North American Policies and Technologies

ELECTRICITY Transmission & Distribution TODAY

THE ELECTRICITY FORUM

July/August 2007
Volume 19, No. 6

Finepoint Factory Day

Pennsylvania Breaker's high voltage test lab is one of the host sites for Finepoint's "Factory Day" tour.

The Circuit Breaker Test & Maintenance Training Conference is slated for October.

See page 28 for the official floor plan.

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in this issue

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MAKING EVERYONE ACCOUNTABLE FOR THEFT

Don Horne

Copper theft has increased 1,150 per cent from 2005 to 2006.

That's one thousand, one hundred and fifty per cent.

This sort of mind-boggling explosion of crime in any other sector of the community would have headlines screaming from one coast to the other, and people demanding immediate action from the police.

But hey, it's only the utility; so who cares, right?

Aside from the complete foolhardiness of stealing copper from active transmission and distribution networks (those who do it wrong once never do it again), these acts of theft and vandalism cost Ontario's Hydro One an estimated $1 million a year.

Copper theft has become the fastest growing form of crime in Ontario, and the copper wire used in power lines is proving to be an attractive target for thieves.

To help combat this runaway crimewave, Hydro One is contributing $10,000 to Crime Stoppers to help raise awareness among the public.

Crime Stoppers is an organization that offers financial rewards leading to the capture and successful prosecution of criminals.

"This is becoming a very serious problem," says Chris Price, Hydro One's Director of Security. "These thefts threaten the safety of the general public and Hydro One staff and could negatively impact electricity reliability. We expect our partnership with Crime Stoppers, and working closely with local law enforcement will help reduce this criminal activity."

Price explained that the benefits of partnering with Crime Stoppers include the option of anonymity when reporting incidents, and rewards for providing information leading to arrests. "We believe that the partnership will increase identification of metal thieves, and those paying for stolen metal." He added that Hydro One continues to undertake investigations of copper/metal thefts, and has invested in improved security systems.

Pat Gillie, President of the Ontario Association of Crime Stoppers emphasized that for citizens who fear reprisal or are reluctant to get involved, Crime Stoppers is an option for reporting information about this dangerous theft. "Calling 1-800-222-TIPS is all it takes," she says.

The mere fact that Hydro One has had to take this drastic step to curb the theft of copper is indicative of the public attitude toward major utilities.

Many feel that they are not stealing. Many are upset with the increase in their electricity bills, and feel justified in stealing from a large corporation.

"They can afford it," seems to be the excuse for many caught red-handed.

The owner and operator of Ontario's 29,000 kilometres of high-voltage transmission network and 122,000 kilometre low-voltage distribution system, Hydro One is responsible for thousands of tons of copper stretching from heavily urbanized centers like Toronto to vast wildernesses like that of northern Ontario.

Not unique in having to deal with the theft of copper, Hydro One is unique in choosing to use Crime Stoppers as an extra weapon in the ongoing battle against theft and vandalism.

With this crime now costing Hydro One $1 million a year, it would be interesting to see if there was an increased public vigilance if this cost was itemized (like the debt retirement) on customers' electricity bills.

It may be only a few extra cents per customer, but the message would be clear - there is a problem, and it is up to everyone to help put a stop to it.

don@electricityforum.com

USING GEOSYNTHETICS FOR OIL CONTAINMENT

By Scott Lucas, President of Albarrie

Oil is oil, whether consumed or used as fuel. So says the USEPA. All oils have the same effect on the environment when allowed to enter the sub-soil or, worse, the water table. Anything that behaves like oil floating on water is considered to be oil.

No site wants to have an oil spill, into the waterway, or groundwater, especially in a residential area. Publicity following a spill will hurt the company's image, not to mention the fines and remediation costs associated with a spill.

Geosynthetics consist of the following polymeric materials used in environmental, geotechnical, transportation and hydraulic engineering applications:

- Geotextiles – porous textiles;
- Geomembranes – impermeable liners;
- Geogrids – reinforcement grids;
- Geonets – drainage nets;
- Geosynthetic Clay Liners – rolls of bentonite in/on geosynthetics;
- Geocomposites – various assemblages of geosynthetic and, sometimes, soil materials.

Geosynthetics, being a man-made synthetic material, can be modified, or combined with various other geosynthetic materials, to give the final results required when building in geotechnical applications.

There is a broad range of geosynthetic materials available, with more coming on stream each year to solve problems in civil engineering.

Some products which are quite common and have been in use for many years are products such as geotextiles. Geotextiles can either be a woven product for lateral flow of liquids or a fibrous product (nonwovens) for filtering and separation of soils. Geotextiles can weigh from as little as 100 g/m - to 1000 g/m - depending on the application. Geotextiles were first developed in commercial use about 35 years ago for use on railroad beds for stabilization. Today they are commonly used in such areas as residential gardens, acting as weed control around plants.

A geomembrane is used in containment applications. It is an impervious sheet, typically made of plastic. The plastic will be polypropylene; HDPE; LLPE; PVC, among other types of resins. These sheets of plastic will range in thickness from 0.25

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THE 2008 SUPER DUTY

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Oil Containment
Continued from Page 8

Testing of the system was conducted at the Kinectrics' Laboratory in Toronto, Ontario

mm to 3.5 mm. Geomembranes are manufactured by machinery very similar to that which manufactures a garbage bag, however the widths can be up to 15 meters. Geomembranes will block the mitigation of fluids.

Another product is a Geosynthetic Clay Liner. This product encapsulates sodium bentonite between two porous sheets of geotextiles. The sheet on the top, the bentonite and the sheet on the bottom are bonded together using a special machine that will take fibers from one sheet of geotextiles and interlock it together with another sheet. Geosynthetic Clay Liners, when saturated with water and under a confining stress, will, like the geomembrane, become impervious. This 6-mm thick composite will have the same permeability characteristics as 1 meter of compacted clay.

All of these geosynthetics working in conjunction with each other have been used for many years in containment applications, such as municipal solid waste landfills to prevent the seepage of leachates from the waste entering into the groundwater. The geosynthetics will also be used to cap the waste once the cell is full, preventing precipitation from entering the waste. These geosynthetics are also used for remediation sites when one wants to prevent the precipitation entering contaminated soils and further contaminating an area down stream.

As these geosynthetics are buried where there is little oxygen and are not subjected to ultra-violet rays, their half-life has been estimated to be up to 400 years.

The geomembranes and the Geosynthetic Clay Liner contain all liquids whether they are water or hydrocarbons. The task was to design a system using geosynthetics which would allow precipitation whether in the form of rain or snow melt to pass through - and, at the same time, contain hydrocarbons while not allowing them to escape.

A product known as Rubberizer, also known as a co-polymer, has been on the market for a considerable period of time. The co-polymer is basically a type of hydrocarbon which will absorb other hydrocarbons. These co-polymers can be designed to absorb hydrocarbons and still be porous and are typically spread over the surface of the water to absorb oil which may be floating on the surface. The co-polymer can also be designed to absorb the hydrocarbons and congeal, becoming impermeable.

Trials with various co-polymers showed that a product that absorbed and congealed would prove very useful. With a product that totally sealed on full saturation of hydrocarbons any migration of hydrocarbons from the containment area would be prevented.

Using the principal developed to manufacture Geosynthetic Clay Liners, the sodium bentonite was removed from the equation. A co-polymer was then substituted between the two porous geotextiles. Trials and laboratory testing were conducted to assure the correct amount of co-polymer was installed in the center of the two geotextiles. A correct amount of co-polymer is required to assure its effectiveness. By spreading the co-polymer mechanically in a production situation, it can be assured that the correct amount of co-polymer is applied to the composite as with the bentonite for the Geosynthetic Clay Liner.

As these geosynthetics are buried where there is little oxygen and not subjected to ultra-violet rays their half-life has been estimated to be up to 400 years.

Hence, another Geosynthetic is born - The Geosynthetic Oil Mat.

As with other containment systems, various types of geosynthetics are used for specific reasons. In the Sorbweb Plus system to contain hydrocarbons, various geosynthetics are also used.

On the bottom of the system, The Geosynthetic Oil Mat is placed over porous soil to allow for drainage of the precipitation, water from outside sources and snow melt. The Geosynthetic Oil Mat is only active once hydrocarbons come into contact with it.

The sidewalls around the perimeter of the system are lined with a geomembrane which is impervious, directing the flow of any liquids to the bottom of the system, and preventing any liquid from leaving the containment area through lateral movement.

Above the Geosynthetic Oil Mat is placed a number of drainage layers with woven geotextiles between the drainage layers. Woven geotextiles give a lateral flow so that in the event of an oil spill, the oil will not flow immediately down to the Geosynthetic Oil Mat allowing for dispersion of the oil and other liquids. This dispersion also gives dwell time for the co-

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Oil Containment

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polymer to fully absorb any hydrocarbon that comes in contact with it.

The system is topped with fire quenching stone which will be the reservoir for both the oil and water in case of a catastrophe. There are also, within the containment system, additional hydrocarbon absorption layers.

If, by some means, the system becomes damaged due to in situ digging or other unknown reasons, the system is repairable.

A case study of the Sorbweb System proving that it works was the successful containment of a 4,000 liter spill following an accident at a site located along the Don River in Toronto, Ontario Canada.

In another instance, in 2005 there was a fire and catastrophic failure of a Main Output Transformer (MOT) at a nuclear generating station that resulted in an oil spill. Some oil was ultimately discharged into a large local lake. As a result, the client commissioned installation of a secondary oil containment system to protect against damage by any potential future incidents.

The Sorbweb Plus oil containment system was selected from several competing systems for this project. One of the major reasons was that there would be no disruption of service from the installation of the containment system.

This turnkey project was divided into phases. Each phase involved three main tasks:

1. Sorbweb Plus system design and material procurement;
2. Construction, including excavation, soil disposal and Sorbweb Plus installation;
3. Environmental engineering, including soil sampling and testing.

Kinectrics acted as the general contractor for the entire project. The containment system is designed to contain 3,600,000 liters of transformer oil.

Stones and soil were removed from around and behind the MOT units. Rebar with concrete sloping towards the containment system areas was installed in some areas where placing Sorbweb Plus would have been impractical. Additional excavation was performed using Gradall scraping, carried out 15 cm at a time.

Pre-cast cement blocks formed the exterior and sides of the below-grade dike of the system. Sand, the initial layer of the Sorbweb Plus, was spread, followed by oil resistant plastic around the entire cement perimeter and interior obstructions to direct any oil or water down through the Sorbweb Plus. Proprietary layers of the Sorbweb Plus were then installed. Finally, additional materials and fire-quenching stones completed the system installation.

Sorbweb Plus solution is an effective and reliable passive system that provides continuous protection against oil spills from transformers. It is a smart system that allows water to drain through a containment area without accumulating, while retaining any oil that might leak from the transformer. Sorbweb Plus provides the client with a cost effective, no maintenance system that will provide reliable secondary oil containment of spills from transformers over a long period of time.

TURNING OFF-THE-GRID CUSTOMERS INTO GRID CONTRIBUTORS

By Don Horne

In the wilds of Northern Ontario, electricity meant the hum of a diesel generator.

The small hamlets and villages that dot the landscape of the Canadian Shield are, for the most part, all populated by First Nations peoples.

Living off the grid has been - and still is - a reality for the First Nations' peoples, but the realities of the modern world – primarily the need to create economic revenue while reducing harmful emissions – are becoming more of a fact of life for the thousands of residents of Northern Ontario.

Negotiations are currently under way with a number of First Nations' peoples to create an east-west transmission corridor from northern Manitoba across Northern Ontario to Sudbury. Tapping Manitoba's hydro-rich generation reserves is part of a larger effort to strengthen the east-west electricity interties across Canada (there are concurrent negotiations with Quebec and Newfoundland-Labrador to build similar transmission links into Ontario).

The obstacles to this new corridor (terrain, distance, an estimated cost of $2 billion) can be overcome (new building techniques, DC transmission and public/private investment), but the land rights issues may be the true sticking point.

For the aboriginal peoples, they want a level of participation and a benefit from the new transmission corridor. Years ago when Quebec launched the massive James Bay hydroelectric project, the Cree people in the area established a cadre of technically trained residents to help build and maintain the project. For Hydro One and, by extension, the province of Ontario, the distance between the communities and small population size makes creating a viable local workforce of properly trained individuals truly daunting in a short span of time.

The question of having the First Nations' peoples make a sizeable investment in the corridor is moot, considering that the vast majority of the various peoples still rely on hunting and fishing to provide an income. The great casino cash cows that are thriving among their fellow First Nations peoples to the south cannot be found here.

So that leaves a better, cleaner access to electricity for these isolated communities – freedom from the noisy, greenhouse gas polluting diesel engines currently running the lights, stoves and refrigerators in Northern Ontario. Simply string a few lines along the corridor and all is well.

Except that the corridor will all too likely be Direct Current, not AC.

The sheer distance of the line necessitates using DC, eliminating the considerable voltage loss and higher cost of AC transmission lines.

For these small communities, it doesn't look likely that they will each have their own conversion station built at their doorsteps along the line, reaping the benefits of the hundreds of megawatts of power running past their homes.

