No. 24

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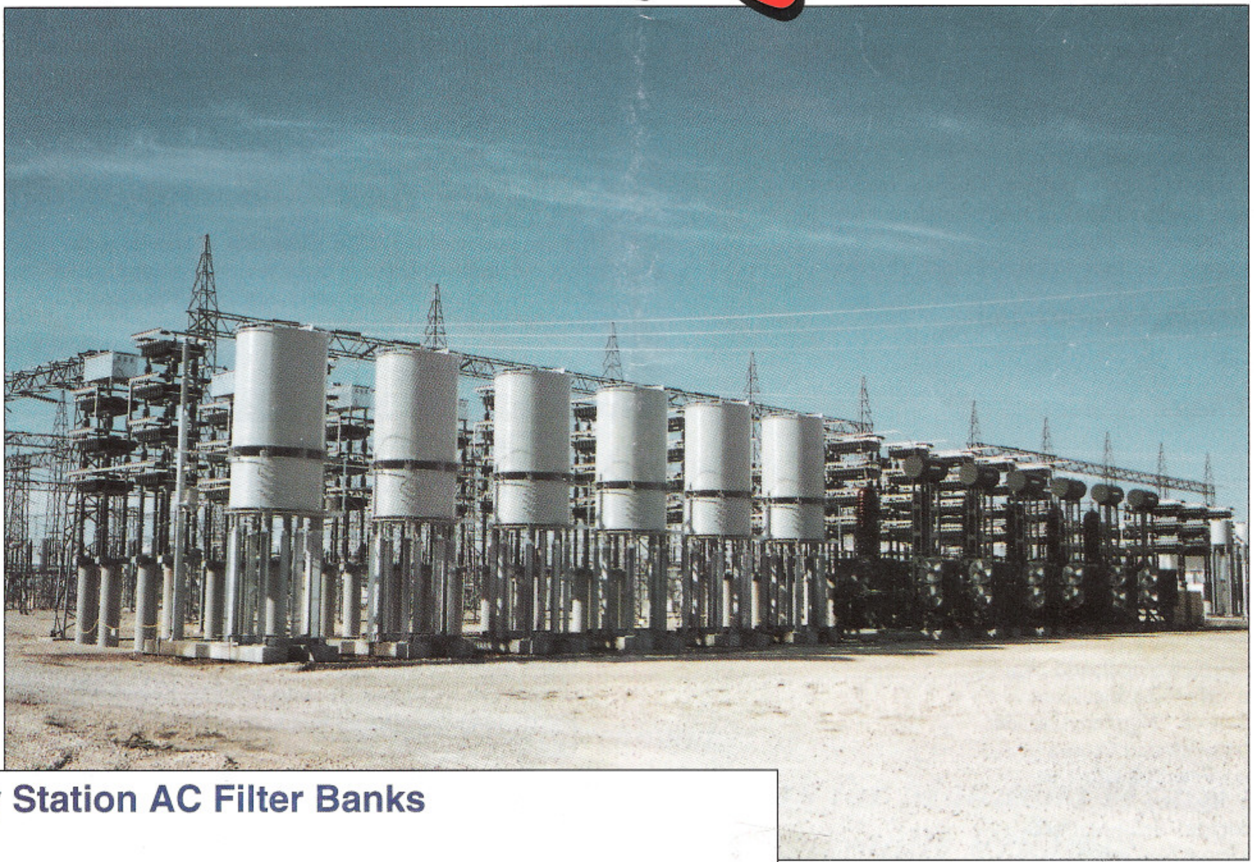
# IEEE Canadian Review



Dorsey Station AC Filter Banks



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# IEEE Canada



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(iii) the associated academic (i.e. universities, colleges, secondary schools), government and business communities in Canada.

To ensure that the ***IEEE Canadian Review*** has the desired breadth and depth, Associate Editors are responsible for identifying issues and screening articles submitted to the ***IEEE Canadian Review*** according to the following general themes :

1- National Affairs
2- International Affairs
3- Industry
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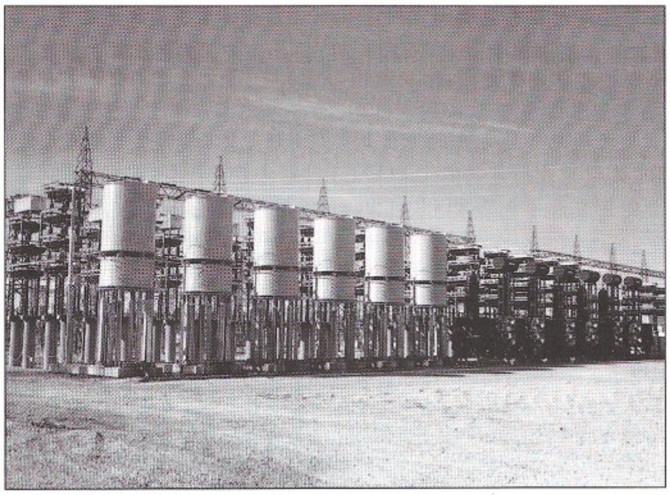
DORSEY STATION, F1 AND F2 AC FILTER BANKS



Left: F1 (11th and 13th harmonic) with Trench air insulated reactors.

Right: F2 (5th and 7th harmonic) with EEC oil filled reactors.

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# DIRECTOR'S REPORT/*RAPPORT DU DIRECTEUR*

## *Linda Weaver*

The field of engineering has always been one that is difficult to describe in general terms. This is becoming even more difficult as the traditional lines between engineering, technology and the basic sciences are becomi less distinct. Compound this with rapidly evolving technologies, dramatic shifts in corporate and government infrastructures, and an unstable economy you have stressed (and cranky) professionals who seem to be working more hours for less pay, and who are receiving less recognition for the work that they do. To survive in this environment, and to recognize and seize opportunities, it is important to find others who understand the problems and are striving to find solutions. This is the strength and the real benefit of the IEEE - not in the "things you can hold", but in the people that you meet and the experiences and knowledge that we share. In the past couple of decades, it seems that IEEE members who have been associated with universities have fostered that environment and built on those strengths through conferences, meetings, and informal get-togethers. Unfortunately, those of us who work primarily in industry seem to be focused mainly on what we "get" for our IEEE membership dollars and in cost-benefit ratios.

It's time for us all to think creatively about what is critical to our achieving success in our chosen fields. Certainly a great deal of our success is based on (1) finding solutions to problems; (2) assessing correctness of solutions; and (3) developing new approaches. With the pace of technological change, it is not often possible to wait for the textbook to be written or the journal to be published so we must learn to access and use our network of professional contacts.

As President of IEEE Canada for 1996-97, my priority is to foster the development of an infrastructure to support professional networking and sharing of experiences and information. This can be achieved by improving communications to and between IEEE Canada members through electronic media (email, www, forums) and other mechanisms. Initally the focus will be in sorting through and cleaning up administrative problems within the IEEE infrastructure (billing, mailing addresses, membership database issues, headquarters responses, etc.). There is a substantial effort at all levels of the IEEE Corporate and volunteer structures to get problems in these areas sorted out, and significant progress has been made.

I welcome any comments or direction from members. Please feel free to contact me at l.weaver@ieee.ca or by phone or fax at (902) 434-2484.

Le monde le d'ingénierie a toujours été difficile à décrire en termes simples. Ceci est d'autant plus vrai aujourd'hui que les frontières entre l'ingénierie, la technologie et les sciences fondamentales perdent de plus en plus de leur netteté. Ajoutons à cela l'évolution rapide de la technologie, le changement radical de l'organisation des compagnies et des gouvernements, une conjoncture économique défvcorable, et nous avons affaire à des professionnels stressés (et revêches) pour qui les journées de travail allongent, le salaire diminue, et dont les réalisations reçoivent moins d'appréciation.

Pour survivre à ces profondes transformations, pour reconnaître et saisir les occasions qui se présentent, il est important de repérer les personnes qui ont compris le sérieux de la situation et qui s'efforcent d'y remédier. C'est là que réside la force de l'IEEE et l'avantage d'en être membre, non pas comme soutien matériel, mais par son réseau de relations que vous fréquentez de même que les expériences et les connaissances que vous y échangez. Depuis une vingtaine d'années, il me semble que les membres de l'IEEE associés à des universités ont favorisé leur développement professionnel en resserrant leurs relations et en participant à des conférences, des réunions ou des rencontres informelles. Malheureusement, certains d'entre nous qui travaillent surtout dans l'industrie paraissent ne rechercher que des avantages monnayables ou, en d'autres mots, un bon rapport coûts/bénéfices de leur adhésion à l'IEEE.

Il est temps que nous fassions preuve de créativité pour découvrir ce qui est indispensable à notre succès dans nos propres champs d'activité. Évidemment, le succès tient beaucoup (1) à la recherche de solutions, (2) à la justesse des solutions et (3) à l'élaboration de nouvelles approches. Étant donné la rapidité des changements technologiques, les documents ou les publications qui pourraient nous renseigner arrivent souvent trop tard. Il nous faut donc nous insérer dans notre réseau professionnel et apprendre à en tirer parti.

