

# STRATEGIC RESEARCH AND DEVELOPMENT



2001 – 2002 HIGHLIGHTS



## Strategic R&D at BC Hydro

The Strategic Research and Development Program was created in 1990 by BC Hydro's Board of Directors to champion the longer range discovery, development and application of new technologies. While much of the research is devoted to maximizing and enhancing the use of existing infrastructure through condition assessment, life extension and efficiency improvement technologies, a portion of the investment is directed to enabling new energy sector related business, through advanced technologies. Strategic R&D is BC Hydro's internal investment fund for technology innovation.

### **Strategic R&D's Mission**

To be recognized as an industry-leading champion of the discovery, development and application of "breakthrough" technologies that have the potential to enhance the existing and future strategic position, competitiveness and sustainability of BC Hydro's generation, transmission and distribution lines of business.

### **Strategic R&D's Objectives**

- Develop and demonstrate technologies of immediate and future strategic importance.
- Foster an atmosphere which encourages the development of intellectual capacity, to serve core operations and maximize intellectual property potential in the marketplace.
- Evaluate and gain experience with new externally developed high impact technologies to facilitate just in time adoption.
- Promote "technology transfer" to ensure return on R&D investments.
- Collaborate with other organizations to promote technical expertise and leverage BC Hydro's R&D investment.

Queries arising from this publication can be directed to BC Hydro's Strategic R&D staff or the individuals listed as contacts for each report.

Contact us at 1-604-528-1600 or toll free in North America at 1-888-964-9376.

[www.bchydro.com](http://www.bchydro.com)



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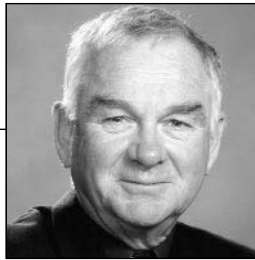
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## M E S S A G E S

### Message from the Chair – Larry Bell

Fiscal 2001/02 was a year of successes and challenges for BC Hydro. While we are pleased with our results, we know we cannot afford to rest on our past successes. BC Hydro will continue to keep pace with changing market structures and increased demand for reliable, cost effective products and services, while delivering value to our customers and Shareholder.

Maintaining and building on our position as one of the world's best-performing electric utilities means being open to new opportunities and taking bold steps. This will be achieved in a number of ways, but one thing is certain, technical innovation is critical.

BC Hydro has invested in research and development since its inception, through focused programs and partnerships with industry associations, manufacturers, educational institutes and our wholly-owned research subsidiary, Powertech Labs Inc. The result has been the discovery, development and application of numerous leading edge technologies. These breakthroughs have enhanced efficiency, productivity, customer service and shareholder value, and provided strategic opportunities for BC Hydro's future.

R&D is crucial to support our company's mission of providing integrated energy solutions to customers in an environmentally and socially responsible manner. Our goal of sustainability has prompted BC Hydro to explore new opportunities and business ventures such as development of hydrogen infrastructure for fuel cell deployment, the focus of one of our current research streams.

While we've had many successes over the past decades in creating a highly effective generation and delivery system, we will continue to enhance the performance of the system through technical innovation. We will measure our efforts against utilities across North America and strive to be first quartile performers in R&D effectiveness. Our success as a major operator of electrical infrastructure will continue to be founded on the creativity of our people and their technical innovations, many of which are described in this first highlights report on our Strategic Research and Development Program.



## M E S S A G E S

### **Message from the Senior Vice President, Transmission – Ron Threlkeld, Strategic Research & Development Executive Sponsor**

In utility companies throughout the world, research and development takes many forms. In some cases, the focus is on improving current operations, products and services. We conduct this kind of research at BC Hydro, but realized that we cannot afford to focus only on our day-to-day operations.

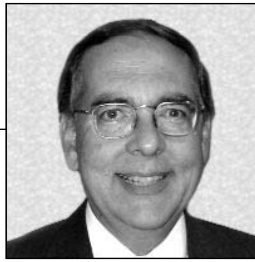
We've expanded our vision of R&D to encompass longer-range objectives. Our Strategic R&D Program was formed in 1990 to invest in "breakthrough" infrastructure technologies that enhance efficiency, productivity, customer service and shareholder value, and provide strategic opportunities for BC Hydro's future.

The Strategic R&D program has recorded some impressive results. To ensure we obtain full benefit from our efforts, we carefully align our projects and initiatives to support the strategies of our lines of business. Another key to our success is leveraging our investment through collaborative research. Our involvement with strategic alliances and research interest groups such as the Canadian Electricity Association Technology Inc. and local universities has enabled us to share expertise, conduct joint research, and provide commercialization opportunities for technology developed in British Columbia. We also collaborate with international partners such as the Electric Power Research Institute (EPRI).

Strategic R&D initiatives are supported by a corporate-wide network aligned to key technology areas in the lines of business. These teams annually evaluate the technology program and make recommendations for the coming year. The work groups play a fundamental role in advocating and monitoring R&D projects, promoting technology transfer and innovation capacity building in the lines of business, and providing links to our research alliance partners.

On behalf of BC Hydro, I'd like to thank all the individuals who have helped us to become a leader in the electricity industry, and who continue to contribute to our promise for the future through excellence in research and development.

A handwritten signature in black ink, appearing to read "R. Threlkeld". The signature is fluid and cursive, written in a professional style.



## M E S S A G E S

### Message from the Manager, Strategic Research & Development – Jim Gurney

The Strategic R&D Program is pleased to be publishing its first highlights report. Our program has been operating for over a decade and we are proud of its many accomplishments. This report highlights some of our recent achievements.

During 2001, we funded over 75 research projects with multi-year commitments of \$5.4 million. We realized income from the sale and licensing of some of our technical innovations. Our efforts to support and work with other research organizations in the province was recognized by the BC Technology Industry Association who honoured us with the Excellence in Technology Innovation award for BC Hydro/UBC/NxtPhase collaboration on a high accuracy optical voltage sensor.

At the same time, we strengthened partnerships with BC and Western Canadian research agencies and educational institutes including the University of BC, University of Victoria, British Columbia Institute of Technology, University of Alberta, National Research Centre Fuel Cell Innovation Centre, BC Ministry of Agriculture and Food, NxtPhase Corporation, IFD Corporation and a host of others.

The past year also saw the successful launch of the industry-leading BCHydroGEN™ program, a key initiative of BC Hydro's Sustainability Program that will establish a new hydrogen sales business for the fuel cell industry. Further, we recorded very promising results from several technologies that will provide lasting value to BC Hydro and its customers, including:

- load forecasting using artificial intelligence
- artificial intelligence assessment of power transformer condition
- transmission tower coating assessment
- energy balance studies for BC pulp mills
- earthfill dam seepage surveillance using self-potential
- the extension of transformer paper insulation by in-situ dicyandiamide additives

As we continue to manage our research and development portfolio with the support of dedicated innovators from BC Hydro, Powertech Labs and other research partners, we look forward to many new technical achievements over the next year that will provide value to BC Hydro and the electricity industry.

We welcome your feedback on our first highlights report and suggestions for future research activities.

A handwritten signature in black ink, appearing to read "J. Gurney".



## PROGRAM

### Strategic R&D Program and Staff

The Strategic R&D (SRD) program at BC Hydro is coordinated and administered by a small group of employees connected to a vast network of technical experts, both internal and external, who contribute to technology advancement through eight R&D committees. The committees represent key technical areas of the company including conventional and alternative generation, transmission and network planning, substations, distribution, protection & control and customer end-use technologies. The work groups identify research and technology needs, evaluate project proposals, make recommendations for investment and membership decisions, and provide links to our research alliance partners.

In any given year, SRD manages over 75 projects with an annual budget of \$3.5 million and multi-year commitments of over \$5.4 million. Much of the research is leveraged through collaborative co-funding arrangements with our partners, to reduce financial and technical risk.

#### **STRATEGIC R&D STAFF**

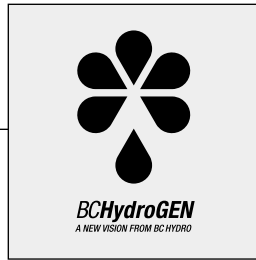
Jim Gurney, Manager  
Donna Barker, Administrative Assistant  
Dulcie Chang, Program Coordinator  
Sherry Ernst, Program Coordinator  
Allan Grant, Program Manager, BC HydroGEN™  
Bob Reid, Project Manager, BC HydroGEN™

A key initiative in the past year was to introduce BCHydroGEN™, aimed at enabling the hydrogen economy using clean, green, hydro electric resources. A successful demonstration of NxtPhase Corporation's optical voltage/current sensor at our Ingledow Substation attracted worldwide recognition of BC Hydro/industry/university collaboration and support for the local high tech sector. These and other highlights of the program are featured in this report.