Any savings that will be had using DC instead of AC would be quickly eaten up if conversion stations are constructed for all of the communities within proximity of the corridor. This would leave the First Nations people back where they started, except that now they would have a transmission line running through their lands.

One option that would be attractive to both the province's electricity provider and the First Nations' groups would be the construction and integration of the tens of thousands of megawatts of wind generation available in Northern Ontario.

Such wind power could supplement these communities with not just electricity, but money from the generation they would be putting into the grid. The staffing, maintenance and construction of these wind farms would also provide the First Nations' peoples with employment opportunities with much greater permanence than a one-off transmission corridor project.

Yes, the wind farm projects would be an additional cost to the entire project; but it makes more sense to put the money into more, cleaner generation on a local level than to just build countless conversion statements drawing power away from the grid.

Wind doesn't offer a stable power supply, but it does offer the First Nations a chance to participate and grow along with the corridor.

HIGH VOLTAGE PROOF DESIGN TESTING

High voltage field acceptance test prior to being placed in service				
Rated Voltage Phase to Phase	dc Hi-Pot Test		dc Hi-Pot Test	
	(15 Minutes)			
	Wall - mils	Kv	Wall - mils	kV
5000	90	25	115	35
8000	115	35	140	45
15000	175	55	220	65
25000	260	80	320	95
28000	280	85	345	100
35000	345	100	420	125
46000	445	130	580	170
69000	650	195	650	195

Note: If the leakage current quickly stabilizes, the duration may be reduced to 10 minutes.

In 1996, the insulated conductor industry determined that DC withstand testing of the plastic (XLPE) insulation systems either in the cable factory as a routine production test or after installation as the higher voltage proof test was detrimental to the life of the insulation and therefore discontinued recommending DC testing.

Medium voltage EPR insulating systems are not subject to the same aging characteristics and, therefore, can be DC tested as required in accordance with the tables below.

When an insulated cable arrives on the job site, the recipient should be able to confidently assume it will attain the designed service life. This means it must arrive free of internal discontinuities in the dielectric such as voids or inclusions, as well as freedom from air pockets at the interfaces between the shielding systems and the dielectric's surfaces. It is, however, the specter of mechanical damage, or substandard splicing and terminating that could cause the engineers responsible for continuity of service to desire a field applied proof test to establish the cable's serviceability.

The time-honored methods of proof testing in the field involve high potential direct current (DC). The advantage of the DC test is obvious. Since the DC potential does not produce harmful discharge as readily as the AC, it can be applied at higher levels without risk or injuring good insulation. This higher potential can literally "sweep-out" far more local defects. The simple series circuit path of a local defect is more easily carbonized or reduced in resistance by the DC leakage current than by AC, and the lower the fault path resistance becomes, the more the leakage current increased, thus producing a "snow balling" effect which leads to the small visible dielectric puncture usually observed.

Since the DC is free of capacitive division, it is more effective in picking out mechanical damage as well as inclusions or areas in the dielectric that have lower resistance.

Field tests should be utilized to assure freedom of electrical weakness in the circuit caused by such things as mechanical damage, unexpected environmental factors, etc. Field tests should not be used to seek out minute internal discontinuities in the dielectric or faulty shielding systems, all of which should have been eliminated at the factory, nor should the DC potential be excessive such that it would initiate punctures in otherwise good insulation.

For low voltage power and control cables it is general practice to use a megger for checking the reliability of the circuit. This consists essentially of measuring the insulation resistance of the circuit to determine whether or not it is high enough for satisfactory operation. For higher voltage cables, the megger is not usually satisfactory and the use of high voltage testing equipment is more common. Even at the lower voltages, high voltage DC tests are finding increasing favor. The use of high voltage DC has many advantages over other types of testing procedure.

DC FIELD ACCEPTANCE TESTING

It is general practice, and obviously empirical, to relate the field test voltage upon installation to the final factory

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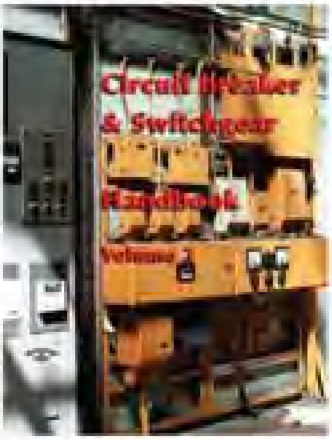

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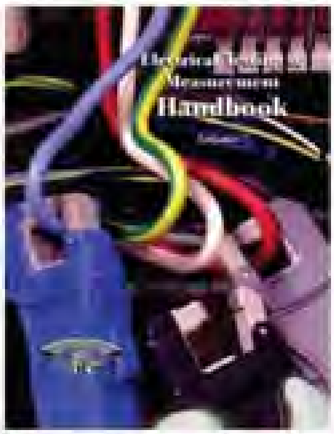

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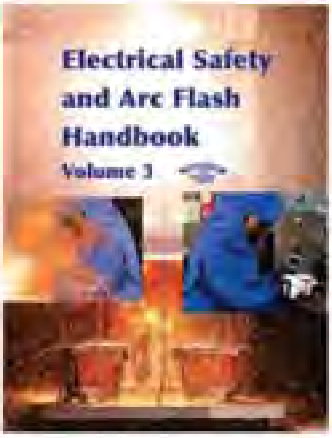

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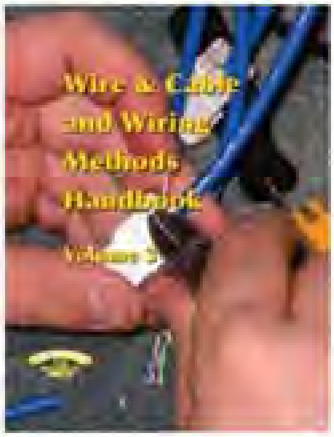

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Design Testing

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High voltage maintenance test for cables in service less than five years*	
Rated Voltage Phase to Phase	dc Proof Test (5 Minutes) kV
5000	20
8000	25
15000	40
25000	60
28000	65
35000	75
46000	100
69000	145

*Consult manufacturer when cables are in service over five years.

applied DC potentials by using a factor of 80 percent. The final factory-test voltages can be found in the appropriate industry specifications. This means that prior to being connected to other equipment, solid extruded dielectric insulated shielded cables rated 5kV and up may be given a field acceptance test of about 300 volts per mil.

The actual test values recommended for the field acceptance test are presented in the table on the previous page. If other equipment is connected it may limit the test voltage, and considerably lower levels more compatible with the complete system would be in order.

TEST LIMITATIONS

The DC leakage can be affected by external factors such as heat, humidity, windage, and water level if unshielded and in ducts or conduits, and by internal heating if the cable under test had recently been heavily loaded. These factors make comparisons of periodic data obtained under different test conditions very difficult. If other equipment is connected into the cable circuit this makes it even more difficult. In the event hot poured compound filled splices and terminations are involved, testing should not be performed until they have cooled to room temperature.

The relays in high voltage DC test equipment are usually set to operate between 5 and 25 milliamperes leakage. In practice, the shape of the leakage curve, assuming constant voltage, is more important than either the absolute leakage current of a “go or no go” withstand test result.

TEST NOTES

From the standpoint of safety as well as data interpretation, only qualified personnel should run these high voltage tests.

After the voltage has been applied and the test level reached, the leakage current may be recorded at one minute intervals. As long as the leakage current decreases or stays steady after it has leveled off, the cable is considered satisfactory. If the leakage current starts to increase, excluding momentary spurts due to supply-circuit disturbances, trouble may be developing and the test may be extended to see if the rising trend continues. The end point is, of course, the ultimate breakdown.

This is manifested by an abrupt increase in the magnitude of the leakage current and a decrease in the test voltage. It should result in relay action to “trip” the set off the line, but this assumes the equipment has enough power to maintain the test voltage and supply the normal test current. Since the total current required is a function of cable capacity, condition of dielectric, temperature, end leakage and length, the test engineer must be sure that “relay action” actually signifies a local fault, rather than being merely an indication that the voltage had been applied too quickly or one of the other factors contributing to the total current had been the cause.

At the conclusion of each test, the discharge and grounding of the circuit likewise requires the attention of a qualified test engineer to prevent damage to the insulation and injury to personnel.

MAINTENANCE PROOF TESTING

It may be justifiable in the case of important circuits to make periodic tests during the life of the installation to determine whether or not there had been significant deterioration due to severe and perhaps unforeseen operational or environmental conditions. The advantage of a scheduled proof test is, of course, that it can frequently "anticipate" a future service failure, and the necessary repair or renewal can be made without a service interruption, usually during a major shutdown.

Furthermore, a DC test failure is seldom burned-out, and visual analysis may disclose the cause and permit corrective action.

As a note of caution, once a complete circuit has been connected and all exposed ends sealed, it is not desirable when maintenance proof-testing to remove these seals, disconnect the conductors, and it is sometimes impossible to provide "ends" with adequate clearance and length of insulation surface to permit high voltage testing even at the levels specified in the following table.

Further, there is the danger of mechanically injuring the dielectric during the seal removal and end preparation. This is a major reason why a "megger test" is often used in maintenance checking of the numerous circuits in a power plant.

Frequency of proof testing

Period After Installation Acceptance Test			
Class of Service	1st Maintenance test	2nd Maintenance Test	Period Between Succeeding Maintenance Test
Lighting	No Test	No Test	None
Normal	3 years	8-9 years	5-6 years
Critical	12 - 18 months	2-3 years	4 - 5 years

FREQUENCY OF TESTS

In the case of power plants, it is customary to schedule desired maintenance proof tests to coincide with planned major shutdowns. It is not necessary or justifiable to check every circuit each year. The above schedule is suggested as a guide.

Courtesy of the Okonite Company. You can find this article and many more like it in our 2007 Wire and Cable handbook. Check out our website www.electricityforum.com for information on how to purchase this handbook or others like it.

YOU SAID IT

Graham Austin, who was an Energy/Environmental Manager with Alberta Distillers Ltd. in Calgary Alberta writes, "I retired on May 31st so your magazine will no longer reach me. Thank you for your past issues - they were most informative and helpful."

Ron Mazur, Manager of the System Planning Department with Manitoba Hydro in Winnipeg, Manitoba says, "I find the magazine articles very informative and practical."

James McLaren, Manager of Bear Creek Consulting in Charlton, Ontario writes, "I find both Electricity Forum and The (Electrical) Source interesting and an asset when looking for information and equipment."

Tim Ross, a Facilities Specialist with Nav Canada in Edmonton, Alberta says, "Very interesting articles."

Bill Kay, an Electrical/Int. Foreman with CVRD Inco Ltd. in Thompson, Manitoba writes, "I look forward to and enjoy this magazine for its material information and the maintenance articles."

Berni Fuchs, CEO of Chalet Enterprises Inc. in Edmonton, Alberta says, "Absolutely great resource. Great articles. Keep up the good work. Really appreciated."

Michael Chocho, a Senior Buyer with ATCO Electric in Edmonton, Alberta writes, "I have found your publication to be very informative, especially the articles. Keep up the good work."

Maurice Renaud, an electrician with the Brockville Mental Health Centre in Frankville, Ontario says, "I enjoy receiving and reading your magazine."

Sumantray Patel, an Engineering Manager with Energy Systems & Applications in Brampton, Ontario writes, "A very useful magazine with a lot of technical information."

Ove Albinsson, a Technologist with BC Hydro in Burnaby, British Columbia says, "Keep up the good work!"

Cole Tucker, a Utilities Technician with the City of Vernon in Vernon, BC writes, "Good magazine. I like the number of areas you cover and that it is not focused on only one or two areas."

Kevin Trottier, an Electrical Supervisor with Canfor in Houston, BC says, "I would just like to comment on how much I enjoy your Canadian Electrical Code sections. It really helps in keeping me up to date and clarifies a lot with the attached formulas and explanations. I usually race to that section and then read the rest of the magazine. Thanks for a good read."

Roy Shields, an Electrical Supervisor with Canfor in Prince George, BC writes, "It is a good read for our electrical room. Thanks."

Leslie Field, a Senior Product Engineer with General Electric Co. in Anasco, Puerto Rico says, "I would like to see more articles on Protective Relays, especially transformer and distance protective relays."

Lynn Wong, an Electrical Discipline Manager with SNC-Lavalin Inc. in Edmonton, Albera writes, "Excellent magazine; informative."

Scott Morris, a Technical Supervisor with Hydro One in Hornby, Ontario says, "I enjoy your magazine and find many topics applicable to my job. Thanks."

Greg Anderson, and Asset Manager Lines Stations with Curchill Falls Labrador Corp. in Churchill Falls, Newfoundland-Labrador writes, "Good work in supplying me information."

Russell Power, and Engineering Planner with Serco in Happy Valley-Goose Bay, Newfoundland-Labrador says, "Your publication has provided the company with valuable information and reference material in the past. Your magazine is passed down to the installers and maintenance people; they look forward to your magazines."

Gordon Reid, a Cableman with BC Hydro in Victoria, British Columbia writes, "I have greatly appreciated the input from other technical professionals and have found their judgements and arguments to be advantageous in justifying various purchases of equipment and software. I also like the emphasis placed on safe work practices and PPE (personal protective equipment). Thank you."

Avtar Bining, a Program Manager with California Energy Commission in Sacramento, California says, "Good magazine!"

