Summer Conference - Hosted by: Bruce Power
August 16-19, 2016
Unifor Education Center
1-115 Av Shipley, Port Elgin, Ontario CANADA

Coordinators:
Nanci White – 519-361-2673 Ext. 12358 or nanci.white@brucepower.com
Naomi Smith – 519-361-2673 Ext. 17817 or naomi.smith@brucepower.com

Please bring:
- PHOTO ID - A government issued document with name and picture will be required to enter the Bruce Power site as well as the station proper. ie: a driver’s license, passport.
- Performance indicators
- Bring your benchmark topics for index card discussion

Evening Social – Mon, August 15, 2016 at 7:00 pm in the Main Assembly Hall
Beverages and hors d’oeuvres hosted by Unitech.

AGENDA: Tuesday, August 16

<table>
<thead>
<tr>
<th>Time</th>
<th>Topic</th>
<th>Speaker</th>
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</thead>
<tbody>
<tr>
<td>7:00-8:00</td>
<td>Continental Breakfast</td>
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<tr>
<td>8:00-8:45</td>
<td>Bus pick up Participants and travel to Site Visitor Center</td>
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<tr>
<td>8:45-9:45</td>
<td>Welcome Comments - Pre-job Brief &amp; PPE</td>
<td>Len Clewett, Bruce Power Executive Vice President &amp; Chief Nuclear Officer</td>
</tr>
<tr>
<td>9:45-12:00</td>
<td>Bruce B Station Tour 1 <em>Information on Bruce Power</em></td>
<td>Rebecca Austman, Bruce Power Section Manager, Safety Support – Bruce A</td>
</tr>
<tr>
<td>9:45-12:00</td>
<td>Fire Training Facility &amp; Fuel Handling Simulator Tour 1 <em>Information on this tour</em></td>
<td>Andre Rivet, Bruce Power Safety Specialist, Safety Support – Bruce B</td>
</tr>
<tr>
<td>12:00-12:30</td>
<td>Lunch–B10 CR1321 and CR1322</td>
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<tr>
<td>12:30-3:00</td>
<td>Bruce B Station Tour 2</td>
<td>Andre Rivet, Bruce Power Safety Specialist, Safety Support – Bruce B</td>
</tr>
<tr>
<td>12:30-3:00</td>
<td>Fire Training Facility &amp; Fuel Handling Simulator Tour 2</td>
<td>Rebecca Austman, Bruce Power Section Manager, Safety Support – Bruce A</td>
</tr>
<tr>
<td>3:00-3:15</td>
<td>Return to Visitor’s Center</td>
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<tr>
<td>3:15-3:30</td>
<td>Break – Refreshments &amp; Light Snack</td>
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<tr>
<td>3:30-4:00</td>
<td>Return to Unifor</td>
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</tr>
<tr>
<td>4:00-4:30</td>
<td>Site Tours Q&amp;A</td>
<td>Nanci White, Bruce Power Section Manager Conventional Safety Programs</td>
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<tr>
<td>Time</td>
<td>Topic</td>
<td>Speaker</td>
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<tr>
<td>7:00-8:00</td>
<td>Continental Breakfast – Unifor</td>
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<tr>
<td>8:00-8:30</td>
<td>Welcome – Opening Comments</td>
<td><strong>Chip Horton</strong>, Bruce Power VP - Nuclear Operations Support</td>
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<td></td>
<td><strong>Joe Parham</strong>, Southern Nuclear NISHA Chair</td>
</tr>
<tr>
<td>8:30-9:00</td>
<td>OSART Review &amp; Safe Management of a CANDU 4 pack</td>
<td><strong>Pierre Pilon</strong>, Bruce Power Plant Manager - Bruce B</td>
</tr>
<tr>
<td>9:00-9:15</td>
<td>Break &amp; Group Photo – Unifor main entrance stairs</td>
<td><strong>Josh Kerr</strong>, Bruce Power Communications Specialist</td>
</tr>
<tr>
<td>9:15-10:30</td>
<td>Go Beyond Zero - Risk Management</td>
<td><strong>Ewan Alexander</strong>, Risk Map Int. Chief Operating Officer</td>
</tr>
<tr>
<td>10:30-11:45</td>
<td>Cobalt 60 Process &amp; Nordion Partnership <em>Information on Cobalt 60</em></td>
<td><strong>James Pope</strong>, Bruce Power Operations Specialist</td>
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<td><strong>Richard Wiens</strong>, Nordion Director, Strategic Supply</td>
</tr>
<tr>
<td>11:45-12:30</td>
<td>Lunch – Meet &amp; Greet</td>
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</tr>
<tr>
<td>12:30-1:15</td>
<td>Managing Outages at an 8 Unit site</td>
<td><strong>Ian Rowley</strong>, Bruce Power VP, Outage and Maintenance</td>
</tr>
<tr>
<td>1:15-2:00</td>
<td>Major Component Refurbishment (MCR)</td>
<td><strong>Jeff Phelps</strong>, Bruce Power VP, Major Projects</td>
</tr>
<tr>
<td>2:00-2:15</td>
<td>Break</td>
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</tr>
<tr>
<td>2:15-3:00</td>
<td>Industrial Safety Performance Trend Update</td>
<td><strong>Paul McNulty</strong>, INPO Manager Radiation Protection</td>
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<tr>
<td>3:00-4:00</td>
<td>Contractor Safety Improvements BHI</td>
<td><strong>Steve Davis</strong>, BHI Energy Director of Human Performance and Environmental, Health and Safety</td>
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<tr>
<td>4:00-4:30</td>
<td>Explore the Bruce – Tourism</td>
<td><strong>Vicky Ly</strong>, Bruce County Tourism</td>
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### AGENDA: Thursday, August 18