À titre de présidente de l'IEEE 1996-1997, j'ai mis la priorité sur le développement d'une infrastructure de réseautage professionnel et de partage d'expériences et d'informations. Ainsi, on pourrait améliorer l'information aux membres et les communications entre les membres de l'IEEE Canada au moyen de médias électroniques (courrier électronique, www, forums), entre autres. Commençons par identifier et solutionner les problèmes administratifs au sein de l'IEEE (facturation, liste d'envoi, base de données de l'information des membres, communications avec le bureau principal, etc). À cet égard, nous avons fait des efforts à tous les niveaux, y compris de la part de membres qui se sont portés volontaires dans ce dossier, et nous avons connu un réel progrès.

Je saurais gré aux membres qu'ils me fassent parvenir leurs commentaires et suggestions. J'apprécierais que vous communiquiez avec moi par courrier électronique à l.weaver@ieee.ca, par téléphone ou par fax au (902)434-2484.

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# Competition, Convergence, and Customer Choice - Finding New Paths to the Customer

*by Rod Taylor, Vice President, Corporate Strategies and Sustainable Development, Ontario Hydro.*

In the fall of 1995, the Ontario government established the Advisory Committee on Competition in Ontario's Electricity System, which is to report on matters of competition, regulation and ownership on April 30, 1996. In January 1996, Ontario Hydro's management submitted to the Committee its proposal for industry restructuring. Three drivers calling for change are competition, convergence facilitated by technological change, and customer choice. Key elements of Hydro's proposed response to these drivers are opening generation to competition, creating an independent Central Market Operator, rationalizing the wires businesses and allowing all retail customers to purchase electricity from generators and/or a spot market.

A l'automne 1995, le gouvernement de l'Ontario a établi un Comité consultatif sur la Concurrence dans le système d'électricité de l'Ontario; celui-ci doit rapporter le 30 avril 1996 tout ce qui touche la concurrence, la réglementation et la propriété. En janvier 1996, la direction de OH a soumis au Comité, sa proposition pour la restructuration industrielle. Cette proposition représente une partie du changement continu au sein de OH et de l'industrie. Trois forces exigeant un changement sont la concurrence, la convergence facilitée par le changement technologique et le choix du consommateur. Les éléments clé proposés par Hydro et répondant à ces forces sont l'ouverture de la génération électrique à la concurrence, la création d'un Opérateur central de marché indépendant, la rationalisation des circuits d'affaires et la possibilité à tous les consommateurs au détail de se procurer l'électri cité par l'intermédiaire des générateurs ou des marchés spécifiques.

Ontario's electricity system consists of Ontario Hydro (OH) as a monopoly supplier of electricity to 306 independent municipal utility wholesalers, to about 950,000 retail customers not in municipal utility franchise areas, and to about 100 large industrial customers. OH generates about 90% of all Ontario's electricity needs; the remainder is supplied by non-utility generators (who sell to OH), customers who self-generate (and whose surpluses may be sold to OH), and several small independent utilities. Interconnections to neighbouring jurisdictions (about 4,000 MW total capacity) provide additional supply opportunities. OH currently sells about 130 TWh of energy per year, with a peak demand of about 24,000 MW.

## WHY RESTRUCTURE?

Late in 1992, OH recognized the need to change due to a decrease in sales since 1989; a large capacity surplus expected to last until the end of the decade; rapid increases in the price of its product; and dissatisfied customers. Since 1993, OH has not increased electricity rates, has reduced staff levels by 25%, reduced annual operating costs and maintenance by $600M, reduced its debt from $35B to $33B and reduced in-service generation capacity by about 3,000 MW. However, a fundamental restructuring of the industry is needed to respond to the drivers and provide Ontario customers with competitive energy services.

There are three key drivers of change operating on the industry. One is the development of competition. A second is technological change in both the generation and end-use of electricity, which is accelerating both competition and the convergence of electricity with other forms of services to homes and businesses, whether wired, wireless, or piped. The third is the advent of increasing demand for customer choice.

The key drivers of change will inevitably bring changes to the structure of the electricity industry in Ontario. As stewards of Ontario's $45 billion investment in electricity infrastructure, OH's management advocates a responsible transition to the most likely future.

### Competition

The generation of electricity is no longer a natural monopoly structure requiring mega-plants, heavy capital investment, long lead times, and centralized and sophisticated technological know-how. Competition is not a future threat to the monopoly structure: it is already here. Efficiency improvements in combustion turbine units, combined with low fossil fuel prices, mean that customers and independent third party generators can make electricity at rates competitive with, or better than, large centralized fossil and nuclear generating stations. Another factor contributing to the increased competition is the development over the past 15 years of huge regional disparities in electricity prices across North America. With increased global competition, and with deregulation already a reality, business customers can no longer afford to have electricity exempt as a competitive input to their cost of doing business.

The existence of large capacity surpluses across North America means that wholesale spot market prices are low. In this economic environment, low-cost producers are anxious to get access to captive high-paying customers and vice versa. Consequently, the obligation to buy from a monopoly utility supplier is under attack, especially from large customers.

### Customer Choice

Industrial customers in jurisdictions with high rates can pursue either self-generation or the right to choose another supplier when rate relief is not forthcoming from their monopoly supplier. Growing pressure for choice is also coming from commercial and residential customers. Choice imposes the discipline and accountability of the market on electricity suppliers.

But choice is not seen solely as a driver of improved efficiency. The right to choose, not to be captive to a single supplier no matter how efficient, is valued by consumers as an end in itself. The consumer desire for choice is a new phenomenon in the electricity business, but is well known in other industrial sectors where monopolies were once the rule (see Figure 1).

There is not only growing consumer demand for choice, there is also growing consumer demand for choices. Consumers want a wider range of products and services, including different rates and ways of billing (unbundling of products and services) at competitive prices. Many residential and small business consumers would prefer to see simple and understandable packages of rates and services, while some have expressed frustration at what they see as a baffling array of choices in long-distance telephone services for example. But indications are that very few of them would prefer to return to the monopoly world where what most people want everybody gets.

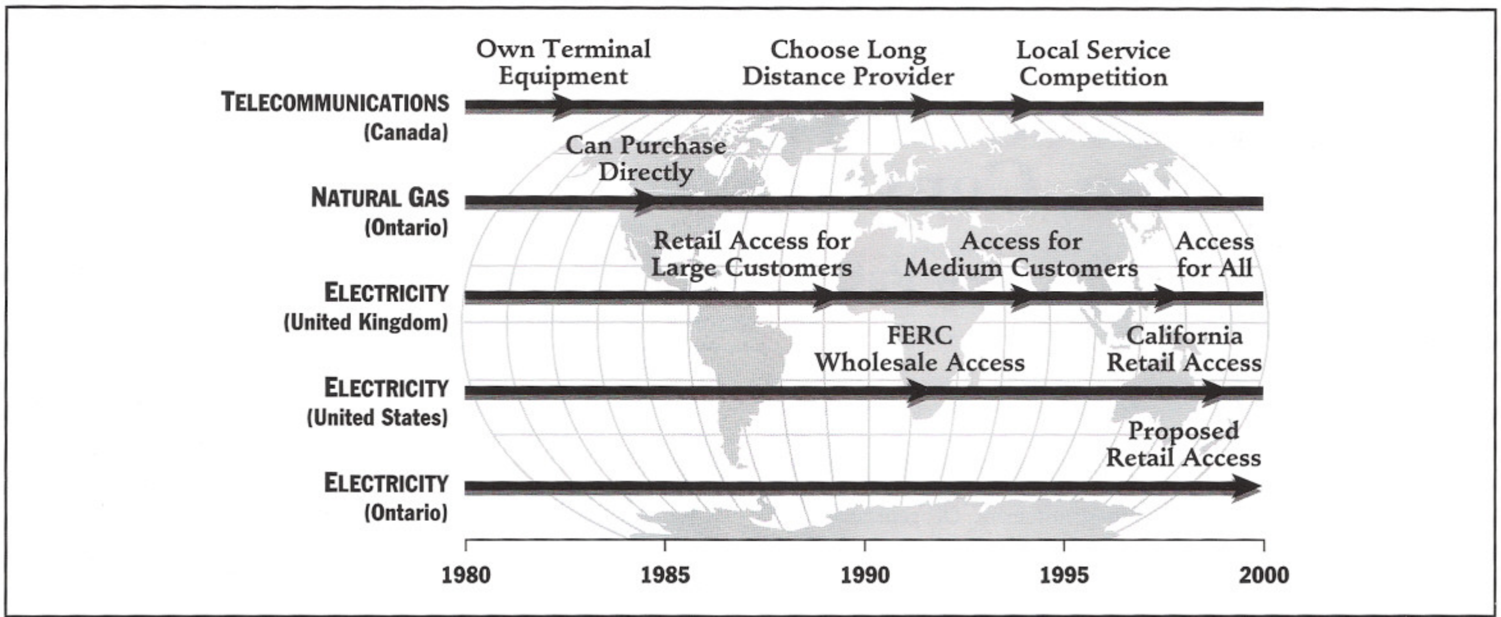


**Figure 1: Evolution of Competion/Customer Choice in Utility Industries**

### *Convergence*

The convergence of electricity with other industries is a force already apparent, although not yet pervasive, in some markets. Convergence refers to "crossover" developments in previously distinct industries, technologies, and markets. In the past, there were separate suppliers of, and uses for, services such as electricity, natural gas, telecommunications and home computers and information systems. Increasingly, these services can be substituted for, or combined with each other - for example home computers with "smart" meters to control lighting and appliances, and monitor home security. Similarly, natural gas can add value to an energy utility because it can be stored to fuel generators to meet peak loads.