*Left to right (Donna Barker, Bob Reid, Sherry Ernst, Jim Gurney, Dulcie Chang, Allan Grant).*





## SPECIAL INITIATIVE

### BCHydroGEN™, The Hydrogen Solution

Building on its strengths as a leading electric utility, BC Hydro has embarked on an ambitious new venture to supply hydrogen to the emerging fuel cell market. This initiative provides a hydrogen product (BCHydroGEN™) for commercial sale and is also developing the infrastructure to supply hydrogen to the market and working to gain public support and acceptance for this new fuel.

Hydrogen is already being used for industrial purposes. It is primarily produced from non-renewable fossil fuels, such as natural gas, and then transported to the point of use. Both the production and the transportation processes result in greenhouse gas emissions and air pollution.

BC Hydro believes using renewable energy to generate hydrogen is the most economic and environmentally sustainable method. This will be accomplished through electrolysis – the process of passing an electric current through water in an electrolyzer, creating pure hydrogen and oxygen. Electrolysis is the cleanest way to produce hydrogen—no greenhouse gas or air pollution result from the process. The electricity network provides the delivery mechanism to connect energy sources to hydrogen users where and when the hydrogen is required.

BC Hydro is uniquely positioned to be a leader in the emerging hydrogen market based on its commitment to sustainability and a core enterprise which already produces electricity using a clean, renewable and economic generating source (water). In addition, BC Hydro can leverage the world-

class high-pressure gas storage experience of its research subsidiary Powertech Labs Inc., to demonstrate the feasibility of hydrogen technologies and remove technical barriers.

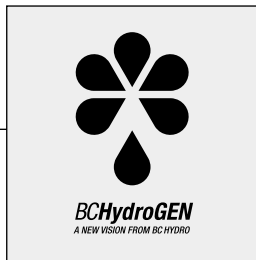
Through its hydrogen program, BC Hydro has the opportunity to build on its core products and services, and explore new business opportunities. The program is also expected to result in the commercialization of new technologies.



*Hydrogen/CNG vehicle.*

Alliances will play a key role in the successful implementation of BC Hydro's hydrogen program. Plans to profitably produce, distribute and sell hydrogen to wholesale and large retail markets means working closely with partners in the transportation, industrial supply, portable power and stationary power markets.

In the transportation sector, BC Hydro hopes to influence automakers to select on-board storage of hydrogen for energy delivery. As hydrogen-powered vehicles enter the marketplace, BC Hydro will also work with petroleum fuel retailers and others to locate electrolytic hydrogen fuelers at existing fueling stations and industrial sites. In the industry supply market, BC Hydro intends to sell hydrogen and associated electricity to industrial customers and offer hydrogen across an ever-increasing range of applications. To serve portable and stationary power markets, BC Hydro is actively involved in the technical aspects of hydrogen supply as well as the development of portable and stationary power fuel cell applications. The hydrogen program is also intended to support the growth and development of the B.C. fuel cell industry.



## SPECIAL INITIATIVE

BC Hydro has initiated a number of demonstration projects to accelerate the development of profitable hydrogen markets, as described below.

### Demonstration projects

#### CH<sub>2</sub>IP Fueling station

Fleet operators will be one of the first target markets for hydrogen fueled vehicles. To facilitate their early acceptance and adoption of this new technology, the fueling infrastructure must be demonstrated to be safe, reliable and economical. As a result, BC Hydro is testing the supply of hydrogen on three of its fleet vehicles using a 51 percent hydrogen and 49 per cent compressed natural gas (CNG) mix. To fuel these vehicles, an innovative hydrogen/CNG production, storage and fueling station was designed and constructed by Powertech Labs, BC Hydro, Stuart Energy and Dynetek Industries in 2001.



Fueling Station.

#### Mobile refueling

As the hydrogen market grows, a more cost-effective method of transporting large quantities of hydrogen will be needed. Lightweight steel tube trailers such as Powertech's Mobile Hydrogen Fueling Station are being developed to respond to this requirement. Housed on a flat deck trailer, the mobile fueling station is comprised of lightweight high-pressure composite storage cylinders, and associated valves, tubing and pressure relief device. These components facilitate high-pressure storage of the hydrogen while reducing the overall weight of the trailer.

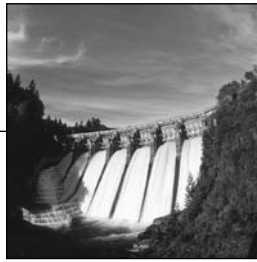
#### 10,000 psi storage tank

High-pressure storage of hydrogen will enable fuel cell vehicles to have the same or better travel range compared to conventional vehicles. Powertech Labs is working with key companies in the hydrogen, energy and transportation sectors to design, test, and certify the world's first high pressure (10,000 psi/70 Mpa) hydrogen fuel tank.

#### Future projects

Future projects include the possibility of developing prototype hydrogen fueling stations in B.C. to support the Vancouver/Whistler 2010 Olympic bid and at the Vancouver airport to facilitate use of hydrogen by fleet operators.

**Contact(s): Allan Grant/Yoga Yogendran/Bob Reid**



## GENERATION

# Develop Self Potential (SP) Tools for Continuous Seepage Surveillance through Embankment Dams

### Purpose

- Develop a reliable system to detect and monitor anomalous seepage paths in embankment dams

### Background

Internal erosion and uncontrolled seepage are major threats to the safe performance of embankment dams. Manifestation of internal erosion is difficult to detect and generally the seepage flow through the dam increases as internal erosion progresses. The resulting damage can be complex and may require extensive remediation.

Over the past several years, dam owners have successfully used a number of non-destructive techniques to detect seepage paths. However, at present, these techniques are typically performed manually and data interpretation consists of visual comparison of different profiles and contour plans. To date, there are no known commercially available systems for continuous monitoring, therefore, repeated manual surveys must be conducted. Further, current interpretation based on visual comparisons is subjective.



*Construction of a 2-dimensional model dam.*

To improve these techniques and provide for continuous automated dam surveillance, this project will produce a pilot continuous monitoring system based on the experience of dam owners. The pilot system will be installed at a BC Hydro dam site to monitor its performance. Based on test results, modeling techniques will be developed to increase the reliability of data interpretation.

Beyond providing for improved monitoring, this project will create an early warning system, mitigating the risk of catastrophic dam failure. Another benefit will be reduced remediation and monitoring costs.

### Deliverables

- Confirmation of SP theory and measurability
- Develop SP computer code (with the University of British Columbia)
- Develop 2-dimensional and 3-dimensional model dam design (with defects)
- Test model dam with two reservoir levels, incorporating defects
- Validate SP computer code with physical model and existing dam

**Status: Active**

**Contact(s): Ray Stewart /Sasi Sasitharan**



## GENERATION

# Computational Fluid Dynamics (CFD) and Enhanced Turbine Efficiency

### Purpose

- Enhance BC Hydro in-house expertise in the cost-effective application of CFD modeling analysis to improve hydraulic turbine efficiency
- Determine the level of potential improvement for hydraulic turbine efficiency at minimal cost
- Support expertise development within the British Columbia high tech sector related to CFD modeling

### Background

The shape of stationary vanes (“stay-vanes”) affects hydraulic turbine efficiency. Recent advances in CFD can be used to assess the effects of modifying stay-vane shape in order to improve flow distribution and turbine efficiency.

CFD research was conducted at Kootenay Canal Generating Station and it was determined that BC Hydro required more in-house knowledge to make informed decisions.

As a result, this project was undertaken in cooperation with the University of British Columbia’s Mechanical Engineering Department to further BC Hydro’s knowledge of CFD. Elements of the project included a survey of current CFD modeling expertise and practices. In addition, CFD modeling analysis was applied to G.M. Shrum generating station turbine stay-vane design to identify the potential for stay-vane efficiency improvements.

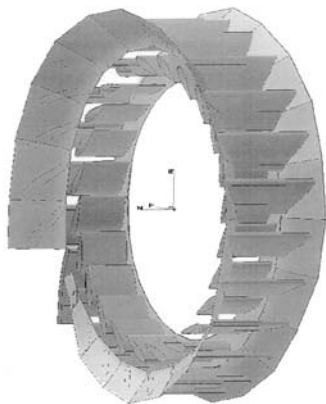
This research provides the potential to reduce or defer spending, improve operational flexibility and system reliability, and enhance environmental stewardship.

### Deliverables

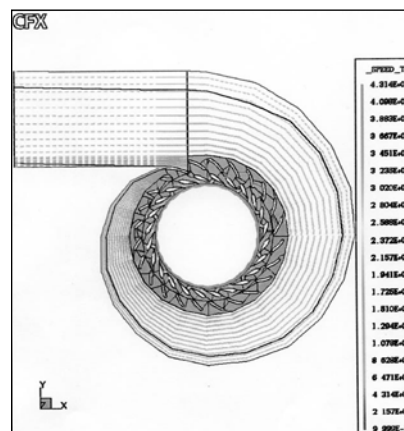
CFD modeling modifications showed a potential for 1-2% gain in turbine efficiency. Further application work will be undertaken through BC Hydro’s Mechanical Engineering Department.