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<tr>
<th>Time</th>
<th>Topic</th>
<th>Speaker</th>
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<tbody>
<tr>
<td>7:00-8:00</td>
<td>Continental Breakfast</td>
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<tr>
<td>8:00-9:00</td>
<td>Preventing Serious Injury</td>
<td><strong>Jason Wemex</strong>, Ameren Sr. Director Corporate Safety</td>
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<tr>
<td>9:00-10:00</td>
<td>Risk Map Injury Prevention</td>
<td><strong>Jon Carlton</strong>, TVA Safety Governance &amp; Oversight</td>
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<tr>
<td>10:00-10:15</td>
<td>Break</td>
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<tr>
<td>10:15-11:30</td>
<td>U8 Rotor Event</td>
<td><strong>Kevin Schmidt</strong>, Bruce Power Department Manager Radiation Protection &amp; Industrial Safety</td>
</tr>
<tr>
<td>11:30-12:30</td>
<td>Legal Implications of Accident Investigations</td>
<td><strong>Lynn Mahoney</strong>, Bruce Power Ethics and Compliance Manager</td>
</tr>
<tr>
<td>12:30-1:15</td>
<td>Lunch</td>
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<tr>
<td>1:15-2:45</td>
<td>Accident Investigation Workshop: Cranes &amp; Rigging</td>
<td><strong>Joseph Kuzar</strong>, Industrial Trng. Int. Cranes and Rigging</td>
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<tr>
<td>2:45-3:00</td>
<td>Break</td>
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<tr>
<td>3:00-4:00</td>
<td>Six Sigma Initiative on Line of Fire Injuries</td>
<td><strong>Christopher Kopec</strong>, Siemens Environmental HS Manager</td>
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<tr>
<td>4:00-4:05</td>
<td>Daily Wrap Up</td>
<td><strong>Nanci White</strong>, Bruce Power Section Manager, Conventional Safety Programs</td>
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<tr>
<td>5:00-7:00</td>
<td>Social Dinner &amp; Vendor Exhibit</td>
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### AGENDA: Friday, August 19

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<tr>
<th>Time</th>
<th>Topic</th>
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<tr>
<td>7:00-8:00</td>
<td>Continental Breakfast</td>
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<tr>
<td>8:00-8:45</td>
<td>NISHA Business</td>
<td><strong>Joe Parham</strong>, Southern Nuclear NISHA Chair</td>
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<tr>
<td>8:45-9:45</td>
<td>Inspiring change, shifting attitudes</td>
<td><strong>Candace Camahan</strong>, Motivational Speaking Inc</td>
</tr>
<tr>
<td>9:45-10:00</td>
<td>Break</td>
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<tr>
<td>10:00-11:30</td>
<td>Industrial Benchmarking – Index Card Discussion</td>
<td><strong>John Zoll</strong>, Bruce Power Section Manager, Safety Support – Bruce B</td>
</tr>
<tr>
<td>11:30-12:00</td>
<td>Closing Remarks</td>
<td><strong>Joe Parham</strong>, Southern Nuclear NISHA Chair <strong>Linda Peerla-Proulx</strong>, Bruce Power Division Manager, Nuclear Operations Support</td>
</tr>
</tbody>
</table>
In April 2015, Bruce Power opened its 23,000-square foot, state-of-the-art fire training facility, adding to its already robust emergency preparedness capabilities. Replicating a variety of scenarios Bruce Power’s Emergency and Protective Services team could face, the facility is widely considered one of the best in the world by peers within the nuclear industry.

The $25-million facility, which took 18 months to build, includes a mock-up of a turbine generator to allow firefighters to practice on realistic scenarios. Propane-fuelled props producing fire and smoke simulate a variety of situations, and thermal cameras located throughout the building capture video footage and stream it back to a central control room.

The main building, which can be used year round, is 80 feet by 227 feet and 30 feet, with a 50-foot tower for high-angle rescue training. There are also a number of outdoor fire simulators including a car, forklift and transformer.

The facility is available for co-training opportunities with local municipal fire departments, and in April 2016, Bruce Power hosted 80 firefighters from 17 local fire stations for the 26th annual Mutual Aid Bruce County Fire School.

The environmentally friendly fire training facility replaced an older fire facility at the same location on the Bruce Power site, and features clean burning props that meet or exceed all regulatory standards.
The Bruce Power Fuel Handling Simulator was built to assist with fuel handling training for all necessary staff, including Fuel Handling Control Room Operators, Shift Managers, Control Room Shift Supervisors, Non-Licensed Operators and Nuclear Power School trainees. The simulator provides real-time simulation of any on-power fuelling machine action and is enhanced with a graphic display for the development of mental models to provide users with a solid understanding of plant design and system interrelationships.

The scope of the Fuel Handling Simulator encompasses the entire fuel route, from loading new fuel into the head from the new fuel room, to fuelling the reactors, right through to discharging irradiated fuel in the primary bay.

The Fuel Handling Simulator consists of touch panel replicas of the South Trolley control panels, virtual machine simulations of the fuel handling control and protective computer, models of the fuel handling control systems and thermal hydraulic processes, and detailed physical models of the fuelling machines, the trolley, the Central Service Area and the Unit 5 Reactor. These are all integrated into the pre-existing Bruce A and Bruce B station simulator models and software.

The physical components of the simulator are modelled in sufficient detail to enable normal and abnormal operating conditions to be simulated. Simulator instructors can insert malfunctions to inhibit or restrict the physical motion of components as well as simulate specific components breaking or jamming.