Companies meeting customers' needs by innovatively combining two or three different kinds of supplied services will be attractive to tomorrow's customers. This will require far more flexible forms of regulation (natural gas, electricity, and telecommunications are now regulated separately) and will require more flexible structures for the electricity industry, so that the resources of in power infrastructure can be leveraged to effectively serve the future needs of Ontario's homes and businesses.

## *OVERALL OBJECTIVE OF RESTRUCTURING*

Hydro's management sees the objective of restructuring as managing the impacts of the driving forces of change on our industry by introducing appropriate changes in the structure of the electricity industry, its regulation, and its ownership so that Ontario and its electricity customers will benefit. If Ontario no longer has competitive prices in a North American market, it risks losing jobs.

## *INDUSTRY RESTRUCTURING (refer to Figure 2)*

Hydro's management proposes that in the year 2000 any Ontario electricity customer can directly purchase electricity from any supplier inside or outside the Province and/or from a spot market in electricity into which any generator could bid. Customers could use agents to make purchases on their behalf. The spot market is essential for guaranteeing universally accessible market access for generators, and serving as a visible market window on where the market price for electricity is moving.

Customers not wanting to shop the market for electricity supplies would automatically join a not-for-profit Price Averaging Pool (PAP) which would provide electricity on various averaged-priced or real-time bases for its members. This would be a second path, distinct from the direct purchase path. Customers choosing the PAP would not have the responsibility of arranging their electricity supplies. The PAP would ensure averaged pricing for any member who wishes to join.

Like competing agents, PAP would buy electricity from the spot market, and also shop the market to get the best deal for its members. In order to avoid the risk of making power purchase commitments for customers who choose to leave the pool, the PAP could require its members to commit to a minimum membership period. The PAP could also offer members services such as energy management.

Agents, regulated through licences, would be free to contract with electricity consumers for purchases of electricity and/or energy services. They would form competition for the PAP.

Independent and utility generators inside and outside of Ontario would be permitted to sell by bid into the Ontario spot market, and to pursue sales agreements with any customer(s) in Ontario. The price of electricity would not be regulated.

Restructuring would make a clear distinction between the regulated monopoly elements of the industry (such as the wires) and the competitive elements (such as sales, energy services, and generation).

A new company could be formed as a regulated common carrier, the "Wiresco". Its assets would comprise the publicly owned transmission and distribution wires systems in the province. This new wires company would be a share-capital structured company, owned by those who have contributed its assets. This ownership structure would not preclude privatization at some later date. Some regional disaggregation of this system into several units would likely be introduced to facilitate administrative and operational efficiency, particularly for distribution.

OH's retail utilities and the municipalities currently owning utilities would no longer individually own discrete wires businesses, but would own shares in the Wiresco. With the introduction of retail access, they would no longer own a geographically-defined customer franchise. The Municipal Electric Utilities (MEUs) could compete with other agents and the PAP as buyers and sellers of electricity and as providers of electricity services to customers.

Charges for sending electricity across the wires infrastructure would be regulated and be distinct from the charges for electricity. The "wires" tariffs for this common carrier function would be regulated through a form of incentive regulation to drive efficiency.

The new industry structure would see the establishment of an independent Central Market Operator (CMO) under separate ownership from that of the Wiresco, the generators and retail suppliers. The CMO is envisioned to be a Crown entity. Its governance and rules of operation to ensure fairness and competition would include the involvement of an advisory body comprising representatives of generators, retail suppliers, customers groups, and the Wiresco.

The CMO would be responsible for soliciting and receiving bids from generators, and for the overall running of the spot market for electricity. It would administer settlements of market trading, manage integrated system security, and dispatch generation.

Retaining a CMO maintains the operating efficiency of Ontario's electricity infrastructure, and helps promote a reliable electricity system through centralized integration and control. It makes for better efficiency if the agent which dispatches generation into the wires is also the agent which has the market information on generator bids for price and volume.

A number of transition steps would be taken in the period 1996-2000 to support retail competition in the year 2000, including restructuring OH into a multi-business holding company structure to oversee the transition to direct retail open access. There will be competition in energy to supply the Ontario power pool. The CMO, PAP and Wiresco will be established. Rates for all customers will be capped, and the PAP will exercise some pricing flexibility to minimize short-term threats of stranded costs from industrial cogeneration.

## *Retail Access for all Customers is Required by the Key Drivers*

Direct retail access will inevitably be required by consumers of electricity services. Retail access initiatives in electricity services are gaining momentum in other jurisdictions such as in natural gas.

Direct retail access will drive efficiencies which will, in turn, result in ratepayer benefit. Retail access is the friendliest model to convergence and competition, and is the only one that embodies real customer choice. The provision of the voluntary PAP accommodates those customers who wish to retain their current way of receiving and paying for electrical services.

Steps to the advent of retail competition include defining roles and rules so that customers and suppliers understand how competition will work, establishing new entities, passing new legislation, and putting in place the technology and infrastructure to access spot market prices.

## *The Implications of a Retail Access Structure*

The fundamental change from a cost-based monopoly structure to a price-based market structure carries with it an acceptance that all electricity customers in North America will be exposed to similar potential price risks and benefits.

Under a competitive market structure, individual advantages would show up in customers' ability to manage risks through hedging or contracts with suppliers. Responsibility for what they pay for electricity would fall on customers' own judgements about markets.

Such a change means giving up cost-based rates defined by political jurisdictions. Where that jurisdiction has particular advantages, such as lower cost supplies of power, the benefits will no longer necessarily accrue to all customers within its boundaries. Instead, customers across Ontario could have responsibility for striking their own competitive advantages by buying shrewdly. But the change for customers means gaining control and accountability, and being able to incent suppliers to better serve their needs.

# *REGULATORY RESTRUCTURING*

In the emerging competitive market there is less need for detailed direct price regulation. Regulatory oversight of the marketplace would ensure fairness and equitability.

There are three key regulatory problems that must be addressed in moving to a competitive open market. Self-dealing is a potential problem if Hydro-owned generators are competing to supply a Hydro-operated spot market and where transmission constraints on a Hydro-owned wires grid could advantage some generators to the disadvantage of others. Market power is a potential concern if Hydro continues to own the vast majority of generators supplying Ontario's needs. Stranding of costs, while not strictly a regulatory problem, is a potential problem whose remedy will likely involve action by the regulator. The problem occurs if assets funded by debt guaranteed by the Province cannot recover their embedded costs at competitive market prices. The regulator might have to determine which costs are legitimately stranded, and impose inescapable charges on customers/suppliers to ensure that the stranding does not occur, and that the debt does not have to be picked up by the taxpayer

The mere structural isolation of the CMO function under Hydro ownership would not be sufficient to safeguard regulatory concerns about self-dealing. Accordingly, Hydro's management proposes that in a new industry structure, the CMO function be divested and wholly independent of Hydro and any other market participant.

Market power concerns would be much ameliorated if markets in North America were to open across jurisdictional and geographic boundaries. Hydro management believes that North American markets will evolve in this direction. Accordingly, the pressure to split up the ownership of generation solely for Ontario market power concerns must be weighed against retaining larger blocks of generation sized to compete effectively in a North American market.

The stranding of costs remains a concern, but would diminish after the year 2000 if spot market prices increase as the market surplus declines. Where there is a potential for stranding costs, the regulator could impose charges on all customers, or the government could impose a stranding tax. In any event, stranding is a problem only of transition in the move from a protected monopoly to a competitive market situation. Once assets are sold to private investors, or the stranded costs are covered through some time-limited regulatory charge, the issue disappears.

In the proposed new structure, the primary regulatory function will ensure that real competition is happening by discouraging anti-competitive dominant market positions.

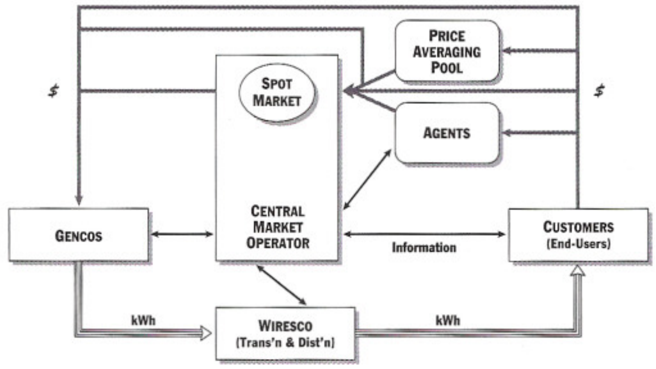


**Figure 2: Industry Restructuring**

Regulation will be needed to ensure a level playing field for competitors, for example, in the assessment of the siting of new facilities. Safety and environmental regulation will be required to ensure safe and sustainable operations. But such regulation might not take the form of "command and control". For example, tradable emissions caps and other market mechanisms could be introduced.

