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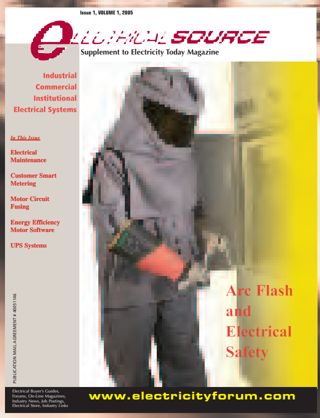

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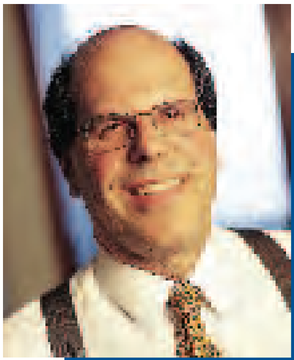

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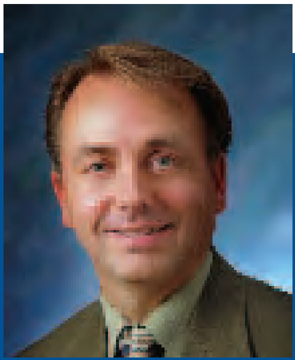

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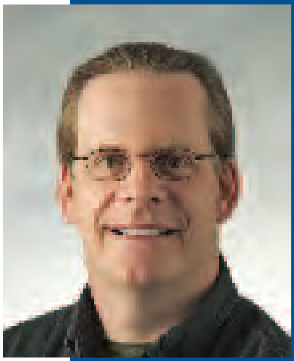

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ENHANCING RELIABILITY OF POWER PROTECTION SYSTEMS ECONOMICALLY IN THE POST-RESTRUCTURING ERA

By H. Wang and J.S. Thorp

The restructuring of the electricity industry has renewed concerns about wide-area disturbances due to their increasing economic and social costs. Power protection systems have played significant roles in propagating these disturbances. In post-restructuring era, smarter relays should be put into service to enhance the overall system reliability.

However, it is not economically feasible to replace all the protection devices. Given limited resources, we would like to find an optimal system upgrading solution that can maximally increase the system reliability. Here we analyze the impact of consecutive relaying malfunctions and pinpoint the vulnerable locations in the New York Power Pool (NYPP) 3000-bus system by simulating electrical blackouts using the Cornell Theory Center's supercomputers. We introduce a heuristic random search algorithm for faster search of important blackout paths.

I. INTRODUCTION

Power protection systems, as shown in recent studies, have played major roles in spreading electric system disturbances [1]. The redundancy and over-protection in the current protection design, while preventing individual hardware damage, tends to promote hidden failures, propagate long-chain disturbances and, as a result, compromise global reliability. As we embark on restructuring the power industry, it is crucial to review the current protection philosophy and investigate the feasibility of improving system reliability through an affordable protection system upgrade. J.S. Thorp et al [2,3] first studied hidden failures in relays and their impact on the power system reliability. Hidden failures denote the incorrect operations that usually remain undetected until abnormal operating conditions are reached. K. Bae et al [4] devised a dual-mode relaying concept that allows each individual relay's hidden failure probability to be adaptively adjusted according to the system's operating status. Although the benefit of applying these advanced relays is obvious, the question where to put them cannot be easily answered without a detailed vulnerability analysis of the bulk power system.

K. Bae et al [5] conducted the earlier simulation work on finding the vulnerable locations by simulating power system blackouts using the importance sampling technique. However, due to the hidden failures' load flow dependent nature and the lack of computational resource, that work was limited to simulating a WSCC 179-bus equivalent system. In this paper, we extended the previous work to simulate the NYPP 3000-bus system utilizing the Cornell Theory Center's supercomputing facility. To speed up the simulation, we introduce a heuristic random search algorithm for faster search of important blackout paths. Our objective is to pinpoint the most vulnerable locations in a real power system, numerically characterize the vulnerability, and find the most economical system upgrading solution.

We describe how we model the power system operations and disturbances in Part II. In Part III, we introduce the heuristic random search algorithm for efficient search of important sample paths. We later analyze the simulation result and study the vulnerability of the NYPP system in Part IV. Part V gives the optimal system upgrade solution.

II. METHODOLOGY

To accurately study the effect of disturbances spreading through the transmission network due to contingencies, we have to first identify the major engaged elements and understand their roles in propagating the disturbances. The example power system shown in Fig. 1 illustrates most elements that we have modeled in our simulation:

1. Generators, loads and transmission lines;
2. Line protective relays;
3. Generator protective relays;
4. Phase-shift transformers;
5. Switch shunt elements;
6. Transmission limits;
7. Generator's VAR limit;
8. Under-frequency load-shedding relays.

While the protective relays operate correctly in most situations, their hidden failures can sometimes be exposed by neighbor faults and lead to further propagation of disturbances. We can model the hidden failure as a stochastic process [5]. The probability of hidden failures depends on the impedance seen by the

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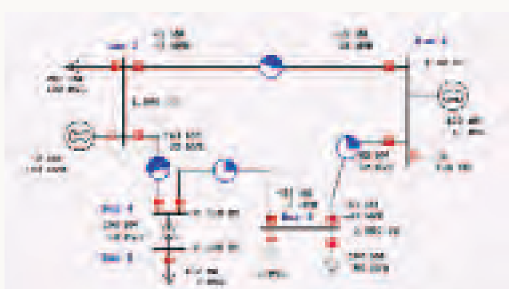

Fig. 1. Illustration of key equipment in a 5-bus system

Fig. 2. Probability of hidden failure in line protective relays

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line protective relays and the VAR limit violation detected by generator protective relays. Fig. 2 shows the probability of hidden failure as a function of impedance seen by the line protective relay. Fig. 3 shows the probability of incorrect generator tripping as a function of reactive power. Let us consider the blackouts in a simple network. In Fig. 4, a legitimate relay operation on line 3 exposes line 2 and line 4. The generator protective relay at bus 2 is exposed due to a VAR limit violation. Now, all the exposed relays are subject to possible false tripping.

Suppose the generator at bus 2 is tripped incorrectly. Then line 1 and line 2 are exposed in the next stage. Incorrect tripping of line 1 will expose line 4 and may eventually lead to a system-wide blackout. Many other blackout paths also exist in this simple 5-bus system. The number of blackout paths grows exponentially with the size of the system.

We are interested in both the probabilities of the sample paths and the amount of load lost for that path. Let $U = \{B_1, B_2, \ldots B_M\}$ be the complete set of all possible blackout sequences, and suppose all initiating events in the power system have the same frequency F^0. Let C_i be the load lost associated with the blackout B_i and L be the system overall load lost. Then, the expected overall lost per unit time can be expressed by

$$E(L) = \sum_{i=1}^{M} \left(F^0 C_i \prod_{j=1}^{n_i} p_{ij} \prod_{j=n_i+1}^{N_i} (1-p_{ij}) \right), \quad (1)$$

where p_{ij} is the probability of j^{th} exposed hidden failure being triggered in the blackout sequence B_i, n_i is the number of triggered hidden failures and Ni is the total number of exposed hidden failures involved in the B_i sequence.

We define the system reliability as

$$\eta = 1/E(L). \quad (2)$$

If V is a subset of U containing all the blackout sequences which has protective relay Rk involved, then

$$\upsilon_k = E(L_k) = \sum_{V} \left(F^0 C_i \prod_{j=1}^{n_i} p_{ij} \prod_{j=n_i+1}^{N_i} (1-p_{ij}) \right) \quad (3)$$

can characterize the vulnerability of relay R_k.

Since p_{ij} is load flow dependent, the simulation program has to recalculate the system status at each stage of the blackout. For large systems, the work of enumerating all possible blackout sequences in U could be prohibitive. In this case, η and υ_k can be estimated by simulating the most probable sample paths.

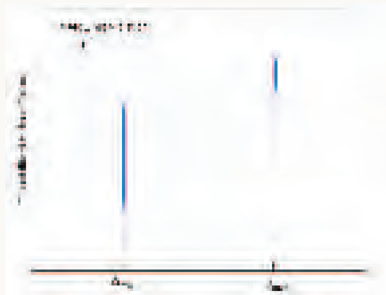

Fig. 3. Probability of hidden failure in generator protective relays

Several special considerations regarding the load flows need to be noted here. In power systems, each transmission line has its maximum transferring capacity. Once the on-line load flow exceeds that limit, the transmission line may be tripped legitimately and promote bigger blackouts. Thus, we have to consider the possible line limit violation in our simulation. Phase-shift transformers and switch shunt elements can also alter the load flows during disturbances.

It is possible that during the disturbance the system is separated into two or more islands each of which can independently maintain the balance between generations and loads. In the simulation, different islands should be simulated separately. We employ the BFS-like algorithm to determine the connectivity of the power network and split it whenever necessary.

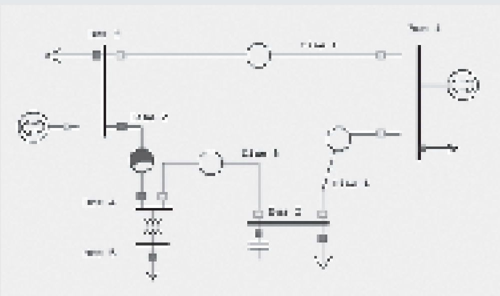

Fig. 4. Evolution of the power system during disturbances

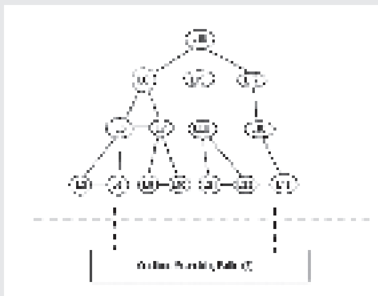

Fig. 5. Illustration of the sample path tree of New England 39-Bus System

III. HEURISTIC RANDOM SEARCH ALGORITHM

One obstacle to studying large-scale disturbances is that such events are rare. Importance sampling technique had been applied in earlier works for the rare-event simulation. However, as shown in Part II, we are merely interested in finding the most probable subset of blackout sequences in $\{B_1, B_2, \dots B_M\}$ and their correspondent probabilities while the importance sampling method usually spends more computing resources in maintaining the original distribution of sample paths. In the case where the underlying stochastic model is given, the heuristic random search algorithm shown below is more appropriate for solving the problems.

Let us consider a tree composed by all sample paths in $\{B_1, B_2, \dots B_M\}$ and their connections (Fig. 5). Each node in the tree corresponds to a blackout and has a probability p_{ij} and a lost C_i associated with it. Each edge corresponds to a single event during the disturbance, either a hidden failure or a legitimate tripping, with a probability pij. The root of the tree represents the power system running in the normal operating condition. The problem is to find the nodes having both high probabilities and large amounts of load lost in the tree with least computation. Two characteristics differentiate the above problem from other search and optimization problems. For one thing, each path in the tree starting from the root is a Markov chain. So,

$$\rho_i = \prod_{j=1}^{n_i} p_{ij} \prod_{j=n_i+1}^{N_i} (1-p_{ij}) . \qquad (4)$$

This implies that the nodes on the top of the tree have higher probabilities. While on the other hand, longer paths have greater amounts of load lost as

$$C_i = \sum_{j=1}^{N_i} c_{ij} \qquad (5)$$

where c_{ij} is the loss introduced by jth event in blackout B_i.

Blackouts whose expected loss $E(L_i) = \rho_{i\Diamond} C_i$ are significant contribute more to the vulnerability defined in (3) and therefore deserve more computation resources. Naively, the favorite nodes locate in a range near the top of the tree. The algorithm should focus on expanding nodes with expected lost greater than a minimum value $E_{min}(L_i)$ and within a maximum depth D_{max}. These two values are different from case to case and therefore should be computed on the fly during the simulation. To keep the accuracy, we set $E_{min}(L_i)$ and D_{max} to some safe boundaries at the beginning and dynamically update them during the simulation by analyzing the blackout sequences already generated. The DFS-like algorithm should be applied for searching nodes in the "blackout tree". Otherwise, hundreds of thousands of power system "snapshots" have to be stored to allow the BFS algorithm to recover the search along any blackout sequence in constant time.

Another issue worth noting here is that the loss and probability of each child node cannot be computed in advance. Hence, we cannot choose the next searching direction based on evaluations of the goal functions. Instead, we have to take a random searching approach based on heuristics and the underlying stochastic process of hidden failures. In the power system, two transmission lines are seldom tripped at the same time, i.e. the spread of disturbances is one-dimensional. We can rescale the probabilities of exposed hidden failures to let one and only one event happen at each stage.

The detailed algorithm is listed below:

1. Calculate the base load flow and set $E_{min}(L_i)$ and D_{max} to 0 and 50 respectively.
2. Randomly select the initial transmission line to be tripped; If enough significant blackout sequences have been collected, terminate the simulation.
3. Determine all hidden failures exposed by the last event and find the probabilities of false tripping from Fig. 2 and Fig. 3; Check the transmission limits.
4. Trip all lines violating transmission limits; If there is no violation, select one and only one hidden failure from the exposed candidates according to their probabilities and trigger it.
5. Check the connectivity of the network and fork the simulation if the system is separated into multiple islands; Track the frequency of each island and shed the load if necessary.
6. Record the current sequence as a possible blackout. If its expected loss is greater than $E_{min}(L_i)$ and the depth is less than D_{max}, push it into a fixed-size set holding the most significant blackout sequences. Replace the trivial one if necessary. Update D_{max} to two times the average depth of discovered significant paths stored in the set. If current depth is greater than D_{max}, return to step 2 to restart searching from the root.
7. Compute the new load flows using Newton-Raphson method. If it is done successfully, go back to step 3 to continue searching the blackout

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nodes at deeper depth. Otherwise, if the system become too ill-conditioned to have a mathematical load flow solution, go back to step 2 to restart searching from the root.

IV. VULNERABILITY ANALYSIS OF NYPP 3000-BUS SYSTEM

The NYPP 3000-bus equivalent system contains 2935 buses, 1304 generators, 6571 transmission lines and 457 transformers. Using a 256-Processor Intel cluster, we simulated 41,053 NYPP blackouts that have lost greater than 10MW. Let us now analyze the system vulnerability. From the simulation result, the vulnerability of each relay is calculated. Fig. 6 illustrates the distribution of the most vulnerable locations in NYPP. Relative vulnerability of relay k is defined as $\upsilon_k / max_{\forall i}(\upsilon_i)$.