Along with the physical modelling of the fuelling machine, a fully coupled 3D graphical representation of the station and fuelling machine equipment was created. This allows simulator users to see exactly what is happening as if they were inside the reactor building. The simulator also provides users with the unique ability to use graphics to move around and view the inside of the fuelling machine, mechanisms and the reactor channel. Both new and experienced operators benefit from this function as they are able to see detailed visual representations of the operations that are taking place, allowing them to develop a mental model of the complex fuelling operations and to enhance their training experience.

The use of the real-time, fully integrated 3D representation of the fuelling system is a first for a CANDU simulator.
Bruce Power has a long-term agreement to supply Cobalt-60 to Ottawa-based Nordion so it can use the radioactive isotopes to sterilize 40 per cent of the world’s single-use medical devices and equipment. These supplies include sutures, syringes, gloves, surgical gowns and masks. Cobalt-60 is also used to sterilize pharmaceutical wares and cosmetics, and irradiate spices and other consumer products that include fruit, seafood, poultry and red meat.

The World Health Organization (WHO) estimates that more than 640,000 major surgeries are performed each day around the world, and sterile disposable medical devices are used in virtually all of these procedures. Cobalt-60 is supplied to over 200 gamma irradiators in 55 countries.

Cobalt is mined like any other mineral. It is removed from the ground and processed into pure Cobalt-60 powder, which is then compressed into slugs and coated with nickel. These slugs are then encapsulated and assembled into adjustor rods, which are used to control the reaction in Bruce Power’s reactors, where the Cobalt is activated by absorbing neutrons to become Cobalt-60.

Bruce Power removes the rods during its planned maintenance outages. The Cobalt-60 rods are then stored in Bruce Power’s secondary fuel bay, suspended on the bay wall approximately 14 feet below the surface. They emit a blue glow called the ‘Cherenkov Effect,’ which is a result of gamma radiation travelling through water faster than the speed of light travelling through water. When that occurs, photons are released, which creates the blue light. Specialized fuel handlers extract the Cobalt-60 rods one at a time, and place them in a shielded flask to be shipped to Nordion’s facility.

Once the bundles are received by Nordion, the Cobalt-60 is removed for its encapsulation and welded into a new double-encapsulated source called a C-188. It is then shipped to the sites of Nordion’s customers for use in irradiators.
A GUIDE TO
BRUCE POWER
Formed in 2001, Bruce Power has transformed its site by returning four units to service through billions in private investment in these publicly owned assets. It has also transformed its workforce through new hiring and training, extended the life of operating units through innovative planned maintenance programs, and positioned the site for long-term stability.

In 2015, Bruce Power signed a long-term agreement with the Province of Ontario that will see Units 3-8 refurbished over the next two decades, extending the life of the site to 2064. This means ratepayers will receive 30 per cent of their electricity from Bruce Power for decades, while enjoying cleaner air because nuclear creates zero carbon emissions. This $13 billion private investment program will guarantee one in three homes, hospitals, schools and businesses receive carbon-free nuclear electricity for generations.

By building on the experience we have gained over the past 15 years, while continuously innovating in order to become more efficient at these important infrastructure programs, we are in a strong position to fulfill our commitment to Ontario’s Long-Term Energy Plan by providing 6,300 megawatts of safe, reliable and carbon-free energy to the province through 2064.
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37 Public education

A GUIDE TO BRUCE POWER
Bruce Power is a Canadian-owned partnership of TransCanada Corporation, Ontario Municipal Employees Retirement Systems (OMERS), the Power Workers’ Union and The Society of Energy Professionals. A majority of our employees are also owners of the business.

Formed in 2001, Bruce Power is Canada’s only private sector nuclear generator, annually producing 30% of Ontario’s power at 30% less than the average residential price of electricity.

Ontario’s Long-Term Energy Plan is counting on Bruce Power to provide a reliable and carbon-free source of affordable energy through 2064. To do so, Bruce Power has signed a long-term agreement with the province to refurbish six of its eight units over the next two decades, investing $13 billion private dollars into these publicly owned assets.

Bruce Power employs over 4,000 people and, over the past 15 years, has been one of the largest investors in Ontario’s electricity infrastructure, investing billions in private dollars into the Bruce Power site, which continues to be owned by the province. The site is leased from the Province of Ontario under a long-term arrangement where all of the assets remain publicly owned, while Bruce Power funds all infrastructure upgrades, makes annual rent payments, and pays for the cost of waste management and the eventual decommissioning of the facilities.
HISTORICAL TIMELINE

1960s
- 1960: Douglas Point construction begins.
- 1967: Douglas Point is powered up for the first time.
- 1968: Plans are announced for Bruce A and the Bruce Heavy Water Plant.
- 1969: Bruce A construction begins. Bulk Steam proposal is accepted.

1970s
- 1972: A site Bulk Steam System is placed in service. Construction begins on the Western Water Management Facility.
- 1973: BHWP A is placed in service.
- 1974: Construction begins on additional heavy water plants.
- 1975: A proposal to build Bruce B is approved by the Ontario government.
- 1976: Construction begins on Bruce B.
- 1977: Bruce Units 1 and 2 are placed in service.
- 1978: Bruce Unit 3 is placed in service.
- 1979: Bruce Unit 4 is placed in service.

1980s
- 1980: BHWP B is commissioned for service.
- 1981: Unit 1 is ranked the #1 reactor in the world with a 97% capacity factor.
- 1983: Construction begins on the Bruce Learning Centre (formerly Western Nuclear Training Centre).
- 1984: Douglas Point and BHWP A are shut down. Unit 6 comes online at Bruce B.
- 1985: Bruce Unit 5 is in service.
- 1986: Bruce Unit 7 is in service.
- 1987: Bruce Unit 8 is in service.
- 1988: Bruce Units 3, 4, 6 and 7 are Top 10 reactors in the world for the previous year’s performance.