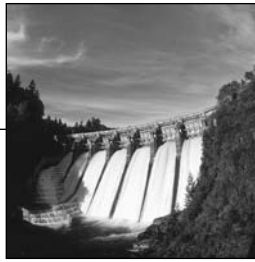
**Status: Completed August 2001**

**Contact: Doug Franklin**



Diagrams of CFD modeling.





## GENERATION

# NiAl Weld Overlay for the Cavitation Protection of Hydraulic Turbines

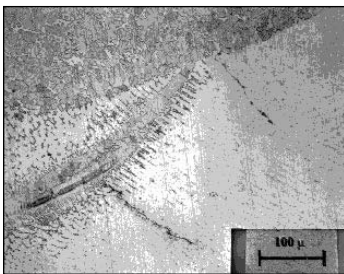
### Purpose

- Find a weld material with the strength and grindability to reduce the incidence of cavitation repair

### Background

Hydraulic turbines experience cavitation due to high pressure water flow. To help prevent cavitation, critical areas of carbon steel turbines are protected with a cladding having superior cavitation erosion resistance compared to the base material. Austenitic stainless steels are commonly used for cladding or weld overlay protection of carbon steel turbines.

Repair to cavitation damaged areas on carbon and martensitic steel turbines is generally made every two to three years. There has been ongoing research to find better materials for that purpose. Recent reviews of cavitation resistant materials show that intermetallic compounds such as NiTi (nickel titanium) and NiAl (nickel aluminum) have the best cavitation erosion resistance among known metallic materials. While, NiTi is costly and requires special processing, NiAl is less expensive since it contains aluminum instead of titanium.



*Cracks near weld deposit.*

This project is expected to develop a weld material that can be easily used for in-situ cavitation repair. NiAl will be assessed as a potential weld material. If results show significant benefits to this approach, further work could develop technology to obtain a cavitation resistant NiAl weld deposit.

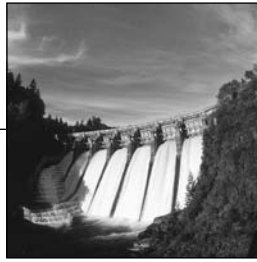
Should co-deposition of nickel and aluminum to produce a cavitation resistant weld prove feasible, it will be a major low cost breakthrough in repair of hydraulic machinery. The cost of the deposited material will be comparable to that of materials currently used while the cavitation resistance will be better. Decreasing the frequency of cavitation repair will result in additional cost savings.

### Deliverables

Initial phases of the project have been completed and a report produced. Further work is required including refinements to the weld deposition process and tests on cavitation erosion, structural integrity, and grindability of the weld deposit.

**Status: Active**

**Contact: Ainul Akhtar**



## GENERATION

# Electrochemical Impedance Spectroscopy (EIS) Coating Condition Assessment for Generation Equipment Steel Structures

### Purpose

- Evaluate and develop the EIS technique as a tool to assess the condition of generation equipment steel structure coatings in the field and determine the degree of deterioration, the remaining life, coating integrity in warranty inspections, and rate of corrosion

### Background

Coating maintenance costs for generation steel structures have increased dramatically due to environmental regulations that require containment during removal of existing coatings. This has led to a shift from stripping and recoating to overcoating.

Overcoating can be cost-effective but it is more risky. The point at which it is possible to overcoat, instead of strip and recoat, is not easily defined. An accurate preliminary condition survey is critical to reducing the chance of premature overcoating failures. The traditional method of assessing coating condition involves visual inspection. Destructive tests such as “pull off” adhesion are used to obtain further information.

EIS is a laboratory technique that has been used extensively to determine the performance of coatings with excellent results. In recent years, the EIS instrumentation system has evolved from a research tool to a routine testing procedure. There has also been some development in making the instrumentation portable. EIS offers significant advantages over other non-destructive assessment technologies—it provides more detailed information and is easier to adapt to field evaluations.

### Deliverables

This project demonstrates the viability of using EIS to assess the condition of in-service coatings and identifies the most appropriate instrumentation to measure EIS. It will determine the relationship between the EIS reading and the condition of the coatings in the laboratory and field.

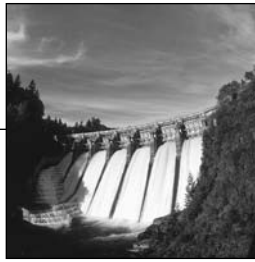
A prototype formable field gel-cell has been developed and refined through laboratory trials. The function and effectiveness of the gel-cell has undergone preliminary testing in the laboratory with excellent results on coatings with simple conditions. Additional testing of more complex coatings will be required before proof of concept is declared or field trials started.

### Status: Active

### Contact: Terry Aben



*Field EIS prototype.*



## GENERATION

# Development and Demonstration of a 75 kW Microturbine Cogeneration Package

### Purpose

- Gain experience with microturbines for distributed generation and non-integrated area applications
- Evaluate microturbine performance including installation costs, operating and maintenance costs, reliability, electrical efficiency, exhaust temperature/exhaust flow rate and emissions
- Design and test air-to-gas and gas-to-water heat exchanger to optimize size and backpressure for microturbine applications

### Background

Many North American utilities are installing distributed generation technologies where they provide increased reliability and efficiency. BC Hydro is proactively exploring distributed generation technologies including the use of microturbines.



Microturbine on trailer.

Microturbines have been available for transportation applications for many years and are only now being developed for stationary applications.

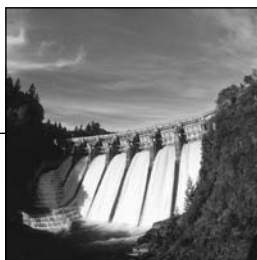
If the use of microturbines for distributed generation proves to be feasible, BC Hydro will have the potential to embark on new business opportunities. In addition, the use of microturbine technology may prove to be low cost (capital, installation and maintenance costs).

### Deliverables

The purpose of the project is to gain experience in siting, permitting, commissioning, and operating distributed generation equipment. BC Hydro has joined the Electric Power Research Institute microturbine user's group, which has over 20 members conducting field tests with microturbines of various sizes. In addition, BC Hydro is a member of the Canadian microturbine user's group through CANMET, a federal research agency. Reports and data are shared among members on a regular basis.

**Status: First phase completed March 2002**

**Contact: P. (Terry) McCullough**



## GENERATION

### Room Temperature Hydrogen Generation from Hydrocarbons

#### **Purpose**

- Investigate the feasibility of producing hydrogen from hydrocarbons using a room temperature process

#### **Background**

The growing demand for the use of hydrogen as an energy carrier is due in large part to advances in fuel cell technology and increased environmental concern. Currently, hydrogen supplies only 1.5 per cent of the world's energy and it is recognized as one of the most environmentally acceptable fuel. However, there are a number of impediments to hydrogen becoming a viable option for distributed power generation including the high cost of hydrogen production, storage issues and distribution at high energy densities.

This project looked at a novel concept of using hydrocarbons as the starting energy source for the distributed generation of hydrogen. Experiments were conducted using the hydrocarbon gases methane and propane, and the liquid hydrocarbon pentane. The project outlined the range of demand that can be met with this process, the purity of hydrogen delivered, the efficiency and energy requirements. The efficiency of using this technique with various modifications was also explored.

This technology offers the possibility of added revenue through the availability of safe, quiet and pollution-free distributed generation on demand. It may also result in a system that is scalable and is compatible with safe building storage standards.

#### **Deliverables**

It is anticipated that a system based on this technology could generate hydrogen for fueling stations. Alternatively, hydrogen generation on-board vehicles may be possible in lieu of methanol or gasoline reforming.

The first phase of the project was completed with a final report issued. Further studies are proposed for work on improving the technique.

**Status: First phase completed March 2002**

**Contact: Ian Wylie**

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#### **Planned Generation Projects include:**

- Power Generation from Biomass
- InSAR Satellite Technology for Monitoring Dam Movement
- Identifying Large Voids in Generator Stator Coil Insulation
- Artificial Intelligence from Plant Information
- Technology Review of Redox-type Battery Storage Technologies
- Impact of Distributed Generation Technologies on the Natural Gas Network





## TRANSMISSION

### NxtPhase Optical Voltage & Current Sensors Demonstration

#### Purpose

- Verify the performance of NxtPhase Corporation's optical sensors in a substation environment

#### Background

The power industry has traditionally measured current and voltage using iron-core instruments. Several devices were required to measure current and voltage for billing purposes, to control the flow of electricity, and to protect the electric system during disturbances, such as lightning storms.