John Quartermain, an Operations Supervisor with New Brunswick Power Corp. in St. Stephen, New Brunswick writes, "I enjoy your magazine and so do the guys in the crew room. Keep up the good work."

Dan Ward, a Principal Engineer with Dominion Virginia Power in Richmond, Virginia says, "Keep up the great work. Outstanding publication!"

Alfie Yip, Regional Electrical Engineer with Transport Canada, Ontario Region in North York, Ontario writes, "You are publishing a very fine technical magazine. I try to read all the articles and study all the advertisements. I need to read your magazine in order to keep up to date and abreast of new technology related to the electrical trade and profession. Keep up the good work."

Philip Wood, Practices and Procedures Engineer with the Toronto Transit Commission in Toronto, Ontario says, "Electricity Today is a good reference to me. Every issue contains a lot of useful and practical information that is related to my work."

Romulus Munteanu, a Manufacturing Engineering Manager with W.C. Wood Company Ltd. in Guelph, Ontario writes, "I consider your magazine one of the best from all available technical publications."

Melvin Liwag, Operations Manger with the Orlando Utilities Commission in Orlando, Florida says, "Looking forward to learning more about cutting edge technologies from your publication."

Paul Krupicz, Engineering Manager with Tiltran Services in Tillsonburg, Ontario writes, "We have enjoyed the magazine and the training sessions put on by Electricity Forum."

Theodore Gherian, a Maintenance Engineer with FirstEnergy Corp. in Akron, Ohio says, "I love this magazine!"

Edward Fatherly, a Senior Electrician with the US Army Corps of Engineers in Russellville, Arkansas writes, "Good magazine."

Paul Duong, an Electrical Technologist with EPCOR in Edmonton, Alberta states that Electricity Today is "A very good and educational magazine."

Dan Ward, a Principal Engineer with Dominion Virginia Power in Richmond, Virginia writes, "Keep up the great work. Outstanding publication!"

Falguni Shah, a Distribution Engineer with Oshawa PUC Networks Inc. in Oshawa, Ontario says, "This magazine is an excellent source of information."

Ken Lucoe, an Electrical Foreman of Rides at Canada's Wonderland in Vaughan, Ontario says, "Great magazine."

Peter B. Mahnke, who is involved with Electrical Maintenance with Karmax Heavy Stamping in Milton, Ontario says, "Good magazine; I like the number of areas you cover and that (the magazine) is not focused on only one or two areas."

If you wish to pass along your comments on the magazine to our editor, please email them to:
don@electricityforum.com

ETHERNET IN SUBSTATION AUTOMATION APPLICATIONS - PART II

By Marzio P. Pozzuoli, RuggedCom inc. - Industrial Strength Networks

RING ARCHITECTURE

A typical ring architecture is shown in Figure 4a. It is very similar to the Cascading architecture except that the loop is closed from Switch N back to Switch 1. This provides some level of redundancy if any of the ring connections should fail.

Normally, Ethernet Switches don't like "loops" since messages would circulate indefinitely in a loop and eventually eat up all of the available bandwidth.

However, 'managed' switches (i.e. those with a management processor inside) take into consideration the potential for loops and implement an algorithm called the Spanning Tree Protocol which is defined in the IEEE 802.1D standard.

Spanning Tree allows switches to detect loops and internally block messages from circulating in the loop. As a result, managed switches with Spanning Tree actually logically break the ring by blocking internally. This results in the equivalent of a cascading architecture with the advantage that if one of the links should break, the managed switches in the network will reconfigure themselves to span out via two paths.

Consider the following example:

- Switches 1 to N are physically connected in a ring as shown in Figure 4 and all are managed switches supporting the IEEE 802.1D Spanning Tree protocol.

- Typically, network traffic will flow in accordance with Path 1 as shown in Figure 4. Switch N will block message frames as they come full circle thereby logically preventing a message loop.

- Now, assume a physical break in the Ring occurs, let's say between Switches 3 and 4.

- The switches on the network will now reconfigure themselves via the Spanning Tree Protocol to utilize two paths: Path 1 and Path 2 as shown in Figure 4 thereby maintaining communications with all the switches. If the network had been a simple cascading archi-

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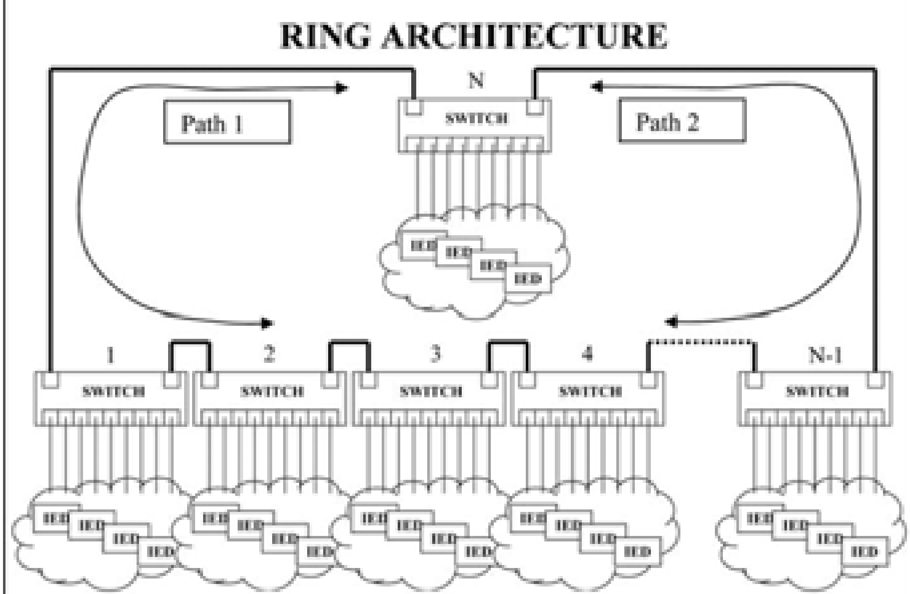


Figure 4a: Ring Network Architecture

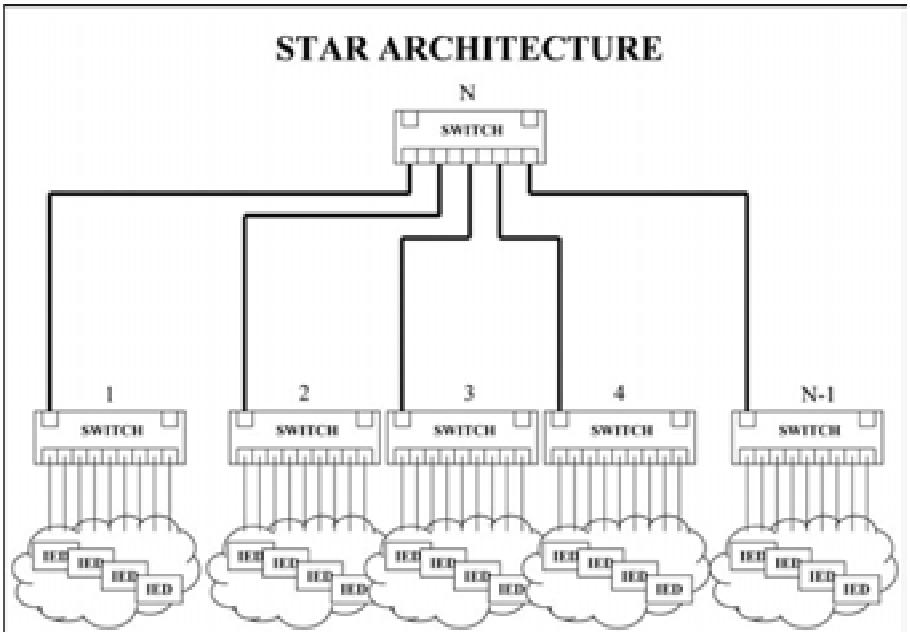


Figure 4b: Star Network Architecture

Continued from Page 20

tecture, the physical break between switches 3 and 4 would have resulted in two isolated network segments.

While Spanning Tree Protocol (IEEE 802.1D) is useful and a must for Ring architectures or in resolving inadvertent message loops, it has one disadvantage when it comes to real-time control.

Time!

It simply takes too long; anywhere from tens of seconds to minutes depending on the size of the network. In order to address this shortcoming, the IEEE developed Rapid Spanning Tree Protocol (IEEE 802.1w) that allows for sub-second reconfiguration of the network.

Advantages:

- Rings offer redundancy in the form of immunity to physical breaks in the network.
- IEEE 802.1w Rapid Spanning Tree Protocol allows sub-second network reconfiguration.
- Cost effective cabling/wiring allowed. Similar to Cascaded architecture.

Disadvantages:

- Latency – worst case delays across the cascading backbone have to be considered if the application is very time sensitive (similar to Cascading)
- All switches should be Managed Switches. This is not necessarily a disadvantage per se but simply an added complexity. Although, the advantages of Managed Switches often far outweigh the added complexity.

STAR ARCHITECTURE

A typical Star architecture is shown in Figure 4. Switch N is referred to as the'backbone' switch since all of the other switches uplink to it in order to form a star configuration.

This type of configuration offers the least amount of latency (i.e. delay) since it can be seen that communication between IEDs connected to any two switches, say Switch 1 and N-1, only requires the message frames to make two 'hops' (i.e. from Switch 1 to Switch N and then from Switch N to Switch N-1.

Advantages:

- Lowest Latency - allows for lowest number of 'hops' between any two switches connected to the backbone switch N.

Disadvantages:

- No Redundancy – if the backbone switch fails, all switches are isolated or if one of the uplink connections fails, then all IEDs connected to that switch are lost.

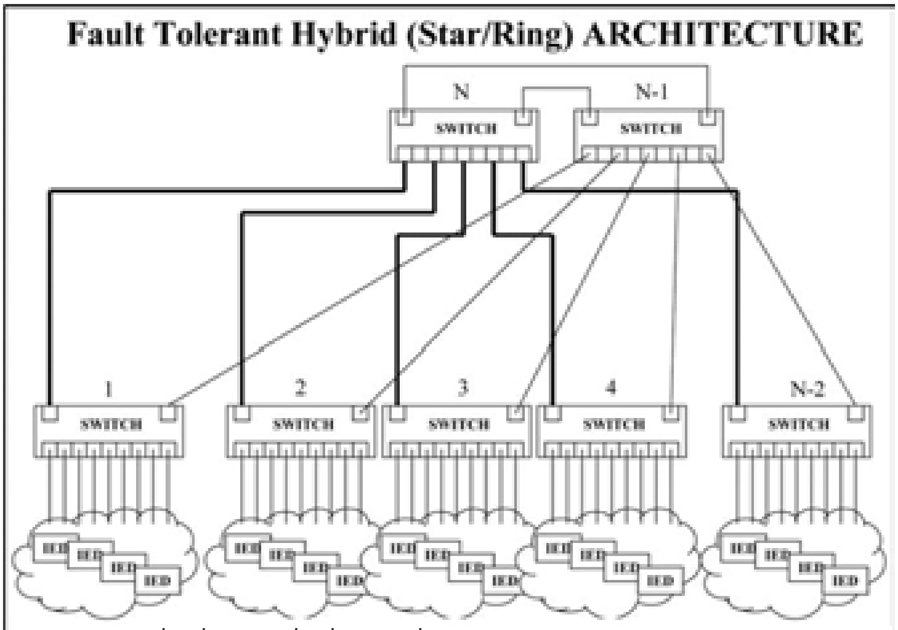


Figure 5: Fault Tolerant Hybrid Network

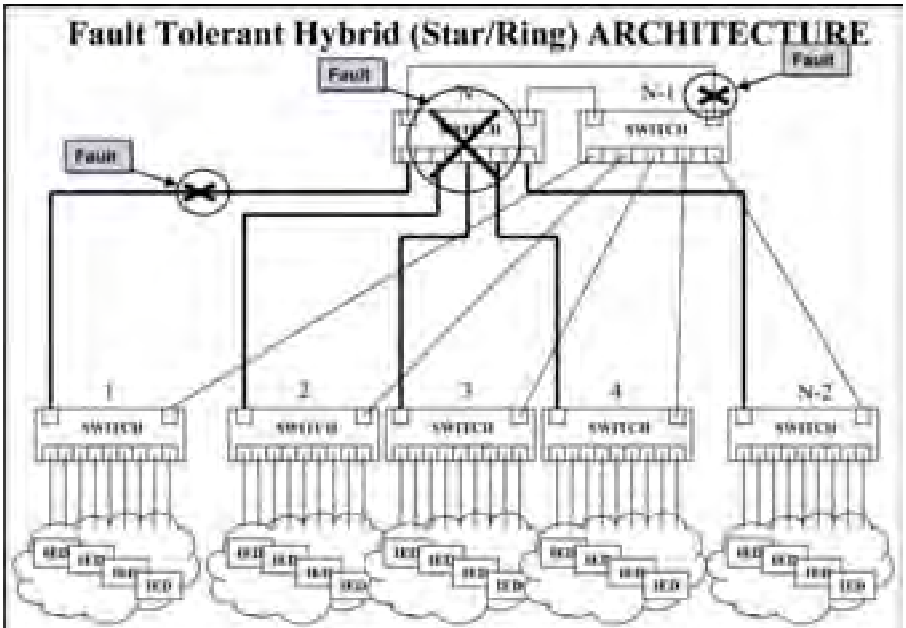


Figure 6: Fault Types Handled

FAULT TOLERANT HYBRID STAR-RING ARCHITECTURE

A hybrid fault tolerant architecture, combining star and ring architectures is shown in Figure 5. This architecture can withstand anyone of the fault types shown in Figure 6 and not lose communications between any of the IEDs on the network.