1990s
- 1991: Rehabilitation project approved for Bruce A.
- 1993: Faced with a largest surplus capacity of electricity in its history, Ontario Hydro defers decision made in previous year to retire Unit 2.
- 1994: Work begins to dismantle BHWP A.
- 1995: Unit 2 at Bruce A is shut down and placed in layup.
- 1997: Unit 1 at Bruce A is shut down and placed in layup.
- 1998: Units 3 and 4 are shut down and placed in layup.
- 1999: Ontario Hydro is divided into five successor companies to prepare for a competitive electricity market.

2000s
- 2001: Bruce Power assumes operational control of the site and confirms plans to restart Units 3 and 4. Terrorist attacks in the U.S. prompt the formation of a full-time, rapid-response, armed security force at Bruce Power.
- 2002: Ontario’s electricity market opens to competition. TransCanada Corp. and BPC Generation Infrastructure Trust (OMERS) join Cameco, the PWU and The Society of Energy Professionals in the Bruce Power partnership, while British Energy withdraws.
- 2003: Units 5, 7 and 8 at Bruce B remain online to help restore power to the grid after a massive blackout leaves large parts of Ontario and the northeastern U.S. without power. Unit 4 is returned to service after being shut down by Ontario Hydro in 1998.
- 2004: Unit 3 returns to service after being shut down by Ontario Hydro in 1998.
- 2005: A multi-billion dollar agreement is reached between Bruce Power and the Ontario Power Authority to pave the way for the refurbishment of Units 1 and 2, shut down in 1997 and 1999 respectively.
- 2006: Bruce Power celebrates its 25th anniversary on May 11 when Lieutenant Governor James Bartleman officially opens a new Support Centre. Bruce B finishes the year as the top performing multi-unit nuclear plant in Canada.
- 2007: History is made in Unit 2 with the first successful replacement of a steam generator in a Canadian nuclear plant.
- 2008: A protocol agreement is signed with the Saugeen Ojibway Nation.
- 2009: A walk-in medical clinic for employees is established in the Bruce Power Support Centre.

2010s
- 2010: Employees on the Bruce site achieve 22 million injury-free hours.
- 2011: Bruce Power responds to the Fukushima nuclear event by revising emergency response capabilities and strengthens where possible. Company celebrates its 25th anniversary by launching a $50,000 post-secondary scholarship program for local students, which continues to occur annually.
- 2012: Staff and contractors return Units 1 and 2 to service, while life-extension programs are completed in Units 3 and 4. A new Emergency Management Centre is installed in the Visitors’ Centre. Bruce Power is recognized as one of Canada’s top employers for young people.
- 2013: On April 22, for the first time in almost two decades, all eight units on the Bruce site provide electricity to Ontario’s grid.
- 2015: For third consecutive year sets a site production record, generating 37.5 trillionth-hours of carbon-free electricity. Also sets site record run of all eight units at 29 days. Signs long-term agreement with province to refurbish Units 3-8, extending life of site to 2044.

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How Our Reactors Work

Bruce Power’s reactors use CANDU (Canada Deuterium Uranium) technology. Considered one of the safest nuclear technologies in the world, CANDUs use ‘heavy’ water and manufactured uranium pellets to generate massive amounts of heat, creating steam to drive a turbine, which creates electricity.

The heat is created in a reactor by the ‘fissioning’ or splitting of uranium atoms. When the centre – or nucleus – of uranium atoms fission, they split into fragments, separating rapidly and generating heat. Two or three neutrons are released and they go on to collide with other atoms.

Heavy water is used to slow the neutrons down in order to sustain the fission process in a controlled chain reaction. Heavy water is also used as a coolant to remove heat from the fuel and carry it to steam generators. The heat in the steam generators turns light water to steam, which is then piped to a series of turbine rotors, which spin a shaft that’s connected to the generator. The action of these spinning mechanisms is converted to electrical energy, which then leaves our station for the switchyard, before making its way to Ontario’s electrical grid.

Unique Design

CANDUs have a number of unique design features and characteristics not seen in other reactor designs. They include:

- A reactor core comprising of several hundred small diameter fuel channels rather than one huge pressure vessel.
- Heavy water (D20) for moderator and coolant.
- Separate low pressure moderator and high pressure fuel cooling systems.
- Reactivity devices that are located in the cool low-pressure moderator, and not subjected to high temperatures or pressures.
- Natural uranium fuel, which cannot be used for weapons.
- Reactors can be refuelled while still safely operating at full power.
- Two fully capable shutdown systems, independent from each other, which are designed to act automatically in the unlikely situation a reactor requires immediate shutdown.

What Fuels A CANDU?

Natural uranium is mined in Saskatchewan, and converted and manufactured into pellets by Cameco Corp., in Port Hope, ON.

Uranium ore is processed into a powdery substance called ‘yellow cake,’ which is then chemically refined into uranium dioxide and baked into small ceramic pellets. The pellets are sealed inside small metal tubes, which are assembled into fuel bundles. These bundles are about the size of a small fire log and weigh 22 kg.

One 20-gram pellet of uranium contains as much potential energy as two barrels of oil (205 litres per barrel).

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A single fuel bundle can supply 100 homes with electricity for a year.
To achieve optimum safety, Bruce Power, along with other nuclear plants, operate using a ‘defense-in-depth’ approach. Using high quality design, equipment and operators ensures accidents don’t happen.