These measurements can now be made by a single fiber optic sensing device, which offers superior performance over conventional equipment at a lower cost. The sensors provide high accuracy measurements of voltage and current, and can be used for metering, equipment protection and power quality management. The devices offer broader dynamic range and bandwidth, provide significant environmental benefits, are lighter in weight and safer than conventional instruments.

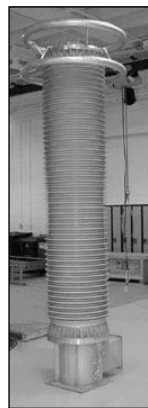
This revolutionary device is the result of many years of research and development. It began in the early 1990s at the University of British Columbia (UBC) when a device was developed to measure the electric field produced by voltage sources. Carmanah Engineering (a UBC spin-off company) formed in 1995 to commercialize the technology for applications in the electricity industry, with BC Hydro funding development and demonstration of early products. Significant technical breakthroughs led to the development

of an extremely accurate optical method for measuring voltage of high voltage buses in substations. A patent for this Optical Voltage Transducer (OVT) was filed in 1998 and the first prototype was successfully tested at Powertech's High Voltage Lab in 1999.

Carmanah Engineering Ltd. and Honeywell Inc. joined forces to form NxtPhase Corporation in 1999. The following year, BC Hydro forged a technology alliance with NxtPhase to develop and demonstrate the precision voltage and current sensors in utility applications.

An initial installation of NxtPhase's fiber-optic current and voltage sensors resulted in the discovery of improvements. Those enhancements were incorporated into the device and testing implemented on the second-generation prototype.

Trials conducted at Ingledow substation verified the performance of the sensor over time and temperature in actual field conditions. These trials also compared the performance of the optical sensors with conventional instrument transformers, and demonstrated the combined operation of digital sensors with digital meters and relays. Future phases will evaluate the application of the technology in power quality monitoring, high precision metering certification, disturbance monitoring, etc.



*NxtPhase Sensor.*



## T R A N S M I S S I O N

NxtPhase technology in partnership with BC Hydro has attracted significant attention, winning awards including:

- 2001 - Excellence in Technology Innovation award by the British Columbia Technology Industry Association.
- 2000 - Natural Sciences of Engineering Research Council of Canada and the Conference Board of Canada's Synergy award for Ventures Involving at Least Two Industry Partners
- 2000 - BC Advance Systems Institute's Technology Partnership award
- 1999 - Canadian Institute of Energy's Research and Development award

### **Deliverables**

Initial field trials at Ingledow Substation are complete.

Demonstrations to evaluate the application and accuracy in power quality monitoring, and high precision metering will be pursued in future projects.

**Status: Completed 2001**

**Contact: Greg Polovick**



## TRANSMISSION

# Life Extension of Transformer Paper by In-Situ Restoration of Additives: Role of Dicyandiamide (DICY) in Thermally Upgraded Transformer Paper

### Purpose

- Develop a technique to measure the residual dicyandiamide content in insulating paper and oil to assist in determining the onset of accelerated paper aging

### Process

Electrical grade Kraft paper is the major solid insulating medium in power transformers. To increase the temperature rating of modern transformers, Kraft paper is thermally upgraded by impregnating it with an additive (DICY is the most frequently used additive). The treated paper also degrades at a much slower rate than ordinary Kraft paper.

Transformers using thermally upgraded paper were designed to have a useful service life of approximately 30 to 35 years. However, recent transformer failures experienced by BC Hydro have been attributed to premature aging of the thermally upgraded conductor paper. Preliminary laboratory results indicate that the DICY additive has been depleted and the paper may no longer have the designed thermal stability.

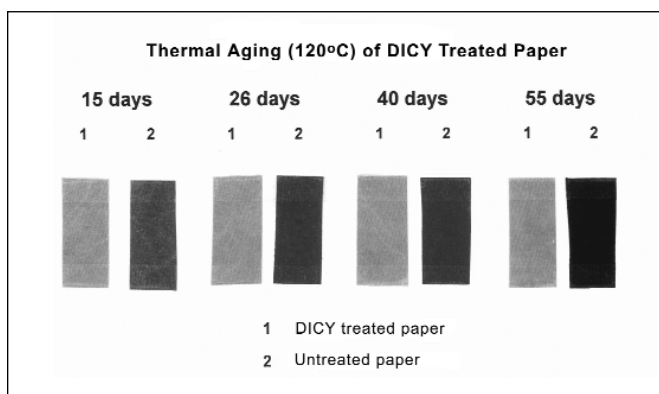
Initial phases of this project explored the correlation between DICY and thermal stability. Testing was also done on additives restoration and treatment of the aged paper with cross-linking reagents to restore some of its mechanical strength and thermal stability. In addition, a non-invasive, on-line technique of applying the thermal enhancement additives to paper in a transformer was evaluated.

### Deliverables

The first four phases of the project resulted in a number of findings. After determining further study was required, an additional fifth phase of the project was initiated to evaluate alternative detectors and additives.

### Status: Active

Contact: Greg Polovick/Dennis Cartlidge



*DICY treated transformer paper.*



## TRANSMISSION

# Oil Leak Detection in Submarine Cables Via Tracer Compounds

### **Purpose**

Review and evaluate available or emerging techniques for detecting oil leaks from submarine cables including:

- use of a chemical tracer
- detection of specific compounds indigenous to cable oil

### **Process**

Locating leaks in oil-filled submarine (underwater) cables via conventional technology is time consuming and expensive. The leak can also result in ecological damage to marine organisms.

A project was initiated to find less complicated and more cost-effective methods to deal with these leaks. The project plan detailed four phases:

- a literature review and monitoring of new developments
- a report on the feasibility of various tracer methods such as an oil soluble fluorescent dye or a fluorinated compound such as perfluorohydrocarbon or SF<sub>6</sub> injected into submarine cables
- a report on the evaluation of detection methods such as fluorimetry and electron capture in a simulated marine environment as a result of simulated laboratory experiments
- field trials

### **Deliverables**

Phase I, a literature review and monitoring of new developments, has been completed. It determined that the best method for locating a leak in underwater cable is a submersible with UV lighting and equipment to track the cable.

However, enhancement of the natural fluorescent properties of the oil using a tracer dye may still be required. To determine if this is necessary, Phase II of the project will first focus on a simulation of oil releases in a marine environment, evaluation of the characteristics of oil from a cable leak into the surrounding sand and water, and evaluation of the natural fluorescence of cable oil. If necessary, the ability of oil soluble dyes to enhance the fluorescence intensity will then be evaluated.

**Status: Active**

**Contact: Nelson Storry**



## TRANSMISSION

# Performance Evaluation of In-service Four-Bundle Spacer Dampers

### Purpose

- Develop a field program to assess the condition of installed four-bundle spacer dampers and of the conductors under their clamps
- Establish a database of the composition and aging characteristics of the elastomeric materials in use
- Perform tests to determine energy absorption and torsional stiffness of various spacer damper models and attempt to establish the remaining in-service life of the four-bundle dampers

### Background

The BC Hydro system has approximately 180,000 four-bundle spacer dampers that have been in service for more than 30 years and are starting to show signs of deterioration. There is a concern that aging of the rubber materials in the articulated joints may affect performance and lead to conductor damage. To prepare for future spacer damper replacements or refurbishment, there is a need to establish the remaining life of the existing spacer dampers.

A three-phase project was initiated to assess the spacer damper condition, establish the exact composition of the rubber materials, evaluate performance, and determine residual life of the spacer dampers.

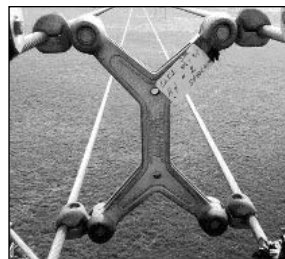
In phase I of the project, the condition of spacer dampers manufactured by Gould, Lacal, and Metalastik was assessed. Evaluation was based on the assumption that a spacer damper has reached the end of its life when it begins to cause damage to the conductors, or the rubber clamp is too stiff for field crews to detach from the conductors. Field personnel gathered data by removing spacer damper samples, taking digital photos of them and visually assessing the conductor condition and the undersides of clamps.

### Deliverables

Based on information discovered in phase I, BC Hydro's database of spacer dampers is being updated. Phase II (sampling and some specific laboratory evaluation) will focus on the metalastic type of dampers. Results from this phase are expected to include: the present condition, arm stiffness and damping characteristics of metalastic dampers of the 5L51/51/12 circuits; the potential consequence of the present status of the metalastic dampers on the structural integrity of the lines; and recommendations for appropriate maintenance and replacement strategies.

### Status: Active

Contact: Joseph Jue /Jim Duxbury



Spacer dampers.