FAULT TOLERANT ARCHITECTURE FOR IEDS WITH DUAL ETHERNET PORTS

A fault tolerant architecture is shown in Figure 7 when IEDs with dual Ethernet ports are used. This architecture provides a high level of availability (i.e. uptime) and is immune to numerous types of faults as shown in Figure 8.

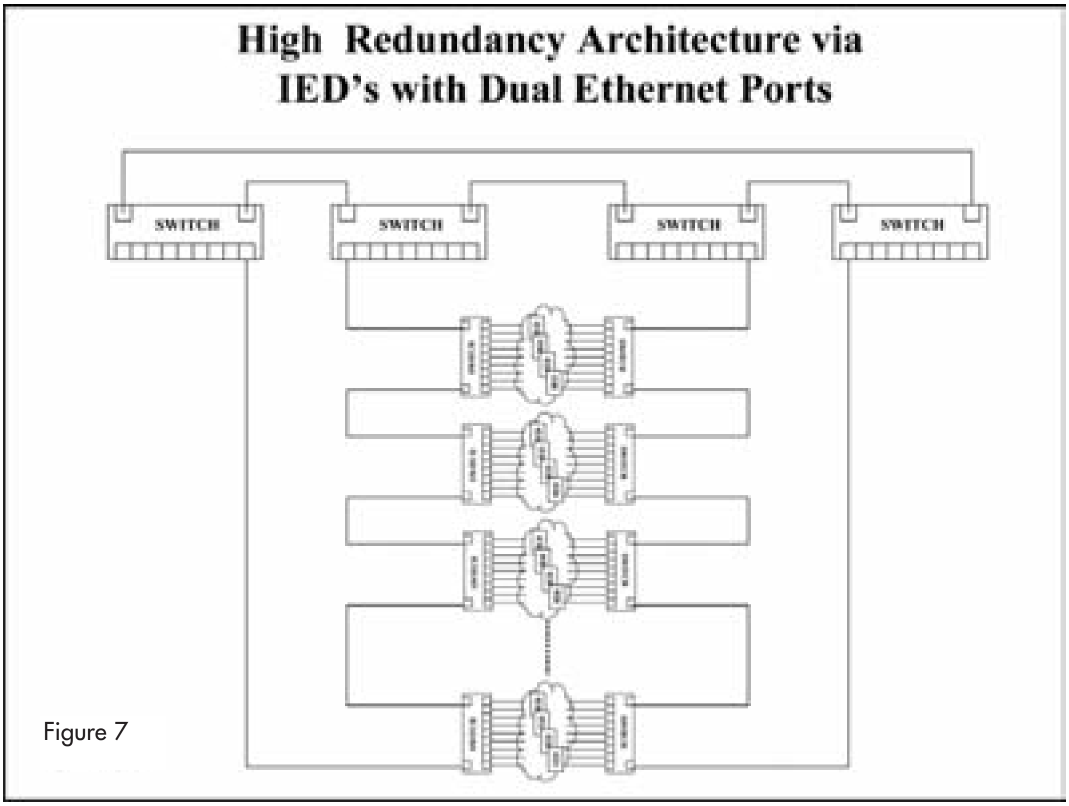


Figure 7

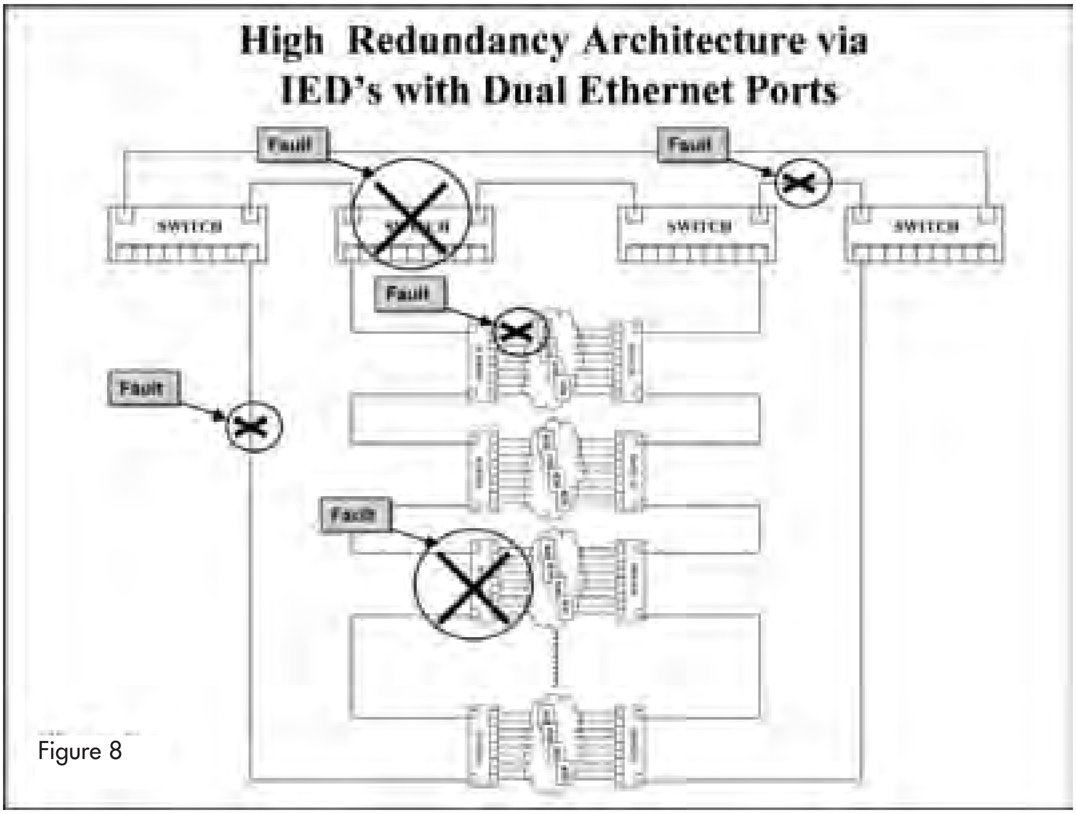


Figure 8

CONCLUSIONS

1. Ethernet switches used in substation automation applications should comply with either:
  - IEC 61850-3 or
  - IEEE P1613

standards for EMI immunity and environmental requirements to ensure reliable operation of networking equipment in substation environments.

2. For applications where the Ethernet network will be involved in critical protection functions the Ethernet switches should comply with the Class 2 device definition given in IEEE P1613 (i.e. error free communications during the application EMI immunity type tests)

3. Managed Ethernet switches with advanced Layer 2 and Layer 3 features such as:
  - IEEE 802.3 Full-Duplex operation (no collisions)
  - IEEE 802.1p Priority Queuing
  - IEEE 802.1Q VLAN
  - IEEE 802.1w Rapid Spanning Tree
  - IGMP Snooping / Multicast Filtering should be used to ensure real-time deterministic performance.

4. A variety of flexible network architectures offering different levels of performance, cost and redundancy are achievable using managed Ethernet switches.

Marzio Pozzuoli is the founder and president of RuggedCom Inc., which designs and manufactures industrially hardened networking and communications equipment for harsh environments. Prior to founding RuggedCom, Mr. Pozzuoli developed advanced numerical protective relaying systems and substation automation technology.

CYBER SECURITY FOR EFFECTIVE DEMAND SIDE MANAGEMENT AND AMI PROJECTS

By Peter Vickery, Executive Vice-President, Sales & Business Development, N-Dimension Solutions Inc.

The electric power industry is developing new operating methods in response to the challenging environment it faces:

• The electric grid is under pressure, according to the North American Electric Reliability Council (NERC), which states that over the next 10 years while the demand for electricity is expected to rise by 19% in the United States and 13% in Canada, confirmed power capacity will increase by only 6% in the U.S. and 9% in Canada. Furthermore, total transmission miles are projected to increase by less than 7% in the U.S. and by only 3.5% in Canada.

• Reflecting their environmental and climate change concerns, today's consumers are becoming interested in changing their power consumption behaviour, particularly if financial incentives are available.

• In some jurisdictions, distribution operators must respond to government-mandated deployment of new technologies.

Consequently, numerous operators are turning to Demand Side Management (DSM) and Advanced Metering Infrastructure (AMI) as a new approach that can deliver great benefits to power operators and to their customers.

Demand Side Management allows an operator to better manage the capacity and reliability of its network through the ability to reduce power demands during critical peak periods. This could greatly help the industry to continue to offer service reliability during the next 10 years and deal with the power generation and transmission capacity gap identified by NERC. Consequently, the adoption of DSM could allow power generation and transmission operators to delay the construction of additional facilities. DSM is also an additional tool for distributors to deliver excellent service while ensuring that costs are kept under control.

From the consumer's perspective, Distribution Side Management empowers distributors' customers to proactively manage their power consumption and to manage their costs. Interruptible load tariffs, time-of-use rates, and real-time pricing deliver the financial incentive for compliance. The assurance of greater service reliability during peak periods also benefits consumers.

As part of their Demand Side Management strategy, a large number of North American distribution operators are working on Advanced Metering Infrastructure (AMI) projects. In some jurisdictions such as the province of Ontario, operators are responding to government-mandated goals for smart meter deployment.

The creation of a fully digital, 2-way communication environment between operators and their customers creates several opportunities in addition to influencing demand and better controlling network load. It allows operators to detect tampering/theft, to connect/disconnect customers based on grid events, and to collect data that will allow distributors to optimize their network. However, this new level of interaction with customers can result in distribution operators being vulnerable to attacks by malicious computer hackers and cyber terrorists who want to illegally access operators' resources. The motivation for these attacks can range from neighbours spying on one another, to attempts at stealing service, and to efforts to destabilize the grid or cause a blackout.

It has been recognized that power & energy organizations are among the top 3 industries to be security targets. The existence of cyber vulnerabilities in the electric system has been confirmed by numerous organizations, including the U.S. Department of Homeland Security, the US-Canada Power System Outage Task Force, the U.S. Department of Energy, and the Canadian Energy Infrastructure Protection Division.

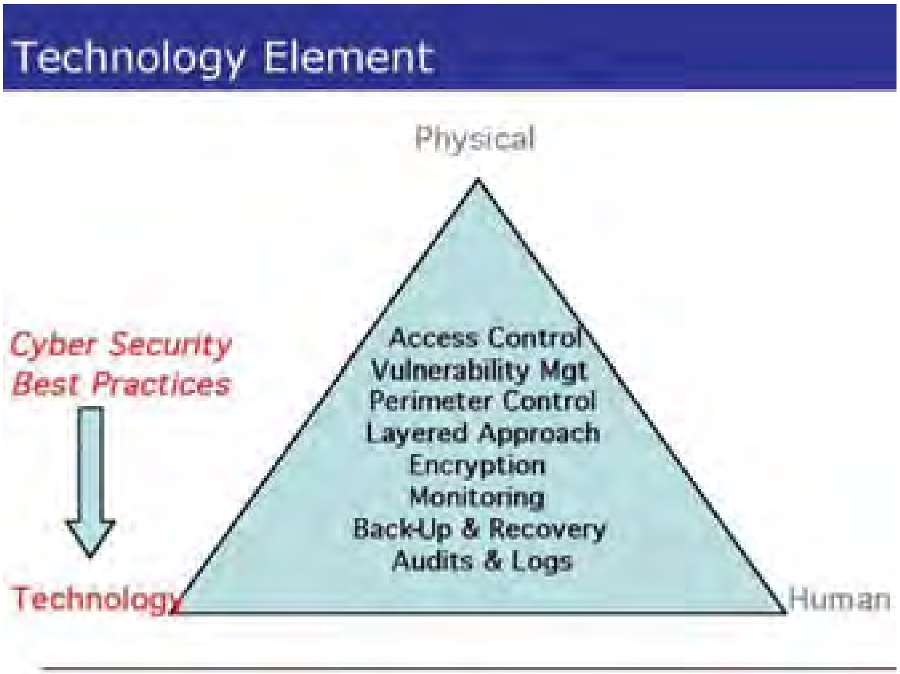
AMI projects are also being deployed over a variety of network types including wireless technologies such as ZigBee, WiFi, and cellular. As recently explained by a U.S. Justice Department Information Technology Security Specialist, each of these wireless communication environments comprises inherent cyber security challenges.

To counter those vulnerabilities and ensure the success of their AMI project, distribution operators should therefore put in place a comprehensive cyber security program. This program should be an integral part of the planning and design phases of the AMI project to ensure that service reliability and information privacy are part of the underpinnings of the AMI deployment. Operators must ensure that cyber security risks are well identified and that appropriate measures are put in place to address those risks. Following is the outline of an effective cyber security approach for Advanced Metering Infrastructure projects.

