control devices.

ZigBee also extended the inherent security of the IEEE 802.15.4 standard with the robust encryption option of AES-128 security, which can be tailored to meet the specific needs of any network.

By creating a standards-based wireless networking solution, ZigBee ensures that vendor-independent product solutions will be interoperable. ZigBee has introduced a certified product program to ensure products wearing the ZigBee certified logo meet stringent quality and operation criteria. Vendors choosing to build on the ZigBee standard can focus on product innovation, instead of developing costly proprietary solutions, and expand on the potential for new and creative applications to be brought to market.

ZigBee continues to work closely with the IEEE to ensure an integrated and complete solution for the market.

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OFFSHORE WIND TURBINES BACK ON TRACK

By Steven Rose, P. Eng.

The public has a right to clean, renewable energy and commercial scale wind turbines are recognized as a proven technology to reap the energy from the natural wind currents that exist over the earth's surface. Offshore wind power generation is far more consistent than land-based turbines, providing higher levels of predictable output.

That's why it's great news that the Ontario government has lifted the moratorium on existing proposals for offshore wind power projects. They are reviewing current applications and will be accepting new onshore and offshore applications soon.

Engineers have a significant role to play in infrastructure development. Rebuilding and creating additional electricity capacity in this province is now near the top of the Ontario government's agenda, providing an excellent opportunity for engineers to market their expertise to the government. Engineers will encourage investment in electricity infrastructure to ensure long-term economic sustainability.

Ontario has a unique opportunity to develop offshore turbine technologies in the Great Lakes which are less harsh than seawater environments. Once proven, these technologies can then be deployed in other offshore locations.

This change will benefit Ontarians by providing access to a significant natural resource - the wind over the Great Lakes. Once the challenges of transporting, erecting and connecting the wind systems over the Great Lakes are resolved, Ontario could become an engineering technology leader.

These projects generate significant employment for engineers, trades people and unskilled workers. For every 1,000 Megawatts of deployment, and presuming that the Ontario government focuses

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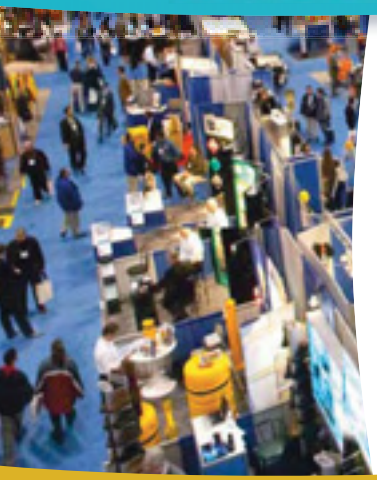

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on local engineering firms, some 5,000 jobs would be created. This is based upon observations of the growth of the wind power industry in Europe.

Key skills needed are in the areas of civil, electrical and mechanical engineering for components of heavy infrastructure - land- and water-based foundations, dealing with ice forces, delivery mechanisms for materials, transfer of energy via conduits, and the design and deployment of mechanical structures to capture wind energy.

The Ontario Society of Professional Engineers (OSPE) recommends that the government leverage the economic opportunity of domestic supply. The advantage for Ontario to guide contracts to suppliers in the province will foster a domestic industry that could become world class in offshore wind turbine development, supporting deployment here and then becoming an exportable expertise.

OSPE also recommends that competitive processes for identifying companies to deploy wind capture systems utilize Qualifications Based Selection as a basic premise. Customers receive the best overall project value when they rely on procurement practices that emphasize the qualifications and experience of engineering service providers. OSPE recognizes that economics play a role in every procurement process, but we believe that innovation, competitiveness and long-term sustainability are more important.

Furthermore, the decision of which technologies to deploy (wind turbines, towers, foundations, cabling and monitoring systems) should consider the need for 20-year lifetime operation, as well as ease of retrofit and maintenance. Total Lifecycle Costing is critical to successful engineering.

We are all aware that there is no single "technological fix" for the challenges confronting our electricity system. A multi-faceted approach that gives equal consideration to conservation, renewable energy and new generation is needed to fuel the economy and provide reliable power to consumers.

OSPE has offered public support for an energy restructuring plan that includes:

- equal consideration for conservation promotion and new generation;
- a basket of technologies in the generating mix including renewable energy sources to avoid shortages; and
- rapid pursuit of coal replacement initiatives, mitigated by the creation of alternate/replacement supply.

OSPE also believes that there is a broad range of expertise available within the engineering community. This expertise can be used to create sufficient renewable energy sources and take advantage of other supply options for cogeneration. In turn, this will lead to employment and economic prosperity.

Steven Rose, P.Eng. is Vice-Chair of the Ontario Society of Professional Engineers and Vice President & Co-Founder of Malroz Engineering Inc., a Kingston-based company of environmental engineers and scientists. For more information visit www.ospe.on.ca.

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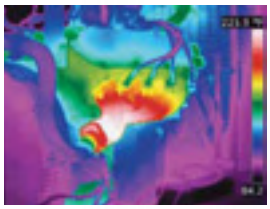

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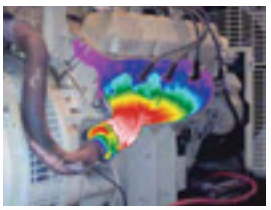

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