## TRANSMISSION

# Computer Assisted Diagnostics, Condition Assessment and Life Extension of Substation Equipment (Apparatus Assessment Assistant) - LABSYS

### Purpose

- Develop a sophisticated equipment diagnosis and condition assessment tool by expanding the capabilities of current software beyond simple data storage and retrieval from substation equipment and laboratory test results

### Process

BC Hydro and Powertech Labs have developed a PC-based software package that captures data from substation equipment and laboratory test results and assembles them in a relational database. Evaluating these results quickly and easily is essential in making informed decisions and in pursuing timely corrective action. However, the primary database tool used by BC Hydro for this purpose, known as PFMS, has a number of limitations. It is not able to capture new test results and has only minimal diagnostic ability.

A number of steps were recommended to move beyond these limitations. First, data would be combined into one relational database. The scope of the program would then

be expanded to capture data from additional test results, equipment operating conditions and maintenance history. Next, neural networks would be used to enhance the program to provide a sophisticated equipment diagnosis and condition assessment tool. The program would be PC-based, user-friendly and compatible with the replacement program for PFMS. The software will be tested with actual case studies in the final stage of the project.

Benefits of the project include reduced maintenance costs, end of equipment life prediction, reduced time and costs for diagnosing equipment and data retrieval, a framework for predictive maintenance and a tool to capture and retain expertise.

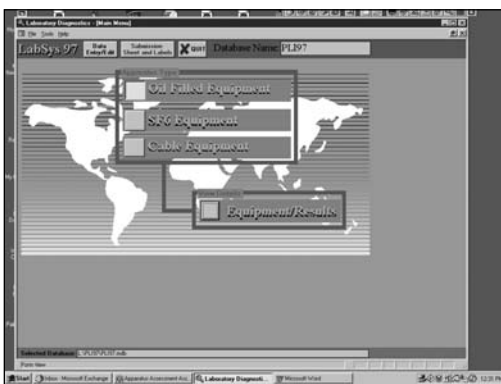
### Deliverables

The software resulting from this project, LABSYS, provides historical data and reports on demand. Officially launched at the Apparatus Technical Conference 2002, LABSYS continues to generate positive feedback from users.

An exploratory application of artificial intelligence for LABSYS is in progress via the "Development of an Intelligent System for Advanced Utility Power Equipment Condition Assessment" project.

**Status: Active**

**Contact: Alex Lam**





## TRANSMISSION

### Development of Small Signal Analysis Tool (SSAT)

#### Purpose

- Develop a new eigenvalue-based Small Signal Analysis Tool (SSAT)

#### Background

Loss of small signal stability in a power system usually causes sustained or growing oscillations in part or all of the system. If not appropriately controlled, there may be severe impacts on secure system operation leading to widespread power outages. The most effective method to investigate the small signal stability problem is to use modal analysis based on eigenvalue techniques. This approach can also assist in designing corrective controls in order to mitigate stability problems.

There are some numerical algorithms capable of solving the eigenvalue problem for large power systems. A number of these methods have been implemented in computer programs specifically designed for small signal stability analysis of power systems. However, these programs have not been routinely used by most utilities because they are not sufficiently compatible with industry standard power system models. In addition, these programs lack necessary features required for practical power system studies.



In developing a commercial grade small signal analysis tool, this co-funded project set out to meet industry needs and requirements by providing:

- state of the art computational capabilities
- comprehensive modeling
- convenient system studies tools
- a user-friendly graphical interface

#### Deliverables

The SSAT package has been used for tuning power system stabilizers at numerous BC Hydro power plants and connected independent power producers. The SSAT greatly facilitates the tuning process and has improved the efficiency and reliability of BC Hydro's generation and transmission system.

Version 2.0 of SSAT, including a number of additions and enhancements, was recently released. SSAT has been licensed to 21 users worldwide and has been used in the following applications:

- investigation of oscillatory problems in complex systems
- IPP impact studies
- control system design and tuning
- operation studies
- research and teaching

**Status: Completed 2001**

**Contact: Kip Morison**



## TRANSMISSION

# Feasibility of Microwave Radiometry for Monitoring Porcelain and Polymer Clad Substation Equipment – Proof-of-Concepts for Bushings, CTs and CVTs

### Purpose

- Determine the effectiveness of  $\mu$ Wave Vision for detection of internal hot spots in porcelain and polymer clad high voltage devices in the laboratory
- Establish the relationship of hot spot detection to imminent failure
- Decide if further development of a field prototype is warranted

### Background

The internal temperature of equipment is usually a good indicator of its condition. Therefore, the ability to remotely detect a hot spot prior to equipment failure could provide an effective method for preventing catastrophic failures. Remote monitoring of equipment temperature would also assist in equipment life extension and end-of-life management strategies. However, there are currently no non-intrusive methods to monitor the internal temperature of equipment.

In active laboratory tests, the  $\mu$ Wave Vision has proven to be effective in the remote detection of hot spots in some high voltage equipment that could not be detected by other techniques. Unlike infrared imaging, which measures surface temperature,  $\mu$ Wave Vision can probe the underlying structure because of the penetrating properties of microwave radiation. However, questions remain about the relevance of the hot spots to the failure modes of the equipment and how the thermal profile of healthy equipment would look.

The scope of this project includes tests in the laboratory on the following “suspect” and “normal” equipment: current voltage transformers (CVT), current transformers (CT), bushings, potheads, silicon carbide and metal oxide surge arresters. The tests will include measurements of the thermal profile of the equipment by  $\mu$ Wave Vision and partial discharge under application of voltage stress and correlating the measurement parameters with the extent and type of damage inside the equipment.

### Deliverables

Testing is underway. When the project is completed, a final report summarizing the findings and containing recommendations for the development of a field prototype will be issued.

### Status: Active

**Contact: Mike Lau/Kal Abdolali**





## TRANSMISSION

### Develop Transmission Pricing Methods Sensitive to Reliability

#### **Purpose**

Develop transmission pricing methods, which are sensitive to reliability and provide:

- Price differentiation for different customers with different levels of reliability
- Price signals to improve overall system reliability
- Incentives to properly locate future generation and load

#### **Background**

Like many utilities in North America, BC Hydro is facing a rapidly changing competitive market, and offering non-traditional transmission wheeling services. A variety of transmission pricing methods have been presented in recent years since deregulation, open access and other changes in the electric power industry. However, none of the proposed methods consider reliability as a factor in rate design formulas, despite a widespread realization that reliability is an important concern.

From a utility perspective, system reliability should become a component in the rate design to reflect long-term incremental cost estimates, to send price signals encouraging the right siting of new generation and to play an incentive role in maintaining excellent system reliability. On the other hand, customers have every reason to ask for prices recognizing reliability since customers at different locations are serviced with different reliability levels based on transmission system constraints and random failure of transmission components.

In examining the applicability of transmission pricing methods sensitive to reliability, this project included a review of pricing methods, the development of a new concept and methods, case studies and applied examples. While it is understood that any given transmission reservation may involve more than one type of service, the impact of three types of transmission services – generation, wheeling and domestic load – were studied independently.

#### **Deliverables**

Results of the project include a number of possible methods of implementing reliability-based pricing. A final report has been issued.

**Status: Completed March 2002**

**Contact: Wenyuan Li/Stephen Tran**



## TRANSMISSION

# Develop a Maintenance Strategy for Coating Below Ground Components of Galvanized Steel Towers



*Steel tower corrosion.*

### **Purpose**

Improve BC Hydro's maintenance strategy for below ground galvanized steel tower components by:

- developing a process to assess the condition of the towers
- identifying towers with potential corrosion problems
- determining the optimum maintenance strategy

### **Background**

Prior to the project, maintenance on tower components was not conducted until the ground line structure appeared badly deteriorated. The result was a potential for a higher risk of structure failure and increased lifetime maintenance costs.

The project focuses on assessing the condition of the tower footings and the anchor rods. The research process for tower footings included developing screening procedures, establishing structural-surface assessment criteria, identifying a suitable sub-surface coating system, establishing cathodic protection parameters, and application of the inspection/rehabilitation process.

The possibility of using ultrasonic techniques at the exposed end of anchor rods to detect metal loss along the length of the rod is also being explored. If the ultrasonic technique proves to be successful in detecting a predetermined corrosion limit, corrosion could be arrested by the application of low-cost sacrificial anode systems. Field work on this new technique is yet to be completed.

### **Deliverables**

As a result of the project, the new maintenance strategy for below ground tower sections includes a screening process which identifies and ranks towers with potential corrosion problems, assessing the condition of the identified towers, and determining the optimum time for maintenance and the most cost-effective measures. In addition, the project provided an enhanced knowledge about the most durable, user-friendly and environmentally acceptable protective systems.

This project may also yield an innovative anchor inspection tool with significant potential for use by transmission and distribution companies as well as other industries.