CYBER SECURITY GUIDELINES

The distribution operator's efforts to develop a cyber security program should be guided by the North American Electric Reliability Council's standards (NERC CIP 002-009), by cyber security best practices, as well as by the directives issued by the U.S. Department of Energy, the U.S. Department of Homeland Security, and the Canadian Energy Infrastructure Protection Division. In addition, the need to adequately protect computer systems is reinforced by the obligation for business managers to comply with current legislation aimed at protecting information privacy as well as shareholder value. Legislation such as Sarbanes-Oxley (SOX), PIPEDA, and Bill C198 penalizes corporations and business managers who do not have documented Cyber Security processes and procedures.

As specified by NERC, the establishment of a strong cyber security program should start with a vulnerability assessment so that potential problem areas can be identified. The first step in this process is to conduct a Threat Risk Assessment (TRA) on the operational systems to which the AMI infrastructure is being added. From this process, the operator determines the prioritization and the focal areas for protection. After the TRA, the vulnerability assessment can be expanded to include: an architecture review; an assessment of security devices, network devices, servers and workstations; a cyber security policy review; and a site audit, including a physical security audit. The assessment can also be expanded further to include the overall cyber security of an operator, including its information systems, to ensure that overall productivity is protected from cyber attacks.



CYBER SECURITY BEST PRACTICES

It is recommended that, when formulating their Cyber Security program, distribution operators consider the best practices that have evolved in this area. The best practices methodology takes a holistic approach to security, and includes 3 distinct elements: physical security, human factors, and technology security. For purposes of this article, we will concentrate on the security of the technology element.

Through the evolution of the variety and of the severity of attacks to which technology resources have been exposed over the past few years, managers have put in place a series of different and separate technical responses. An analysis of the suitability and reliability of the Cyber Security measures already in place in a corporation's environment can be done by referring to today's Best Cyber Security Practices. Current Best Cyber Security Practices comprise 8 elements, as follows:

• Access to the various technology resources should be controlled through mechanisms such as user profiles, user IDs, and passwords as well as through network segmentation.

• An analysis of the overall vulnerability of the technology environment should be conducted. This analysis may start with an extensive security assessment conducted by outside consultants; it may also rely on the vulnerability scanning capabilities delivered by some security appliances. Once the vulnerabilities have been identified, they should be addressed with specific short-term solutions as well as with a policy to implement an automatic testing process to uncover new vulnerabilities as they develop.

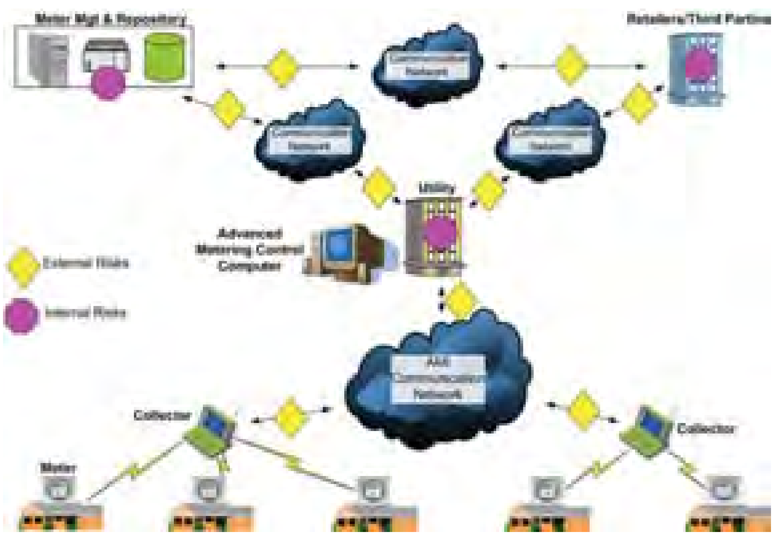
• A layered approach to security is preferable as it ensures the best protection is available to each technology resource. The multiple layers create additional impediments to hacker intrusions. Perimeter control is attained through protection implemented at the gateway level while additional protection, such as anti-virus, can also be implemented on the PC.

• Sophisticated encryption techniques are now readily available, and they should be deployed.

• For maximum effectiveness and reliability, a cyber security system must be monitored and its performance measured periodically to ensure that the stated goals have been reached.

• Mission-critical technology resources must be backed up regularly to ensure that the corporation could recover effectively from any system breakdown.

• Periodic assessments of the effectiveness of the cyber



Security measures and of the corporation's compliance with legislation and industry-specific security standards, such as Sarbanes-Oxley, PIPEDA, Bill C198, and NERC require that extensive Audit Logs and Reports be available to the organization's management.

EXTERNAL AND INTERNAL RISKS

The deployment of an Advanced Metering Infrastructure project is a complex undertaking where numerous components need to work well together. As illustrated below, the implementation of an AMI project results in the distribution operator being exposed to both external and internal cyber security risks.

CYBER SECURITY EXTERNAL AND INTERNAL RISKS

External risks result from the various interconnections with related resources while internal risks are the result of the breakdown of various corporate systems and policies.

To counter external risks, different layers of protection should be installed, including:

- Perimeter protection through firewalls and gateways
- Monitoring
- Intrusion Detection/Intrusion Protection
- Encryption

Internal risks should be addressed with:

- Security Policies and Procedures
- Access Control
- Password Policies
- Vulnerability Assessments
- Monitoring
- Physical Security Measures

Once protection measures have been put into place, it is necessary to monitor results and to take corrective action when appropriate.

MANAGEMENT COMMITMENT

Given the complexity involved with successfully deploying an AMI project, it is essential that a strong management team lead the project. This team will ensure that the efforts of various departments are well coordinated and that the cyber security program encompasses all affected operational systems. Furthermore, the team should commit to a periodic cyber security re-assessment program in order to keep up with constantly changing, ever more sophisticated cyber attacks.

INTEGRATION

The cyber security solutions put into place to support the AMI deployment should be capable of fully integrating with the operator's other operational systems and they should support the operator's cost containment goals. Consequently, operators should favour solutions that deliver: strong cyber security, flexibility, open standards, integration with existing operational systems, compliance with relevant standards and regulation, reduced complexity, and cost-effectiveness.

CONCLUSION

Power operators fully recognize the numerous benefits associated with Demand Side Management. Distribution operators are making considerable investments in Advanced Metering Infrastructure and they expect to enjoy improvements in system efficiencies, service reliability, and profitability.

It must, however, be clear that the creation of a 2-way communication network between operator and consumer creates a challenging environment where assets must be protected against today's computer hackers and cyber terrorists. The implementation of an effective Demand Side Management strategy and of a successful Advanced Metering Infrastructure project must, therefore, include a comprehensive, well monitored, and frequently updated Cyber Security program.

Peter Vickery's 25+year successful track record in the Power & Energy industry has enabled him to develop an in-depth understanding of the requirements of North American Transmission & Distribution Operators. While at Siemens, Schlumberger, BC Hydro's PowerSmart, and JPH International, Peter Vickery designed product and service solutions that met and surpassed his clients' expectations.

ARE YOU WORKING SAFELY? TRAINING FORUMS ENSURE YOU WILL

By Don Horne

Are you working safely?

Hopefully the answer is yes - but in the majority of cases, many are working without the proper PPE (Personal Protective Equipment), or choosing not to wear it, or not using safe practices while working on live circuits.

Every year, the Electricity Forum has training courses on safety and arc flash hazard across Canada, from Vancouver, British Columbia to St. John's, Newfoundland. This fall, the forum is offering courses on NFPA 70E Arc Flash Awareness Training and Advanced Electrical Safety Training during the months of September and October. These courses are tailor made for those who require basic arc flash and safety training or advanced awareness.

The speakers at the upcoming forums include Jim Anderson of Algonquin Power Systems, who brings more than 30 years experience in the electrical power industry.

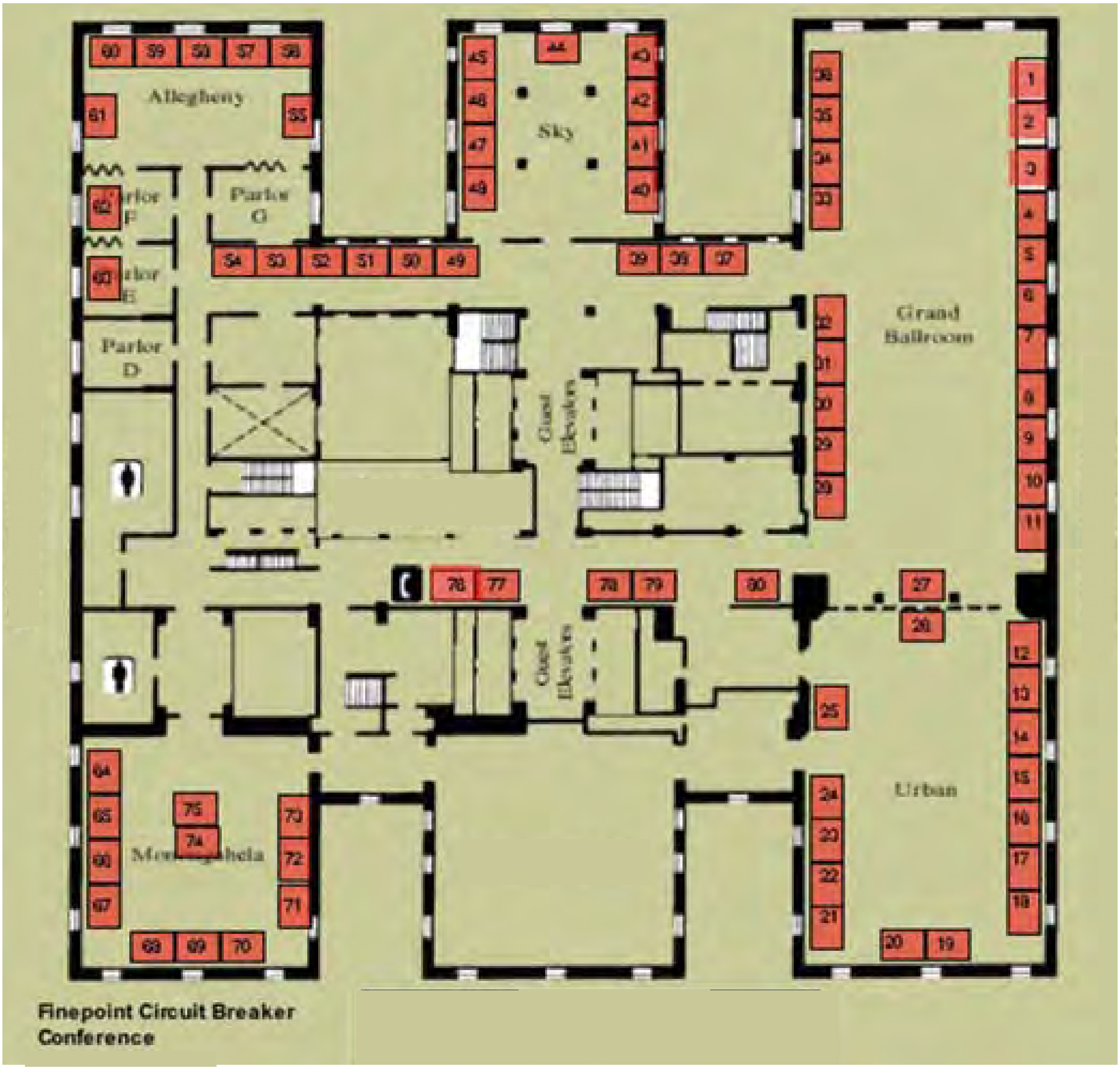
Over the past 30 years Jim has developed and delivered training program for Electrical Safety, Arc Flash Awareness and Training, Hazardous Energy Control, General Safety in the Workplace, Job Hazard Analysis, and On the Job Technical Training and Skills Development as related to Power Production.

Len Cicero, President of Lenco Training & Technical Services, shares his personal experience with the ongoing development of CSA Z462, Canada's version of NFPA 70E. His knowledge of arc flash awareness and the requirements for a company to build and develop an electrical safety program are unparalleled.

Other speakers, like Wes Procyshyn of Manitoba Hydro, Bryan Johnson and Bill Murphy of AGO Industries, enhance each training forum with practical experience and decades of hands-on expertise and industry know-how.

Concurrent with the arc flash and safety training courses are the Canadian Electrical Code Training seminars. Information on all these courses - and our on-site courses - can be found at: www.electricityforum.com/forums/courses; or by calling: 905 686 1040.

2007 FINEPOINT CIRCUIT BREAKER TEST &



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9-	Breaker Service
10-	Filmax
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CONFERENCE AN OCTOBER TRADITION

In 1994 Finepoint inaugurated the annual Circuit Breaker Test & Maintenance Conference, the electric power industry's premier event for substation/switchgear maintenance personnel.

Participants receive practical training from users' perspectives, learn factory authorized test and maintenance procedures, network with their peers, and view cutting-edge products at the supplier exhibits each evening in the hospitality rooms. Over 490 delegates attended the 2006 conference, representing 210 different companies, 46 states, and nine countries.

The conference provides attendees, speakers, and exhibitors with a high quality, low key opportunity to exchange information with their peers and learn from the experts.

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

Continued on Page 30

October Tradition

Continued from page 29

work.

One unique aspect of the conference is that most speakers are the electric utility and testing company delegates themselves, not suppliers.