SAFETY SYSTEMS
Each CANDU unit has four special safety systems. They include Shutdown System No. 1, Shutdown System No. 2, the Emergency Coolant Injection System, and the Containment System. These systems are tested frequently but not used in day-to-day operations. Completely independent of one another, they activate automatically if reactor systems exceed established parameters.

Each system is completely independent and designed to be fail-safe, which means if a component of one of the shutdown systems fails, the rest of the system is capable of performing its function, or is automatically activated to shut down the reactor.

SHUTDOWN SYSTEM NO. 1 (SDS1)
This primary method of quickly shutting down the reactor when certain parameters enter an unacceptable range is the automatic release of spring assisted gravity-drop absorber rods. The rods absorb neutrons, stopping the fission process in seconds.

SHUTDOWN SYSTEM NO. 2 (SDS2)
An alternate method of quickly shutting down the reactor, is the rapid injection of concentrated gadolinium nitrate, solution into the moderator system through horizontal tubes. When triggered automatically, high pressure helium forces the gadolinium through the tubes to absorb neutrons and shut down the reactor in seconds.

EMERGENCY COOLANT INJECTION SYSTEM (ECI)
This system is designed to provide cooling water to the heat transport system if a leak occurs. When called upon, the system injects light water over the fuel to stop it from overheating.

The ECI works in three stages: high pressure injection, medium pressure injection and low pressure recirculation. High pressure injection uses pressurized tanks to inject water into the heat transport system. The medium pressure stage supplies water by pumping it from a storage tank. The long-term recirculation stage recovers water that has been collected in the basement of the reactor building and pumps it back into the heat transport system through heat exchangers.

CONTAINMENT SYSTEM
Each reactor is located in its own airtight vault with concrete walls that are more than a metre thick. Maintained at a negative pressure, the reactor vault is connected to the station’s central fuelling duct. The central fuelling duct in turn connects to two pressure relief ducts that link to a large cylindrical structure called the vacuum building.

Maintained at one-tenth atmospheric pressure, the vacuum building is poised to suck up radioactive steam and contaminants in the unlikely event of a reactor accident. Once triggered, it douses the steam and contaminants with water from an overhead storage tank.

Unique to multi-unit CANDU stations like Bruce A and B, the vacuum building provides an additional protective barrier to the release of radioactivity.

The CANDU reactor design has two independent, fast-acting Shutdown Systems that are physically separate and have their own power supplies and monitoring equipment.
The prototype 20,000 kilowatt (kw) CANDU plant came online in 1962 in Deep River, ON, followed in 1968 by the 200,000 kw Douglas Point Generating Station, located on the Bruce Power site. Douglas Point was decommissioned in 1984. Construction on Bruce A began in 1969 and its four units were fully operational by 1979. Bruce B construction began in 1976 and its four units were fully operational by 1987.

There are currently 19 operational CANDU reactors in Canada – Bruce Power (eight), Pickering (six), Darlington (four) and Point Lepreau, New Brunswick (one). Refurbishment of six units at Bruce Power and four units at Darlington have been approved by the Province of Ontario and will take place over the next two decades, extending the life of the units by an estimated 30+ years. Pickering is slated for decommissioning in 2024.
**STATION PROFILES**

**BRUCE A - 4 REACTORS**

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<td>1997/10/18</td>
<td>2012</td>
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<tr>
<td>Unit 2 - 1977/06/01</td>
<td>1999/09/08</td>
<td>2012</td>
</tr>
<tr>
<td>Unit 3 - 1978/04/01</td>
<td>1998/04/09</td>
<td>2004</td>
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<tr>
<td>Unit 4 - 1979/01/18</td>
<td>1999/04/16</td>
<td>2003</td>
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Net Rated Output

- **UNIT 1**: 781 MW
- **UNIT 2**: 781 MW
- **UNIT 3**: 781 MW
- **UNIT 4**: 781 MW

**BRUCE B - 4 REACTORS**

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<tr>
<td>Unit 5 - 1981/05/01</td>
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<tr>
<td>Unit 6 - 1981/09/04</td>
<td></td>
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<tr>
<td>Unit 7 - 1981/04/10</td>
<td></td>
</tr>
<tr>
<td>Unit 8 - 1981/05/22</td>
<td></td>
</tr>
</tbody>
</table>

Net Rated Output

- **UNIT 5**: 822 MW
- **UNIT 6**: 822 MW
- **UNIT 7**: 822 MW
- **UNIT 8**: 822 MW

**FUEL**
Natural uranium dioxide (UO₂)

**COOLANT**
Heavy water (D₂O)

**MODERATOR**
Deuteron oxide heavy water

---

16  A GUIDE TO BRUCE POWER
**BRUCE A**

### BUILDING, STRUCTURES AND REACTOR VESSELS

<table>
<thead>
<tr>
<th>AREA/ITEM</th>
<th>WIDTH</th>
<th>LENGTH</th>
<th>HEIGHT</th>
<th>WALL THICKNESS</th>
<th>MATERIAL</th>
<th>OTHER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reactor Building</td>
<td>92 ft (28.04 m)</td>
<td>104 ft (31.7 m)</td>
<td>162.5 ft (49.53 m)</td>
<td>Reinforced concrete</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reactor Vault</td>
<td>92 ft (28.04 m)</td>
<td>104 ft (31.7 m)</td>
<td>46.5 ft (14.18 m)</td>
<td>6 ft (1.83 m)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reactor Auxiliary Bay</td>
<td>150 ft (45.7 m)</td>
<td>1,426 ft (434.7 m)</td>
<td>48 ft (14.6 m)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Turbine Hall</td>
<td>180 ft (54.86 m)</td>
<td>1,460 ft (445 m)</td>
<td>134 ft (40.8 m)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vacuum building</td>
<td>160 ft 6 in (49 m) (Inside diameter)</td>
<td>149 ft (45.4 m)</td>
<td>3 ft 9 in (1.14 m)</td>
<td>Water storage 2.2 million gallons (10,000 m³)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calandria</td>
<td>27 ft 9 in (8.46 m) (Inside diameter)</td>
<td>19 ft 6 in (5.95 m)</td>
<td>149 ft (45.4 m)</td>
<td>1.25 in (3.17 cm)</td>
<td>Austenitic stainless steel</td>
<td></td>
</tr>
<tr>
<td>Calandria tubes</td>
<td>5.077 ft (1.59 cm) (Inside diameter)</td>
<td>0.054 in (0.137 cm)</td>
<td>Zircaloy – 2 seam welded</td>
<td>Quantity 480</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### FUEL FACTS