**Status: Active**

**Contact: Gerhard Kehl/Terry Aben/Avaral Rao**



## TRANSMISSION

### Transmission Line Surge Arresters

#### Purpose

- Reduce induced transmission line outages due to lightning strikes in the most exposed line of a common right-of-way (ROW)

#### Background

An unusual number of simultaneous faults on parallel circuits in the BC Hydro transmission system has been attributed to lightning strikes, and it was believed that a simultaneous parallel circuit trip was caused by separate lightning stroke(s) or possible protection mis-operation.

To reduce the risk for simultaneous outages, this project set out to develop a methodology for surge arrester use on multiple operating voltage transmission lines on a common ROW. The project would also identify and develop other remedial measures to be applied with or without surge arresters, and explore the use of Fault Location and Reporting System (FLAR) technology as part of the solution.

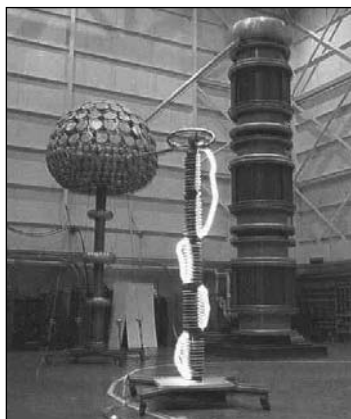
Beyond a reduction in the risk for transmission line outages on common ROWs, other benefits of the project included improving asset utilization and power quality.

#### Deliverables

Following a review of event fault records, transmission line protection mis-operation was ruled out and results indicated that many of the simultaneous faults are caused by inter-circuit ground coupling. Based on these discoveries, several types of mitigation are recommended depending on the circuit voltage class.

**Status: Completed October 2001**

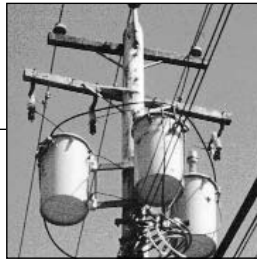
**Contact: Jack Sawada**



*Simulated lightning strike.*

#### Planned Transmission Projects include:

- On-line Monitoring of Transformer Insulation Degradation Products
- Develop an Intelligent System for Advanced Utility Power Equipment Condition Assessment
- Investigate Applications of Phasor Measurement Technology to BC Hydro Remedial Action Scheme (RAS)
- Investigate Application of Synchronized Phasor Measurement Technology to BC Hydro Power Oscillation Monitoring Applications
- NxtPhase technology applications – 230 kV replacement, substation metering, capacitive voltage transformer calibration



## DISTRIBUTION

# Acoustical On-line Monitoring of Armour Damage to Submarine Distribution Cables

### Purpose

- Investigate the feasibility and ultimately construct a prototype on-line acoustical monitoring system for submarine cables

### Background

Every two to three years, the armour of one of BC Hydro's submarine cables is damaged and repairs can be costly. There is currently no technology available to monitor submarine cables for possible mechanical damage and because cable failure may not occur immediately, it has been difficult or impossible to determine cause and responsibility for the damage.

This project aims to change how BC Hydro responds to submarine cable damage and offers potentially large savings. The first phase of the project, a survey of sites and equipment, is underway. At the same time, a search is being conducted to determine if there is a system available to actively monitor submarine cables and provide a real-time alert or alarm when potentially damaging action is occurring. The search will also determine if there are suitable techniques that could be combined with commercial equipment to provide a cost effective solution.

Future project phases include conducting tests on an actual cable crossing, developing a prototype monitor package and testing it for an extended period.

### Deliverables

At project completion, a commercial package may be produced for use by a variety of industries such as electrical distribution companies, ocean wind farms, tidal power projects, and offshore oil and gas producers.

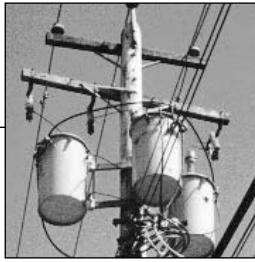
### Status: Active

**Contact: Gino Valli/Mike Stephens**



*Submarine cable.*





## DISTRIBUTION

# Development and Production of Internal Fault Detectors (IFD™) for Distribution Transformers

### Purpose

- Refine and apply IFD Corporation's patented Internal Fault Detector (IFD™)

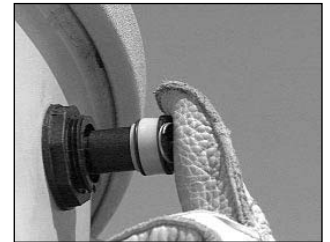
### Background

Most transformers used on distribution systems are protected against overloads and short circuits by devices incorporating fuse links. However, the short circuit that caused the fuse to operate may have occurred either inside the transformer or outside on the primary bushing or secondary circuits connected to the low voltage terminals. Generally, if there are no visible signs of damage to the transformer tank, an attempt will be made to restore service to the affected area by re-energizing the transformer. If the transformer contains an undetected fault, re-energizing it can be extremely hazardous. Explosive failures of transformers though rare, do happen.

The IFD™ is an inexpensive accessory that can indicate whether or not a distribution transformer has been subjected to an internal fault. Several IFD™ prototypes have been built and successfully tested. However, when utilities were surveyed, a majority preferred the IFD™ to be located in a position in the transformer side-wall where it could be readily seen from the ground.



*IFD™ installed transformer*



This Canadian Electricity Association Technologies Inc. co-funded project was initiated to re-design the device and perform electrical, environmental and ergonomic testing.

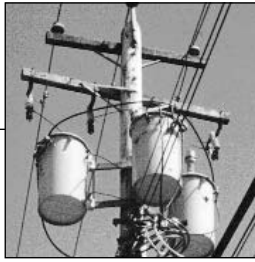
By preventing the re-energizing of faulty transformers, the IFD™ improves safety for operating crews. The device will also increase chances of future restoration for transformers with an internal fault by preventing further damage if they are re-energized. In addition, the IFD™ can speed up power restoration after outages caused by storms by clearly indicating which transformers have failed.

### Deliverables

IFD™ has been patented in the US and other patents are pending. All new distribution transformers received by BC Hydro include an IFD™. A number of these units will be tracked through installation and operation.

**Status: Completed 2001**

**Contact: Terry Einarson**



## DISTRIBUTION

# Field Assessment Techniques for Harmonic Source Detection

### Purpose

- Verify if the latest techniques can correctly separate utility and customer harmonic contributions
- Determine if they can be applied to BC Hydro's system
- Demonstrate how they can be applied

### Background

Harmonic distortion is one of the main power quality concerns for utilities. While standards have been established to limit harmonic distortion levels, it is difficult to apply them, as there is no method to determine if the harmonic sources originate from the customer or the supply system. In addition, the dominant harmonic sources in a power system need to be determined before mitigation methods can be designed.

Various methods to determine the responsibility of harmonic contributions and measure harmonic sources have recently surfaced. Co-funded by the Natural Sciences and Engineering Research Council of Canada, and in conjunction with University of Alberta (U of A) researchers, this project is investigating some of those techniques through field tests. Existing methods will be improved based on the test results and analysis. A later project phase will determine and demonstrate an application of techniques to BC Hydro's system.

As a result, the power industry could be provided with a revolutionary class of tools that will improve current power quality management practices by saving engineering time and costs to troubleshoot harmonic problems. Disputes between utilities and customers over who causes harmonic violations will be easier to settle. In the long run, the technique may lead to an incentive based harmonic management scheme that charges harmonic generators an amount commensurate with their harmonic pollution levels.

### Deliverables

Significant progress has been made on improving U of A's harmonic source detection method. This includes a new method for harmonic source detection and a robust scheme to combine the new and existing method into a practical source detection instrument. IEEE transaction papers have been submitted and additional patents have been awarded to U of A.

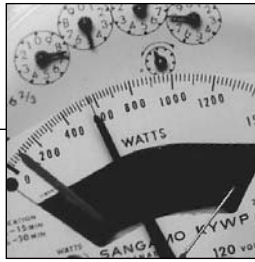
### Status: Active

### Contact: Brent Hughes

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### Planned Distribution Projects include:

- Dynamic Voltage Restorer Applications
- Investigate Application of High Speed Internet on Distribution Systems
- Intelligent Variable Inductor/Harmonic Filter for Distribution System Applications



## CUSTOMER TECHNOLOGIES

### Pinch Energy Optimization Studies

#### Purpose

- Demonstrate the benefits of Pinch studies in British Columbia's pulp and paper industry by conducting projects to cooperatively improve industrial process efficiency

#### Background

By understanding energy use patterns and options at an industrial site, the utility and industrial user can work together to improve process efficiency and energy usage, and to define mutually beneficial investment and operating decisions.