The four-day conference begins the first Monday of each October with a welcoming reception that evening. The factory day is on Tuesday. The expo of supplier exhibits debuts Tuesday evening and is also open to participants Wednesday and Thursday evenings. The conference presentations and training seminars are scheduled each year on Wednesday, Thursday, and Friday.

FACTORY DAY

The full day at a circuit breaker manufacturing plant has been a unique feature of the conference since 1996. Participating manufacturers are ABB (Greensburg/Mt. Pleasant PA in 1996, 2000, 2005, and 2007), AREVA (Charleroi PA in 1997, 2001, and 2006), HVB AE Power Systems (Suwanee GA in 2004), Mitsubishi (Warrendale PA in 1998 and 2002), Pennsylvania Breaker and Pennsylvania Transformer Technology (Canonsburg PA in 2007),and Siemens (Jackson MS in 1999 and 2003).

The 2007 factory day hosts will be ABB, Pennsylvania Breaker, and Pennsylvania Transformer Technology. Attendance growth has compelled Finepoint to add an additional factory day host for the conference this October and ABB has recently accepted the opportunity to also open their doors to conference participants. The PA Breaker and PA Transformer Technology facilities in Canonsburg can accommodate only part of the attendees expected to register for this year's event, therefore we are expanding to multiple facilities for the first time.

Pennsylvania Breaker LLC (PAB) is the only US owned manufacturer of high voltage breakers and has established a 90,000 ft2 design, test, and manufacturing facility located within the 1.2 million sq. ft. Pennsylvania Transformer Technology Inc. (PTTI) facility in Canonsburg.

Recent renovations include upgrades to the W.E. Kerr High Voltage Test Center and the addition of state-of-the-art production tooling. The PAB facility supports the design, testing, and manufacturing of circuit breakers from 72.5kV to 550kV, including interrupters and mechanisms.

The PTTI facility is an industry leader in manufacturing a total range of types and sizes of single- and three-phase power transformers and voltage regulators. A partner of PTTI, PAB was formed to serve USA users of high voltage breakers with products designed to ANSI/IEEE standards for typical USA applications (60Hz, high fault currents, high X/R, long lines) and with USA based expertise and application support. Finepoint Conference participants will tour both Canonsburg facilities.

ABB's state-of-the-art high-voltage breaker facility in Mt. Pleasant serves as the headquarters for ABB's High Voltage Product division in the United States. Mt. Pleasant replaces the nearby Greensburg facility which previously hosted the conference in 1996 and 2000. Equipped with the latest in production and quality systems, the Mt. Pleasant facility is the pinnacle of high-end breaker manufacturing. A full line of high voltage dead tank circuit breakers (DTB) ranging from 38 to 800 kV, non-synchronous and synchronous, with interrupting capacities in excess of 80 kA are manufactured in this ISO-9001, ISO-14001 and OHSAS 18001 compliant facility.

The complete line of ABB circuit breaker and GIS legacy brands (ABB, Asea, BBC, ITE, and Westinghouse) continue to be actively supported through the High Voltage Service group, also headquartered at the Mt. Pleasant facility. The service group boasts the industry's largest available parts inventory located within their Greensburg PA service shop. ABB's service capabilities include authentic OEM parts, life extension kits, up-rates, retrofits, re-manufacturing, field services, turnkey installations, fleet assessments, customized products, diagnostics, monitoring, and customizable training.

Finepoint Conference participants will tour both the new DTB factory and the service shop while participating in interactive technology presentations.

HALF-DAY TRAINING SEMINARS

In addition to more than a dozen presentations, each year the conference features two half-day training seminars at no additional charge. The 2007 conference includes seminars of vital interest to the electric utility industry. The "SF6 Gas Handling and Management" seminar jointly presented by the EPA and DILO is on Wednesday afternoon, October 3, and the "Circuit Breaker Timing and Analysis" seminar jointly presented by Kelman and Vanguard Instruments is on Friday morning, October 5.

The timing and analysis seminar includes details about both traditional timing and travel-motion testing and energized first trip testing.

The seminar is being jointly presented by Kelman North America, leaders in first trip testing, and Vanguard Instruments, leaders in timing and travel-motion testing, on Oct. 5. Timing and travel-motion testing of circuit breakers has been around for over 60 years, while first trip testing is a relatively recent enhancement. Both techniques have their unique benefits and the purpose of the seminar is to thoroughly cover all aspects of circuit breaker timing and analysis.

Over the last year, global warming has become a front-burner issue. With that comes increased pressure on SF6 users to eliminate even the smallest gas emissions. Borrowing on the 15+ years of experience in the U.S. utility market (50+ years in Europe), DILO Company's Eric Campbell and Lukas Rothlisberger will conduct the SF6 gas handling and management seminar with the U.S. Environmental Protection Agency's Climate Change Division SF6 Program Manager Jerome Blackman.

Based on feedback and input from customers, DILO will present current industry practices with regard to SF6 handling, safety, and transportation issues. Topics will include how to efficiently work with SF6, including complete cylinder emptying, and consolidation. Proper breaker entry procedure, safety equipment, cleaning process, evacuation of air, and refilling of SF6 will also be discussed.

A case study of a recent breaker replacement project - describing the testing of the SF6, its removal, cleaning, and eventual refill into newer equipment - will be included.

POWER TRANSMISSION CAPACITY UPGRADE OF OVERHEAD LINES - PART I

By D.M. Larruskain, I. Zamora, O. Abarrategui, A. Iraolagoitia, M. D. Gutiérrez, E. Loroño and F. de la Bodega, Department of Electrical Engineering, E.U.I.T.I., University of the Basque Country

There are different constraints that limit the power transmission capacity of a system. The power transmission capacity in permanent regime is defined by:

A. Switchgear characteristics

Certain lines have load capacity limited by some of the switchgear elements associated to them. The element with the smaller rated current in any end of the line is identified.

B. Environmental specifications

The determination of load capacity in high voltage cables must take into account on the one hand the thermal conditions of the conductors work, such as temperature, wind speed, and wind direction, and on the other hand the electric conditions of operation. This is to respect minimum safety distances and maintain the voltage and the network stability within suitable limits.

C. Voltage drops

In the network, lines transmit a great amount of energy from the generating ends to the consuming ones. In these cases, if the receiving zones do not have compensating reactive elements, the voltage can drop below the limit fixed by quality criteria.

In such situations, it is advisable to limit the transmission of these lines to prevent excessively low voltages in the receiving end as well as to prevent a possible voltage collapse of the transformer regulators because of a performance over their possibilities.

D. System stability

Cases of long interconnection lines between zones with no reactive problems are considered with the voltages maintained in an acceptable limit; but there can be situations in which strong interchanges of power demand an excessive angular phase angle between the positions of the generator rotors of each area. It is advisable to limit the transmission of these lines with a view to avoiding the loss of stability and electric separation between both zones.

Studies of rated capacities of the different elements that take part in transmission and distribution have been made, in an effort to establish the necessity of substitution of those with insufficient capacity and to be able to establish a plan of equipment maintenance and repair..

These constraints in the operation of the lines are detected, based on the following criteria: maximum possible current to transmit over the lines, maximum current of transmission by thermal limit of the lines and maximum permissible current, due to switchgear connected to the lines.

TRANSMISSION CAPACITY UPGRADING BY INCREASING VOLTAGE

Voltage is a measure of the electromotive force necessary to maintain a flow of electricity on a transmission line. Voltage fluctuations can occur due to variations in electricity demand and to failures on transmission or distribution lines. Constraints on maximum voltage levels are set by the design of the transmission line. If the maximum is exceeded, short circuits, radio interference, and noise may occur, transformers and other equipment at the substations and/or customer facilities may be damaged or destroyed. Minimum voltage constraints also exist based on the power requirements of customers. Low voltages cause inadequate operation of a customer's equipment and may damage motors.

Voltage on a transmission line tends to "drop" from the sending end to the receiving end. The voltage drop along the AC line is almost directly proportional to reactive power flows and line reactance. The line reactance increases with the length of the line. Capacitors and inductive reactors are installed, as needed, on lines to partially control the amount of voltage drop. This is important because voltage levels and current levels determine the power that can be delivered to customers.

In recent years there has been much emphasis placed onmaking appropriate modifications to existing overhead lines and to eliminating old AC transmission lines and substituting them with new compact AC lines.

Both these solutions lead to an increase in the transmitted power by the overhead line increasing the rated voltage. This is possible by utilizing the experience acquired from using HVAC lines and permitting reduced safety margins in designing clearances. For compact AC lines, insulated crossarms and a shorter span are also used, thereby reducing the line sag so that a substantial increase in power density is achieved.

TRANSMISSION CAPACITY UPGRADING BY INCREASING CURRENT DENSITY

When the flow of electrons passes through the line, it produces heat and the conductor's temperature increases. It is necessary to make a thermal study to determine if the conductor can stand that temperature. The temperature of the conductor is limited by two factors:

1) The limit of the conductor's material
2) Conductor – ground distance

Although aluminium conductors have been used in overhead transmission since the end of the 19th century, their widespread use did not occur until the 1940s, when copper was designated as a vital war material and was no longer available for use by electric utilities. To obtain the desired strength required for transmission lines, lightweight aluminium was combined with the high tensile strength of steel in the development of aluminium conductor steel reinforced (ACSR). Today, most overhead transmission lines use this conductor construction.

Steel can stand high temperatures, up to 200ºC with no changes in the conductor's properties. Aluminium, on the other hand, experiences change in the mechanical properties when the temperature is higher than 90ºC. The temperature is a function of the electrical current and environmental conditions. On a continuous basis, ACSR may be operated at temperatures up to 100ºC and, for short term emergencies, at temperatures as high as 125°C without any significant change in the physical properties.

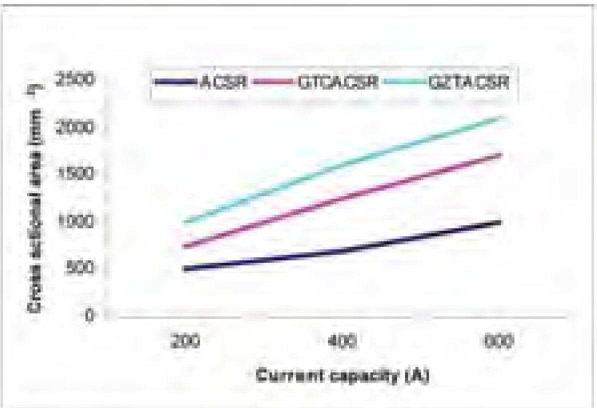

Fig. 1. Current capacity in function of the cross sectional area

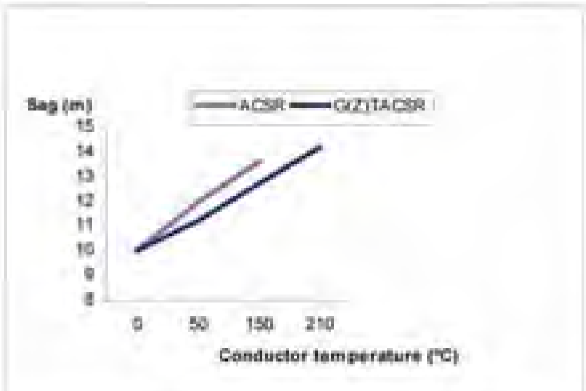

Fig. 2. Sag in function of the conductor temperature for a span length of 400m

Given the many changes in the way power transmission systems are being planned and operated, there is a need to reach higher current densities in existing transmission lines, to increase the thermal rating of existing lines. There are different ways to achieve this increase:

1) Increase the maximum allowable operating temperature to 100°C. For example, if the line is limited to a modest temperature of 50°C to 75°C, and the electrical clearance is sufficient to allow an increase in sag for operation at a higher temperature, then the thermal rating of the line can be increased. If sufficient clearance does not exist in all spans, then conductor attachment points may be raised, conductor tension increased or other mechanical methods applied to obtain the necessary clearance at the higher temperature.

2) Use dynamic ratings or less-conservative weather conditions relating to wind speed and ambient temperatures. For example, if the existing line is already rated at a temperature near 100°C, and a modest increase of 5% to 15% is desired, then monitors can be installed and the higher ratings used when wind speed is higher than the standard 0.6 m/s and the ambient temperature is lower than 40°C.

3) Replace the conductor with a larger one or with one capable of continuous operation above 100°C. These solutions would be ideal if the line was already limited to 100°C, and the thermal rating increased by more than 25%. Given the low cost, high conductivity and low density of aluminium, no other high-conductivity material is presently used. Therefore, replacement with a larger conductor will result in an increased load on existing structures because of an increase of wind/ice and tension.

The thermal rating of an existing line can be increased about 50% by using a replacement conductor that has twice the aluminium area of the original conductor. The larger conductor doubles the original strain structure tension loads and increases transverse wind/ice conductor loads on suspension structures by about 40%. Such large load increases typically would require structure reinforcement or replacement. This drawback to the use of a larger conductor may be avoided by using the high-temperature, low-sag (HTLS) conductor, which can be operated at temperatures above 100°C while exhibiting stable tensile strength and creep elongation properties.

Practical temperature limits of up to 200°C have been specified for some conductors. Using the HTLS conductor, which has the same diameter as the original, at 180°C increases the line rating by 50% but without any significant change in structure loads. If the replacement conductor has a lower thermal elongation rate than the original, then the structures will not have to be raised.