As we can see in Fig. 6, the top three most vulnerable relays locate around the Indian Point Power Plant at Buchanan while the rest distribute around NYC, Oswego and Niagara regions respectively. We shall keep in mind that this result does not necessarily reflect each relay's actual vulnerability since we have assumed in Part II that all relays exhibit the identical hidden failure characteristics and the frequency of initiating events (flashovers, human faults, etc.) does not change with locations. However, the NERC Disturbance Analysis Working Group (DAWG) Database [6] does indirectly support our assumptions and analysis. For instance, the following documented disturbance is a typical one having hidden failures involved and matches well with our simulation result.

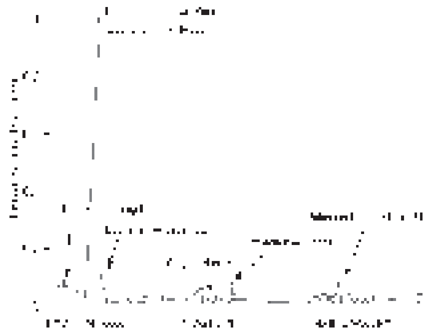


Fig. 6. Locations of most vulnerable relays in NYPP

"On Apr. 26, 1995, some shorting bars inadvertently left on a test block caused a relay to operate as if there was a breaker failure. The breaker failure scheme caused several breakers to open at the Volney Station (NYPP), and it sent a direct transfer trip signal to the Scriba Station (shown in Fig. 6, NYPP) to open other breakers at Scriba removing the line connecting the two stations. A phase-to-phase fault occurred at the Volney Station and it was seen correctly as a line fault by relays at Volney, and the relays opened breakers at Volney and Oswego Stations. Then a phase distance directional relay at the Clay Station misoperated and caused a breaker to open at Clay and a direct transfer trip signal was sent to Nine Mile Point No. 1 (NYPP) to open, removing the Clay-Nine Mile Point No. 1 line from service."

Relays with highest vulnerabilities are good candidates to be upgraded to increase the system reliability. Table 1 lists the twenty most vulnerable relays in NYPP and their relative vulnerabilities. They should gain more attentions than other relays when planning a protection system upgrade.

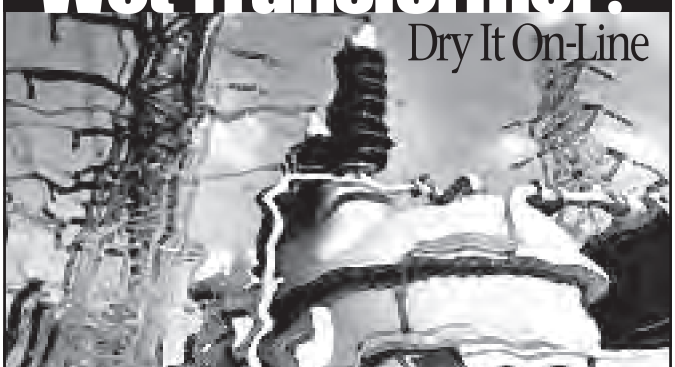
V. OPTIMAL SYSTEM UPGRADING SOLUTION

System reliability can be increased by using reliable relays with lower hidden failure probabilities. In Part IV, we have pinpointed the most vulnerable locations in the NYPP protection system. Upgrading relays at those locations can of course increase the reliability. However, to find the most economical solution, we shall optimize the reliability defined in (2) as

$$\max_{Cost'' H} \eta = \min_{Cost'' H} \sum_{i=1}^{M} \left(F^0 C_i \prod_{j=1}^{n_i} p_{ij} \prod_{j=n_i+1}^{N_i} (1-p_{ij}) \right), \quad (6)$$

where H is the budget.

We have recorded p_{ij}'s for hidden failures in all significant blackout paths during the simulation. Suppose the probabilities of hidden failures in the new relays are reduced by a half as shown in Fig. 2. Then, all pij's associated with the new relays in (6) will also be reduced by a half. In the case that H can be used to upgrade relays at ten locations in the NYPP system, solving the equation (6) yields the optimal solution listed in Table 2. The ten locations in Table 2 are quite different from the top ten in Table 1 where records are sorted by vulnerabilities. Their improvements over the original system are compared in Fig. 7. In both cases, the major improvement comes from the new relays around Indian Point. However, their difference is still significant. In general cases where many relays have similar vulnerabilities, the optimal solution is expected to yield a much better improvement.



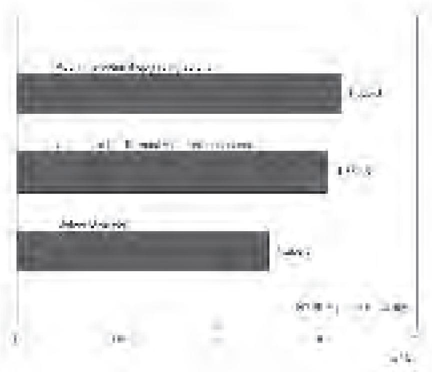


Fig. 7. A comparison of different upgrading solutions

An even better solution exists if the hidden failures can be reduced more than a half by spending more resources. For example, in the NYPP system, it will be better if the hidden failures around Indian Point can be reduced to one quarter, instead of one half.

VI. CONCLUSION

It is not our intention to simulate every aspect of the running power system. Instead, we focus on studying key elements relevant to transmission line protection, generator protection and system stabilities. Our goal is to illustrate the basic methodology for planning system upgrades and to show the feasibility of studying rare events of power systems precisely using modern powerful parallel computing facility.

System reliability and vulnerability are defined in this paper. They are then used to pinpoint vulnerable relays. By solving the equivalent optimization problem based on blackout records collected in our simulation, we found the optimal upgrading solution for the NYPP system.

TABLE 1. List of most vulnerable relays in NYPP (locations & relative vulnerabilities)

Line No.	Bus from	Bus to	Zone	Relative	
Vulnera	bility 0127	Buchanan	Indian	Point	Millwood
1.000	0126	Buchanan	Millwood	Millwood	0.993
0128	Buchanan	Ladentown	Millwood	0.122	
0047	E. 13th St.	Farragut	N.Y.C.	0.084	
0036	Hellgate	W. 179th	St.	N.Y.C.	0.084
0673	Robinson Rd.	Stolle Rd.	West	0.082	
0426	Fitzpatrick	Scriba	Central	0.078	
0664	Davis Rd.	Stolle Rd.	West	0.074	
0663	Harrison Radiator	Hinman	West	0.071	
0048	W. 179th St.	Dunwoodie	N.Y.C.	0.070	
0035	Poletti	E. 13th St.	N.Y.C.	0.070	
0354	Mountain	Swann Rd.	West	0.063	
0627	Cedars	Rosemont	North	0.045	
0848	Beebee	Beebee	Genesee	0.043	
0630	Dennison	Rosemont	North	0.042	
0631	Malone	Willis	North	0.041	
0628	Cedars	Rosemont	North	0.041	
0629	Dennison	Rosemont	North	0.040	
0658	Plattsburch	Ashley Rd.	North	0.038	
0384	Clay	Hopkins	Central	0.036	

TABLE 2. List of ten locations in NYPP where the relays should be upgraded first (under limited budget)

Line No.	Bus from	Bus to	Zone	Vulnerability Rank
0127	Buchanan	Indian Point	Millwood	1st
0126	Buchanan	Millwood	Millwood	2nd
0047	E. 13th St.	Farragut	N.Y.C.	4th
0663	Harrison Radiator	Hinman	West	9th
0035	Poletti	E. 13th St.	N.Y.C.	11th
0627	Cedars	Rosemont	North	13th
0630	Dennison	Rosemont	North	15th
0628	Cedars	Rosemont	North	17th
0629	Dennison	Rosemont	North	18th
0384	Clay	Hopkins	Central	20th

We characterized the blackout simulation as a tree-searching problem and devised a random search algorithm based some power system heuristics for faster rare-event simulation.

VII. ACKNOWLEDGMENTS

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PARTITIONING HELPS BUILD SYSTEM RELIABILITY

By Jeffery Hall

Networking capabilities are becoming a requirement for embedded systems. While the ability of systems to communicate with the rest of the world creates a huge number of new capabilities and useful features, it also opens the door to many new security threats. Securing a networked system requires a high-availability, maximum-reliability real-time operating system combined with a secure method of transmitting information.

For all practical purposes, it's impossible to find and fix every bug in any reasonably complex application - the amount of testing and review necessary to find every bug in a large application is prohibitive. If we accept that an application of any real complexity will always have bugs in it, how can we make our devices as reliable as is economically possible?

To create reliable applications, we must use an operating system designed from the ground up to help create reliable systems. Note that we are talking about the reliability of the "entire" system, not just of the operating system. One of the easiest ways to make a system more reliable is to partition it into independent subsystems. A failure in one subsystem should not affect the execution of the rest of the system in any way. This has long been a requirement in safety-critical systems, such as avionics control and medical systems.

The first step in properly partitioning an application is using memory protection. Most developers are familiar with the idea of memory protection - the OS uses the processor's memory management unit (MMU) to isolate applications in protected address spaces. With memory protection enabled, an application can only corrupt itself. Any attempt to read or write memory mapped into another address space will cause an MMU exception to be raised. The kernel will be notified of the attempted access and can handle it as it sees fit.

Though application A may not be able to directly read or write to application B's memory, there are still ways it can cause application B to fail. For example, assume two tasks are in a system. If the system designer wants the two tasks to share the processor time, both tasks would be given the same priority (round-robin scheduling). If task A needs 40 percent of the CPU time to execute properly, this design will work fine - there are two tasks in the system, so each task will get 50 percent of the execution time. But if task B creates an additional task, now we have three tasks in the system (A, B1, B2), each getting 33 percent of the CPU time, and task A will no longer function properly. Now, although there is no bug in task A, a bug in task B has caused task A to stop behaving properly. A more extreme case would be if there's an actual bug in task B and it creates 98 additional tasks (A, B1, B2-B99). There are now 100 tasks in the system and each gets exactly 1 percent of the CPU time. At this point, the system will really start to grind to a halt.

The cleanest solution would be to start each task with an execution "weight". If a task wants to create an additional task, it must give up some of its own weight. CPU time per priority level would be divided up based on the total weight at that priority level. For example, if in our original example, each task was given a weight of 3, the total weight at our priority level would be 6. Since each task has half the total weight, they will each get 50 percent of the CPU time. If task B wants to create two additional tasks, it must give up some of its weight (one weight to each new task). Now we have four tasks in the system. Task A has a weight of 3 and tasks B1, B2, and B3 each have a task of 1. There's still a total weight of 6 - task A's weight of 3 is half of the total weight, so it gets 50 percent of the CPU time. Task A is now protected from bugs or poor design in other tasks in the system. Nothing task B can do will steal processor time from task A.

Another potential way for one task to interfere with the execution of another one is through the use of system memory. Virtually every operating system today (embedded or not) has one central memory pool for the entire system. The major disadvantage: any application can starve other applications and the kernel itself for memory. If application A has a bug that causes it to request all the memory in the system, every other task will be prevented from allocating any additional memory. Perhaps more frightening, the kernel itself won't be able to create additional kernel objects (tasks, semaphores, etc.). This is another way in which a single bug in one part of a system can cause other parts to stop behaving as designed. A classic attack that shows this problem is a Unix fork bomb. A fork bomb is a process that just spawns other processes that are clones of itself. Each new process spawns new processes. The system quickly bogs down as thousands of processes are created. Each process requires new memory. Eventually the system crashes as all available memory is consumed.

One solution to this problem is to statically allocate a specific amount of memory to each part of the system. Each application can be guaranteed the minimum amount of memory it needs to function properly - any additional memory allocation can come from this central store of memory. This way, if application B uses all of its memory, its additional memory allocations will fail, but other parts of the system (application A and the kernel) will be unaffected.

True partitioning of a system should include not only protecting the kernel and application code, but the communication stack and associated device-driver code. Communication protocols are complex pieces of code rarely written by end users. As this software increasingly becomes commoditized, application developers are choosing to license rather than write their communications protocols. Unfortunately this means the internals of the stack are often poorly understood, and its reliability and behavior under all conditions cannot be guaranteed.

Time-to-market pressures are also forcing developers to use standardized controllers (Ethernet, serial, etc.) and the device drivers provided by the manufacturer. Unfortunately, this again means using somebody else's code without being able to verify the correctness of it.

Typically the stack and the device drivers are linked with the kernel. Unfortunately, this means that a bug in somebody else's code can completely crash the entire system. If the TCP/IP stack or device driver is in its own address space (instead of being statically linked with the kernel), it cannot affect other applications. Additionally, it can be restarted and upgraded on the fly, without requiring an application reload.

PROTECTING COMMUNICATIONS

So far we've discussed how to secure the actual application from bugs and malicious code. We've concluded that a combination of memory protection, CPU time guarantees and guaranteed memory allocation will allow us to guarantee that an application will not only be safe from other applications running on the same system, but also have the system resources necessary to run properly. Unfortunately, the work to create a reliable networked device does not stop there.

We must protect against three main dangers when considering secure and reliable communications. First, our data packets could be modified in transit. Second, the remote side's real identity is unknown. Finally, transactions can be snooped and replayed. Any of these can compromise security and reliability, possibly allowing an attacker to insert malicious code into your application, take control of the device, or both.

The easiest solution is to add Internet Protocol Secure (IPsec). It offers strong encryption of transferred data, guaranteeing that nobody can read transmitted information. It provides integrity and authentication, discarding modified packets and certifying a peer's identity. Finally, IPsec provides replay protection by ignoring duplicate transmissions.

IPsec allows this protection to be specified per packet, per socket, and per source and/or destination host. Its use is transparent to applications - they don't need to be modified to take advantage of the security IPsec provides. Old and new TCP/IP applications are automatically protected with no modification.