Tariffs for delivery of electricity over the wires, a natural monopoly component, would be regulated through price caps or some other form of regulation that would drive efficiency and innovation. Since the wires would be common carriers for all suppliers, equal access and comparability of tariffs within regions would be key regulatory issues.

In addition to these structural elements, the entry of many new players into the electricity industry will require that technical standards to safeguard safety and operational efficiency be in place for all sectors. Brokers and agents would have to be licensed to standards of training and competence.

## *RESTRUCTURING AND OWNERSHIP*

Trends toward greater competitive behaviour (such as involving electricity, gas, water, and other utility companies) will put new requirements on future electricity suppliers.

Because introducing new ownership helps facilitate the development of competition and because competition in the industry will happen first in the generation sector, Hydro's management believes it is in this sector where privatization can most beneficially begin.

The transfer of generation assets to the private sector should follow definition of the industry structure, and associated regulatory and market rules. The exact configuration of the entities that are candidates for privatization requires further consideration and depends on the objectives to be achieved. The definition of objectives, and therefore the choice of divestment strategy, belongs to government.

Because Ontario's existing generation infrastructure has been built over the years to be synergistic and not competitive, the issue of how to best configure them for competition is complex. To face a North American market, they might best remain integrated. Privatization would then mean selling in tranches the shares in the integrated Genco.

### *Change of Ownership*

It is also possible to privatize the wires assets. However, the wires business would be a regulated common carrier under the new structure, and would benefit less from privatization, being a true monopoly. Furthermore, the wires businesses would be newly formed under a combined new public ownership and rationalized for efficiency. It would make sense to allow that new structure to be up and operating before considering privatizing.

### *Implications for Ontario Hydro's Structure*

OH should be restructured into a multi-business holding company structure to oversee the transition to direct retail access. The structure would have separate subsidiaries for the generating companies, the Price Averaging Pool, the wires business, and the Central Market Operator.

OH's corporate efforts will continue to focus on the efficient and reliable operation of the electricity industry during the transition, and to ensure that the transition can be smoothly effected.

A multi-business structure permits setting up the new businesses, and divesting businesses to separate private or public ownership as appropriate.

## *About the author*

Rod Taylor is Vice-President, Corporate Strategies and Sustainable Development at Ontario Hydro. His responsibilities include developing corporate strategies for Ontario Hydro and Providing leadership and direction in areas of the environment and sustainable energy development.

Mr. Taylor attended the University of Toronto where he earned an Honours Bachelor of Arts Degree (1975) and a Master of Arts Degree (1977). He has also completed the Harvard/MIT "Program on Negotiation for Senior Management".

Since joining Ontario Hydro in 1989, he has held various positions in Corporate Relations and Communications and with the Executive Office, where he was Director from 1989 to 1993. Mr. Taylor was Director, Corporate Strategic Planning from 1993 until his appointment to his current position in 1995.

From 1991 to 1995, Mr. Taylor served as Ontario Hydro's representative to the E7, an association of the world's eight largest utilities.

### *IEEE CANADA ACTIVITIES/NEWS*

#### *Central Canada Council*

Central Canada Council of IEEE Canada held a special meeting to celebrate the 50th anniversary of the London, Ontario section on October 21, 1995. Dr. Ray Findlay, President of IEEE Canada presented a banner to John Dixon, the Chairman of London Section, one of the members of the London Section at a dinner meeting at London for the achievements of the Section and their contributions to the Electrotechnology.

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Registration for Members (IEEE, IEE, OSA, SPIE, CAP)* and Non-members include one banquet ticket and admittance to the conference proceedings. All registrants have access to all sessions and exhibits and to the free services offered at the conference. Fees are payable in Canadian dollars. (One US dollar is equivalent to approximately 1.37 Canadian dollars.) Canadian residents must add 14% GST and QST.

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Extra Banquet Tickets: $65, and extra Conference Proceedings: $90

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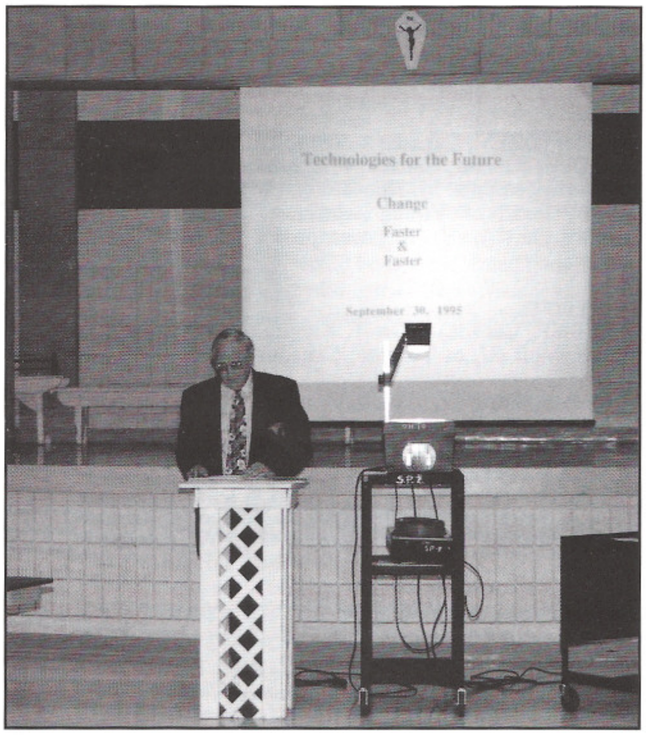
*IEEE CANADA ACTIVITIES/NEWS*

***Peterborough Section***

The Peterborough Section of IEEE Canada hosted a fall Conference entitled "Pushing the Technical Frontiers" on September 30, 1995. This was the first attempt by the section to host a public conference. The purpose of the event was to provide a forum for business groups/companies to come together and share information regarding new projects, products and developments. The event provided a technical history of the Peterborough area and a showcase of the community's achievements. IEEE Canada's contributions to technology and industry worldwide were highlighted through excellent media coverage ty the press, on radio and TV News.

The conference included eight presentations and twelve displays by local companies which covered a wide range of Peterborough's technical and academic institutions. Central to the event was a topical dialogue on Peterborough Year 2000 which was moderated by Dr. Ray Findlay, President of IEEE Canada. Among the participants were Peter Adams, M.P., Roy Wood, representing the Mayor of Peterborough and Russ Woodland, CEO of ORTECH.

The conference attendees were very impressed by the quality of the presentations and exhibits.




# A few words from the Managing Editor

*By Vijay K. Sood*
*Managing Editor*

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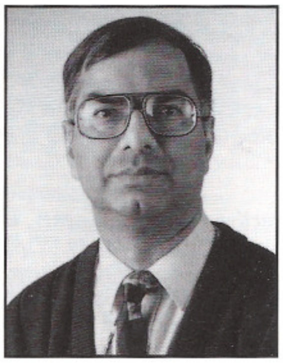


It is with apprehension that I take over the helm at the IEEE Canadian Review magazine for the next two years from Paul Freedman who has been running the show for the past two years. It is customary to write a few kind words for the outgoing Managing Editor. I can indeed write that Paul has been instrumental in bringing the IEEE Canadian Review to prominance. I only hope that I can manage to keep the ball rolling. It is indeed fortunate for me that Paul has agreed to stay on as an Associate Editor until I can find my bearings. I have a lot to learn and look forward to his aid.

It would also be in order for me to thank Francine Riel at CRIM, Gerard Dunphy at Newfoundland and Labrador Hydro, and Ray Lowry at Intera Information Technologies for their considerable efforts in producing the magazine.

I have as my assistant Eileen Dornier from IREQ, who agreed to help without knowing fully what she was getting into! Eileen took a crash course on the editing software, and came through with flying colors.

Je tiens à remercier M. Marc Hung, Directeur Vice-président Technologie et IREQ, ainsi que M. Alain Vallée, Chef de service, Simulation de réseaux pour leur support dans cette aventure.

I would also like to introduce Mr. Joe Mariconda (LaserMike) and Mme Bruni. Sanso (Ecole Polytechnique, Montreal) as the two new Associate Editors. I thank both of them for replying to the <<Call for Associate Editors>>. I hope that they will find the experience rewarding enough. For those of you who would like to consider contributing as Authors, please do get in touch with any one of us; our addresses are inside the front cover. We will be calling our contacts near and far to provide us with articles of topical interest.

The focus of the magazine will remain to showcase technical articles about Canadian success stories and products. If you have comments or suggestions, please write or email me. I will be pleased to hear from you.

