

Tale OF TWO Power Plants

Cost overruns, suspect safety systems and radioactive waste have cast a dark shadow on nuclear energy. But proponents of nuclear energy say it's the ultimate environmental solution to increasing energy needs and the escalating price of other energy sources. What role will nuclear energy play in the changing market? What factors propel some nuclear power plants to flourish while others flounder?

by Connie Vitello

It has been almost a year since the biggest power failure in North American history. It was a hot Thursday afternoon in August. The blackout left 50 million people in the northeast United States and south central Canada asking who turned off the lights. Some stewed and suspected the worst — terrorists — and frantically searched for answers on their battery-powered radios. Others headed straight for the exit doors, relieved at the prospect of a little time off. Everyone who experienced the absence of electricity will never again take for granted the simple pleasures of air conditioning and cold beer.

In Ontario, CANDU (CANada Deuterium Uranium) nuclear energy came to the rescue within a few hours of the blackout, while other power sources remained off-grid and out of commission, for as long as three days. (See diagram.)

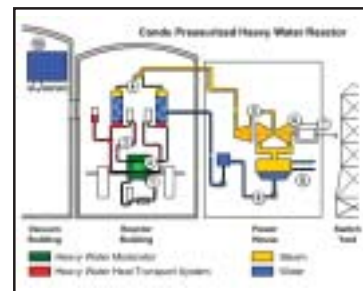
The blame for the blackout, for the most part, fell on a few old tripped-out transmission lines near Cleveland, Ohio. The Ontario government's response was to announce a renewed focus on energy conservation and a reduction in the reliance on imported energy. Why aren't our power plants operating at optimal efficiency? And while they're at it, the government also vowed to increase clean energy alternatives and reduce



The Industrial Accident Prevention Association invited Duncan Hawthorne, president and CEO of Bruce Power, to speak at its conference about how Bruce Power's "safety first" culture has helped the company become one of the most successful nuclear operations in North America.

Bruce Power, one of Ontario's largest independent power generators, is located by Lake Huron, about 250 kilometres northwest of Toronto. As an integrated multi-unit site, the plant is able to generate enough electricity to supply up to 20 per cent of Ontario's power needs.

All of OPG's nuclear reactors were developed by Ontario Hydro and Atomic Energy of Canada Limited using the CANDU (CANada Deuterium Uranium) reactor technology, which uses natural uranium fuel and heavy water. The reactors produce heat by splitting the atoms of the uranium fuel. This process is known as fission. Heat from the reactors is used to boil ordinary water in boilers. This produces high-pressure steam that is then used to spin the blades of the turbines at very high speed. These turbines turn the electrical generators. The electricity is then sent to the grid that carries the power to homes, businesses, schools and industries within southwestern Ontario. Diagram courtesy of OPG.



Ontario Power Generation's electricity-generating portfolio has a total in-service capacity of 22,733 megawatts (MW), including three operating nuclear stations with a capacity of 6,103 MW (comprising four units at Darlington, four units at Pickering B and one unit at Pickering A). Two nuclear stations, formerly operated by OPG, are leased on a long-term basis to Bruce Power LP.

greenhouse gas (GHG) emissions. Some would argue that since last summer there has been, for all intents and purposes, progress on the energy resource management front. But there are still significant economic and technological challenges to address.

Ontario Energy Minister Dwight Duncan says that keeping the province's lights on will cost between \$25-billion and \$40-billion over the next 15 years. The minister plans to table a bill in June to create the Ontario Power Authority, the mandate of which will be to anticipate the province's energy demands. The goal is to construct, refurbish, rebuild, replace or conserve 25,000 megawatts of generating capacity by 2020 — this represents new opportunities for Ontario's energy industry. (See sidebar.)

Ontario currently relies on nuclear energy to supply 50 per cent of its electrical power. Ever-growing increases in the demand for electrical power — combined with the province's intention of mothballing coal-fired generating plants by 2007 — point to a greater reliance on nuclear energy in the future.

To some, nuclear energy is an attractive option. Proponents cite that nuclear power plants do not produce carbon dioxide emissions, which are a major contributor to the greenhouse effect. Recent estimates indicate that worldwide reliance on nuclear energy has reduced GHG emissions by almost 500 million metric tons annually.

While it does have its drawbacks, including radioactive waste, there seems to be somewhat of a consensus of sorts that the pros outnumber the cons and that the nuclear energy option is here to stay. So, it's worth determining what factors make one nuclear facility run more efficiently and safely than another.