Although IPsec is available in IP version 4 (IPv4), its use is required in IPv6. IPv6 also provides automatic configuration (essential for embedded systems), and a huge increase in the number of IP addresses (from 232 to 2128). This will become more essential as the number of networked devices grows; houses will have multiple networked devices (computers, gaming systems, etc.), and the average person will carry multiple networked devices (PDA, cell phone, etc.).

The combination of IPsec and IP v6 provides networked devices with security, compatibility with future networking systems and easier configuration.

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ABB's Bob Fesmire, a member of Electricity's Editorial Board will give his valuable input on existing policies, new technologies and other current happenings in the North American industry.

The Transmission Paradox

By Bob Fesmire

There is a question in the industry over how to characterize transmission expansion. Traditional approaches paint it as an enabler, a means for low-cost generation to supply disparate loads instead of running more costly local plants, and a way to allow plants to be located near fuel sources. This view is also reinforced in competitive energy markets where transmission acts as a "highway" for generators to bring their "goods" to market.

The other side of the debate presents transmission as not simply an enabling force, but an active participant in wholesale power markets, ultimately competing with generation. Indeed, a new transmission line would likely represent a much greater competitive threat to a given generator than the construction of a single local plant by virtue of the many more plants that would be able to sell into that generator's market.

The question of who pays for transmission expansion projects depends to some extent on which side of this debate you're on. But there are other considerations that affect cost, both in terms of direct expenditures and in potential consequences. I'm speaking now about reliability.

The U.S. Congress will likely take up the famed energy bill this year, and the one part of it that everyone agrees on is the reliability standards it will likely impose on grid operators. When we talk about improving reliability, we usually mean strengthening the transmission and distribution infrastructure, either by building new lines or implementing equipment and systems to improve the transfer capacity of existing ones.

The question of who will pay for these enhancements is sticky enough. The thing that really worries me is how the costs of grid reliability, or more specifically grid failure, are to be distributed. As the transmission system becomes more complex, the potential for events in one area to impact the reliability of another increases tremendously. If we are going to impose penalties for poor reliability, the question of who is responsible becomes very complicated indeed.

A veteran industry consultant recently described to me a paradox in which, under long accepted standards, adding transmission capacity can actually decrease reliability. Assume there is a need to increase transfer capacity between two areas 300 miles apart, and in that span there is a 50-mile section where most of the congestion occurs. Assume also that there are four transmission lines, for the sake of argument all of the same rating. Adding a new 50-mile line in that congested area will reduce the loading on those other four lines, all else being equal. However, that new 50-mile line will also increase the loading on the rest of the lines in the 300-mile span on either end of it.

Grid planners and operators work under a commonly accepted rule that states you must be able to withstand the loss of one line/facility without overloading the remaining circuits in parallel paths. So, each of our four lines would never be loaded beyond 75 per cent of their limits (if one goes down, the other three can still pick up the slack). With a new line in place, however, there are now five lines, each of which could then be loaded to 80 per cent of capacity under the standard. All that extra power - on the new line as well as the now-higher loaded existing ones - winds up flowing over the circuits at either end of our 300-mile span as well. While this fact alone does not automatically equate to more and larger outages, it does imply greater risk.

The increasing burden on our transmission system is being driven by a number of factors, not least of which is competitive markets' need for power to be "shipped" over longer distances. There are technologies available today (FACTS, HVDC) that can enhance both transmission capacity and reliability. The fact remains, though, that as the grid is pushed harder, the chances for a locally minor disturbance to have far-reaching effects - and the chances of those effects having more dire consequences - increase considerably.

I wonder if, for the time being at least, our desire for competitive markets has outpaced our ability to ensure reliability, or perhaps more specifically, to account for it fairly. The reliability standards that everyone agrees are on the way beg the question: who pays? So far, that question has been considered primarily within the context of assigning the cost of additional transfer capacity. The real challenge, it seems to me, is going to come when we try to find a model for assigning the cost of meeting a reliability mandate.

Bob Fesmire is a communications manager with ABB. The views expressed here are his own and not those of ABB. **ET**

RARE CONVERGENCE CREATES UK OPPORTUNITIES IN THE U.S. RENEWABLES MARKETS

By Michael Rosenfeld

BRITISH COMPANIES ARE MAKING INROADS INTO THE U.S. RENEWABLE MARKET SECTOR

PPM Energy, a subsidiary of ScottishPower, announced 175 MW of new wind energy with more to come in the U.S., following the signing into law of the Production Tax Credit by President Bush.

Also, BP Solar announced initiatives to grow the U.S. photovoltaic energy market by increasing its global production capacity from 90 MW to 200 MW by the end of 2006.

At 280 MW and 214 turbines, King Mountain in Texas was the world's largest wind farm when constructed in 2001 by RES, U.S.A. (Renewable Energy Systems Ltd.), one of the world's leading renewable energy companies based in Britain.

Now more than ever, British businesses have attractive opportunities to sell technologies, products and services in the U.S. renewable energy sector. The ability of UK experts to anticipate sector growth and resulting business opportunities in America is based on their own domestic development of model practices. Opportunities for the UK renewables industry in the U.S. include:

- Developing business for UK exporters in the fields of renewable technologies, services and products, and energy efficiency;
- Identifying technology partners;
- Attracting inward investment to fill gaps in skill and technology left by the rapid growth within the UK's own renewable energy sector;
- Exploiting ambitious UK and EU renewable energy targets as part of the UK proposition to potential US inward investors; and
- Promoting UK centers of excellence as sites for collaborative R&D and product testing (e.g. New and Renewable Energy Centre (NaREC), Blyth and the European Marine Energy Centre (EMEC), Orkney).

The UK is the premier inward investment location in Europe. In recent benchmark surveys in the United States, the UK ranked 4th in the world in science and technology among decision makers and decision leaders. In addition, the UK has a 36.5 per cent share of all U.S. investment in the EU — as much as Germany, France, the Netherlands and Ireland combined.

THE PROMISE OF THE US MARKET

The renewable energy sector in the United States is on the verge of its biggest boom ever. Optimism is driven by a convergence of problems: climate change, pollution associated with fossil-fuels, the volatility of natural gas prices, the high price of coal, and the increasing hazards of dependence on foreign energy. American politicians and business leaders realize that these issues can be addressed in part with a realistic solution: renewable energy. Congress already has found rare common ground by turning to this politically transcendent issue.

The stars are aligned in the industry's favor. According to Environmental Business International, the U.S. environmental sector (which includes renewable energy operations) brought in $231.5 billion in revenues in 2003, an increase of 3.4 percent over the previous year. Most notably, the Renewable Energy/Clean Power segment of the environmental sector accounted for $12.7 billion in revenues in 2003, a 13 percent increase over the previous year, and the most growth for any of the 14 segments of the U.S. environmental sector.

At the national level, the federal Production Tax Credit (PTC) is key to financing renewable energy projects. The PTC provides a 1.5 cent-per-kilowatt-hour tax credit for electricity generated from wind turbines. After its expiration in December 2003, the PTC was extended the following September. The restoration kick-started a year's worth of stalled projects, and will likely drive a record number of capacity installations in 2005. Overall, annual installations of renewable energy are expected to increase from approximately 880 megawatts (MW) per year in 2004 to more than 4,000 MW per year in 2013.

Ironically, the gap in PTC subsidies came after a banner year for the American wind power industry. In 2003, the industry installed a near-record 1,687 MW of generating capacity, enough to serve nearly half a million average American homes.

Below the federal level, efforts are robust. Eighteen states have established renewable portfolio standards (RPS). The typical state's RPS is similar to the UK's Renewable Obligation: 10 percent of the total energy supply must come from renewable sources by 2010, 15 percent by 2015, and 20 percent by 2020.

A CLOSER LOOK AT THREE PROMISING US RENEWABLES

Wind. Wind power is the fastest growing renewable resource for the U.S. The nation has the second-largest installed wind capacity of any in the world, with about 6,400 MW in 2003. Nearly 1,700 MW of new wind energy capacity went on line in 2003, marking a near-record year, according to the American Wind Energy Association. In recent years the industry has proven that it can ramp up quickly to meet demand.

Under a consistent policy regime, investments would flow on an even larger scale into the U.S. wind energy market. Some UK concerns already are entering the market. PPM Energy in Portland, Oregon, a subsidiary of ScottishPower Group, operates a portfolio of more than 830 MW of wind power in seven states. The company also plans to bring an additional 2,300 MW of new wind power to market by 2010. With its newly acquired subsidiary, PPM Atlantic Renewable, PPM has expanded its successful west coast and Midwest wind business to energy markets in the Northeast. PPM Atlantic Renewable is responsible for about 65 percent of installed wind power capacity on the east coast, and has more than 500 MW additional capacity in development.

A leader in wind energy, RES has built or developed wind projects in Washington State, California and Texas, with capacity totaling 610MW. Their projects include the world's largest wind farm, located at King Mountain, Texas.

Biomass/Biogas. The various geographies of the United States make biomass/biogas projects subject to diverse efforts. In California, rice straw is widely used, while corn and soy are the biofuels of choice in the Midwest (Ethanol and biodiesel are the most prominent products).

Current emphasis by the Department of Energy is on cellulosic ethanol and biorefineries. Such projects produce a variety of products that can replace those now derived from petrochemicals.

Two types of biorefineries are of special interest in the U.S. Sugar platform biorefineries break down biomass into component sugars for fermentation or further processing. Thermochemical biorefineries convert biomass into synthesis gas or pyrolysis, the components of which are used directly as fuel or converted to other fuels and chemicals.

Cellulosic ethanol has greater energy content than starch-based ethanol, and is a popular investment. The cost to create it is \$2.50 per gallon, though current goals are to lower that price to \$1.07. International renewables firms including Iogen Corp. and Shell Global Solutions International have recently started up operations at a demonstration cellulosic ethanol production plant in the U.S.

Solar. The solar energy segment of the renewables industry is growing fast. The Solar Energy Industries Association reports that the market is five times the size it was in 1999, and doubles about once every 30 months. California and New Jersey are especially strong solar photovoltaic (PV) markets, in large part because of local incentives of \$3 to \$4 per watt. The consistent decline in cost of solar power is another driver, though prices remain high. The historic decline in price

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GO CAJUN AT NETA

By Don Horne

There's more than Mardi Gras in New Orleans this year, as NETA hosts its annual technical conference, seminars and trade show from March 21-24.

The InterNational Electrical Testing Association (NETA) conference boasts the largest group of electrical testing professionals in the industry, with more than 300 elite individuals expected to come out. With 21 industrial professionals sharing their expertise on such topics as batteries, cables and terminations, circuit breakers, partial discharge, safety and rotating equipment, the trade show includes more than 70 industry-specific suppliers showcasing the latest products and techniques.

On March 21, conference attendees will be able to preview the newest and most innovative electrical testing products, techniques and strategies at the New Product Forum. Manufacturers and suppliers give two-minute highlights on the latest changes in electrical testing technology and techniques. Any questions attendees may have can be answered the following day during the Trade Show on Tuesday, when the presenters will be in their booths ready for in-depth discussions.

Also on Tuesday will be three panel discussions on Insulation Systems, Rotating Machinery and Safety. Just a few of the companies weighing in on these question-and-answer discussions are Eaton Electric, Power Systems Testing, Cadick Corporation, and Baker Instruments.

Tom Biship of EASA will be examining the Field Testing of Electric Motors as part of an overall discussion on Rotating Equipment. The testing of installed electric motors is crucial for diagnosing suspected faults and maintaining continued service.

John Cadick looks at Managing the Safety Process and the challenges faced by industry in the face of ever-changing regulatory requirements, personnel turnover and new technology.

Claude Kane of Eaton Electrical will lead a discussion on Experiences in the Monitoring of Partial Discharges, and the increasing demands placed on the management of physical assets in a competitive environment. The experiences of large industrials in applying both periodic, continuous monitoring and off-line tests for partial discharges - and their effectiveness in doing so - will be the thrust of his paper.

Delivering the keynote address is **Ray A. Jones** of ESCS, Inc., who chaired the committee responsible for revising the Standard for Electrical Safety in the Workplace. His theme will include some of the safety issues not specifically addressed in consensus standards, such as:

- The roles of the employer, employee or facility owner as they relate to electrical safety;
- What is the best way to conduct a hazard/risk analysis and interpret the results; and
- The current state of knowledge on arc flash.

Applauded as a hands-on, practical conference, the NETA conference, seminar and trade show can be custom-made for those attending.

The InterNational Electrical Testing Association conference runs from March 21 through 24.

C&I CONSUMERS CAN LEVERAGE DEMAND AND COST FOR BETTER CONSERVATION

By Robert Ziemer

For many commercial and industrial (C&I) facilities, electricity costs can be a significant drain on the operating budget. Fortunately, C&I consumers can leverage a variety of energy and demand saving options to better manage their energy use and associated costs.

There are three key steps that can help guide C&I consumers in identifying significant energy cost savings: (1) understanding the how, where, and when of their energy usage, (2) identifying opportunities to reduce energy consumption and cost, and (3) developing a plan to prioritize and implement investments in energy efficiency.

UNDERSTANDING ENERGY USE

An average small business consumes about 40 percent of its annual electricity through its heating and cooling system (HVAC). Approximately 30 percent is spent on indoor and outdoor lighting. The balance is typically associated with other equipment use, including "plug loads" which account for an average of 20 percent. These percentages and the amount of total energy used can vary significantly depending on the business type, size, and equipment used.

Facility energy assessments and auditing services can help consumers identify the share of equipment consuming and implement verifiable energy and project cost saving measures. The Energy Star® web site (www.energystar.gov) is a good starting point in assessing a facility's energy use. This web site includes tools to estimate where a facility's energy dollars are

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remains 6 to 8 percent annually, and is likely to continue, but new installations remain in the mainstream-prohibitive price range of $15,000 to $20,000. More good news for the industry is that the California senate passed a bill in 2004 making solar PV systems mandatory on some new housing.

Receding market share held by U.S. PV system and component producers are creating yet more opportunities for UK efforts. The U.S. share has fallen to 13 percent of the global solar energy market, compared with 49 percent for Japanese producers and 27 percent for European companies.