Pinch technology facilitates this approach by examining industrial processes as an integrated system. The result is identification of practical and cost-effective modifications to reduce energy costs by 20 to 40 per cent. By matching heat sources and sinks for an entire plant, Pinch identifies heat exchange opportunities that make use of waste heat. In this way, a plant's total thermal energy requirements are lessened, and energy consumption lowered, as process streams and equipment arrangements are reconfigured.

Pinch is applicable to all industries and, in many cases, improves plant capacity, eliminates process bottlenecks, facilitates compliance with environmental regulations, and

identifies new technology opportunities. Pinch analysis can also provide opportunities to recycle and reuse water, and determine the appropriate role for cogeneration. For utilities, Pinch fosters load retention and strategic growth with their industrial customers. Information provided by Pinch can also support utility demand-side management and marketing programs.

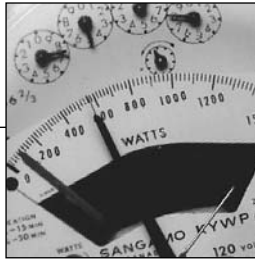
In partnership with EPRI, BC Hydro applied Pinch studies in 11 pulp and paper mills with excellent results. For example, the Kamloops Pulp project investigated the opportunities for saving steam from process users (through heat recovery or process configuration changes) so it could be used to generate additional condensing power.

#### Deliverables

Ten of the Pinch study projects have been completed; one is still in progress. Overall results of the Pinch studies indicate a 10 to 50 per cent energy savings identified with payback in less than three years.

**Status: 10 projects completed, 1 ongoing**

**Contact: Al Boldt**



## CUSTOMER TECHNOLOGIES

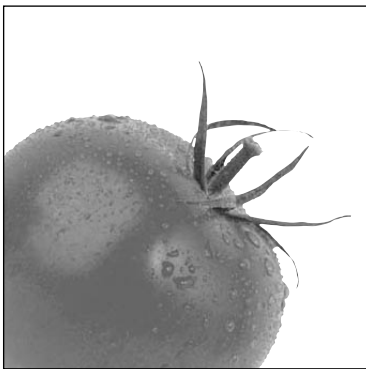
### Supplemental Lighting for Production of Greenhouse Grown Tomatoes

#### Purpose

- Evaluate the economic viability of using supplemental lighting for winter production of tomatoes

#### Background

The greenhouse sector has been one of the fastest growing agricultural industries in British Columbia. However, despite its success, one of the challenges facing the BC greenhouse industry is the lack of year round production. The most promising means of increasing production during the winter months is the use of supplemental lighting.



The project aimed to determine how the duration and intensity of supplemental light affect the growth of tomato plants under winter growing conditions. Research included collecting growth and yield data from tomato

crops grown under supplemental lights, and a control group with no additional lighting. The project was also intended to establish the costs for the winter production of greenhouse tomatoes.

The project was to include two phases. The first evaluated the differences in growth and production of tomato plants grown under 16,000 Lux supplemental lighting versus tomato production under normal lighting conditions. If the results from Phase I looked promising, the second phase would potentially evaluate the use of higher lighting density. If Phase I did not prove financially viable, then lower lighting density would be explored.

#### Deliverables

Successful implementation of the technology was expected to result in dramatic increase in the annual fresh crop and resulting sales.

Phase I of the project showed a potential 300 per cent increase in tomato yield under the supplemental lighting versus the control crop with a noticeable increase of leaf growth versus fruit. Phase II of the project was to include refinements such as different lamps and climate control. However, the project was cancelled due to changes in the hothouse industry. No further work will be done at this time.

**Status: Completed 2001**

**Contact: David Rogers**





## CUSTOMER TECHNOLOGIES

### Water and Wastewater Centre (WWC) for Customer Solutions

#### Purpose

- Support customer retention and competitiveness
- Increase electricity market share
- Provide new business opportunities and alliances
- Increase customer value of electricity
- Introduce and evaluate use of electrotechnologies

#### Background

In 1996, BC Hydro established the WWC in partnership with the Electric Power Research Institute (EPRI), American Water Works Association Research Foundation (AWWARF), BC Water and Wastewater Association, Greater Vancouver Regional District, and the Universities of British Columbia and Alberta. The centre was the first of its kind in Canada and the Pacific Northwest, delivering innovative electrotechnology solutions for water and wastewater treatment.

#### Deliverables

The Centre provided:

- Opportunities for research, development and demonstration of new technologies
- A directory of expert consultants and technology providers
- An events calendar for water and wastewater technology
- Pilot projects including water and energy audits
- Energy efficiency and technology advice and support
- Seminars and workshops
- Technical literature
- A web site listing the services, contacts and links to industry partners' web pages

Projects completed through the WWC include:

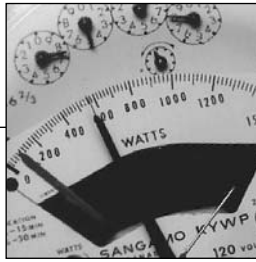
- Investigation of Water Treatment Unit Performance at Seymour Plant Facility Using Various Raw Water Qualities
- Detoxification of Log Yard Run-off by Ozonation
- Electroflocc Electric Technology Wastewater Pilot Plant in the Town of Ladysmith
- Optimization of Sequential Batch Reactors Wastewater Treatment and Residuals Management with Methanol Addition

The Water and Wastewater Centre officially closed March 31, 2002. The closure reflects a change in direction from the use of electrotechnologies to demand-side management. WWC projects still active will be managed by the newly established Power Smart Technology Centre.

**Status: Completed March 2002**

**Contact: Grad Ilic**





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## CUSTOMER TECHNOLOGIES

### **Planned Customer Technology Projects include:**

- Increasing energy efficiency of electrocoagulation wastewater treatment
- Participation in Electrotechnologies Innovation Network
- Implementation of demand side management technologies through a newly established Power Smart Technology Centre



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## RESEARCH PARTNERS

BC Hydro collaborates with other research partners and organizations to advance electricity industry technologies while maximizing return on research investment and minimizing risk. Strategic R&D maintains a wide range of

partnerships with large research organizations, educational institutions, and smaller startup companies, focused on advancing technologies related to the electricity industry.

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### Powertech Labs Inc.

Powertech Labs Inc. (PLI), a wholly owned subsidiary of BC Hydro, provides testing, consulting and research services to power utility customers in a number of industries. PLI solves technical problems spanning the life cycle of power equipment and systems. In a single facility with 18 labs (high-voltage, high-power and high-current labs etc.) Powertech offers electrical, chemical, environmental, mechanical, metallurgical, materials, civil and structural engineering expertise.

Powertech also hosts a newly constructed hydrogen fueling station and is conducting fundamental research and testing to develop 10,000 psi hydrogen storage systems.

Powertech employs approximately 80 professional engineers, scientists and technologists. Its representatives participate in BC Hydro's network of strategic research and technology (SR&T) work groups, and also provide contract services on SR&T projects.

For more information, visit the Powertech Labs website at [www.powertechlabs.com](http://www.powertechlabs.com)

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### Canadian Electricity Association Interest Groups

BC Hydro participates in a wide range of technology research interest groups with Canadian Electricity Association Technologies Inc. (CEATI). The Interest Groups include members from Canadian and International utilities who share information, identify research priorities and fund projects.

#### BC Hydro's 2001 Membership

##### Dam Safety

This group investigates new diagnostic tools, monitoring techniques, stability assessment and safety tools, repair

materials, and refurbishment techniques to evaluate and mitigate safety issues associated with aging dams. The group also sponsors technology development projects designed to improve assessment and safety standards.

CEATI Projects BC Hydro participates in:

- A Guide to Dam Risk Management
- Investigation of Geophysical Methods for Assessing Seepage and Internal Erosion in Embankment Dams

BC Hydro Representatives: Ray Stewart/Al Imrie



## RESEARCH PARTNERS

### **Distribution Assets - Life Cycle Management**

This group helps further understanding of the problems and available tools to evaluate the state of distribution assets, and to suggest the appropriate course of action. It also investigates advanced techniques to assess the risks and benefits associated with the trend to utilize equipment at capacity levels that exceed nameplate.