After consulting experts in the industry and representatives of two major nuclear energy facilities, it's clear that there are no easy answers. However, energy industry stakeholders across the country should know that by employing certain key principles a plant can drastically optimize investments and increase operating efficiencies.

Bruce Power LP in Tiverton, Ontario provides some good examples for the industry.

But before getting to the nucleus of the matter, it's prudent to first understand past challenges and how these were overcome.

Trials and tribulations

In the 1970s, nuclear energy was a new and innovative option with the potential to reduce

pollution and environmental impacts. Nuclear power plant start-up costs were high, but the ongoing costs of producing nuclear energy seemed low compared with traditional resource extraction methods.

However, even the most vocal proponents of nuclear energy temporarily conceded that they were somewhat disenchanted by the accidents at Three Mile Island and Chernobyl.

The accident at Three Mile Island's nuclear power plant near Middletown, Pennsylvania occurred on March 28, 1979, and was the most serious in U.S. history. The sequence of events — equipment malfunctions, design-related problems and worker errors — led to a partial meltdown of a reactor core and small off-site releases of radioactivity. Even though there were no deaths or injuries, the incident contributed to public fear and distrust.

The accident at Chernobyl in the former USSR (now Ukraine) was far worse. While testing a reactor on April 26, 1986, numerous safety procedures were disregarded and resulted in massive explosions and the pinnacle event — a fireball that blew off the reactor's heavy steel and concrete lid. The instant release of radiation killed more than 30 people immediately. More than 18 years after the devastating accident, there are still lingering effects of radiation. Health risks in the area remain higher than normal and the rate of thyroid cancer continues to rise. It is considered the world's worst nuclear power accident.

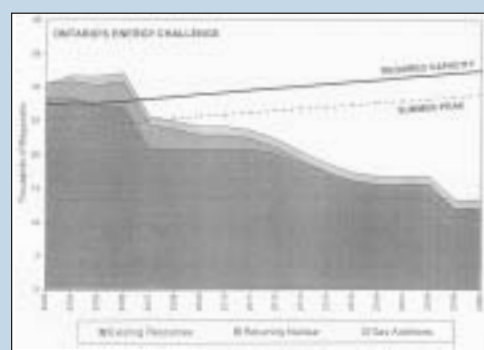
As a result of these incidents, the U.S. Nuclear Regulatory Commission's regulations and oversight became broader and more robust, and management of the plants was scrutinized more carefully.

In Canada, all nuclear activities come under the control of the Canadian Nuclear Safety Commission (CNSC), which administers the *Nuclear Safety and Control Act*. This Act regulates the development, production and use of nuclear energy to prevent unreasonable risks to the environment, health and safety (workers and members of the public) and national security. Every nuclear activity requires a license from the CNSC.

"There are many variables to examine when it comes to nuclear safety," says Michel Clereoux, media and community relations liaison for the CNSC. "We require licensees to meet minimum standards and public and private plants alike all have to

play by the same rules."

The CNSC's latest "report card" on nuclear generating stations indicates that,



Ontario's new energy strategies

Ontarians currently pay an artificially low 4.3 cents a kilowatt hour, a government-subsidized price that will rise to between 4.7 and 5.5 cents under a new pricing plan recently introduced by Energy Minister Dwight Duncan.

The plan includes the following:

- Establish a new Ontario Power Authority (OPA) that will be responsible for ensuring an adequate, long-term supply of electricity, including a new Conservation Secretariat;
- Require the energy minister to set targets for conservation, the use of renewable energy, and the overall supply mix of electricity in Ontario;
- Encourage private sector investment in new generation.
- Set prices for electricity in two ways: part will be price-regulated by the Ontario Energy Board (OEB) and part will be priced by the market;
- Eliminate price caps and create a new standard rate plan for small businesses and homeowners, under which prices will be adjusted and approved periodically by the OEB. According to the ministry, this will ensure that prices are stable while allowing the true cost of electricity to be passed on to consumers; and,
- Allow industrial and commercial customers to choose between buying electricity at market prices or using other tools help manage energy costs.

The OEB will establish a framework to help local distribution companies (LDCs) deliver conservation programs. Until now, the LDCs have had no real incentive to promote conservation. Any disincentives will be removed, suggesting a much bigger role for metering companies and service providers.

While Minister Duncan confirmed the government's commitment to replace coal-fired generation, he also stated that adequate alternatives will have to be in place before this happens.

more or less, all of the currently operating plants achieve good grades (As and Bs) with regard to operating performance, environ-

mental performance, safeguards and emergency preparedness. There are a few Cs, in which case the plant makes a swift effort to rectify the shortcoming.