- **Type**: 37 element bundles
- **Length**: 19.5 in (49.5 cm)
- **Number per channel**: 12
- **Total weight of bundle**: 52.1 lb (23.65 kg)

### TURBINE GENERATOR

- **TURBINE**
  - Turbine set per reactor: 1
  - Number of high-pressure cylinders: 1
  - Number of low-pressure cylinders: 3
  - Speed: 1,800 rpm
- **GENERATOR**
  - One per turbine: 18,500 volts

---

**BRUCE B**

### BUILDING, STRUCTURES AND REACTOR VESSELS

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### FUEL FACTS

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### TURBINE GENERATOR

- **TURBINE**
  - Turbine set per reactor: 1
  - Number of high-pressure cylinders: 1
  - Number of low-pressure cylinders: 3
  - Speed: 1,800 rpm
- **GENERATOR**
  - One per turbine: 24,000 volts
WHAT IS RADIATION?

Radiation is energy that travels through space. Humans have been exposed to radiation from natural sources since the dawn of time. We get radiation from the ground, air, food we eat and our entire solar system.

There are several types of radiation including – **alpha**, **beta** and **gamma**.

**1. ALPHA**. These particles are produced from the radioactive decay of heavy elements such as uranium. They are composed of two neutrons and two protons identical to the nucleus of a helium atom. Alpha particles can only travel a short distance in any material, due to their relative size and electrical charge from two protons. This means a sheet of paper can stop alpha particles.

**2. BETA**. These particles are electrons that come from the transformation of a neutron in the nucleus of an atom to a proton. They can travel up to about five metres in air and one centimetre in tissue.

**3. GAMMA**. These rays are electromagnetic radiation similar to rays. Unlike alpha and beta, which are produced by machines, gamma rays are emitted from the nucleus of a radioactive atom that is in an excited state. Gamma rays travel at the speed of light and can penetrate long distances in air and tissue. Several centimetres of lead or metres of water are needed to stop typical gamma rays such as those from Cobalt-60, which is used to sterilize medical devices and is harvested from Bruce B’s reactors during planned maintenance outages.

HOW IS RADIATION MEASURED?

The amount of radiation received by a person is referred to as ‘dose’ and is measured in units known as microsieverts.

Background radiation comes from natural sources (soil, rocks, water, air and vegetation) and artificial sources (medical rays, industrial sources like smoke detectors and even watches). According to Health Canada, the amount of natural radiation each of us receives is between 2,000 and 4,000 microsieverts per year. The Canadian Nuclear Safety Commission has established an upper limit of 1,000 microsieverts of human-made radiation per year for members of the public.

To reduce radiation exposure, nuclear energy workers keep their distance from radioactive sources, limit their exposure time and use shielding. They are also equipped with a wide range of personal protective equipment to limit exposure.

<table>
<thead>
<tr>
<th>ESTIMATED DOSE (MICROSIEVERTS)</th>
<th>ACTIVITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>The most Bruce Power’s year-round neighbours could have received in 2014, the equivalent of eating 13 bananas. Source: Bruce Power’s 2014 Environmental Monitoring Program Report</td>
</tr>
<tr>
<td>5</td>
<td>sleeping next to your spouse for one year</td>
</tr>
<tr>
<td>10</td>
<td>a year of watching TV at an average rate</td>
</tr>
<tr>
<td>10</td>
<td>a year of wearing a luminous dial watch</td>
</tr>
<tr>
<td>10</td>
<td>a day from background radiation (average, varies depending on location)</td>
</tr>
<tr>
<td>20</td>
<td>having a chest x-ray</td>
</tr>
<tr>
<td>65</td>
<td>flying from Melbourne to London via Singapore</td>
</tr>
<tr>
<td>300</td>
<td>yearly dose due to body’s Potassium-40</td>
</tr>
<tr>
<td>450</td>
<td>maximum possible off-site dose from Three Mile Island accident in 1979</td>
</tr>
<tr>
<td>400-1,000</td>
<td>average annual dose from medical sources</td>
</tr>
<tr>
<td>1,000</td>
<td>Canadian Nuclear Safety Commission’s allowable limit for residents for human-made radiation per year</td>
</tr>
<tr>
<td>7,000</td>
<td>having a PET scan</td>
</tr>
<tr>
<td>8,000</td>
<td>having a chest CT (CAT) scan</td>
</tr>
<tr>
<td>2 million</td>
<td>typical single dose to cancer region from radiation therapy</td>
</tr>
<tr>
<td>65 million</td>
<td>typical total dose to cancer region from radiation therapy</td>
</tr>
</tbody>
</table>
The CANDU system has a unique ability to refuel the reactor while it is still safely operating at full power.

Two identical fuelling machines rise from a fuelling duct under the reactor and latch onto opposite ends of a designated fuel channel (of which there are 480 on each reactor, holding 5,760 fuel bundles). Each machine is operated remotely in the Control Room by our highly trained Fuel Handling Operators.