CEATI Projects BC Hydro participates in:

- Condition Assessment of Porcelain Insulated Fused Cutouts
- Improved Performance of Switched Capacitor Banks
- Remaining Life Estimation of Distribution Transformers
- Testing and Development of Ultrasonic Detection as a Predictive Maintenance Tool for UG Accessory Failure
- New Distribution Design
- Recycled Oils Standard for Distribution Transformers
- Reliability of Steel Distribution Poles
- Underground Cable Diagnostics to Determine Degradation of In-service URD (Distribution) Cables
- Aesthetic Overhead Distribution Design

BC Hydro Representative: Terry Einarson (Chair)

### **End-Use Technologies**

This group's objective is to provide utilities with information on advanced end-use technologies that produce bottom-line advantages. Electrotechnologies can:

- provide new technology solutions to customer problems
- displace less efficient energy based technologies
- reduce customers' overall energy costs
- enhance the value of electricity for industrial, commercial and residential applications
- address environmental concerns

BC Hydro participates in the following CEATI initiatives:

- Reduction of Energy Costs in Canadian Pulp and Paper Processes – Case Studies (PAPRICAN)
- Scoping a National Network for Electrotechnologies Innovations (CCE – Canadian Council on Electrotechnologies)
- Study of Refiner Motor Failures
- Energy Reduction in the Pulp and Paper Industry – Monograph. *Completed April 2000.*
- Guide to IEA End-use R&D. *Completed June 2000.*
- Report on the World's Latest Developments of Single-Room Heat Pump Systems for Electric Utilities. *Completed March 2000.*
- Effects of Voltage Pulse Width Modulation (PWM) on Adjustable Speed Drive (ASD) Motor's Insulation System. *Completed June 2000.*

BC Hydro Representative: Grad Ilic

### **Hydraulic Integrated Resource Management**

The scope of this group includes all aspects of water resource management, from planning and operations to environmental assessment and mitigation. As hydraulic projects substantially affect water storage and regulation in many Canadian river systems, this group focuses on water management effects on fish, environmental impacts, and scientific and regulatory issues.

CEATI Projects BC Hydro participates in:

- Comprehensive River Ice Simulation System Project

BC Hydro Representatives: Brian Fast/Murray Kroeker



## RESEARCH PARTNERS

### Hydraulic Plant Life

The highly competitive North American utility environment emphasizes a need for reduction of capital investments for equipment and parts replacement, as well as outage time for equipment repair and maintenance.

Topics covered include: plant modernization guidelines; improved maintenance and repair techniques; equipment life extension; improved equipment efficiency; diagnostics and monitoring; operations and maintenance cost reduction; future turbine studies; intakes/spillways.

CEATI Projects BC Hydro participates in:

- Life Cycle Management of Hydro Plant Assets
- Technology Reviews
  - Innovative Ways to get More Value
  - Methods to Assess Equipment Condition
  - Biodegradable Oils
  - Reliability of Discharge Facilities
  - Hydraulic Smoothing
  - Experience with Self-lubricating Bushings
  - Cost of Producing Ancillary Services

BC Hydro Representative: Niels Nielsen (Chair)

### Ice Storm Mitigation

This group evaluates risk of extensive damage due to ice, and combinations of ice and wind if extreme storms exceed design. Reducing these impacts can take different forms:

- mitigation techniques before ice becomes a danger to the installations;
- mutual assistance and sharing of logistics, equipment and components in case overhead lines are seriously damaged by a storm;
- improved design approaches to prevent failure and to reduce the consequences of failures.

CEATI Projects BC Hydro participates in:

- Assessing Design Approaches for Overhead Transmission Lines under Climatic Loads for New Projects as well as for Verification of Lines to be Upgraded
- Assessment of Effectiveness of Load Reduction Devices and Mechanical Fuses
- Crisis Management and Mutual Assistance Programs
- De-icing Techniques Before, During and Following Ice Storm
- Development of Coating-less High Frequency Method for De-icing Overhead Lines
- Inspection Techniques to Detect Latent Damage to Existing Lines from Previous Ice & Wind Storms
- Preparation of Icing Maps
- Reliability Design Practices for Transmission Line Steel Poles
- Technical Studies on Mechanical & Electrical Performance of Substation Equipment; Assess Performance of De-icing Robot; Anti-icing & Ice Repellent Products

BC Hydro Representative: Ron Nixon (Chair)



## RESEARCH PARTNERS

### **Life Cycle Management of Station Equipment and Apparatus**

The group facilitates research to optimize the life cycle management of station equipment and apparatus. There are increasing pressures to optimize the use of existing station plant assets, and to develop new equipment and applications that are lower cost, more efficient and more reliable than existing ones. Since a great deal of station equipment in use today is aging with a current installed life of 20 to 40 years, maintenance costs will rise as reliability of aging plant starts an inevitable decline.

CEATI Projects BC Hydro participates in:

- Condition Monitoring of Circuit Breakers by Oil Analysis
- Transformer Oil Leak Mitigation Program (completed)
- Vibration Diagnostic Test to Evaluate Power Transformer Winding Condition

BC Hydro Representative: George Dang

### **Power Quality**

This group provides a forum for leading Canadian utilities to review their policies concerning damages caused by power quality problems from growing electronic loads. They are also revising the standards practices that would allow utilities and manufacturers to coordinate their development and guarantee electromagnetic compatibility (EMC). In addition, the group is investigating and providing services to their customers offering different levels of electricity quality at different rates.

CEATI Projects BC Hydro participates in:

- Design Guide for Sag Resistant Motor Control Center
- Impact of Harmonics on Utility Equipment: A Survey & Review of Published Work

- Load Acceptance Tool: Harmonics
- Sag, Swell and Short Interruption Evaluation from the Canadian Power Quality Survey 2000
- Approaches for Embedded Solutions
- Using Power Quality Indices to Track System Performance
- Power Quality Survey

BC Hydro Representative: Brent Hughes

### **Strategic Options for Sustainable Power Generation**

Utilities are facing pressures to pursue environmentally sustainable operations while having to maintain sound business practices in an increasingly competitive environment. A better understanding of full cycle cost accounting must be attained so that a level playing field is created on which all appropriate technologies, their impacts and benefits can be evaluated and, where appropriate, promoted.

Topics covered include: fuel advancements in coal cleaning and refining; advanced generation cycles: combustion turbines, gasification, reciprocating engines, district cooling; repowering/refueling; distribution generation; cogeneration and district heating; non-utility generation such as biomass, wind, solar, wave, tidal; fuel cells and fuel production for fuel cells; greenhouse gas mitigation; full cost accounting.

CEATI Projects BC Hydro participates in:

- Solid Oxide Fuel Cell Commercialization Association
- Power Generation from Biomass

BC Hydro Representative: Terry McCullough



## RESEARCH PARTNERS

### **Transmission Lines Asset Management**

This group facilitates research to optimize the management of transmission system assets (overhead lines and cables). A key focus is to extend the life of existing assets or upgrade them, and thus defer or eliminate the need for major capital expenditures for new transmission systems.

CEATI Projects BC Hydro participates in:

- Condition Assessment of Transmission Line Wood Poles, Braces & Cross-arms
- Insulator Diagnostics

BC Hydro Representative: Ed Shantz

### **Power Systems Planning & Operation**

This group focuses on new technologies available for enhancing the use of existing lines and facilities, and their application to design and implementation of new lines. Recent developments in restructuring and deregulation of vertically integrated utilities, environmental pressures and the quest of independent power producers for fair access to the transmission systems make construction of new lines and large generating plants difficult.

CEATI Projects BC Hydro participates in:

- Fault Current Management

BC Hydro Representative: Bruce Sunga



## RESEARCH PARTNERS

### EPRI

BC Hydro has maintained an annual membership with the Electric Power Research Institute (EPRI) based in Palo Alto, California, since 1992. Involvement in EPRI's collaborative research programs and directed projects are a major portion of our annual R&D investment. The main areas of focus are Power Delivery, Thermal Generation, Power Quality, Distributed Resources, and special initiatives such as Infrastructure Security. BC Hydro is also involved with the Research Advisory Council (RAC) and many of the business councils, providing input for program development and governance.

BC Hydro is a major contributor to the demonstration of new technologies developed in conjunction with EPRI and major equipment manufacturers. Our installations of the DSTATCOM (Distribution Static Compensator) and the PMDVR (Platform Mounted Dynamic Voltage Restorer) were the first of their kind in North America.

This past year, BC Hydro participated in a number of collaborative projects and activities including:

- SF<sub>6</sub> Leak Detection
- ANNSTLF (Artificial Neural Network Short Term Load Forecasting)
- Microturbine User's Group
- Thermal Generation Training Program for Steam Turbines
- Smart Ground Multi-meter
- Pinch Energy Optimization Studies for Pulp and Paper Mills
- Enterprise Infrastructure Security Collaborative

Planned Activities for 2002 include:

- DayCor Camera Inspection
- Distribution Fault Anticipator
- Video Sagometer Rating on 500 kV lines

### Other Affiliations & Research Partners

Strategic R&D has affiliated with other partners and research organizations over the past year, including:

- B.C. Advanced Systems Institute
- British Columbia Institute of Technology (BCIT)
- CANMET – Natural Resources Canada's Energy Technology Branch
- Canadian Energy Research Institute (CERI)
- E-Source
- Electric Vehicle Association of Canada (EVAC)
- IFD Corporation
- NxtPhase Corporation
- PRECARN Incorporated
- Solid Oxide Fuel Cell Commercialization Association (SOCA)
- University of Alberta
- University of British Columbia
- UFTO – Utility Federal Technologies Opportunities





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