But a recently released book continues to fuel the fires of concern over nuclear energy. *Fueling the Future* Editors Andrew Heintzman and Evan Solomon cast a critical eye on North American energy policy. With the help of leading energy thinkers.

Thomas Homer-Dixon, director of the Centre for the Study of Peace and Conflict and associate professor in the Department of Political Science at the University of Toronto, points to huge operational problems and expensive maintenance issues.

Allison Macfarlane, associate professor of International Affairs and Earth & Atmospheric Science at Georgia Tech in Atlanta, Georgia argues the claim that nuclear power produces no GHG emissions is not actually correct. Ms. Macfarlane refers to the GHGs emitted during the extraction of uranium for fuel, during uranium processing and enrichment, and in the production of construction materials for nuclear power plants, such as concrete and steel.

In addition, nuclear waste remains an unresolved problem, says Ms. Macfarlane. Considering 20 to 30 tonnes of used nuclear fuel are produced per gigawatt per year, the current capacity of the world's nuclear power plants produces between 7,000 and 11,000 tonnes of spent fuel annually. This high-level waste contains all the thermally and radioactively hot materials that the original spent fuel contained.

(The Nuclear Waste Association contends that nuclear waste is managed in coded fuel bundles in guarded locations. And the Nuclear Waste Management Organization, a newly established advisory body, plans to make fresh recommendations to the federal government by November 15, 2005 for dealing with waste fuel. The results should introduce some new business opportunities in waste management.)

Even with a waste management solution, Ms. Macfarlane questions the risks and their potentials: could there be a nuclear bomb made from diverted nuclear materials, and is the aftermath of one of these weapons worth the money saved from renewable energy technologies and the advantages for the climate?

It doesn't help that nuclear energy is tied so directly to the still very real threat of nuclear weapons — a fear that has been amplified by the terrorist attacks of 9/11.

Despite all this, Geoffrey Ballard, the pioneer of the innovative hydrogen fuel cell, believes nuclear energy is the best and the only viable, wide-scale source of hydrogen required to power the new hydrogen economy. He has said that the risk of a recurring accident have to be weighed against the risks of increased use of fossil fuels. Within the scope of today's technology, Mr. Ballard says, nuclear fission is the only viable, clean source of large quantities of energy. Mr. Ballard is one of many current advocates of nuclear energy.

A panel of experts headed by former Deputy Prime Minister John Manley issued a report on March 18 recommending that most of Ontario's future electrical demands should be filled by nuclear power. The report says nuclear power plants will produce electricity at a cost of two to three cents a kilowatt hour less than a natural-gas plant.

"The nuclear industry has a new lease on life," says Murray Elston, the new president of the Canadian Nuclear Association (CNA). "There's now an ability to propose new ways of doing things based on lessons we've learned over the years. There are more business opportunities than ever before and the possibilities are endless."

There is an undeniable buzz in the industry that certain plants are outperforming others and it seems, more than anything else, that management makes the greatest difference.

In hot water

The publicly-owned Ontario Power Generation (OPG) electricity-generating portfolio includes three operating nuclear stations comprising four units at Darlington, four units at Pickering B and one unit at Pickering A. Two nuclear stations, formerly operated by OPG, are leased on a long-term basis to Bruce Power L.P.

OPG's facility in Pickering has been plagued by cost and schedule overruns amounting to hundreds of millions of dollars, due to the attempted reengagement of some of the units. Pickering A, the only operating unit, was out of service for nearly two weeks at press time. On June 1, it missed another target date for refurbishing its generating station. More importantly, there are issues worth examining with regard to safety.

Pickering's fourth-quarter "Nuclear Performance Index" summary looks grim. The index provides an overview of perfor-

mance based on 10 key indicators that cover a number of areas, including safety and production. The nuclear performance index rate for Pickering B was 69.8 — which is worse than the target of 78.3 — and well below the industry benchmark of 96.0.

"The Reactor Trip Rate" — a significant measure of safety system performance — represents the number of unplanned reactor shutdowns triggered by automatic safety systems.

Reactor trips indicate potential problems that need to be addressed. In the fourth quarter of 2003, the reactor trip rate at Pickering B measured 1.78 trips per 7,000 hours of operation — which is worse than the target and industry benchmark of only 1.0 trips.

"At Ontario Power Generation our commitment to safety and protection of the environment is uncompromising and absolute," says OPG Pickering's spokesperson John Earl. →

He adds that OPG has revised its corporate safety rules for the first time in 10 years, "making them more relevant to the shop floor and aligned with current legislation."