Although the use of a larger conductor provides a reduction in losses over the life of the line while operating temperatures remain at a modest level, the use of the HTLS conductor reduces capital investment by avoiding structure modifications. In either case, replacing existing conductors should improve the reliability of the line because the conductor, connectors and hardware will all be new.

INCREASING TRANSMISSION CAPACITY OF OVERHEAD LINES USING HTLS CONDUCTORS

Replacing original ACSR conductors with HTLS conductors with approximately the same diameter is one method of increasing transmission line thermal rating. HTLS conductors are effective because they are capable of:

1) High-temperature, continuous operation above 100°C without loss of tensile strength or permanent sag-increase so that line current can be increased.
2) Low sag at high temperature so that ground and underbuild clearances can still be met without raising or rebuilding structures.

The original conductor's "initial installed sag" increases to a final "everyday sag", typically at 16°C with no ice or wind, as a result of both occasional wind/ice loading and the normal aluminium strand creep elongation that is a result of tension over time. This final sag may increase occasionally because of ice/wind loading or high electrical loads, but these effects are reversible.

For most transmission lines, maximum final sag is the result of electrical rather than mechanical loads. It is important that any replacement conductor be installed so its final sag under maximum electrical or mechanical load does not exceed the original conductor's final sag and the existing structures need not be raised or new structures added. Under these circumstances, where structure reinforcement or replacement is to be avoided, HTLS conductors are used to advantage.

New construction, long-span crossings can be achieved with shorter towers. These can be accomplished using the existing right-of-ways and using all the existing tower infrastructure, thereby avoiding extensive rebuilding, avoiding difficult and lengthy permitting, and reduced outage times.

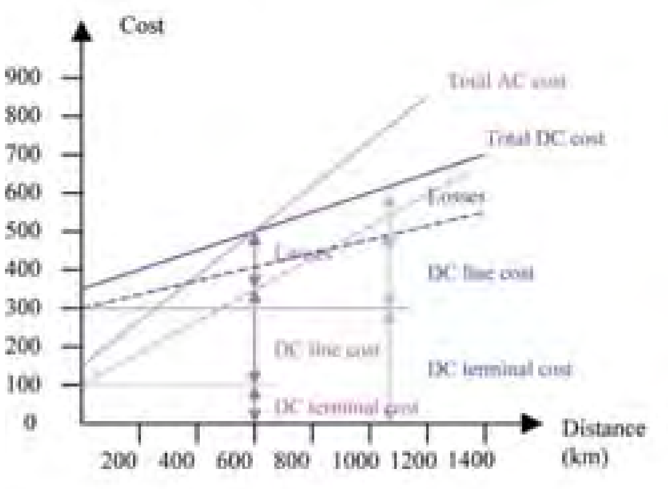

Fig. 3. HVAC-HVDC cost

TYPES OF HTLS CONDUCTORS

Conductors are constructed from helically stranded combinations of individual wires where galvanized steel wires are used for mechanical reinforcement, aluminium wires for the conduction of electricity, and hard-drawn aluminium for both mechanical and electrical purposes.

Desirable properties for reinforcing core-wire material include a high elastic modulus, a high ratio of tensile strength to weight, the retention of tensile strength at high temperatures, a low plastic and thermal elongation, a low corrosion rate in the presence of aluminium and a relatively high electrical conductivity. The material must be easy to fabricate into wire for stranding.

Among the choices available for HTLS conductors are:

1) ACSS and ACSS/TW (Aluminium Conductor Steel Supported) Annealed aluminium strands over a conventional steel stranded core. Operation to 200°C.
2) ZTACIR (Zirconium alloy Aluminium Conductor Invar steel Reinforced) High-temperature aluminium strands over a low-thermal elongation steel core. Operation to 150ºC (TAI) and 210°C (ZTAl).
3) GTACSR (Gap Type heat resistant Aluminium alloy Conductor Steel Reinforced) High-temperature aluminium, grease-filled gap between core/inner layer. Operation to 150°C. GZTACSR (Gap Type super heat resistant Aluminium alloy Conductor Steel Reinforced).
4) ACCR (Aluminium Conductor Composite Reinforced) High-temperature alloy aluminium over a composite core made from alumina fibres embedded in a matrix of pure aluminium. Operation to 210°C.
5) CRAC (Composite Reinforced Aluminium Conductor) Annealed aluminium over fibreglass/thermoplastic composite segmented core. Probable operation to 150°C.
6) ACCFR (Aluminium Conductor Composite Carbon Fibre Reinforced) Annealed or high-temperature aluminium alloy over a core of strands with carbon fibre material in a matrix of aluminium. Probable operation to 210°C.

TRANSMISSION CAPACITY UPGRADING BY USING AC LINES TO TRANSMIT DC POWER

The fast development of power electronics based on new and powerful semiconductor devices has led to innovative technologies, such as HVDC, which can be applied to transmission and distribution systems. The technical and economical benefits of this technology represent an alternative to the application in AC systems.

Some aspects, such as deregulation

in the power industry, opening of the market for delivery of cheaper energy to customers and increasing the capacity of transmission and distribution of the existing lines are creating additional requirements for the operation of power systems. HVDC offer major advantages in meeting these requirements.

HVDC transmission systems are point-to-point configurations where a large amount of energy is transmitted between two regions. The traditional HVDC system is built with line commutated current source converters, based on thyristor valves. The operation of this converter requires a voltage source like synchronous generators or synchronous condensers in the AC network at both ends. The current commutated converters cannot supply power to an AC system which has no local generation. The control of this system requires fast communication channels between the two stations.

FEASIBILITY OF HVDC TRANSMISSION

A HVDC system can be ‘monopolar’ or ‘bipolar’. The monopolar system uses one high-voltage conductor and ground return. This is advantageous from an economic point of view, but is prohibited in some countries because the ground current causes corrosion of pipe lines and other buried metal objects. However, in Europe, monopolar systems are in operation. Most of them are used for submarine crossings.

The bipolar system uses two conductors, one with plus and one with minus polarity. The mid point is grounded. In normal operation, the current circulates through the two high-voltage conductors without ground current. However, in case of conductor failure, the system can transmit half of the power in monopolar mode. Besides, this operation can be maintained for a limited time only.

Recently, ABB and Siemens started to build HVDC systems using semiconductor switches (IGBT or MOSFET) and pulse width modulation (PWM). The capacity of a HVDC system with VSCs is around 30-300 MW. Operating experience is limited but many new systems are being built worldwide. The PWM controlled inverters and rectifiers, with IGBT or MOSFET switches, operate close to unity power factor and do not generate significant current harmonics in the AC supply. Also, the PWM drive can be controlled very accurately. Typical losses claimed by ABB for two converters is 5%.

DC VERSUS AC

The vast majority of electric power transmissions use three-phase alternating current. The reasons behind a choice of HVDC instead of AC to transmit power in a specific case are often numerous and complex. Each individual transmission project will display its own set of reasons justifying the choice.

General characteristics

The most common arguments favouring HVDC are:

1) Investment cost. A HVDC transmission line costs less than an AC line for the same transmission capacity. However, the terminal stations are more expensive in the HVDC case due to the fact that they must perform the conversion from AC to DC and vice versa. On the other hand, the costs of transmission medium (overhead lines and cables), land acquisition/right-of-way costs are lower in the HVDC case. Moreover, the operation and maintenance costs are lower in the HVDC case. Initial loss levels are higher in the HVDC system, but they do not vary with distance. In contrast, loss levels increase with distance in a high voltage AC system

Above a certain distance, the so called “break-even distance”, the HVDC alternative will always give the lowest cost. The break-even-distance is much smaller for submarine cables (typically about 50 km) than for an overhead line transmission. The distance depends on several factors, as transmission medium, different local aspects (permits, cost of local labour etc.) and an analysis must be made for each individual case (Fig. 3).

2) Long distance water crossing. In a long AC cable transmission, the reactive power flow due to the large cable capacitance will limit the maximum transmission distance. With HVDC there is no such limitation, so, for long cable links, HVDC is the only viable technical alternative.

3) Lower losses. An optimized HVDC transmission line has lower losses than AC lines for the same power capacity. The losses in the converter stations have, of course, to be added, but since they are only about 0.6% of the transmitted power in each station, the total HVDC transmission losses come out lower than the AC losses in practically all cases. HVDC cables also have lower losses than AC cables.

4) Asynchronous connection. It is sometimes difficult or impossible to connect two AC networks due to stability reasons. In such cases, HVDC is the only way to make an exchange of power between the two networks possible. There are also HVDC links between networks with different nominal frequencies (50 and 60 Hz) in Japan and South America.

5) Controllability. One of the fundamental advantages with HVDC is that it is very easy to control the active power in the link.

6) Limit short circuit currents. A HVDC transmission does not contribute to the short circuit current of the interconnected AC system.

7) Environment. Improved energy transmission possibilities contribute to a more efficient utilization of existing power plants. The land coverage and the associated right-of-way cost for a HVDC overhead transmission line is not as high as for an AC line. This reduces the visual impact. It is also possible to increase the power transmission capacity for existing rights of way. There are, however, some environmental issues that must be considered for converter stations, such as: audible noise, visual impact, electromagnetic compatibility and use of ground or sea return path in monopolar operation.

In general, it can be said that a HVDC system is highly compatible with any environment and can be integrated into it without the need to compromise on any environmentally important issues of today.

See September’s issue of Electricity Today for Part II.

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EXAMINING ADVANCED TRANSMISSION TECHNOLOGIES - PART I

By Jeff Dagle, Steve Widergren, John Hauer, Pacific Northwest National Laboratory
Tom Overbye, University of Illinois at Urbana-Champaign

This article discusses the use of advanced technologies to enhance performance of the national transmission grid (NTG). We address present and developing technologies that have great potential for improving specific aspects of NTG performance, strategic impediments to the practical use of these technologies, and ways to overcome these impediments in the near term.

Research and development (R&D) infrastructure serving power transmission is as badly stressed as the grid itself, for many of the same reasons. The needs are immediate, and the immediate alternatives are few.

Timely and strategically effective technology reinforcements to the NTG need direct, proactive federal involvement to catalyze planning and execution. Longer-term adjustments to the R&D infrastructure may also be needed, in part energy policy can evolve as the NTG evolves.

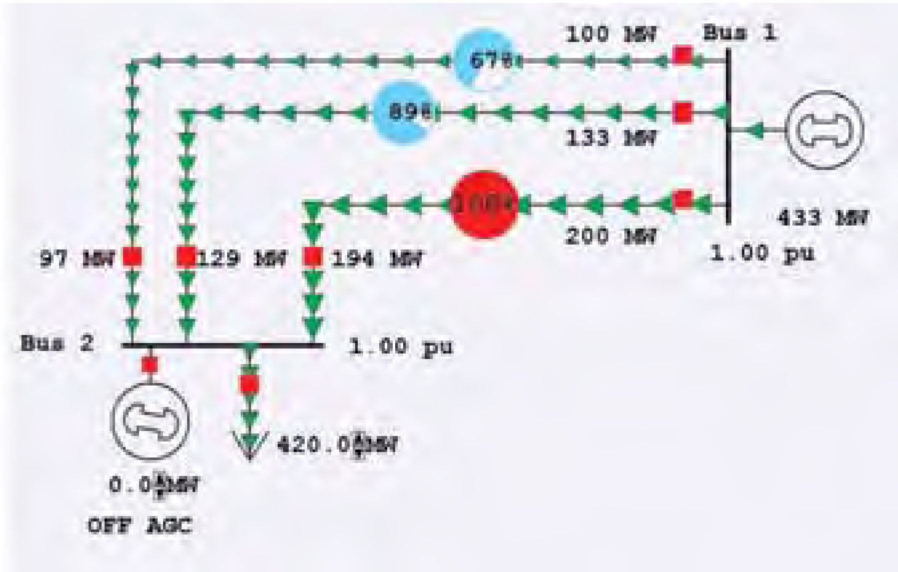

Figure 1: Two-Bus Example with No Local Generation

POWER SYSTEM COMPONENTS AND RECIPROCAL IMPACTS

The power system has three components: generation, load, and transmission. Electric power is produced by generators, consumed by loads, and transmitted from generators to loads by the transmission system.

Typically, the “transmission system” (or “the grid”) refers to the high-voltage, networked system of transmission lines and transformers. The lower-voltage, radial lines and transformers that actually serve load are referred to as the “distribution system.” The voltage difference between the transmission system and the distribution system varies from utility to utility; 100 kV is a typical value. This paper focuses only on advanced technologies for the transmission system.

It is important to understand reciprocal impacts among the transmission system, load, and generation.

Because the transmission system’s job is to move electric power from generation to load, any technologies that change or redistribute generation and/or load will have a direct impact on the transmission system. This can be illustrated using a simple two-bus, two-generator example shown in one-line form in Figure 1. The solid lines represent the buses, the circles represent the generators, and the large arrow represents the aggregate load at bus 2. Three transmission lines join the generator at bus 1 to the load and generation at bus 2.

Superimposed on the transmission lines are arrows whose sizes are proportional to the flow of power on the lines. The pie charts for each line indicate the relation between the loading on each line and its rated capacity.