With both machines latched on and brought up to system pressure, the ends of the fuel channel are opened and new fuel is exchanged for used fuel – one machine discharging and the other accepting.

Each bundle stays in the reactor for 12 to 20 months, depending on where it is located. Once removed, it enters the primary fuel bay. Fuel bundles are very radioactive after being removed from the reactor, yet just a few metres of water in a used fuel storage bay provides adequate shielding to protect workers and the public from radiation.

One year after removal from the reactor, a used fuel bundle gives off less than 0.1% of the heat it emitted while in the reactor. Despite the dissipation of heat, fuel bundles will still spend 10 years in the primary and secondary fuel bays, which are about the size of an Olympic swimming pool, before being cool enough to be placed in a dry storage container. It is then transferred to Ontario Power Generation’s Western Waste Management Facility, which is located on the Bruce Power site, for long-term, above-ground storage.
The reliability of our equipment continues to improve, which means our units operate more consistently, providing carbon-free Bruce Power electricity to the people of Ontario, keeping our air clean.

Bruce Power keeps in constant contact with its independent regulator, the Canadian Nuclear Safety Commission (CNSC), in order to ensure our safety and operations standards remain at the highest level. The CNSC also has staff permanently based at the Bruce Power site. The CNSC’s mandate is to regulate the use of nuclear energy and materials to protect health, safety, security and the environment, and to implement Canada’s international commitments on the peaceful use of nuclear energy, while disseminating objective scientific, technical and regulatory information to the public.

In 2015, Bruce Power received a five-year operating license extension from the CNSC after four days of public hearings in both Ottawa and Kincardine. Dozens of people and organizations from across Ontario either wrote a letter of support for Bruce Power or spoke in person to recommend the license renewal. Bruce Power prides itself on being open and transparent with our surrounding communities, and the overwhelming support we received during the relicensing hearings was a testament to these relationships.

The CNSC was established in 2000 under the Nuclear Safety and Control Act and reports to Parliament through the Minister of Natural Resources. It was created to replace the former Atomic Energy Control Board (AECB), which was founded in 1946. The CNSC has up to seven appointed permanent members whose decisions are supported by more than 800 employees. These employees review applications for licenses according to regulatory requirements, make recommendations to the Commission, and enforce compliance with the Nuclear Safety and Control Act, regulations, and any license conditions imposed by the Commission.
As part of our operating license, Bruce Power maintains a robust and multi-faceted emergency response program. This includes our Emergency and Protective Services department, which features an award-winning security service, a fully equipped fire department, an ambulance and an around-the-clock emergency response organization.

The company also has five pump trucks that can provide an external source of water to station fire water systems, which, in turn, are used as an emergency cooling water source for critical systems. These five, specially designed fire trucks were purchased after the Fukushima nuclear event to add to our layers of safety systems at both Bruce A and B.

In fact, we never stop improving the depth of our safety systems and our ability to respond in the unlikely occurrence of an emergency. Other upgrades we’ve made since Fukushima include:

• Purchasing nine back-up generators that are stored off site, on high, dry ground. They can be deployed to either station and operational within 30 minutes, in the unlikely situation that the two layers of safety systems built into the station design were to fail.
• Building a state-of-the-art Emergency Management Centre at the Bruce Power Visitors’ Centre. This facility acts as the control room for any emergency situation and allows for a clear and efficient chain of command. We have also implemented the Incident Management System for emergency response, bringing us in line with emergency response organizations across the province.
• Providing potassium-iodide tablets to all residents within a 10 km radius in the unlikely event of a nuclear emergency.
• Receiving Canada’s first emergency test broadcasting license for portable AM units, which will make communicating during an emergency more effective than ever before. We have also collaborated with the Municipality of Kincardine to deploy ALERT FM radios in all homes within a 10 km radius of the site. The ALERT FM receiver is linked to the Emergency Alert Ready System and broadcasts an audible alert and text message within seconds.

For more information on our Fukushima upgrades, visit:

Bruce Power YouTube page:  www.youtube.com/user/brucepower4you

Bruce Power Website:  www.brucepower.com/news-and-media/videos

The effectiveness of Bruce Power’s emergency response program is continuously assessed through a series of drills and exercises, which are evaluated by the Canadian Nuclear Safety Commission. The regulator consistently rates Bruce Power’s capabilities as 'Fully Satisfactory', which is equivalent to an A+.
In December 2015, Bruce Power and the Independent Electricity System Operator (IESO) announced an amended, long-term agreement to secure 6,300 megawatts of electricity from our site, through a multi-year, $13 billion investment program.

The amended agreement allows us to immediately invest in life-extension activities for Units 3-8 to support a long-term refurbishment program that will commence in Unit 6 in 2020, optimizing the operational life of our site.

The life-extension investment and refurbishment programs mean we will provide 30% of Ontario’s electricity through 2064, while injecting billions into Ontario’s economy annually, while directly and indirectly creating and sustaining 18,000 jobs every year. We will do this while assuming all financial risk, while providing 30% of Ontario’s electricity at 30% less than the average price of residential power in the province.

It’s fantastic news for our company, the communities across Bruce, Grey and Huron counties, and the people of Ontario, where over 90 per cent of our suppliers employ thousands of residents. This agreement means another generation of carbon-free nuclear energy to keep our air clean, and more life-saving medical equipment being sterilized by Cobalt-60 that is harvested from our reactors.

The refurbishment of Bruce Power’s reactors doesn’t just touch the lives of our 4,000 employees – it makes a difference for millions of Ontarians, every day.
Nuclear energy can produce the majority of Ontario’s electricity while generating zero carbon emissions.