Happy reading!

# Air Core Filter Reactors for Manitoba Hydro's System: - The Environmentally Friendly Solution

*by Richard F. Dudley, Walter Cimino, Haefely Trench*
*Masarrat Naqvi, Manitoba Hydro*

The oil immersed filter reactors employed in Bipole 1 of Manitoba Hydro's HVDC link are being replaced by dry air core filter reactors for both environmental and economic reasons. The general design and construction features of the new air core filter reactors are presented in this paper.

Les inductances à bain d'huile des filtres utilisés au 1er bipole du réseau CCHT de Manitoba Hydro sont en train d'd'être remplacées par des inductances à noyau d'air pour des raisons écologiques et économiques. Les caractéristiques générales de conception et de construction des nouvellles inductances à noyau d'air de filtres sont décrits dans cet article.

Manitoba Hydro's High Voltage DC (HVDC) link from the hydro electric generation in Northern Manitoba to the city of Winnipeg, 900 km. to the south, consists of two bipoles constructed at various periods to reach the present day capacity. Not only does this pioneering HVDC link provide electrical energy to the metropolis of Winnipeg, Manitoba, but power is also sold to the Northern States Power Company in Minnesota as well as to the neighbouring provinces of Saskatchewan and Ontario. The first stage, called Bipole 1, started in the late 1960's and completed in the early 1970's used the then state-of the-art technology consisting of mercury arc valves and oil immersed filter and smoothing reactors. The second stage, called Bipole 2, started in the early 1970's and completed in the mid 1980's used thysistor valves and dry type air core filter reactor technology. Since the experience with these dry type air core filter reactors has been excellent for the nearly 20 years that they have been in service, Manitoba Hydro decided to employ dry type air core reactor technology when replacing the oil immersed filter reactors that were included in Bipole 1.

### *Environmental Concerns with Oil Immersed Filter Reactors*

Most of the immersed filter reactors employed in Bipole 1 are now more than 25 years old and have a theoretical life expectancy of 35 years. Based on a number of factors, Manitoba Hydro has decided to replace these units for the following reasons:

1) Oil leaks at the bushing and tank interface, which had been a problem throughout the service life of these reactors, had become more of a concern in recent years. Not only did this problem impact availability and maintenance costs but there were significant concerns regarding the environmental impact associated with oil leaks. Today, oil catch basins must be utilized with oil immersed equipment.
2) In the extremely cold winters of Manitoba, the oil immersed filter reactors experienced operational problems.
3) In the existing installation, capacitors containing PCBs were mounted on racks just behind the reactors. In case of fire this was both a safety and an environmental concern and had the risk of high clean-up costs. When the required fire protection with water deluge system required for the oil reactors was taken into consideration, an additional cost was incurred.

### *The Dry Type Air Core Filter Reactor Solution*

After a detailed evaluation it was decided to utilize dry type air core filter reactors to replace the oil immersed units originally supplied. Some of the important considerations were as follows:

1) Dry type, air core reactors were lower cost than oil immersed iron-core units.
2) The dry type, air core reactors fit into the same space as the oil immersed units. In fact, the dry type, aircore reactors are essentially the same height as the oil immersed units, if one includes the height of the bushing, and they occupy slightly less real estate area. This is aptly illustrated in the photograph in Figure 1 (on the cover page of this issue of IEEE Canadian Review) which shows the installed 11th and 13th harmonic dry type air core filter reactors and the 5th and 7th harmonic oil immersed filter reactors located adjacently.
3) The dry type, air core reactors had none of the environmental concerns mentioned earlier. There is no fire hazard and no oil catch basin is required. There are no ground contamination concerns such as would exist should a leak occur in an oil immersed reactor.
4) Dry type, air core reactors can be supplied with a built-in inductance tapping system with sufficient accuracy to meet all tolerance r
5) With dry-type, air core reactors separate de-Q'ing resistors may not be required. Air core reactors for 6th and 12th harmonic dc filters have de-Q'ing rings. De-Q'ing rings were not used for all reactor designs. Cost, overall dimensions and overhead clearance were factors that impacted this evaluation as all reactors had to be fitted into the existing space allocations.
6) Dry-type, air core reactors are virtually maintenance free.

### *General Design and Construction Features of Dry-Type Air-Core Filter Reactors*

In order to achieve an optimized cost, HVDC dry type, air core filter reactors are custom engineered and manufactured. The major construction features and auxiliary components of a dry-type filter reactor are illustrated in Figure 2. Auxiliary components and support structure configuration are determined by the performance specification and installation requirements. The most important general features as well as the use of add-on elements to meet specific project needs are described below.

The winding of the reactor consists of multiple, cylindrically shaped, epoxy impregnated fiberglass encapsulated winding groups (packages), consisting of either one layer of insulated aluminum cable or several parallel layers of insulated wire, and all electrically connected in parallel by welding their ends to metallic beam structures (spiders).

- The number of packages and their respective turns are selected based on current and inductance requirements.
- The concentric parallel windings are configured such that radial voltage stress is virtually nil and the remaining axial voltage stress results in surface stress values that are far less than those on porcelain insulators and conductor to conductor steady state operating voltages that are well below the level at which partial discharge can occur.
- The packages are radially separated by uniform circumferentially spaced fiberglass reinforced 'ductsticks' which form vertical air ducts for natural convective cooling of the windings.
- Both the top and bottom spider are clamped together by several sets of fiberglass ties located along the winding. The spiders are held, by the ties, against fiberglass reinforced winding end supports, which provide the mechanical link and the electrical isolation between spider arms and the end turns of the winding.
- Typically filter reactors are mounted on a number of support insulators and may include specifically engineered metallic or composite support elements to provide additional clearance under the reactor (for example, snow clearance to the insulators).
- Foundations for dry type reactors are simple reinforced concrete slabs without any special oil catch basins.
- Since the materials in dry type reactors do not support combustion, special fire control precautions such as deluge systems are not required.

### *Design Considerations*

The ac and dc filter reactors were an engineering challenge due to the space restrictions, the severe climate of Manitoba and a combination of technical ratings and features required by Manitoba Hydro. The 6th and 12th harmonic dc filter reactors (Figure 3) are used to illustrate some of the more interesting features and design challenges for dry type air core filter reactors. These reactors rated at 1550 kV BIL, are unique in that they employ a tap section with extremely tight tolerances, and a de-Q'ing ring section to provide damping (and eliminating the need for a separately mounted resistor).

### *Tapping of Filter Reactors*

Assuming stable power frequency conditions, the highest possible efficiency of HVDC filters (e.g. minimization of harmonic distortion and telephone influence factors) is achieved by tuning the filter circuits as precisely as possible. Therefore it is common practice to provide HVDC filter reactors with taps, to allow optimum field tuning of the filter circuits during commissioning. In the case of the 6th and 12th harmonic dc filter reactors, an inductance variation with a total range of 6% in steps of 0.5% was required, plus tolerance taps. Input and output of the reactor was fixed by the use of a special tap changing device.

### *De-Q'ing of Filter Reactors*

A filter is basically a resonant circuit. The damping of a resonant circuit, consisting of a reactor and a capacitor, is governed by the resistive component of the reactor, which is expressed by the reactor's Q-factor. The Q-factor is the ratio of reactive power to active power in the reactor. Typical Q-factors of filter reactors over the harmonic frequency range are between 50 and 200.
In some cases filter applications require a Q-factor which is very much lower than the natural Q of the reactor. This has often been achieved by connecting a resistor in the circuit; typically in series or in parallel with the reactor.

In the mid 1970's the use of special de-Q'ing spiders was developed. For the 11th and 13th harmonic filter reactors supplied as part of Bipole 2 in 1976 the design employed spiders with 64 spokes at each end of the reactor resulting in the Q-factor at the 11th harmonic being reduced from 500 to 100. In the early 1990's a more economic alternative was developed, and today's de-Q'ing ring technology is more flexible than the spider based system and is capable of reducing the Q factor of a reactor by as much as 10 times. A spare 11th/13th harmonic filter reactor for Bipole 2 was supplied with this system in 1993.

The de-Q'ing ring system comprises a single or several coaxially arranged short circuited rings which couple with the main field of the reactor. The induced currents in the rings dissipate energy in the rings and thus lower the Q-factor of the reactor.

Because of the high energy dissipated in the rings they are constructed to have a very large surface to volume ratio in order to dissipate the heat and are therefore constructed of thin tall sheets of stainless steel. Cooling is provided by thermal radiation and by natural convection of the surrounding air, which enters between the sheets at the bottom end of the de-Q'ing ring system and exits at its top end. The stainless steel material used for the rings may be loaded up to approximately 300°C without altering its technical properties. Furthermore the variation of resistance with temperature is negligible.

The physical dimensions of the sheets, their number and location with respect to the winding are chosen to give the desired Q-factor at the appropriate frequency. Usually the sheets are mounted above the top of the upper spider as shown in Figures 2 and 3 but other arrangements such as mounting below the lower spider or outside the coil might sometimes be more appropriate in order to meet the Q and loss requirements. Depending upon the layout of the de-Q'ing rings and the technical parameters of the filter reactor (BIL, voltage drop, power rating, etc.) loss ratings of the de-Q'ing ring system up to 150 kW are feasible.