The upper and middle transmission lines have a rating of 150 MVA, and the lower line has a rating of 200 MVA. In addition, we assume that the bus 1 generation is more economical than the generation at bus 2, and the entire load is being supplied remotely from the bus 1 generator. With a bus 2 load of 420 MW, the power distributes among the three lines based on their impedances (which are not identical), so the upper line is loaded at 67 percent, the middle at 89 percent, and the lower at 100 percent. Note: there are 13 MW of transmission line losses in this case.

TRANSFER CAPACITY

A natural question to ask is: what is the transfer capacity of the transmission system described in Figure 1? That is, how much power can be transferred from bus 1 to bus 2?

The answer is far from straightforward. At first glance, the transfer capacity appears to be 420 MW because this amount of power causes the first line to reach its limit. However, this answer is based on the assumption that all lines are in service. As defined by the North American Electric Reliability Council (NERC), transfer capacity includes consideration of reliability. A typical reliability criterion is that a system be able to withstand the unexpected outage of any single system element; this is known as the first contingency total transfer capa-

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AMRA APPLAUDS NARUC RESOLUTION ELIMINATING REGULATORY BARRIERS TO AMI

The Automatic Meter Reading Association (AMRA) endorses the far-sighted leadership embodied in a National Association of Regulatory Utility Commissioners (NARUC) resolution to eliminate regulatory barriers to the broad implementation of advanced metering infrastructure (AMI).

The resolution acknowledged the role of AMI in supporting the implementation of dynamic pricing and the resulting benefits to consumers. The resolution further identified the value of AMI in achieving significant utility operational cost savings in the areas of outage management, revenue protection and asset management.

"We commend NARUC on its visionary policy statement, and AMRA recommends that state jurisdictions give close consideration of the NARUC resolution in their deliberations under the Energy Policy Act of 2005," said Bernie Bujnowski, AMRA Sr. Vice President of Advocacy.

The resolution also called for AMI business case analyses to identify cost-effective deployment strategies, endorsed timely cost recovery for prudently incurred AMI expenditures and made additional recommendations on rate making and tax treatment of such investments.

"We commend NARUC on its visionary policy statement, and AMRA recommends that state jurisdictions give close consideration of the NARUC resolution in their deliberations under the Energy Policy Act of 2005," said Bernie Bujnowski, AMRA Sr. Vice President of Advocacy.

AMRA, the international voice of the AMR/AMI industry, provides information critical to the understanding and application of the wide range of AMR/AMI technologies. Through industry analyses, symposia and relevant publications, AMRA serves the business interests of utilities and utility technology suppliers.

Transmission Technologies
Continued from page 38

bility (FCTTC). Based on this criterion, Figure 2 shows the limiting case with an assumed contingency on the lower line, which results in a transfer capability of only 252 MW. Which number is correct?

The answer depends on system operational philosophy and on the availability of high-speed system controls.

If the operational philosophy requires that no load be involuntarily lost following any individual contingency, and if there are no mechanisms to quickly increase the generation at bus 2, voluntarily decrease the load at bus 2, or redistribute the flow between the remaining upper two lines, then the limit would be 252 MW. With these limitations, the only way to increase the transfer capacity would be to construct new lines.

However, if we relax one or more of these conditions, the transfer capacity could be increased without construction of new lines. For example, one approach would be to provide at least some of the bus 2 load with incentives so that, following the contingency, some customers on bus 2 would voluntarily curtail their loads.

Incentives might involve price-feedback mechanisms or agreements to allow the system operator to curtail load through some type of direct-control load management or interruptible demand. Another approach would be to have a mechanism for quickly committing some local bus 2 generation. Availability of local generation reduces the net loading on the transmission system and can increase its capacity. A third approach would be to use advanced power electronics controls such as flexible AC transmission system (FACTS) devices to balance the load between the upper two lines.

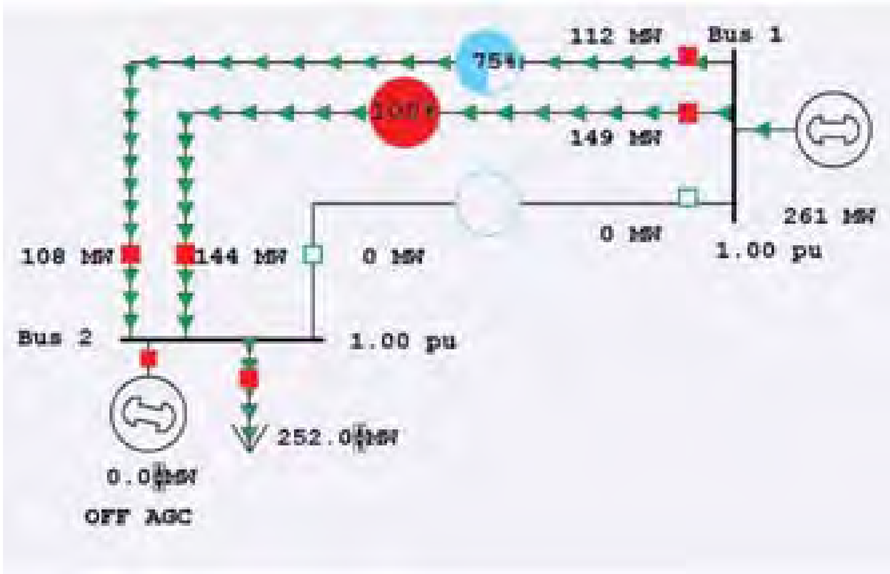

Figure 2: Two-Bus Example with Limiting Contingency

The unifying themes of these alternative approaches are knowledge about the real-time operation of the system, availability of effective controls, and an information infrastructure that permits effective use of the controls.

To understand these themes, it is important to understand the complexity of the actual national transmission grid.

COMPLEXITY OF THE NATIONAL TRANSMISSION GRID

The term "national transmission grid" is something of a misnomer. The North American transmission grid actually consists of four large grids, each primarily a synchronous alternating current (AC) system. Together, these four grids span parts of three sovereign countries (U.S., Canada, and Mexico). By far the largest grid is the Eastern Interconnection, which supplies power to most of the U.S. east of the Rocky Mountains as well as to all the Canadian provinces except British Columbia, Alberta, and Quebec. The Western Interconnection supplies most of the U.S. west of the Rockies, as well as British Columbia, Alberta, and a portion of Baja, California. The remaining two grids are the Electric Reliability Council of Texas (ERCOT), which covers most of Texas, and the province of Quebec. In contrast to the two-bus example presented above, the Eastern and the Western Interconnections contain tens of thousands of high-voltage buses and many thousands of individual generators and loads. Because the individual grids are asynchronous with one another, no power can be transferred among them except in small amounts through a few back-to-back direct current (DC) links. Several major DC transmission lines are also used within the individual grids for long-distance power transfer.

At any given time the loading on the grid depends on where power is being generated and consumed. Load is controlled by millions of individual customers, so it varies continuously. Because electricity cannot be readily stored, generation must also vary continuously to track load changes. In addition, the impedances of the many thousands of individual transmission lines and transformers dictate grid loading. With several notable exceptions, there is no way to directly control this flow—electrons flow as dictated by the laws of physics. Because electricity propagates through the network very rapidly, power can be transferred almost instantaneously (within seconds) from one end of the grid to the other. In general, this interconnectivity makes grid operations robust and reliable. However, it also has a detrimental effect if the grid fails; failures in one location can quickly affect the entire system in complex and dramatic ways, and large-scale blackouts may result.

The grid's ability to transfer power is restricted by thermal flow limits on individual transmission lines and transformers; minimum and maximum limits on acceptable bus-voltage magnitudes;

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and region-wide transient, oscillatory, and voltage-stability limitations. Given NERC's reliability requirements, these limits must be considered not only for current and actual system operating point but also for a large number of statistically likely contingent conditions as well. The complexity of maximizing the power transfer capability of the grid while avoiding stressing it to the point of collapse cannot be overstated.

TECHNOLOGIES TO INCREASE TRANSFER CAPACITY

The goal of this issue paper is to examine technologies that can be used to increase the grid's power-transfer capability. This increase can be achieved by a combination of direct technical reinforcements to the grid itself along with indirect information and control reinforcements that improve grid management practices and infrastructure.

Direct reinforcement of the grid includes new construction and broad use of improved hardware technology.

Strategic decisions regarding these two types of improvements are a function of grid management—planning, development, and operation. Grid management involves recognizing transmission needs, assessing options for meeting those needs, and balancing new transmission assets and new operating methods. Timely development and deployment of requisite technology are essential to reinforcing the grid.

Requisite technology may not mean new technology. There is a massive backlog of prototype technology that can, given means and incentives, be adapted to power system applications.

Indirect grid reinforcement includes improving grid management by means of technology. Historically, the transmission system was operated with very little real-time information about its state. During the past few decades, advances in computer and communication technology in general and SCADA (supervisory control and data acquisition) and EMS (energy management system) technology in particular have greatly improved data capabilities. Significant real-time data are now available in almost every control center, and many centers can conduct advanced on-line grid analysis. Despite these improvements, more can and should be done.

In the control center, additional data needs to be collected, better algorithms need to be developed for determining system operational limits, and better visualization methods are needed to present this information to operators. Beyond the control center, additional system information needs to be presented to all market participants so that they can make better-informed decisions about generation, load, and transmission system investments.

INSTITUTIONAL ISSUES THAT AFFECT TECHNOLOGY DEPLOYMENT

In order to effectively discuss the role of advanced transmission technologies, we have to consider how their deployment is either hindered or encouraged by institutional issues. Ultimately, the bottom line is economics— technologies that are viewed as cost effective will be used, and those that are considered too costly will not. The issue of cost is not simple; public policy must address how costs and benefits should be allocated.

For example, it is difficult to beat the economics of traditional overhead transmission lines for bulk power transfer. The lines are cheap to build and entail relatively few ongoing expenses. But the siting of new transmission lines is not so simple; right of way may be difficult to obtain, and new lines may face significant public opposition for a variety of reasons from aesthetic to environmental. Advanced technologies can reinforce the grid, minimizing the need for new overhead lines, but usually at higher cost than would be paid to build overhead lines. The challenge is to provide incentives that will encourage the desired transmission investments.

Unfortunately, in recent years the uncertainties associated with electricity industry restructuring have hampered progress in transmission reinforcement. The boundaries between responsibilities for operation and planning were once clearly delineated, but these responsibilities are now shifting to restructured or entirely new transmission organizations. This process is far from complete and has greatly weakened the essential dialogue between technology developers and users. Development of new technology must be closely linked to its actual deployment for operational use. Together, these activities should reflect, serve, and keep pace with the evolving infrastructure needs of transmission organizations. The current uncertainty discourages this cohesiveness.

The details and the needs of the evolving infrastructure for grid management are unclear, and all parties are understandably averse to investments that may not be promptly and directly beneficial. Some utilities are concerned that transmission investments may be of greater benefit to their competitors than to themselves. In the near term, relief of congestion may actually harm their businesses.

As a result of such forces, many promising technologies are stranded at various points in route from concept to practical use. Included are large-scale devices for routing power flow on the grid, advanced information systems to observe and assess grid behavior, real-time operating tools for enhanced management of grid assets, and new system planning methods that are robust in relation to the many uncertainties that are present or are emerging in the new power system.

Another important issue is that some technologies that would enable healthy and reliable energy commerce are not perceived as profitable enough to attract the interest of commercial developers. Special means are needed to develop and deploy these technologies for the public good. Involvement by the federal utilities and national laboratories may be necessary for timely progress in this area, as well as a broadening of some activities of EPRI or similar umbrella organizations focused on energy R&D along with development of better mechanisms to spur entrepreneurial innovation.

Look for Part II in the September issue of Electricity Today

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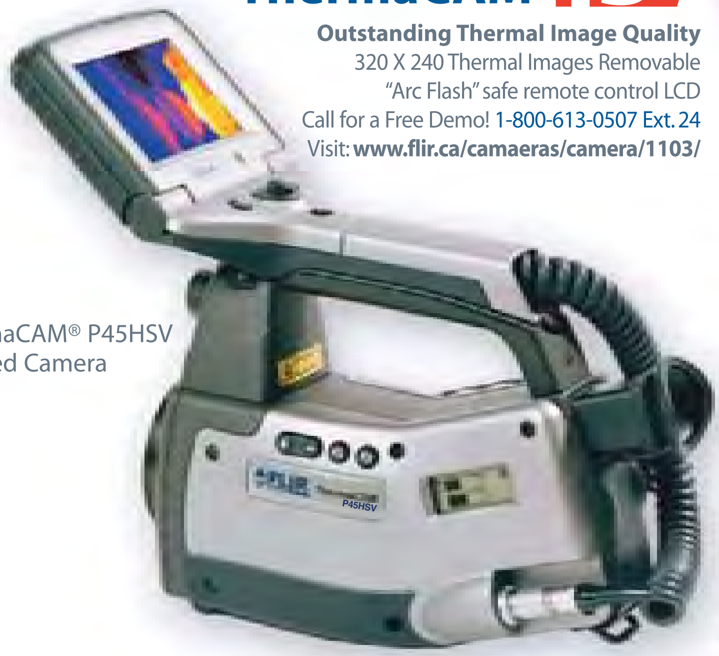

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