UK-based BP Solar is moving deeper into the U.S. market. Already one of the world's largest solar companies, the company has announced plans to double its Frederick, Maryland plant capacity. In addition, BP Solar recently introduced a co-operative program to fully install solar home power systems. Its partners in the effort are selected Home Depot stores in southern California, home to many residents whose expressed concern for the environment may lower their resistance to the relatively high cost of entry.

NEEDED: A NUDGE IN THE RIGHT DIRECTION

The incentivizing of the UK market has boosted the renewables industry at home, and transformed the sector into a world leader for trade, investment and development. The U.S. could — and should — do the same, and recent political and environmental concerns may force the government's hand. State incentives provide a sound and proven model for federal efforts. The PTC is a good start; similar programming is possible that is relatively low in cost and high in impact.

The US is on the verge of becoming a major market for UK renewable resources. All that is needed now is the catalyst, a nudge from those controlling the economic levers from Washington.

Michael Rosenfeld, Vice Consul in the British Consulate-General in Los Angeles, co-leads the UK Renewable Energy Strategy in the United States. He serves as a commercial officer with UK Trade & Investment, responsible for promoting trade opportunities for British companies with technologies, products and services to sell into the US market and investment opportunities for American firms targeting the UK. He can be contacted by telephone at 310 481-2986 or by email: mike.rosenfeld@fco.gov.uk. **ET**

CLARITY OIL HELPS SEMINOLE ENHANCE EFFICIENCY AND CUT COSTS

A Florida-based Seminole Generating Station experienced severe operating problems such as pump failures, filter plugging and valve sticking with the fluid it was using in its hydraulic systems. These issues were causing production inefficiencies and rising maintenance costs.

Seminole decided to test ChevronTexaco's Clarity Hydraulic Oil, an ashless additive system that is biodegradable, in the generating station's coal unloading rotary dumper.

Since implementing use of the new oil, Seminole hasn't experienced a single costly hydraulic system failure, according to their maintenance team. This outstanding performance convinced the team to employ the oil in additional applications, and it has since successfully eliminated copper leaching from ZDDP in oil coolers and motors. "We have not had a single problem since we started using Chevron Clarity Hydraulic oil about six years ago," said Thorp. "It's an extremely high quality product that has worked consistently well in our equipment. We have been able to extend oil drain intervals from the one year initially recommended by our vendor to as long as five years. And with some of our blowers using approximately 300 gallons per reservoir, this adds up to huge savings. This is especially significant given that the total cost of a gallon of oil is actually four to five times higher than its listed price - this figure incorporates the added charges involved in receiving, handling, storage and disposal."

Located on 2,000 acres in Palatka, Florida, Seminole Cooperative's Generating Station consists of two 650-megawatt coal-fueled generating units that burn 10,000 tons of coal and

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Brian Thorp, Predictive Maintenance Technician, Seminole Electric, inspecting the hydraulic system that operates the arm that drops down and connects with the knuckle between the coal cars. Once the arm is attached to the knuckle, the cable system pulls and positions the cars to dump coal.

STREET LIGHTING CABLE FAULT LOCATION USING THE LEXXI T810 AND THE T272 HIGH RESISTANCE CABLE FAULT LOCATOR

By John Willis

INTRODUCTION

Cable faults take two forms:

- Open Circuits, High Resistance Joints.
- Insulation Resistance can be any value from a few ohms to hundreds of kilohms.

In this paper two complementary techniques are described which will find most common faults.

They are:

- Conductor Faults and Low Resistance Insulation Faults
- High Resistance Insulation Faults

PRE-TESTINGAND USE OF LEXXI T810

Before commencing fault location on a street lighting network all fuses and neutral links should be removed so that the cable is isolated. The removal of the neutral links is important, since if the neutral is not damaged it can be used as the sound return conductor for T272 bridge location. Also if fuses are left in, the tests referred to in the next paragraph will give misleading results.

Conventionally the first step in fault location is to carry out tests to check insulation, (MEGGERING), and conductor continuity. Whilst it is easy to megger the phases and neutral from the feeder pillar, checking continuity from the feeder pillar to each load on a “teed” network can be time consuming, particularly if there is no record of which phase feeds each load. On a “looped” system checking continuity is obviously simpler. The results of these tests will indicate whether the Lexxi or T272 should be used.

An open circuit is often indicated by the fact that some lamps are not illuminated but no fuse has blown. In this case the Lexxi can be used to “look” for the fault, either from the feeder pillar, or from the lamps on either side of the open circuit, i.e. the last lit lamp and the first unlit lamp on the faulty phase. It is essential to remember that fault diagnosis will give the most important clue to deciding which instrument to apply and testing for continuity is best done with a simple multimeter and not a “megger”. TDRs will find low resistance shunt faults up to about 300 ohms and high resistance series faults over about 300ohms. Beyond these limits apply the T272.

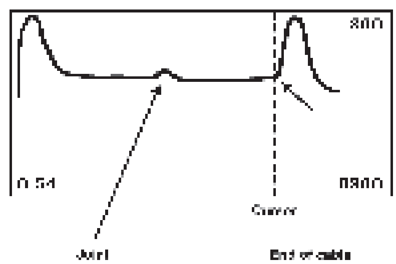

Figure1 Straight joint at 100 metres on a 200 metre length of cable

Figures 1, 2, 3 and 4 show wave forms when the Lexxi is applied to a cable under various circumstances.

Figure 1 shows the reflection from a straight joint at 100 metres on a 200 metre length of cable and figure 2 the same cable with a 5 metre long “TEE” at 100 metres. The far end of the cable is easily visible in both cases. In figure 3 the length of the “TEE” has been extended to 40 metres and it can be seen that the wave form becomes much more complex because of the multiple reflections.

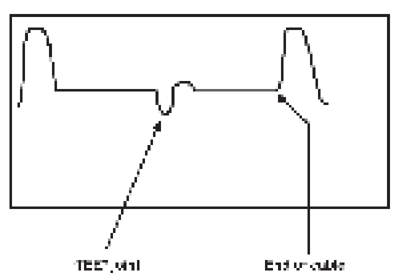

Figure2 5 metre “TEE” at 100 metres on a 200 metre length

An open circuit with the conditions that

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Total view of the forced draft fan, whose fan bearing oil circulation system was having a copper leaching problem from the coolers. Since converting to Chevron Clarity(r) Hydraulic Oil AW ISO 46, this problem has been eliminated.

View of a submerged oil cooler in a vertical condensate pump motor. The bright color of the tubing metal shows copper leaching and ZDDP issues from the oil that had been used previously

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petroleum coke daily in a 24-hour, 7-day maximum capacity operation. Both of these units incorporate environmental protection systems that originally cost more than $233 million. The station is part of Tampa, FL-based Seminole Electric Cooperative, Inc., which generates and transmits bulk supplies of electricity through its member cooperatives. It represents the third largest segment of electrical consumers in Florida, serving more than 1.5 million residential and business users throughout 45 counties.

The decision to try a new product came about when Seminole's maintenance personnel saw the oil become spoiled due to the moist and dusty operating environment of the hydraulic systems that pull and position freight cars through the coal unloading rotary dumper. This spoilage caused problems that necessitated frequent service, such as pump failures, filter plugging, valve sticking and strong odor. According to Brian Thorp, Predictive Maintenance Technician, each incidence of hydraulic fluid decay required the entire system to be shut down for drainage, flushing and refilling of fluid. "Every four to six months, we had to conduct extensive maintenance and clean up of all our hydraulic systems and oil reservoirs," said Thorp. "This cost us an inestimable amount in terms of labor, maintenance expenses, replacement oil costs and loss of efficiency."

Chevron Clarity has also successfully been used in other equipment, which has enabled oil change intervals to be extended up to five years or more.

The oils are designed to give maximum protection to mobile and stationary hydraulic vane-, piston and gear-type pumps in high-performance, severe stress industrial applications utilizing axial piston pumps where pressures may exceed 5000 psi, as well as in environmentally sensitive areas. They are formulated with ISOSYN® base stocks and an ashless ("zinc-free") additive system that provides excellent water separability, foam suppression, and protection against wear, rust and corrosion. In addition, the oils are long-life lubricants with superior oxidation stability, and extend engine life by protecting against sludge, varnish, ash deposits, wear, oxidation and foam. They pass the stringent acute aquatic toxicity (L-50) test and are inherently biodegradable, minimizing long-term environmental concerns. **ET**

MANITOBA RECEIVES 'A' FOR EFFICIENCY

UTILITY ALSO ANNOUNCES DOUBLING OF POWER SMART TARGETS BY 2018

By Don Horne

Manitoba and Manitoba Hydro received an A from the Canadian Energy Efficiency Alliance (CEEA) in its Fifth Annual National Report Card on Energy Efficiency - the highest grade in the country.

The well-designed integration of the provincial government's energy efficiency activities and Manitoba Hydro's comprehensive Power Smart programming resulted in that province being recognized as the top jurisdiction in Canada for their shared commitments to energy efficiency and for promoting the wise use of energy in the marketplace.

Manitoba Hydro's Power Smart Commercial Lighting Program also received recognition from the CEEA as a "Best Practice". In addition, the Power Smart Industrial Performance Optimization Program, the Commercial Heat Pump Program, and Power Smart Design Standards all received an Honourable Mention.

"Manitoba, which ranked first with an A, is setting the gold standard for the rest of the country," said Peter Love, the CEEA's Executive Director. "The judges were very impressed with the renewed commitment to energy efficiency from the Province and Manitoba Hydro."

The CEEA is a non-profit, member-supported organization charged with promoting energy-efficiency in Canada and includes membership from private companies, several provincial energy utilities, and the federal government.

Manitoba's Energy, Science and Technology Minister Dave Chomiak said, "Manitoba is honoured to be receiving an 'A' for efficiency on the Canadian Energy Efficiency Alliance's Fifth National Report Card. It's rewarding to see that the integration of provincial government energy efficiency activities and the commitment and support for delivery of energy efficiency programming by Manitoba Hydro has resulted in the province being recognized as the top jurisdiction in Canada."

Manitoba Hydro President and CEO Bob Brennan added "We're delighted that the CEEA has recognized our efforts to promote energy efficiency - the Corporation takes its commitment to the environment and sustainable development very seriously. That's why I'm also pleased to announce today that Manitoba Hydro will be doubling its Power Smart energy savings targets over the next 13 years."

Power Smart targets have now been set at 640 megawatts (MW), or 1767 gigawatt-hours (GW.h) of electricity from 2005 to 2018, approximately doubling the savings achieved from 1991 to 2004.

Power Smart savings to date of 872 GW.h equals enough electricity to service approximately 10 per cent of the City of Winnipeg. Combining the savings to date with the projected savings over the next 13 years would service approximately a third of the City of Winnipeg.

In addition to the more aggressive electrical conservation targets, Manitoba Hydro is also committed to increasing the promotion of natural gas efficiencies and conservation measures. A natural gas conservation potential study is being prepared, with the development of efficiency programs to follow, that will encourage residential, commercial, and industrial customers to achieve natural gas savings.

Currently, Manitoba Hydro offers over 15 Power Smart programs for its residential, commercial, and industrial customers, from lighting, heating, air conditioning, and manufacturing, to energy efficient standards for buildings and appliances. In the coming months, a comprehensive province-wide educational campaign will be delivered to customers in all sectors to assist in promoting and conserving electricity and natural gas.

ET

(On the left) Peter Love of the CEEA congratulates Manitoba Hydro President and CEO Bob Brennan on receiving an 'A' for energy efficiency.

ARC FLASH PREVENTION AND PROTECTION FOCUS OF ELECTRICAL SAFETY FORUMS

By Randy Hurst

In today's ever changing environment of electrical power distribution equipment and systems, electrical safety and reliability are becoming the focal point of utility and industrial switchgear users. Because of this fact, the Canadian Electricity Forum has organized a series of **"Electrical Safety In The Workplace"** forums across Canada in May that will address several electrical safety awareness issues, with a focus on "arc Flash" hazards, preventions, and protective equipment.

These forums are scheduled for the following cities and dates:

Vancouver, BC - May 3-4, 2005
Edmonton, AB - May 5-6, 2005
Saskatoon, SK - May 9-10, 2005
Winnipeg, MB - May 11-12, 2005
Toronto, ON - May 19-20, 2005

These forums, which are being supported by CSA, Ontario's Electrical Safety Authority (ESA), the B.C. Safety Authority, the Saskatchewan Electrical Safety Authority and The Manitoba Hydro Electrical Safety Authority, will feature a One-Day Tutorial on Arc Flash, titled: Arc Flash Hazards in the Workplace, presented by Kerry Heid, president, Magna Electric Corporation, will provide delegates with the information they will require to understand the dangers of arc flash and what they can do to improve electrical workplace safety. Our Arc Flash educational program will focus on arc flash incidents, recommendations for mitigating risk and current guidelines to help train yourself and your fellow employees, with an emphasis on ensuring that your facility meets current standards.

The tutorial will also assist electrical professionals in how to determine arc flash incident energy levels and boundary distances by demonstrating how to perform an arc flash analysis. The energy level provides an understanding of the potential arc flash incident energy and boundary distances provide guidance as to the range of a potential ar flash "event".

ARC FLASH TUTORIAL

This one-day tutorial will introduce forum participants to arc-flash hazard. Upon completion, forum participants will learn what causes an arc-flash, what regulations and standards say about arc flash, reasons for performing an arc flash hazard analysis, and what the steps are for accurately performing an anlysis. Participants will also learn the information that is required to perform an analysyis as well as determine the proper personal protective equipment required for arc flash protection.

New terms will be introduced such as limited, restricted, and prohibited approach boundary as well as flash protection boundary, incident energy and arcing fault current. Various manual and computer techniques will be introduced to calculate arc-flash hazard. IEEE Standard 1584 will be the primary focus along with information from various texts, standards, and regulations including NFPA 70E: Standard For Electrical Safety in the Workplace.

Other Electrical Safety Forum topics include:

- CSA Standards and the Canadian Electrical Safety System
- Provincial Electrical Safety Codes & Industrial Facilities
- Personal Protective Equipment (PPE) and ASTM Guidelines
- Electrical Safety and Flame Resistant (FR) Garments
- Electrical Safety and Electrical Protective Equipment

ADDED BONUS!