Figure 4 shows the Q-factor versus frequency characteristic for the dry-type air core filter reactor used in the 6th harmonic dc filter. The natural Q-factor of the reactor at 360 Hz was about 210 and the required Q of the filter at 360 Hz was to be about 120. The plot compares the Q-characteristic for the reactor alone, the reactor with a series resistor and the reactor with a de-Q'ing ring system. As can be seen the Q-characteristic for the reactor equipped with a de-Q'ing'ring system is very similar to that of the reactor connected in series with a resistor.

The advantages of a de-Q'ing ring system versus a separate resistor are:

- The de-Q'ing ring system has no BIL rating requirement,
- No additional components are required (the De-Q'ing'ring system is an integral part of the reactor),
- Less space is required than for a reactor plus a resistor,
- No mounting structure is required,
- No electrical connection circuitry is required,
- The system is more reliable than that of a reactor with a separate resistor.
- The system is more economical than the combination of a reactor with a resistor in parallel or in series (within a specified range).

## *INSTALLATION CONSIDERATIONS AND EXPERIENCE*

One of the major requirements on this project was that the reactors had to be installed during very narrow opportunity windows of time so as not to interrupt the service requirements of this very important dc link. Air core reactors again, because of their ease of installation, were the technology of choice. Air core reactors provided the following advantages:

1) Air core reactors could be delivered to the site and stored, with no special precautions.
2) Simple construction equipment is required for the installation of

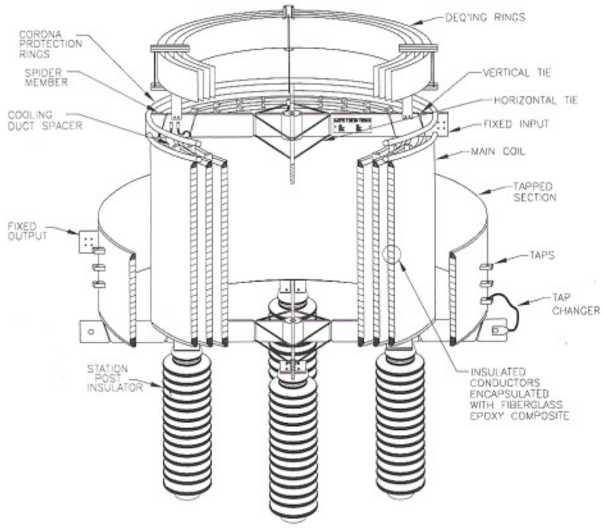



**Figure 2: Dorsey Station, AC Filter Banks**

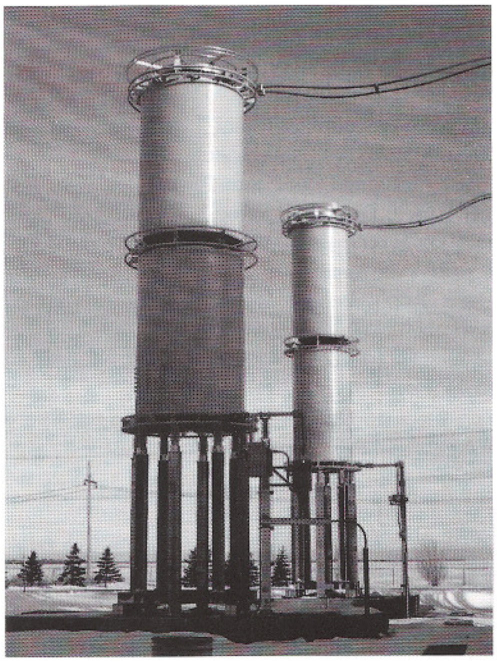


**Figure 3: Pole, 6th and 12th harmonic filter reactors**

dry type air core reactors. An overhead crane is required to lift the unit in place and simple tools are required. No special commissioning requirements, de-gassing requirements, etc. are needed for dry type, air core reactors.

3) Simple support structures were utilized to mount the air core reactors, providing snow clearance and personnel protection. Care had to be taken in the design of the structures to eliminate electromagnetically coupled losses and the associated thermal effects. Lattice framework or structural loops could not be used.

4) Since air core reactors were lighter than the existing oil filled units, no new foundations were needed. Existing foundations were adequate and were used with minor modifications. Because of the height of the support structures used for the dry-type air core reactors, no special considerations had to be employed in terms of the rebar design in the existing foundations.

## *FUTURE TRENDS*

Since the early 1970's dry type air core reactors have been used for HVDC filter reactor applications. Today the dry type air core reactor solution is the technology of choice and was selected by Manitoba Hydro to replace its oil immersed filter reactors. In fact, because of the many advantages associated with dry type air core reactor technology, smoothing reactors for HVDC projects are now also based on this approach.

**Acknowledgements**: The photographs of the installation were provided by Alan Forrest of Teshmont.

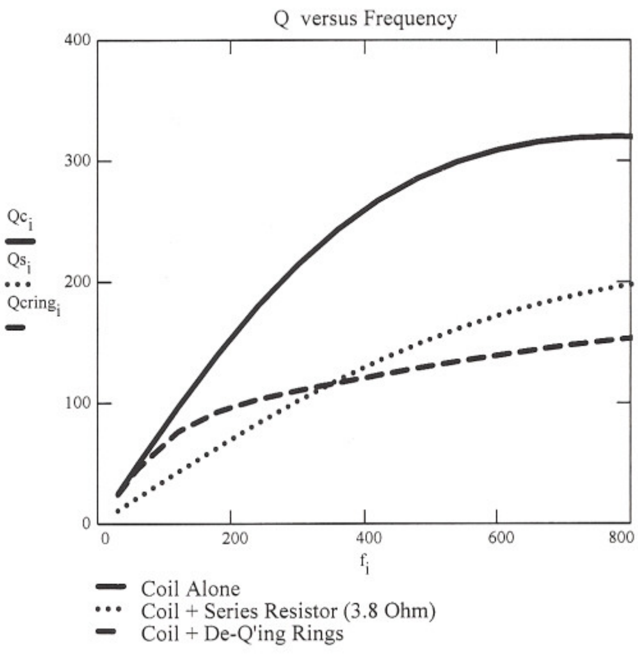
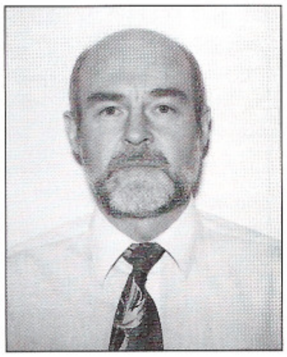
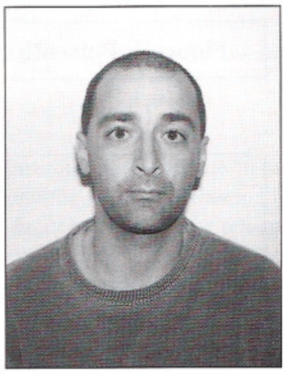



**Figure 4: Q versus frequency characteristic**

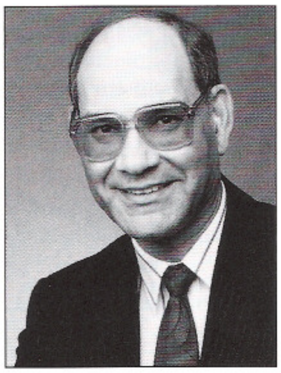
## *About the authors*



Richard F. Dudley was born in Winnipeg, Manitoba, Canada on November 10, 1943. He received his B.A.Sc. and M.A.Sc. in Electrical Engineering from the University of Toronto in 1968 and 1970 respectively. In September 1972 he joined the R&D Department of Trench Electric in Toronto, Canada. In 1977 he assumed the position of Manager of Research and Special Product Engineering. Since 1982 he has been Chief Engineer of Haefely Trench Coil Products Division. He is a member of the IEEE and the IEEE Transformers Committee where he is chairman of the Dry Type Reactor Working Group. He holds a number of patents and published numerous technical papers.



Walter Cimino was born in Toronto, Ontario, Canada in 1957. He graduated from the Electrical Engineering Technology Program at Ryerson Polytechnic Institute in Toronto, in 1982. He has been employed in the reactor design engineering group of Haefely Trench since 1988. As a Senior Designer/Project Coordinator for the Shunt and Filter reactor engineering group.



Masarrat Naqvi was born in India on October 28, 1937. He received B.Sc. (E.E.) degree from University of Dacca, Bangladesh in 1961, M.Sc. (E.E.) degree and Post Graduate Certificate in Management in 1970 and 1983 respectively from the University of Manitoba, Winnipeg, Canada.

He worked with Winnipeg Hydro from 1962 to 1973 as a Design and Planning Engineer Engineer, and from 1974 he is with Manitoba Hydro where presently his position is HVDC Projects Engineer.