A report of OPG's 2003 safety performance says that site specific safety measures and targets are incorporated into the goalsharing plans for all unionized employees in the Power Workers' Union and the Society of Energy Professionals. The document also indicates that the "Accident Security Rate" and the "All Injury Rate" performance were better than target in 2003, and were the best performance that OPR has achieved since its incorporation in 1999.

But Mr. Earl also confirmed that OPG has out-sourced some elements of its safety contracts. Few may know that OPG has turned over some of its safety inspections and security activities over to The Babcock & Wilcox Company — the same company that was signaled as a detriment to safety at Three Mile Island by a presidential commission. The reasons include inadequate safety precautions and training. Mr. Earl would not disclose the details of the contract.

Meanwhile, Bruce Power, Canada's first privatized nuclear power generation facility has managed to bolster its safety rating and boost performance efficiency in the same time frame.

Cultivating the nuclear garden

Duncan Hawthorne was born in the United Kingdom and at the age of 15, he began working at various labour jobs. These days, the 47-year-old taps more than 25 years of experience in the power engineering business to run Bruce Power. As president and CEO, Mr. Hawthorne has, by all accounts, implemented a "safety first" culture.

The Industrial Accident Prevention Association (IAPA) asked Mr. Hawthorne to describe at its recent conference how he achieved the company's "safety first" culture and helped make it one of the most successful nuclear operations. But before disclosing some of the details, let's get down to brass tacks.

Bruce Power is the largest generating plant in North America, and the only privately run nuclear generating station in Canada. The corporation leases Bruce Power generating station from the Ontario government for an 18-year lease (with an option to renew for up to another 25 years) which started in May 2001.

The other nuclear power plants in Canada are operated by provincial government utilities (a situation that is in direct contrast to that of the U.S., where only three of 103 nuclear power plants are operated by the government).

Bruce Power is a partnership of Cameco

Nobel Laureate Mario Molina talks about global warming at the North American Energy Summit. Photo courtesy of the Western Governors Association.



Terminating old strategies

The energy profile of North America is changing, and experts at the North American energy summit held in April by the Western Governors Association discussed the future impacts to the industry. The association represents the 17 U.S. states that run south from North Dakota to Texas and west to the Pacific coast. Provincial counterparts from B.C., Alberta, Saskatchewan and Manitoba were also in attendance.

Governor Bill Richardson of New Mexico and Governor Arnold Schwarzenegger of California set the tone by releasing a letter calling for development of at least 30,000 MW of clean energy in the west by 2015 and to increase the efficiency of energy use by 20 per cent by 2020. They also proposed that the western states create new energy sources such as hydrogen fuelling systems on western highways.

"This has been a very productive, bipartisan energy summit," said Governor Richardson, WGA chairman. "We laid the foundation for greater regional cooperation toward sustainable energy policies that will reduce dependence on foreign oil and create a lot of jobs."

Governor Schwarzenegger proposed that California create a "hydrogen highway" with 200 hydrogen fuelling stations operating by 2010. The City of Vancouver, B.C. recently announced a similar highway project that will be built in time for the Vancouver Olympics.

Corporation (31.6 per cent); TransCanada Corporation (31.6 per cent); BPC Generation Infrastructure Trust, a trust established by the Ontario Municipal Employees Retirement System (31.6 per cent); the Power Workers' Union (four per cent); and, the Society of Energy Professionals (1.2 per cent).

There are eight nuclear reactors on the site. Four are housed at Bruce A, which was commissioned between 1977 and 1979 and laid up between 1995 and 1998. Four others are at Bruce B, which was commissioned between 1984 and 1987.

With the return of service of Bruce A units

three and four, the plant is able to generate enough electricity to supply approximately 20 per cent of Ontario's power needs. There is a feasibility study under way to examine restarting Bruce A units one and two.

Canadian Nuclear Association (CNA) president Murray Elston says Bruce Power represents a migration in nuclear technology. "They have implemented modifications that make it more competitive than the average plant," Mr. Elston says. As MPP for Bruce County from 1981 to 1994 Mr. Elston is intimately familiar with the site, having lived only about 30 kilometres away.

"New pride in the site has been a major factor," Mr. Elston says of the recent improvements. "There's now a clear drive toward higher performance standards. I think it helps to have a climate of healthy competition."

Michel Cleroux of the CNSC refers again to the report card and insists that all plants are doing about the same. He acknowledges, however, "The notion that some public plants cannot afford to keep running as efficiently as some private ones or have more troubles financially is an ongoing debate."