Every delegate attending one of our Electrical Safety forums will receive a FREE copy of the NFPA 70E: Standard For Electrical Safety in the Workplace (Value: $79.00) as well as the Electricity Forum's 120-page 2005 Electrical Safety Handbook (Value: $35.00)

WHAT CAUSES ARC FLASH?

Arc Flash, sometimes known as "arc fault", is the passage of substantial electric currents through air and typically the vaporized arc terminal material such as copper. Arcing involves high temperatures of up to or beyond 35,000∞F at the arc terminals. This is approximately four times the surface temperature of the sun. The pressures created by an arc flash are extremely explosive. Pressure is generated by expansion due to metal vaporization and the rapid heating of the air by the arc passing though it. Copper vapor expands to 67,000 times the volume of solid copper. For example, 16.39 cm3 (1 inch3) of copper vaporizes into 1.098m3 (1.44 yd3) of vapor. The air in the arc stream expands in heating up from ambient to that of the arc at about 35,000∞F. The vaporization of metal and heating of the surrounding air results in a very rapid blast due to the high pressure. In incidents, workers have been knocked off ladders and thrown across rooms. One positive consequence of high blast pressure of arcing faults is that it can reduce the time a worker is exposed to the arc flash temperatures. A serious hazard is that this explosion of metal and air results in propelling molten metal and equipment parts from the incident point.

Arc flashes can cause serious injury or death to workers. At the initiation of an arc fault, tremendous energy can be released in a very brief time. Metal conductor parts can vaporize resulting in hot vapors and hot metal being violently spewed. The thermal energy can result in severe burns to workers caused by direct exposure or by igniting clothing. The rapid thermal escalation of the air and vaporization of metal can create a very loud explosion and tremendous pressures. This can result in ruptured eardrums, collapsed lungs, and forces that violently knock workers back.

For more information about our Electrical Safety In The Workplace Forums, visit www.electricityforum.com /forums/safety.html **ET**

ELECTRICITY FORUM TRAINING INSTITUTE'S COURSE SCHEDULE

Circuit Breaker And Switchgear Testing, Maintenance and Application Forum

April 4-5, 2005 – Toronto, ON
Park Plaza Hotel

Students will learn safe and proper maintenance, testing and safety procedures for servicing a variety of Low Voltage (750V and less), Medium Voltage (750V–7.5kV) and High Voltage (7.5kV and higher) circuit breakers. Topics will include maintenance and adjustment requirements, as well as insulation resistance, contact resistance and high current primary injection tests for Low Voltage circuit breakers and high potential and power factor testing for Medium- and High Voltage circuit breakers.

For detailed information visit our web site at
www.electricityforum.com/forums/breaker_on.html

• bonus

Included with your registration is our 2005 CIRCUIT BREAKER AND SWITCHGEAR HANDBOOK Vol.1. This 100+ page handbook covers the most important aspects of switchgear design, applications, safety, and maintenance - giving electrical engineers and contractors the vital information they need to select and specify switchgear and control equipment. (Value $35)

Early bird registration fee $599.00 + 41.93 GST
(8 days prior to the course start date).

Electrical System Maintenance and Testing Forum

April 5-6, 2005 – Saskatoon, SK
Saskatoon Inn

April 7-8, 2005 – Winnipeg, MB
Radisson Hotel Winnipeg Downtown

Our two-day electrical maintenance and testing forum is designed to provide maintenance personnel with critical, problem solving information on the what, why and how of electrical maintenance testing. By reviewing electrical testing specifications, maintenance personnel can create a maintenance program designed to meet your facility's needs. It will also help them decide what can be done by inhouse personnel and what is best left to an accredited electrical testing professional.

For detailed information visit our web site at
www.electricityforum.com/forums/electrical_testing2005.html

• bonus

Included with your registration is our 2005 Electrical Testing and Maintenance Handbook Vol.5. There are many aspects to proper and effective proactive, predictive electrical maintenance and this 120 page handbook discusses the details of this critical and timely issue. (Value $35)

Early bird registration fee is $649.00 + $45.43 GST.
(8 days prior to the course start date).

Electrical Safety Forum

April 11-12, 2005 – Vancouver, BC
Executive Airport Plaza Hotel and Conference Centre

April 13-14, 2005 – Edmonton, AB
The Coast Terrace Inn

This course is designed to train all electrical staff on the proper care, maintenance, inspection and utilization of the power distribution system. It is also designed to ensure that delegates are instructed to work within the guidelines of current CSA, Provincial government, Electrical Utility Safety Association and OSHA (Canada) safety regulations. It will help employees and companies reduce the risk of personal injury and equipment damage due to operator error. The course is also designed to ensure that, under emergency conditions, the proper steps are taken to restore power in an efficient and safe manner.

For detailed information visit our web site at
www.electricityforum.com/forums/safety.html

Topics include:

- Important Definitions
- Personal Protective Equipment
- Isolation and Lockout Practices

Early bird registration fee is $649.00 + $45.43 GST.
(8 days prior to the course start date).

Electrical Motors and Drives

April 25-26, 2005 – Toronto, ON
Park Plaza Hotel

The objective of this course is to build confidence in the student by providing him/her with useful information and practical hands-on exercises that demonstrate the relevance of the course material. This course is recommended for electrical engineers, technicians, designers and electrical maintenance personnel responsible for VFDs.

For detailed information visit our web site at
www.electricityforum.com/forums/drives2005.html

This course is designed to enable participants to:

- Properly Matching A Drive to A Machine
- Choosing the Correct Motor
- Choosing the Best Type of Drive
- Identify & Correct Drive System Problems
- Identify & Test Major Drive Components
- Perform Start-Up of an AC Drive
- Program & Adjust the Drive for Desired Operation

Early bird registration fee $649.00 + 45.43 GST
(8 days prior to the course start date).

• registration fees

Register and prepay 8 days prior to the course start date and receive an early bird registration fee. Companies registering 3 delegates at the regular price will receive a 4th registration FREE. The fee includes forum participation, a delegate materials package, a Handbook, a subscription to Electricity Today Magazine, a $100 Coupon towards a future 2005 Electricity Forum event, refreshments and luncheons on both days. (GST #R105219976).

hotel reservations

A special bedroom rate (non-commissionable) has been arranged with each hotel. To receive this rate, simply inform the hotel that you are a delegate with the Canadian Electricity Forum.

Park Plaza Hotel
33 Carlson Court [near the airport], Toronto, ON Tel: 416-675-1234

Radisson Winnipeg
288 Portage Avenue, Winnipeg, MB Tel: 204-956-0410

Coast Terrace Inn
4440 Calgary Trail North, Edmonton, AB Tel: 780-437-6010

Saskatoon Inn
2002 Airport Drive, Saskatoon, SK Tel: (306) 242-1440

Executuve Airport Plaza Hotel and Conference Centre
7311 Westminster Hwy., Richmond, BC Tel: 1-800-663-2878

air flight information

We have appointed Air Canada as the official airline of our 2005 forums. Simply contact Air Canada's North American toll-free number at 1-800-361-7585 or locally at 514-393-9494 or your travel agent and take advantage of the Special Discounted Airfares. Please quote convention number CV053569.

cancellation and refund policy

Registration fees are refundable only upon receipt of written notification 10 days prior to the conference date, less a 10 per cent service charge. Substitution of participants is permissible up to and including the day of the forum. The Canadian Electricity Forum reserves the right to cancel any conference it deems necessary and will, in such event, make a full refund of the registration fees.

4 easy ways to register

phone: 1-905-686-1040
fax: 1-905-686-1078
online: www.electricityforum.com/forums/reg.htm
mail: The Electricity Forum 15 Harwood Ave. S., Suite 204 Ajax, ON L1S 2B9

RENEWABLE ENERGY DEVELOPMENT IS THE REMEDY FOR ONTARIO'S ENERGY FUTURE

By Ted Ferguson

It could hardly be argued that Ontario is in a good place with regards to electricity. The past few years have seen calamities of the first kind, blackouts, nuclear plant shut-downs, dramatic increases in coal-fired emissions, and supply demand crunches, to name a few. These factors provide a dramatic backdrop and impetus to the need for a new electricity vision in Ontario, a Sustainable Energy vision.

The new Ontario energy reality needs to balance financial, environmental and social drivers that are intrinsic to how the electricity business works. How do you attain multiple goals with one policy? It's the imperative when you're talking about energy. The answer is in applying a sustainability lens to your decisions. Take a sustainability approach to long term energy planning and we'll all benefit.

We're not talking about fleecing everyone so that we have the most 'green' system in the world. Rather, sustainability is about the 'triple bottom line'. A sustainable energy strategy for Ontario would increase the financial, social and environmental performance of our electricity system, and it's hard to argue that its time is not due. A sustainability goal is a circular performance matrix, and it's harder to hit all three than just one. However, if we want an electricity system that truly provides good service and value to the rate payers, we need to hit all three, and hit them hard!

I think it's difficult for Ontarians to put this much thought into energy. Compared to other provinces, where energy production is a key economic sector filling government coffers and the professional ranks, Ontario looks at energy as simply an input to a largely manufacturing- and services-based economy. In the past it's been 'plug and play,' without much consideration of what's behind the plug. After all, how else could we get in the mess we're in now? The answer to today's difficulties lies in changing that perspective to one which looks at Ontario's energy sector as something that should be driving sustainable economic growth through good financial, environmental and social performance well into the future.

Renewables fit because it provides

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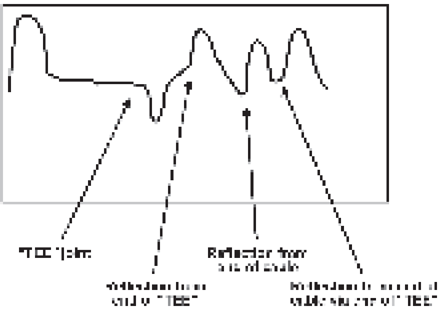

Figure3 40 metre "TEE" at 100 metres on a 200 metre length

apply in figures 1 and 2 could be located either from the feeder pillar or from the lamps on either side of the break.

For a system like that indicated in figure 3 the complexity of the network means that the easiest way to locate the fault is to use the Lexxi from the lamps on either side of the fault.

Figures 41, 4b show wave forms obtained in this way.

Since we are testing from the last lamp 'on', the circuit is continuous back to the feeder pillar, thus on the longest range we can see the reflection from the feeder pillar, but there is another reflection close to the transmitted pulse, which is the reflection from the open circuit fault. The range is then reduced as necessary until the reflection from the fault can be clearly seen, in this instance the 30 metre range. Note that there is a substantial reflection from the 'TEE' joint.

If this reflection is not there but the feeder pillar can be seen, this would indicate that the fault was very close to the 'TEE' joint on the leg towards the first lamp 'off'. Similarly if the Lexxi was being used from the first lamp 'off' and the 'TEE' joint reflection was missing but lamps towards the far end of the cable, or the far end of the cable itself could be seen, this would indicate a fault near the 'TEE' joint feeding the first lamp 'off'.

If a reflection is observed at about 1 metre it might only be due to the mismatch between The test lead and the cable, so double check before excavating.

It is always a good idea to 'look' at the cable using the longest range first. The range can then be reduced as necessary to make the required measurement.

For an insulation fault the Lexxi is only effective if the fault resistance is quite low. In the circuits indicated in figures 1 and 2 (i.e. minimum reflection from joints), it should be possible to see faults with a resistance upto300ohms.

On a circuit where there are major 'TEE' joints, and hence complex wave forms, it might be difficult to see a fault with a resistance of only a few ohms, depending on its position relative to the instrument, i.e. if the fault is between the test point and the first major 'TEE' then there will be no problem. If there are several 'TEES' between the test point and the fault it will be very difficult to interpret the wave form.

In all instances it is vital that the insulation resistance is measured with a low voltage instrument, (e.g. AVO or DVM), rather than a MEGGER. On a complex net work with a low resistance fault it might be possible to find the fault by looking at the cable from the ends of the various 'TEE' joints, but this will be time-consuming.

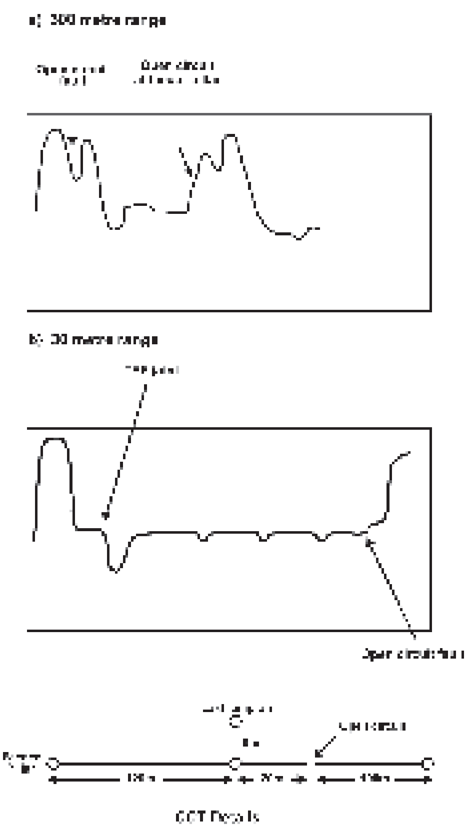

Figure4 Both waveforms with LEXXI connected at last lamp on

FAULT LOCATION USING THE T272

For an insulation fault that cannot be 'seen' by the Lexxi, the fault location procedure will be dictated by the fault conditions.

A) ONE OR MORE PHASES "DOWN", BUT NEUTRAL "HEALTHY"

In this instance a conventional MURRAY loop test can be carried out using the T272. The test can be made from the feeder pillar with the faulty phase and neutral solidly connected at the furthest lamp on that phases (See figure 5). When the T272 is 'balanced', the distance to the fault will be indicated as a percentage of the loop length, (2L). Normally where a cable consists of lengths of different cross-sectional area, allowances have to be made for the difference in resistance per unit length of the cables.

On a street lighting network advantage can be taken of the access to the phase afforded at the 'TEE' joints to overcome this problem.