# Real-time Operating System

*by Jeffrey George*

Unlike desktop software applications (word Processing, spreadsheets, etc.), software-based systems in manufacturing, medical instrumentation, and telecommunications require 'real-time' operating system sup-port. In this article, we examine the key features of performance, reliability, and 'configurability', and then describe one such real-time operating system, QNX.

Par rapport aux logiciels de nature 'bureautique' (traitement de texte, chiffrier, etc.), les applications logicielles en usine, en instrumentation médicale ou encore en télécommunications, exigent un soutien "temps-réel" de la part de leur système d'exploitation. Dans cet article, on identifiera les éléments essentiels, soient la performance, la fiabilité et la "configurabilité" et par la suite, on passera en revue un des systèmes d'exploitation temps-réel, QNX.

Today's advances in automation demand a lot from an operating system (OS). Whether it's the seemingly mundane task of selling fast food or the time-critical reality of monitoring nuclear power plants, an OS must offer everything from deterministic scheduling and robust file storage to protected-mode computing and network fault tolerance. Many of these features aren't found in "desktop" operating systems from Microsoft (e.g. DOS, Windows) and Apple (e.g. MacOS), or even in Unix. As a result, "real-time" operating systems such as QNX have become the backbone of today's Intel-based real-time solutions. In this article, we look at how these operating systems -- and the QNX OS, in particular -- form a key part of reliable engineering solutions.

### *Real-Time Operating Systems and Process Control*

In most factory automation and process control systems, you will find three main functional components. The first is data collection. The amount of data collected varies greatly with the application; in some larger projects it may be thousands of data points. This data can represent temperatures, valve positions, pump pressures, and a host of other parameters.

Often used for quality assurance, these values not only help monitor and control the manufacturing equipment but also ensure the integrity of the process. Take semiconductor manufacturing, for example, where the process control system must track any microscopic impurities and variances that could mean the difference between usable and useless product.

Because this data is often used for post-production analysis, it is essential that the OS can reliably collect the data from all its sources and store that data permanently. This requires a file system that is both fast and robust.

The second main function of most control systems is to respond to alarm conditions and take action. This is where prioritized "pre-emptive" computing comes in. The concept is simple. First, the "kernel", which is the heart of the real-time OS, associates different priorities with the various software "processes" that perform the application's functions. Then, if an alarm condition occurs, the kernel suspends whichever lower-priority process is currently running in order to run a higher-priority process that will immediately handle the alarm. Of course, the key to doing this successfully is a kernel that requires little overhead to perform "context switching" among computing processes. For an example of a preemptive system, consider a kidney-dialysis instrument that controls blood pumps, temperature, chemical mixtures, and sensors. As blood is drawn from the patient, cleansed, and returned, it's critical that no air bubbles form. If bubbles do form, the instrument's air-detection software process must immediately preempt any other process in order to shut off pumps that return blood to the patient.

While collecting and processing data, the process control system must also perform its third main function: controlling the various steps of the process itself. The function often relies upon a number of cooperating sub systems that must share information. As a result, real-time operating systems often provide message-passing mechanisms of varying complexity (mailboxes, FIFO queues, etc.). Message passing provides both a convenient method for interprocess communication (data exchange) as well as a synchronization (semaphoring) mechanism for scheduling computing processes.

### *A closer look at QNX*

QNX Software Systems Ltd. has been a technological leader in the real-time OS marketplace since 1980. Its main product, QNX, has become the OS of choice for X86-based real-time applications thanks to features such as prioritized preemptive multiprocessing, message-passing for interprocess communication, built-in fault-tolerant networking, power-failsafe data storage, and distributed processing.

The last two items deserve special attention. Many operating systems use caching systems to gain performance, and, as a result, can lose data and file-system integrity if the application is powered down in an uncontrolled fashion. Recognizing that some data may be expendable and some not, QNX's filesystem can determine what data must be immediately written to the archive medium (e.g. hard disk, flash memory) and what can be cached. In either case, the filesystem will maintain its integrity through uncontrolled power down.

As for distributed processing, QNX's message passing is integrated into its networking, making it easy to move from a single-processor solution to a multi-processor solution. Whether two software processes exchange messages on the same node or across the network, the code is exactly the same. So, for example, if data acquisition and control become more complex, you can easily distribute the increased processing load across any number of processors, without modifying your application.

Finally, note that QNX follows the POSIX standards of the IEEE. (POSIX stands for Portable Operating System Interface). Consisting of a number of working groups, each dealing with a separate area of computing, the POSIX document defines a consistent OS interface so that applications written for one POSIX-compliant system can be easily moved to another POSIX-compliant system. Up to now, only a few of the working groups have finalized their portions of the document, which is standardized by ANSI and ISO. QNX is currently certified for POSIX 1003.1, which defines a standard way for an application to obtain basic OS services.

POSIX clearly intends to define only the "external characteristics" of an OS. As a result, various POSIX systems may look and behave in much the same way on the surface, while their performance and architecture differ dramatically.

### *QNX's "microkernel" architecture*

Over the years we've seen a number of trends come and go in software architecture. One technique that remains -- whether in the design of an OS or an application -- is modularity. In the case of QNX, modularity means that the operating system is separated into discrete components, each with a well-defined interface. These components communicate with each other via a message-based form of interprocess communication.

At its lowest level, QNX consists of a microkernel that manages a core set of OS services; see Figure 1. The small (about 10K) microkernel provides three essential services:

- local and network-wide interprocess communication (IPC)
- process scheduling
- interrupt dispatching

All other OS services are handled by optional resource managers--this is the key to QNX's extensibility.

The main idea behind a microkernel architecture is to provide essential services in a small core of code, then build all the higher-level functionality of the environment around that core. As a result, the OS can be scaled down to create resource-constrained solutions for austere environments or scaled up to create full-featured workstation-class applications. In all cases, the OS is never larger than necessary.

Apart from size, a microkernel architecture should exhibit high performance by minimizing layering and resource contention. In QNX, applications stay close to the hardware for performance, yet still operate in a protected address space.

In QNX, all resource managers, whether supplied in-house or written by application developers, are purely optional. Furthermore, resource managers are just like any other user-level process -- the only difference is that resource managers provide a standard, controlled interface to devices or other processes. This lack of differentiation yields an interesting benefit: resource managers execute in user space and therefore can be debugged using the full suite of QNX debugging tools (symbolic debugger, execution profiler, etc.).

Since QNX resource managers don't have to be bound into the OS, they can be started and stopped dynamically. For example, let's say you are at a workstation that doesn't usually require a filesystem and want to transfer some data via a floppy to another machine. You simply start up the filesystem manager, then copy the data. Once the data has been copied to disk, the filesystem manager can be removed to reclaim its resources.

### *Off-the-shelf resource managers*

As a fully functional OS, QNX offers a variety of resource managers to aid application developers in their system design. In comparison, many real-time executives leave the creation of resource managers to the developer.

### *Filesystem managers*

QNX offers not one but several filesystem managers so the developer can strike the right balance of cost, size, and functionality. These include:

POSIX Filesystem -- Provides full POSIX 1003.1 and UNIX semantics in a multithreaded, power-failsafe manner. The filesystem's disk drivers, which support most commercially available PC hardware, deliver virtually platter-speed performance.

DOS Filesystem -- Allows any QNX program on any node of the QNX network to transparently create, read, write, and delete files that reside on DOS disks.

Embedded Filesystem -- Lets you manage an embedded filesystem on a solid-state disk. Supports various flash memory devices, including PCMCIA flash cards; the Intel 386 EX Evaluation Board; and a variety of other single-board computers and solid-state disks.

### *Network manager*

QNX's network manager, Net, provides networking by merging all the microkernels on the LAN into a single kernel. As a result, any process can transparently access all resources on the LAN--from disks to modems to data acquisition ports.

Net also supports multiple network links per machine. This provides two major benefits:

- fault-tolerance--If one network link fails, QNX automatically re-routes the data through the other networks
- greater throughput--QNX performs automatic load-balancing across the multiple network links.

The QNX network drivers deliver virtually the full bandwidth of the hardware to the application. Currently, QNX supports drivers for Ethernet, Arcnet, FDDI, Token Ring, and ATM.

These drivers include the Net.fd module, which makes it easy to turn any "openable" service in the system into a full-function network link. For example, you can connect two machines via an RS-232 link and have them behave as a network.

The newest version of Net also offers built-in network bridging. With this facility, any node on a network can talk to any node on another network--transparently. Which means you can connect effortlessly to other networks, whether they're across the street or across the country.

To provide connectivity to other systems, QNX offers a high-performance implementation of TCP/IP that includes a full suite of utilities (ftp, telnet, rsh, etc.), NFS (Network File System), RPC (Remote Procedure Calls), and client-side SNMP (Simple Networking Management Protocol).

### *Device manager*

QNX's device manager is a high-throughput, low-overhead server that provides the interface between all process and terminal devices. It features an architecturally lean design that can support 115 Kbaud, even on slower 386 processors. It also includes drivers for consoles, keyboards, touchscreens, as well as serial and parallel devices. Since some developers need to write their own drivers for character-based devices, QNX Software Systems provides the source for the serial and parallel drivers.