Since the change in management at Bruce there has been an investment in upgrades and infrastructure worth about \$1.5-billion.

Bruce Power's nuclear performance index rate for the fourth quarter of 2004 was 73.3 per cent — below the industry benchmark but better than Pickering's performance.

The reactor trip rate for the same time frame was an impressive 0 (zero).

"While we celebrated many commercial and operational successes last year, safety remains our first priority," says Mr. Hawthorne. Bruce Power operates on the principle that emphasis on safety also makes good business sense, since experience shows that the nuclear plants with the best safety records are also the ones with the lowest operating costs.

Bruce Power dramatically improved its safety record in a short time by making improvements in a number of key areas, Mr. Hawthorne says. These include: investment in additional personnel resource safety training (including \$30-million in increased security since 9/11) and the implementation of the International Safety Rating System, which involves in-depth plant inspections and accident investigations, and continuous performance improvements.

Bruce Power most recently recorded an industrial safety accident rate of only 0.12 lost-time injuries for every 200,000 hours worked during a year that saw a significant increase in production from Bruce B and a sustained flurry of activity around its Bruce A restart project. (That exceeded the company's already-demanding safety target of 0.20.) Its 0.09 per cent accident frequency rate is significantly lower than the rate of 4.02 that existed before the facility went private.

Frank Sanders, vice president of safety and environment at Bruce Power has also worked for OPG. (Bruce Power still has close ties with OPG, and currently contracts OPG to store and manage its waste.)

"The safety systems are generally similar," says Mr. Sanders. "However, the major difference is that workers are engaged more effectively at Bruce Power. Duncan [Hawthorne] is really involved and he encourages the rest of the management team."

He adds: "The focus and mandate is more apparent and we are able to make decisions within the company. There's a clear management perspective that I'm not sure exists on the public side."

Bruce Power's philosophy that safety and operational success go hand in hand is clearly reflected in year-end results.

The plant enjoyed a year of strong performance. Backed by reliable operations from its Bruce B units, the company generated an 18 per cent increase over the year before.

"It's important to give staff a sense of ownership and responsibility," says Duncan Hawthorne. "The myth that managers are stupid and employees are lazy is just that, a myth."

The work environment fosters opportunities for continuing education at the Bruce Technology Skills Centre and the Target Outstanding Performance program appoints safety managers throughout the plant (allow-

Nuclear power by the numbers

Currently there are 440 nuclear power reactors in 31 countries that produce one-sixth of the world's electricity. Though the United States gets only 20 per cent of its electricity from nuclear power, it still has the largest nuclear energy fleet in the world. As of 2003, the U.S. had 103 licensed operating reactors in 31 states. As of 2004, Canada has 17 reactors in operation, accounting for 16 per cent of the country's electricity needs. However, nuclear energy has provided Ontario with half of its electricity over the last decade.

Number of operating reactors in Canada (2004):

Pickering A (Ontario):	1 reactor
Pickering B (Ontario):	4 reactors
Darlington (Ontario):	4 reactors
Bruce A (Ontario):	2 reactors
Bruce B (Ontario):	4 reactors
Gentilly (Quebec):	1 reactor
Point Lepreau (New Brunswick):	1 reactor

Total: 17

Number of reactors returning to service:

Pickering A (Ontario):	3 reactors
Bruce A (Ontario):	2 reactors (feasibility study under way)

Total: 5

Source: CANDU Owners Group Inc.

"Over the past year, we've introduced hundreds of new employees and contractors to our site and engaged in some very labour-intensive projects," says Mr. Hawthorne. "Through it all, we've managed to not only meet our safety targets, but exceed them.

By operating safely, I believe we've been able to operate better."

Yugo Ivanovich, owner and principal consultant of ARPT Safety Consulting, based in Sarnia, Ontario, offers a positive review. "Bruce Power's safety record is five to seven times better than other nuclear facilities in Canada," he says.

Looking back to his presentation at the IAPA show, it was fitting that Mr. Hawthorne said that it's important to "cultivate your garden." Voltaire's famous assertion that talents and energies need to be realized and used to cultivate a garden using unique talents and abilities to the fullest seems to be a goal at Bruce.

Looking ahead it will be interesting to see how government and business and energy consumers address the critical need for new energy supply at reasonable prices while balancing environmental, safety and conservation goals. No doubt well-managed nuclear power facilities will be positioned to take a big piece of the pie.

But just in case all else fails, make sure that a back-up generator is in place for that air conditioning and beer. **HMM**

Connie Vitello is editor of this magazine.

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ing more than just senior managers to be responsible).