For example, in figure 5 the fault might be indicated at 46%L. Examination of the cable records or cable route would indicate that this was somewhere between lamps R7 and R10. By leaving the bridge set up as it is and applying a solid earth to the phase only at lamp R7and repeating the bridge test would yield an answer of 41%L.

Similarly, removing this earth and applying it to the phase at lamp R10 would give an answer of 47.5%L. This

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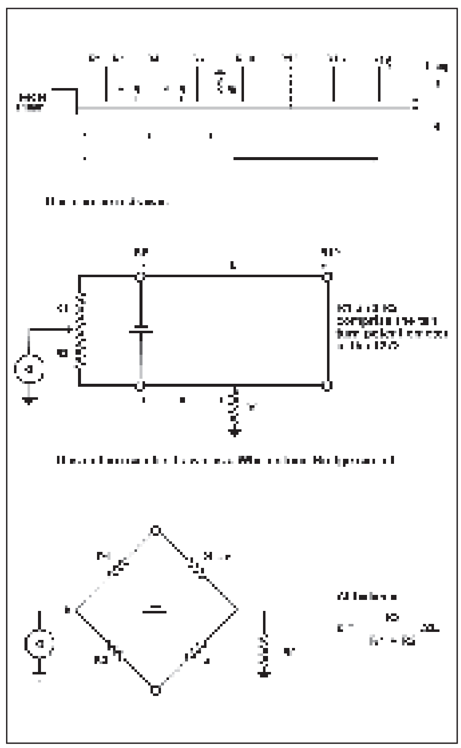

Figure5 MURRAY LoopTest

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would confirm that the fault was between R7 and R10, and the numbers would indicate that the fault was closer to R10 than R7. The bridge test could then be carried out with phase and neutral looped at R10 rather than R19, the bridge reading would then give a percentage of the loop length between the feeder pillar and R10.

When carrying out a bridge test a fault anywhere along a 'TEE' will appear to be at the 'TEE' joint. Thus if a bridge indicates that a fault is close to a major 'TEE' the bridge test should be repeated with a loop at the end of that 'TEE' to prove whether the fault is in fact at the 'TEE' joint or some where along the 'TEE'.

This procedure can be carried out on other faulty phases to ascertain whether there is more than one fault.

B) ONE PHASE AND NEUTRAL "DOWN", TWO PHASES HEALTHY

A variation of the MURRAY loop - the HILBORN loop - can be used in this situation. If we assume standard phase rotation in figure 5, then lamp 18 will be on the Blue Phase (B18) and lamp 20 on the Yellow Phase (Y20). A single insulated wire, (cross-section unimportant), is run from B18 to R19 and a similar wire from Y20 to R19. At the feeder pillar the red bridge terminal is connected to the faulty phase, (in this case also red), the black bridge terminal is connected to one of the healthy phases and the battery is connected between the other healthy phase and the faulty phase. This time, when the bridge is balanced, the reading will give the fault position as a percentage of the cable length (L) between the feeder pillar and R19. Again, by applying a solid earth to the faulty phase at a lamp, the 'TEE' joint feeding this lamp can be identified relative to the fault.

C) ALL PHASES AND NEUTRAL "DOWN"

In this case we again utilize the HILBORN loop but, since there are no sound conductors, a special 'overland' lead is used. This is a twin lead which is used to span the gap between two lamps on the same phase. The conductor cross-section should be about 1 square mm. (1mm). The more lamps that can be spanned at one go, the easier the fault location will be, but practical limitations with respect to handling the 'overland' lead means that 200-300metres is probably the maximum length.

Figure 6 shows how the location would proceed for the fault on the Red phase. It is assumed that the 'overland' lead is long enough to span between a lamp and the next but one on the Red phase and the initial test is carried out somewhere near the middle of the run. The two cores of the 'overland' lead are connected to the faulty phase at R13 and the bridge is set up at R7, faulty phase to red bridge terminal and one conductor from the 'overland' lead to the black terminal, the battery is connected between the other conductor in the 'overland' lead and the faulty phase.

When the bridge is balanced, the fault position will be indicated as a percentage of L, (the cable length between R7 and R13). A reading close to 0%* would indicate that the fault is between the feeder pillar and R7, (or in 'TEE' joint R7), a reading close to 100%* would indicate that the fault is between R13 and the far end, (or in 'TEE' joint R13).

The 'TEE' joints can be identified as before, i.e. a solid earth at R4 would show the position of 'TEE' joint R7 and an earth at R16 would indicate 'TEE' joint R13. If the fault reading indicates that the fault is between R7 and R13, then an earth at R10 would enable its position to be established relative to the fault. If the indication was that the fault was between the feeder pillar and R7 or between R13 and the far end, then further

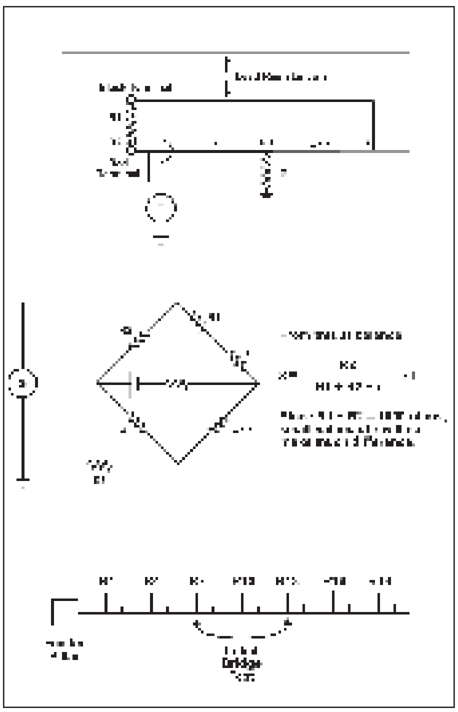

Figure6 HILBORN LoopTests

bridge tests would have to be carried out between the appropriate points.

* It is difficult to put exact values on these two figures, since the tails to the lamps at each end are included and the fact that the cross-section of these cables is smaller than the main feeder means that their "effective" or "equivalent" length will be greater than their physical length.

Example:

Main feeder 4c 75 mm, tails to lamps 2c 16 mm, spacing between lamps 40Êm, total length of main R7-R13 = 240Êm, tails 4Êm long but since they are only 16 mm, effective length = 4 x / = 19Êm, total length presented to bridge = 240+19+19 = 278m, so 'TEE' joint 7 = / x 100% = 7%, similarly, 'TEE' joint 13 = 93%.

The actual position of the 'TEE' joints could be found as explained above.

FAULT LOCATION ON A LOOPED NETWORK

A looped network is one where a single phase cable is used. The cable runs from the feeder pillar into the first lamp and then from first lamp to second lamp and so on. The cable thus "loops" in and out of each lamp, rather than having a 'TEE' joint from a main cable to each lamp, often there are subsidiary loops to illuminated bollards and signs.

An open circuit could be located from the feeder pillar or from the lamps on either side (last on, first off as before).

If the neutral is healthy, an insulation fault location could be carried out using a MURRAY loop on the complete cable length in the same way as on a 'TEED' network, using earths to identify the position of intermediate lamps relative to the fault.

If phase and neutral are faulty, then it is best to 'sectionalize' the cable to find which length is faulty. This is done by 'breaking' the connection at approximately halfway and meggering both lengths of cable and repeating this until the fault is known to lie between two lamps. A HILBORN loop could then be carried out on this short length of cable.

Many looped systems use a split core concentric cable, where the neutral consists of a number of individually insulated conductors. Often by separating the neutral wires at both ends of the faulty section, a fault location can be made

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Editor's note: The newly appointed Chief Executive Officer of the fledgling Ontario Power Authority spoke at the recent North American Power Markets Conference in Toronto, providing a glimpse of how he sees the province's competitive electricity market functioning in a post-Bill 100 world under the guiding hand of the OPA. Here is his speech:

HAVE MARKETS MET THEIR MATCH?

THE EMERGING ROLE OF CENTRAL PLANNING IN COMPETITIVE ELECTRICITY SYSTEMS

By Jan Carr

When I originally committed to speaking here today, I was Vice Chair of the Ontario Energy Board (OEB) and Ontario's Bill 100 was progressing through the legislative process. I had in mind that it would be useful to provide a general backdrop to how I see regulation and competition fitting together in light of experience with restructured electricity systems. I thought that a question I first heard from Howard Wetston, Chair of the OEB, captured the issue at hand extremely well - "in electricity, have markets met their match?" As a former Commissioner of Canada's Competition Bureau and an experienced Vice Chair at the Ontario Securities Commission I felt that this was a very insightful question posed by a very credible person. So I stole it as a jumping off point for what I wanted to say here.

Since then, Bill 100 has become an Act and many of its subsidiary regulations have been promulgated. This has clarified much speculation and, I am sure, both simplified the tasks of many speakers at this conference and focused the interests of all participants in the conference over the next two days.

Another significant change occurred a couple of weeks ago when I was appointed as the CEO of the Ontario Power Authority (OPA), an entity that is central to many of the policy changes embodied in Bill 100. I guess I had the perfect excuse to back out of the conference without needing to admit that I was weeks behind in preparing my comments and would not make the organizer's deadlines. However, recognizing the enormous amount of work that Neil Stalport and the people at the Conference Board had completed, I was uncomfortable with that and explored whether to press somebody else from the OEB to speak on the same theme, or whether to talk myself on a theme more relevant to the newly minted status of the OPA. What was decided between Howard Wetston, Neil Stalport and I was something down the middle. No change of topic just a change to the affiliation of the presenter.

I have changed the title slightly by dropping any discussion on administered commodity prices. This topic is covered collaterally, not only here but I expect, in some of the other presentations you will be hearing. However, my focus is on central planning and how it can fit with a competitive market.

I give you the benefit of all this preliminary thinking to avoid any actions against the Conference Board, the OEB or I related to truth-in-advertising. What I have to say will be a disappointment to those of you who expected either a description of OPA or a statement on competition from OEB. This is a think piece from a person who used to be at the OEB and now works at the OPA. So here we go.

Little more than a decade ago many places throughout the world had embarked on what seemed like an unstoppable movement toward replacing a centrally planned monopoly with a competitive market as the vehicle for providing electricity service. Today, it is evident that this movement is, if not stoppable, subject to a major reassessment and a resulting redirection.

The situation might be summed up in the observation that competition is no more a panacea for correcting the imperfections of a centralized monopoly than vice versa. Each works perfectly in theory but practical realities result in neither being the perfect answer. My thesis is that the structure of the electricity sector poses some very fundamental and unique challenges that might best be met by some combination of centralized decision making and decentralized competition.

Let me outline some specific examples by way of illustration.

About 2 years ago, and to the great surprise of many, Alberta made a radical change to its transmission system development policy by adopting central planning as a key ingredient. Prior to that, new transmission projects would get built when a would-be transmission investor saw the required investment as being worthwhile. The business case for investment would be based, in essence, on the level of congestion on the transmission system or anticipated need for system additions.

The investor might take a merchant approach using some form of pay-per-use or might apply to the regulator to have the project added to the provincial transmission assets such that it received payments under a regulated tariff from all users of the provincial system. Since the merchant approach is clearly a more risky business proposition, the main interest was in the regulatory approach.

The application that the regulator would have needed to see in order to make a decision on whether or not to include the proposed project into rate base was essentially one of need and necessity. If the project were to be built would it be both used and useful, a question that is fundamentally no different from that which would need an answer in the business case for an unregulated merchant facility.

The detail of the process for constructing new transmission in Alberta at the time was really a moot point since basically no projects were even close to the point of being implemented. Yet this was at a time when the growth of the Alberta economy was outstripping all of the rest of Canada and probably the rest of the western industrialized world. The electricity supply system was heavily stressed since there had been no significant new investment in generation or transmission for the better part of a decade. Calgary experienced at least one load shedding event related to supply constraints and routine maintenance outages for generators were being deferred and rescheduled in the eleventh hour almost as a matter of routine.

Much needed new investment by a large and sufficient number of ready investors was not happening due, in great measure, to two critical factors.

Firstly, a lack of clarity on how transmission development would take place and, in particular, the role that constraint pricing would play in the longer term. In Alberta, generators that are constrained off are not compensated so prospective generation investors faced a significant risk in that their ability to earn on their new investment was influenced by system constraints triggered in the future from investment by others.

Secondly, even if there were a clear-cut mechanism that linked new transmission development to the existence of system constraints, the lead-time for constructing a transmission line was 3 to 4 times longer than for constructing a generation project. The overall result was that a generator would have to demonstrate a transmission need by committing to a project before any commitment could be made to any transmission that might be needed. Then the generator would have to live with constraints for 5 or more years due to the relatively longer lead-time for the transmission project.

The government changed the policy to its present one where the Alberta Electric System Operator (AESO) is responsible for developing a long-range transmission plan that is based on the requirement that transmission constraints will not exist for any generator under normal circumstances. To paraphrase the Minister of the day, "It makes no sense to hold up large investments in generation due to a lack of smaller investments in transmission." Since this policy effectively results in transmission being built ahead of generation, it was necessary for electricity users to pay the entire transmission cost, replacing the previous policy that intended to share the cost between loads and generators. While this resulted in a backlash from electricity consumers, it did have the very positive effect of clarifying that transmission investments were for the benefit of consumers and any benefits to generators were secondary.

The transmission plan in Alberta will therefore act as an invisible hand guiding the type and location of generation that is built under purely competitive conditions. In effect, through directly planning transmission development, Alberta indirectly controls new investment in generation.

Ontario, too has reintroduced a central planning function in its new electricity structure. As for Alberta, this resulted from the lack of investment in new generation. The specifics are quite different and I won't go into those today since I see from the conference agenda that other speakers will. But the bottom line was clear - the competitive structure in place would not attract sufficient investment in new generation.

Unlike in Alberta, a separate entity, the OPA, has been established to undertake that planning since in Ontario both transmission and generation will be planned centrally. Let me underline that point because it is of critical importance - central planning of the electricity system in Alberta is confined to the transmission system whereas in Ontario it will cover both transmission and generation.