### *Opening a window to your applications*

QNX's remarkable flexibility extends to its rich selection of windowing environments, which fit everything from memory-constrained embedded systems to high-end workstations.

### *Photon microGUI*

For low-end systems, the Photon microGUI, (a microkernel-based windowing system) allows even the smallest X86-based product to support a high-performance graphical user interface (GUI). In fact, with QNX and Photon one can create an embedded application that includes a full- featured GUI, a real-time POSIX operating environment, and complete PC hardware support (input devices, networking, etc.) in under 1MB of RAM or ROM; see Figure 2.

In addition to its small size, Photon offers seamless connectivity to other windowing systems. From Microsoft Windows (NT, 95, or 3.1), X, or OS/2, you can open a window to a Photon application, even through a modem. Which means you could sit at home on your Windows desktop, dial into the plant floor, and interact with the Photon application running there. And best of all, you don't have to recompile or relink your application to make this happen. The connectivity is built right in.

Photon also provides "jump gates" that let you transport live applications from one Photon desktop to another -- ideal for work sharing.

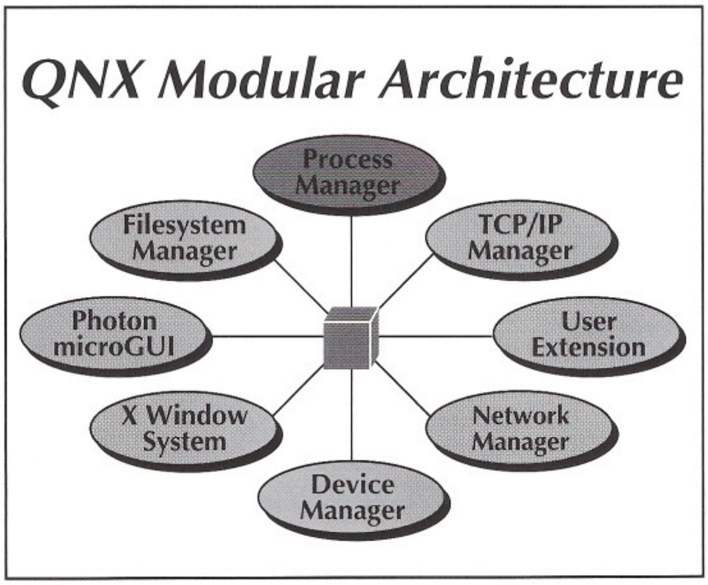



**Figure 1: QNS's microkernel architecture**

Support technicians can also go through a jump gate to "be" at a remote user's workspace and provide hands-on support. The Photon environment is so transparent that you can even drag applications from screen to screen or stretch a single application across multiple screens.

### *X Window System*

As the standard open-systems GUI environment, X offers a rich functionality set more suited for high-end PC workstations. With QNX, X not only provides the connectivity and sophisticated graphics that it's known for, but also takes on a real-time dimension. The X for QNX server and libraries form an integral part of the QNX real-time environment, readily delivering over 220,000 Xstones on a 486 machine. In other words, workstation-class performance on inexpensive PC hardware.

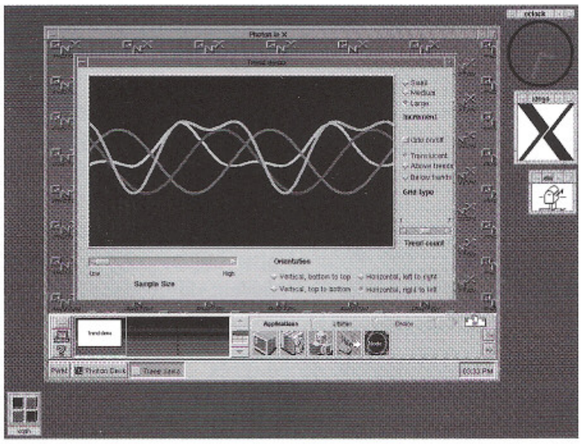


**Figure 2: Screen capture of Photon microGUI.**
**In this illustration, Photon's point-and-click application builder is being used to create a compact-disc player for the Photon**

As a full X11R5 implementation, X for QNX includes full support for Motif, scalable fonts, touchscreens, accelerator cards, and multimedia hardware (handy for process-control applications). It also offers a unique dual-connection mechanism that lets you take advantage of TCP/IP connectivity while enjoying QNX's high-speed messaging.

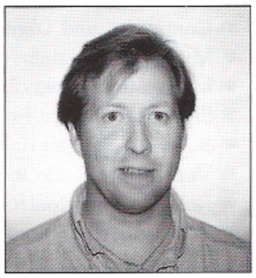
### *QNX Windows*

For midsize systems where X would be overkill, there is QNX Windows. Smaller than X, QNX Windows looks after screen-related events so your real-time application does not have to worry about routine activities like redrawing windows, popping up menus, or cleaning up after mouse events. This leaves your applications free to focus on more important issues--such as taking care of time-critical tasks.

### *About QNX Software Systems*

QNX software Systems (QSSL) is an industry leader in high-performance realtime operating system software. The company was formed in 1980 to develop and market the OS. For more information, visit the company's Web site at http://www.qnx.com, send Email to info@qnx.com, phone 800-676-0566, or send a fax to 613-591-3579. Company address: QNX Software Systems Ltd., 175 Terrence Matthews Crescent, Kanata, Ontario K2M 1W8 Canada.

## *About the Author*



Jeffrey George is a graduate of St. Lawrence College (Kingston, Ontario) where he studied computer-software engineering. After graduation, Jeffrey worked for two years at Pansophic Corporation, where he helped developed an interactive-design graphics system. For the past eight years, Jeffrey has held a variety of positions at QNX Software Systems. After starting out in R&D, he was given the responsibility of opening a branch office in Frankfurt, where he maintained the company's indirect sales channel for Europe. He has since returned to the company's headquarters in Kanata, where he now works as an applications engineer for medical instrumentation and point-of-sale systems



## 1997 Canadian Conference on Electrical and Computer Engineering
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## 1996 CANADIAN CONFERENCE ON ELECTRICAL AND COMPUTER ENGINEERING

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**SUNDAY - MAY 26 1996 / DIMANCHE - 26 MAI 1996**

**Pre-conference Sessions/Sessions pré-conférence**

| | |
|---|---|
| 8:00-17:30 | Rapid Prototyping of Digital Designs |
| 09:00-12:00 | The Internet: What is in this for me? |
| 14:00-17:00 | WindowsNT |
| 18:00-21:00 | Registration/Inscription |
| 19:00-21:00 | Welcoming Reception / Réception de bienvenue |

**MONDAY - MAY 27 1996 / LUNDI - 27 MAI 1996**

| | |
|---|---|
| 08:00 | Registration / Inscription |
| 08:30 | Opening Session / Cérémonie d'ouverture |
| 09:00 | Plenary Session - Session plénière - Mac Evans, President, Canadian Space Agency |
| 10:00 | Break - Pause |
| 10:20 | Technical sessions - Sessions techniques |
| 12:00 - 14:00 | Luncheon and invited speaker - Dîner Conférence - Speaker/Conférencier: Bob Church, Chair Alberta Science and Research Authority |
| 14:00 | Technical sessions - Sessions techniques |
| 15:40 | Break - Pause |
| 16:0 | Technical sessions - Sessions techniques |

**TUESDAY - MAY 28 1996 / MARDI - 28 MAI 1996**

| | |
|---|---|
| 08:00 | Registration - Inscription |
| 09:00 | Plenary Session - Session plénière - Alain Poirier, Canadian Space Agency |
| 10:00 | Break - Pause |
| 10:20 | Technical Sessions - Sessions techniques |
| 12:00 - 14:00 | Luncheon and invited speaker - Dîner Conférence - Speaker/Conférencier: John Glawson City of Calgary, |
| 14:00 | Plenary Session - Session plénière - John Meech, Univ. of British Columbia |
| 15:00 | Break - Pause |
| 15:20 | Technical sessions - Sessions techniques - |
| 18:30 | Reception (No Host Bar) - Réception (Bar payant) |
| 17:30 | Banquet and IEEE Awards Ceremony/Banquet et Cérémonie de remise de prix IEEE |

**WEDNESDAY - MAY 29 1996 / MERCREDI - 29 MAI 1996**

| | |
|---|---|
| 08:00 | Registration - Inscription |
| 09:00 | Plenary Session - Session plénière - Peter Garrett, NorTel |
| 10:00 | Break - Pause |
| 10:20 | Technical Sessions - Sessions techniques |
| 12:00 - 14:00 | Luncheon and invited speaker - Dîner Conférence - Speaker/Conférencier Lorry Wilson, Alberta Power Pool |
| 14:00 | Plenary Session - Session plénière - Douglas Barber, President Gennum Corporation. |
| 14:30 | Technical Sessions - Sessions techniques |
| 15:40 | Closing - Fermeture |

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