The need to separate the planning function from the market operator, the IESO in Ontario, results from two factors. Firstly, Ontario has adopted a policy of providing revenue support to specific generation projects in order to ensure that the quantity, type and location of generation are appropriate. This is different to Alberta where no such support mechanism exists and all investment in new generation carries full market risk. The projects involved will of course be identified in Ontario's planning process and will directly impact market prices and market behaviour. To preserve the option for a truly competitive market that ultimately does not require revenue support for investors, it is vitally important that the market operator be seen as completely disinterested in prices and not at all involved in the process of creating winners and losers.

Secondly, Ontario's market is not as mature as Alberta's as evidenced by the heavy reliance Ontario places on the spot market. Unlike Ontario, Alberta has a respectable volume of longer term bilateral contracting and a small but growing availability of standardized futures contracts trading anonymously on privately owned and operated exchanges. Alberta has also instituted a system that ensures that the requirements of default customers - those customers who are not supplied by a competitive retailer - are procured through a portfolio of wholesale contracts that include longer-term contracts.

Ontario's emphasis on the spot market would exaggerate any effect that the market operator might have or be perceived to have in influencing prices were the IESO to be charged with

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the long term system planning responsibility. At such time as Ontario's market matures so that a relatively small proportion of transactions are in the spot market - perhaps as low as 5-10% as in Scandinavia - it will be feasible to combine long-range system planning with market operation. Such a low percentage not only reduces the influence of spot market prices on the effective prices seen by generators and consumers but it also implies that Ontario will no longer be in a position of having to provide revenue support to ensure adequate investment in new generation. Without the need to provide revenue support, the importance and relevance of generation planning declines and Ontario could be in a position like Alberta where long range planning covers transmission only.

Both of these examples outline how central planning has been introduced into a competitive system to stimulate investment in generation. It is interesting to consider why such intervention was needed in these two competitive electricity markets when other types of commodity markets, most notably the natural gas market, clearly operate with little or no central coordination.

The key probably lies in electricity's "just-in-time" characteristic. Since it cannot be stored, production must exactly equal supply on an instantaneous basis. Achieving that balance makes a central coordinator necessary and since dispatch is on the basis of relative price, that central coordinator needs to consider relative prices. The most effective and reliable way of "discovering" prices is to run an exchange - a place where buyers and sellers arrange transactions without knowing their counterparties. But while electricity markets began with these centralized exchanges, all other commodity markets developed in the exact opposite direction.

Natural gas, for example, was originally bought and sold on a purely bilateral basis. This resulted in a marketplace that was limited by who knew who and so brokers established themselves, basically to introduce buyers and sellers to each other. The brokers found that many potential transactions failed due to a mismatch between the size of sale a producer wanted to make and the size of purchase a consumer wanted to make. Brokers therefore started arranging multilateral transactions whereby the aggregate requirements of several buyers matched the size of sale that a single producer wanted to make - or vice versa.

The ability to arrange multilateral transactions became limited due to the different creditworthiness of the parties and their different appetites for credit risk. To overcome this, brokers required all parties using their brokerage to post security, which meant that buyers and sellers no longer needed to know each other. With the ability to trade anonymously, buyers and sellers sought out those brokerages that had the largest volume of trading opportunities. They also sought out the brokerages that maximized the trading opportunities for each dollar of security they had posted - in short, the brokerages that had the most effective settlement and risk management systems. Brokers saw the value in adopting a standardized contract since it gave buyers and sellers the greatest flexibility in comparing prices and improved market liquidity by simplifying - in fact removing - any potential confusion about contract terms.

All this culminated in the establishment of exchanges - a place where standardized contracts can be bought and sold anonymously and where liquidity is maximized through minimizing both the transaction cost and amount of capital tied up in security deposits. In the natural gas market, the exchange is the culmination of marketplace development and its existence indicates market maturity. That is, a central exchange operates on a platform of brokerages, settlement arrangements and credit pass-throughs which provides a sound basis for all the diverse contract arrangements that a multitude of buyers and sellers need but which a single exchange cannot provide. The same is true for other types of commodity markets but not for electricity.

In the case of electricity, the physics of the commodity mandates the existence of a centralized marketplace so it gets established first. Not only does the underlying market infrastructure not immediately exist, but its development can be impeded by the dominance of the mandatory exchange. While electricity markets do develop to a level of maturity for a reliably functioning commodity market, we should recognize that this process is essentially backwards to traditional markets and therefore very much a unique feature of electricity. That being the case, we should perhaps not be surprised to find interventions such as central planning mixed in with competitive markets in the case of electricity. I think the analogy is weak but I do observe that walking backwards requires more planning than walking forwards.

So, electricity markets develop differently and introducing some central planning is becoming seen as an important element in guiding that development. An official system development plan provides a target or guideline against which investors can make their decisions with greater confidence than would be possible in the absence of a plan. In effect, the plan provides some boundaries that limit the range of possible risks that have to be considered by an investor. At the very least, Ontario's power system development plan will ultimately result in the construction of new generation which will add some measure of liquidity to the competitive market and advance it along the path to greater maturity.

I'd like to point out another anomaly of electricity markets compared to other commodity markets. The centralized market is, by design, a market organized for the purposes of developing a dispatch sequence for generators. That is, it has as its focus supply and supplier issues. In contrast, most markets are based on a user perspective. Historically, a wholesale market in some good or service developed to supply an established retail market that involved many retailers. Prior to the existence of that wholesale market, individual retailers would have purchased directly from source suppliers. Limited to small volumes and a large number of transactions, transaction costs were high and scales of economy were difficult to achieve. The new wholesale market allowed producers to access bigger markets and gave retailers access to a wider range of products - all this was spurred on by a reduction in transaction costs.

Contrast this situation to electricity

where virtually all talk about markets revolves around wholesale markets. In electricity, we are preoccupied with generation and supply-side issues and yet, like any other commodity or service, the only fundamental reason the market exists is to meet the needs of users. I said at this conference two years ago that one of the failings of electricity restructuring has been the relatively scant attention that has been paid to the users of electricity and in particular the multitude of small volume consumers who have the dominant political voice. With the benefit of two more years worth of wisdom I will restate that in a less accusatory tone - the more I think about it the more I think that the dominance of supply-side thinking is a natural result of the need for a central market which results directly from the fact that electricity cannot be stored.

However, whatever the reason, it does not change the fact that markets can only operate if they work for buyers and the dominant buyers are the multitude of small consumers in the retail market. Successful market evolution will therefore require our greater attention to the way we serve small volume retail consumers which appear in aggregate in the wholesale market as the biggest single piece of the overall system load that is essential to the existence of any and all suppliers.

One final point I would like to comment on before concluding and that is the dominance of natural gas fired plants in the ranks of newly built generators in electricity systems that are based on a competitive structure. Taking again the two examples of Alberta and Ontario, with only one major exception, virtually all new generation built has been natural gas fired.

This results from the fact that natural gas-fired power generation has the most favorable risk profile from a business perspective. The machinery at the heart of a gas-fired combined cycle or cogeneration plant is standardized and in some cases available virtually from stock in an open market. The finished plant has a relatively small and well defined footprint and, as industrial plants go, has a relatively benign impact on its neighbours and the environment. These features mean that the project development time, and especially the time from financial commitment to first revenue, is shorter than most other types of generating stations. The period during which a plant is under construction is one of the most risky for an investor since cash flow is all negative and the project economics can be affected by changing interest rates, commodity prices and all the other acts of man and God which drive business decisions. Changes in the business context can nonetheless result in the investment being no longer viable. However, since turning back would be an effective declaration of bankruptcy, the investor is stuck in a "good money after bad" situation. Clearly, minimizing the construction time minimizes the exposure to this change-of-context risk and that is where gas fired generating plants shine.

When they do get into operation, gas plants have an operating risk profile that is very manageable. The fuel source is a commodity that is available from a wide range of suppliers through a very mature and liquid market. While its price can be volatile, there are many opportunities to hedge not only its cost but also the cost of its transportation. Particularly with gas-fired plants based on aero-derivative engines, costs for routine maintenance and even forced outages and catastrophic engine failures can be hedged. The engines exist in such large numbers that global fixed-price maintenance contracts are available and lease pools exist which can provide a replacement engine on 24 hours notice in the event of an unexpected major breakdown.

Gas fired plants are therefore probably the least risky type of generator in which to invest since so many of their costs can be locked in and the high risk construction period is relatively short. Furthermore in an electricity market that is dominated by a spot market that pays all bidders the clearing price, the incentive to build lower operating cost generation is dulled. This is especially the case when lower operating costs typically come at the expense of higher capital costs and longer construction times - both of which equate to higher risk. It remains to be seen whether the "pay as bid" spot market design adopted in the UK will affect the type of generation built in the longer term.

I mentioned one major exception in this pattern of building gas-fired plants in Alberta and Ontario. That exception is the coal fired Genesee plant in Alberta that is presently under construction. But looking more closely, it is not a conventional new plant development project but rather the extension of an existing coal fired plant. The mining, transmission, cooling water and all site services already exist, albeit some need expansion. As a result, construction time will be both shorter and more predictable and construction cost will be reduced from the situation were it a greenfield project.

While reliance on gas fired plants may be appropriate for Alberta since gas is an indigenous resource, Ontario is faced with a quite different situation and the government has stated its intent to develop a policy on the long term goal for fuel mix. Investment in nuclear or hydro generation, which involve

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2005 ITC CANADA TRAINING SCHEDULE LEVEL I, II, III

Month	Dates	Course	Location
January			
	17 - 20	Level I	Edmonton
February			
	7 - 10*	Level I	Calgary
	21 - 24*	Level I	Winnipeg
	28 - 3	Level II	Edmonton
March			
	7 - 10*	Level I	Moncton
	21 - 24	Level I	Oshawa
April			
	25 - 28*	Level I	Vancouver
May			
	9 - 12*	Level I	Montreal
	16 - 19*	Level I	London
	30 - 2*	Level II	Moncton
June			
	7 - 10	Level II	Edmonton
	14 - 17	Level III	Burlington
	20 - 23*	Level I	Halifax
July			
	18 - 21*	Level I	Saskatoon
August			
	8 - 11*	Level I	Burlington
	15 - 18*	Level I	Sudbury
	22 - 25*	Level II	Quebec
September			
	12 - 15*	Level I	Windsor
October			
	17 - 21	InfraMation – Las Vegas	
	24 - 27*	Level I	Regina
November			
	7 - 10*	Level I	Moncton
	14 - 17*	Level II	Burlington
	21 - 24*	Level I	Edmonton
December			
	12 - 15*	Level I	Burlington

*** 1/2 day software course in the afternoon of the last day of course**

2005 ITC CANADA TRAINING SCHEDULE APPLICATION COURSES

Month	Dates	Course	Location
January			
	10 - 11	Mechanical	Burlington
	12	Operator	Burlington
	13	Building Science	Burlington
February			
	11	Operator	Calgary
	18	Operator	Burlington
	25	Operator	Winnipeg
	28 - 01	Law Enforcement	Toronto
March			
	4	Operator	Edmonton
	11	Operator	Moncton
April			
	4 - 5	Law Enforcement	Burlington
	7 - 8	Roofing	Mississauga
	12 - 15	Building Science	Burlington
	18	Building Science	Vancouver
	19 - 20	Roofing	Vancouver
	21 - 22	Law Enforcement	Vancouver
	29	Operator	Vancouver
June			
	3	Operator	Moncton
	24	Operator	Halifax
July			
	25 - 26	Electrical	Calgary
	27 - 28	Mechanical	Calgary
August			
	2	Operator	Burlington
	3 - 4	Mechanical	Burlington
	5	Building Science	Burlington
	19	Building Science	Sudbury
September			
	19	Operator	Vancouver
	20 - 21	Mechanical	Vancouver
	22	Building Science	Vancouver
October			
	11	Operator	Burlington
	12 - 13	Electrical	Burlington
	31	Operator	Moncton
November			
	1 - 2	Electrical	Moncton
	3 - 4	Mechanical	Moncton
	25	Operator	Edmonton
	29 - 30	Mechanical	Burlington
December			
	1 - 2	Electrical	Burlington

Infrared Training Center itc

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some of the best performance across all three bottom lines. They typically provide low environmental impact, with reasonable rates (not the cheapest, not the most expensive) and are reliable.

A Sustainable energy supply and market would mean three things:

- Social Goals: These are captured in the price options, economic development opportunities, and low health effects from pollution. Prices were reasonable because they reflected the cost of power, mixing time of day use with special considerations for low income customers.

- Financial Goals: The rates need to be high enough to encourage investment, while low or flexible enough to take the ‘essential service’ nature of energy consumption into account. Too often companies that have tried to invest in the Ontario electricity market can’t make a buck, and their plants sit virtually idle as a result.

- Environmental Goals: Environmental impact is incorporated into costs. Adjust electricity prices for their environmental performance. Low impact, pay more for it. No GHG emissions, pay more for it. Let all rate payers dampen the costs of incorporating environmental externalities, rather than a few enlightened companies willing to buy ‘green’ power.

Near Term Priorities

ENERGY EFFICIENCY

Top of the heap, the first ‘to do’ item regarding a sustainable energy system should be energy efficiency. It hits on all three drivers – reduces customer costs, lowers environmental impact, creates jobs through capital being directed towards efficiency upgrades and retrofits. Energy efficiency programs are the priority.

RENEWABLES

Secondly, renewables should be maxed out. The Ontario government was wise starting a renewables 'Request for Proposals'. The current Renewables RFP will lead to significant price discovery, which will be essential for long term planning. The cost of electricity is not really known in Ontario anymore. We’ve had subsidized power from a variety of old centralized government owned plants for so long we don’t have a clue what the true marginal cost of electricity is in this Province. Knowledge is essential to determining a long term sustainable energy solution for Ontario. Clean renewable energy comes in cheaper than most energy planners thought possible.

A key goal for a sustainable energy system is improved environmental performance. However, how much should the consumer pay for it? The current RFP approach will reveal an idea how much it might cost, however that approach is a bit too open ended. No price range has been provided for bids. So, if all costs are inflated, then the cost for power will be too high.

The private sector needs to build new power where all forms of industry including residential consumers can benefit. Developers need to be making money too with a good 'Return on Investment', however if it's too expensive it won’t serve their needs. Policy makers

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going and to benchmark the facility's energy use against other facilities.

IDENTIFYING OPPORTUNITIES AND PRIORITIZING ENERGY EFFICIENCY INVESTMENTS

Once a consumer understands their energy usage, they can make decisions on what end uses to target in analyzing energy efficiency options. In addition to tools offered by the Energy Star® website, local utilities or energy service companies often provide free or low cost energy audits to identify energy efficiency improvements.

An energy audit will make recommendations on the energy savings measures that can be installed along with the associated savings and payback. Based on this information consumers can prioritize the energy saving options and implement those that make the most sense relative to their budget and operations.

Facility energy assessments and auditing services can help consumers identify the share of equipment consuming and implement verifiable energy and project cost saving measures.

Some businesses may find that they may be able to shift some of their electricity use to off-peak hours to take advantage of lower off-peak rates while continuing to operate their business at optimal levels. Other businesses may need to make energy efficiency investments that reduce their electricity use around the clock, particularly if it is difficult for them to shift their electricity use away from periods of high customer traffic, production, or other work activities.

GENERAL TIPS TO REDUCE YOUR FACILITY'S ELECTRICITY COSTS

Effective energy conservation will vary according to the specific C&I consumer. In addition to installing more efficient equipment, a number of basic energy management options are available to help control energy costs. A first place to start is the lighting and HVAC systems. From simple lighting occupancy sensors and setback thermostats to more complex energy management systems controls, after understanding where the energy dollars are going a facility manager can use these controls to better manage energy consumption. When buying new equipment, consumers should seek out equipment endorsed by the Energy Star® program. The Energy Star® brand is only available on high-efficiency equipment.

Robert Ziemer is a Senior Consultant for KEMA Inc. with over fifteen years experience in energy efficiency. He can be reached at rziemer@kema-xenergy.com. **ET**

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will push back, saying clean energy is too expensive, and we should return to large centralized power plants which might leave the Ontario coal plants in operation.

How Can This Sustainable Energy Vision Happen?

THE RIGHT PRICE SIGNAL

Next RFP – set a price cap, with environmental premium's included, and learn from the results. BC Hydro based theirs on the long run marginal cost of gas fired generation, and became swamped with small hydro and biomass energy (all rated low environmental impact). Prices were under $55/MWh. It was low impact meaning renewables with high social value in that they were located in economically depressed rural communities.

The current Renewables RFP gives the government all environmental value (emissions credits plus green value) and offers the proponents 25% of the value if it is ever cashed in by the government. This is simply not the way to reward good environmental performance. Especially not in a world of emissions trading, green tag trading and renewable portfolio standards.

In Alberta, the provincial government went out into the market to find a long term power purchase agreement with renewable energy making up a portion of it. They ended up meeting almost all their needs with renewables because it came in at a fraction of the cost they had anticipated. Compared to the price spikes associated with gas-fired generation, renewable energy can be an attractive option.

Alternatively, for clean green power to be brought on line, you need to set a province-wide renewable portfolio standard that all discos must meet (including Hydro One, where they are the provider). Allow them to pass the associated rate premium through to customers. Discos would need to be allowed to conduct their own renewable energy tenders, and possibly wheel power within their own jurisdiction without paying Hydro One charges.

Another option is to wait for the federal government's Kyoto regulation treatment for renewables to come to pass. Currently they are looking at a performance target-based emissions credit for renewable generation. This would work by establishing a volume, say 200 tonnes per GWh as the emissions credit delivered to eligible facilities. The value of the credit to the developer would depend on the value of GHG tonnes on the market. If it's $10 per tonne, you could sell your credits and earn 2000 bucks per GWh.

'DISCO' LIVES

Distribution companies (Discos) need to be given more control over their destiny. If you have witnessed the success of EPCOR and ENMAX from Alberta, you really can appreciate how a Disco, when empowered, can deliver great value for its rate payers. Toronto Hydro, Hydro Ottawa, Enersource, Hamilton Hydro, these are all large organizations residing close to their customer base. They understand what's available as distributed power in their area, and what cogeneration opportunities are going begging. Let them loose! They need to keep up their 'consent to operate' with their rate payers.

Discos should be given a renewable energy portfolio standard. They need to meet 50% of their demand growth through renewable energy. On top of that, they are allowed to pass through the extra costs associated with it in the rates they charge. If they can't meet their targets, they are permitted to purchase 'green tags' from Discos that have gone above and beyond their RPS target. This form of trading would help keep the costs down, while we still met Ontario's long term sustainable energy needs. This concept has even been tried for energy efficiency and might be a worthy idea for Ontario to consider. Italy has instituted a system of 'Tradeable Energy Efficiency Certificates' for its gas and electricity distributors. They each are allocated an annual Demand Side Management (DSM) target. Those that go beyond it have a surplus of 'negawatts' to sell, and it's the opposite for those below their target. The laggards can purchase surplus negawatts from Discos that have gone above and beyond the call of duty. This provides a profit incentive to do lots and lots of boring energy efficiency. Each Disco is given a demand side management target, say meeting 10% of new load through DSM. If the first city can't meet its target this year, however the second city scored a big load reduction, then it could sell its surplus negawatt certificates to the first city.

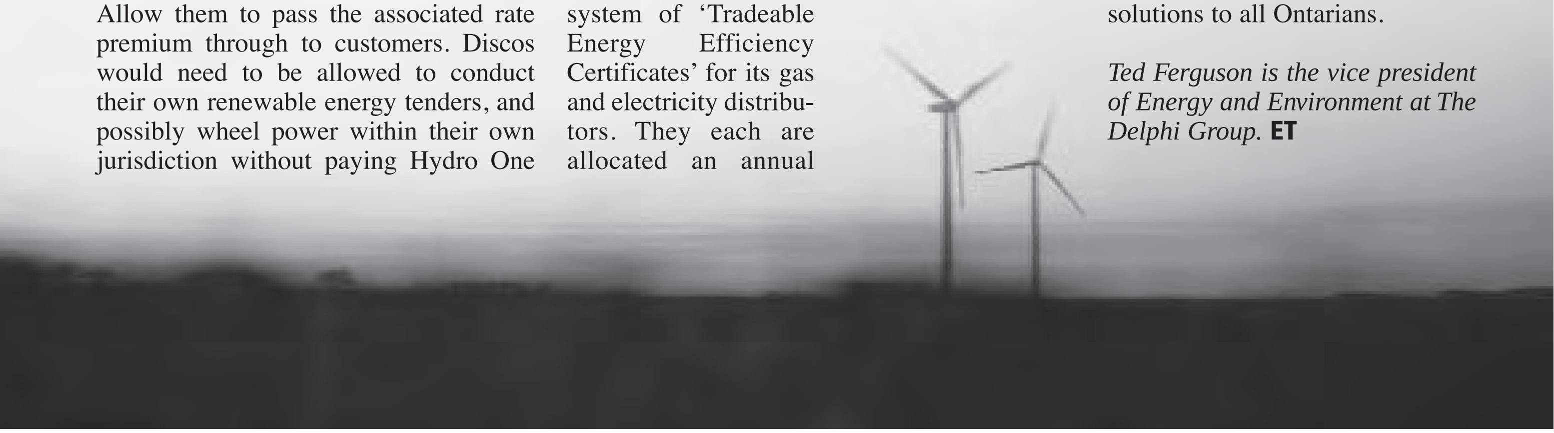
What's The Next Step?

Currently, in terms of long term energy planning, Ontario's electricity system is a rare breed, a unique animal when comparing it to the rest of the provinces. Some of the unique features include: no monopoly utility, a small overworked group in the Ministry of Energy running several large groundbreaking RFPs, relatively large Discos with limited operating leeway, and an Independent Market Operator (IMO) and an Ontario Power Authority (OPA) which are trying to understand how to avoid overlapping roles and responsibilities planning for the future of Ontario's electricity system.

Someone clearly needs to be given the mandate to create a long term sustainable energy supply for Ontario's electricity system - one that delivers fair rates, minimal pollution and land-based impacts, and attractive ROIs for investors.

Many people involved in this business in Ontario seem resigned to the fact that the system will never change, and it will always be faulty. Ontario can do better: it has the capital, mind power, bodies, and need for a sustainable electricity system delivering sustainable energy solutions to all Ontarians.

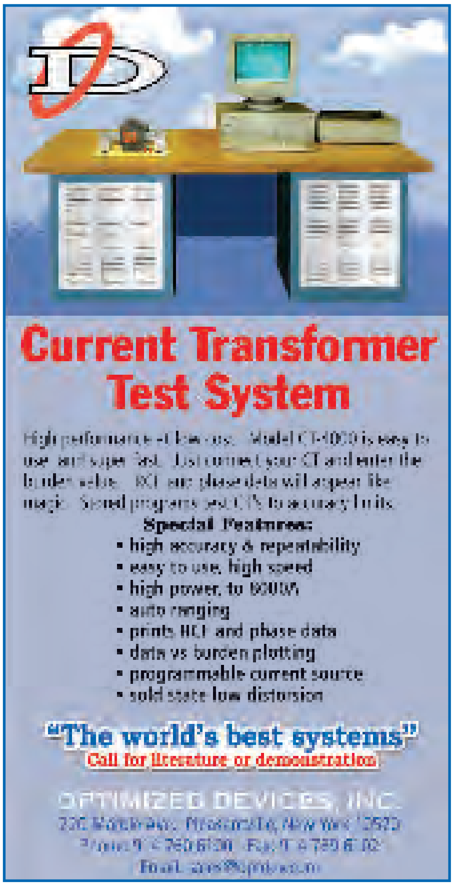
Ted Ferguson is the vice president of Energy and Environment at The Delphi Group. **ET**



TORONTO FORUM ON EFFECTIVELY MANAGING THE MEDIUM VOLTAGE POWER CABLE SYSTEMS

There was a large turnout at the Toronto forum on Effectively Managing Your Medium Voltage Power Cable Systems on January 6 and 7 at the Park Plaza Hotel near the airport. Several speakers passed along their knowledge on how cable systems are designed, and how aging systems are tested and designed. The forum was held by the Electricity Forum, and is just one of many educational and instructional forums held across Canada throughout the year.

Photos by Randy Hurst



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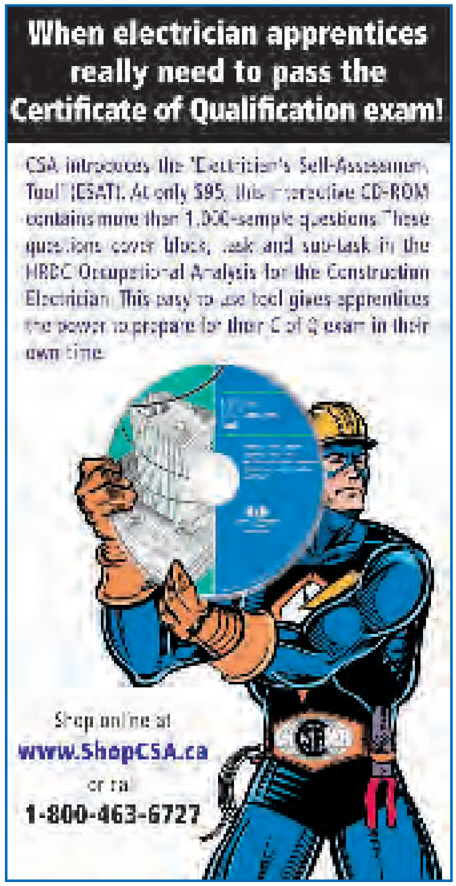

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without the need for an Overland lead. Sometimes a check on each individual neutral to earth with the T810 will indicate an obvious difference on some wires. If this is not successful then a check on the insulation resistance between the individual neutrals and earth will often show that one or two have a much higher resistance than the rest. This will allow a MURRAY Loop location to be carried out on one of the faulty neutral wires or if two neutrals have a high insulation resistance, a HILBORN loop location can be carried out on the line conductor.

IMPORTANT POINTS WHEN CARRYING OUT BRIDGE TESTS

1 After the overland lead has been run out, MEGGER it before connecting it to the cable. If it is faulty it will affect the bridge measurement.
2 Before carrying out a bridge test, check that the loop is continuous. If carrying out a MURRAY loop test, the connection at the far end must be a low resistance connection. If possible, put L and N into a terminal block in the cut out.
3 Connections from bridge to cable and battery to cable must be made with separate cables, otherwise the lead resistance will be included in the cable circuit, where it could have a marked effect on the accuracy of the location.
4 Tails from the main cable to the cut out in a lamp are of much smaller cross section, therefore their effective length is greater than their physical length.
5 If applying a temporary earth to identify a 'TEE' joint, use an AVO, (or other low voltage instrument), to make sure that a low resistance earth exists.

Other Instruments which may be used on street lightning systems:

a) M225 Cable and Pipe Locator – useful where the route of the cable is not known.
b) S5000 AXXIS – for locating Sheath Faults.

John Willis, Applications Engineer, Bicotest. **ET**

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bigger business risks than does gas fired generation, will therefore require either a continuation of revenue support payments or a much more liquid and mature electricity market than we presently have.

The same might also be said for investment in many types of conservation and demand-side management (CDM) initiatives which will become an increasingly important component of Ontario's plans to close the supply-demand gap. While competitive markets and the optionality they provide to customers who are being encouraged to make choices about their energy use can provide appropriate price incentives, they will not necessarily provide sufficient margins to support the additional risks entailed in establishing new technologies for a consumer market which is in its infancy. Ontario's policy is to put CDM and new supply on an equal footing and, until such time as our electricity markets are more mature, this could entail leveling the business risks between them through revenue support payments to CDM as well as to new generation.

I have described how central planning made necessary to stimulate generation investment in an immature electricity market can be a useful tool in enhancing that market. I have also mentioned that central planning is necessary insofar as selected generating and CDM projects are to receive revenue support payments - in effect choosing who gets to participate in the market and how they participate. Clearly then, there is a role for central planning in the Ontario market in the years ahead until at least we are at the point where a mature and liquid electricity market can ensure both an adequate level of investment in new generation and sufficient economic opportunity to support investment in a diversity of types of generation as well as CDM. **ET**

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