It’s a fact.

Nuclear annually provides about 60% of Ontario’s power — with Bruce Power providing half that nuclear and meeting the needs of 30% of the province at 30% less than the average residential price of power. We provide the baseload electricity needed to power Ontario’s homes, schools, businesses and hospitals, while emitting almost no harmful carbon dioxide into our atmosphere.

In the 1990s, when Bruce A’s four nuclear units were shut down by the former Ontario Hydro, coal-fired generation rose from 12% of the province’s supply mix in 1995 to 29% in 2000. This resulted in a high number of smog days and increased lung-health problems, including asthma exacerbations.

Since 2003, Bruce Power has refurbished these four nuclear units and doubled its output, creating 70% of the energy the province needed to shut down all coal-fired generating stations — a feat that was accomplished in early-2014 and is still considered one of the largest clean-air initiatives in North America.

The result of increasing the province’s reliance on nuclear power and shutting down coal had a profound impact on the quality of Ontario’s air, with significantly fewer summer smog days since 2005, when there were 53 smog alerts, compared to none in 2014.

Ontario’s success in shutting down coal plants — mainly through the refurbishment of Bruce Power’s four nuclear units — is an example of how jurisdictions can meet energy demands while improving human health and quality of life.

<table>
<thead>
<tr>
<th>Source</th>
<th>CO2 Emissions (Tonnes of CO2 equivalent per GWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal</td>
<td>1,041</td>
</tr>
<tr>
<td>Natural gas</td>
<td>622</td>
</tr>
<tr>
<td>Solar</td>
<td>39</td>
</tr>
<tr>
<td>Hydro</td>
<td>18</td>
</tr>
<tr>
<td>Nuclear</td>
<td>17</td>
</tr>
<tr>
<td>Wind</td>
<td>14</td>
</tr>
</tbody>
</table>

COMPARISON OF LIFE-CYCLE EMISSIONS
Another way Bruce Power positively impacts millions of people, aside from the light switch, is through the world’s health care systems.

Bruce Power has a long-term agreement to supply Cobalt-60 to Ottawa-based Nordion so it can use the radioactive isotopes to sterilize 40% of the world’s single-use medical devices and equipment. These supplies include sutures, syringes, gloves, surgical gowns and masks. Cobalt-60 is also used to sterilize pharmaceutical wares and cosmetics, and irradiate spices and other consumer products that include fruit, seafood, poultry and red meat.

The World Health Organization (WHO) estimates more than 640,000 major surgeries are performed each day around the world and sterile disposable medical devices are used in virtually all of these procedures. Cobalt-60 is supplied to over 200 gamma irradiators in 55 countries.

**HOW IT WORKS**

Cobalt is mined like any other mineral. It’s removed from the ground and processed into pure Cobalt-59 powder, which is then compressed into slugs and coated with nickel. These slugs are then encapsulated and assembled into adjuster rods, which are used to control the reaction in Bruce Power’s reactors, where the cobalt is activated by absorbing neutrons to become Cobalt-60.

Bruce Power removes the rods during planned maintenance outages. The Cobalt-60 rods are then stored in Bruce Power’s secondary fuel bay, suspended on the bay wall about 14 feet below the surface. They emit a blue glow called the ‘Cherenkov Effect,’ which is a result of gamma radiation travelling through water faster than the speed of light travelling through water.

When that occurs, photons are released, which creates the blue light. Specialized fuel handlers extract the Cobalt-60 rods one at a time, and place them in a shielded flask to be shipped to Nordion’s facility.

Once the bundles are received by Nordion, the Cobalt-60 is removed from its encapsulation and welded into a new double-encapsulated source called a C-188. It is then shipped to the sites of Nordion’s customers for use in irradiators.

For more about the role Bruce Power and Nordion play in providing Cobalt-60 to keep our hospitals safe, visit [www.cleannuclearpowersafehospitals.com](http://www.cleannuclearpowersafehospitals.com)
Social Responsibility

Bruce Power and its employees are extremely active in our communities across Bruce, Grey and Huron counties.

Every year, we invest about $2 million into our communities through our Sponsorship and Community Investment Program, our Aboriginal initiatives, an Environment and Sustainability Fund and over $100,000 in elementary, secondary and post-secondary educational scholarships.

Bruce Power also works closely with the Aboriginal communities, on whose Traditional lands our site is located. We are an active member of the Canadian Council for Aboriginal Business and were awarded a Gold level certification in its Progressive Aboriginal Relations program, which is the highest level offered by the CCAB. We are only one of 12 companies in Canada to receive this designation.

We also work closely with our suppliers and contractors, encouraging them to become active members of the CCAB.

We also hold many events each year, including Aboriginal Day celebrations, which welcome members of our First Nation communities to our site to teach employees about their culture. We host a Beach Party each summer between our host communities of Kincardine and Port Elgin, which involves thousands of participants. Our employees have also continued to grow our Multicultural Day celebrations, where community members are introduced to different customs, arts, crafts and foods unique to dozens of different cultures from around the world, but whose descendants live in the Kincardine area. The weeknight event is enjoyed by over 1,000 people annually.

Our community is integral to our success. We enjoy great support along the Lake Huron shoreline, but it’s something we will never take for granted, and that’s why we strive to be the best corporate citizen we can be.

$2 million invested locally through our various community-based programs.

$100,000 in elementary, secondary and post-secondary educational scholarships annually. 
That’s why our Visitors’ Centre is open year-round and offers its **15,000 annual visitors** interactive and educational presentations, exhibits and displays for all ages. It’s also why we’ve reopened our site for summer bus tours, which have been a major success, drawing thousands of people from across Ontario and the globe for a look at the **world’s largest operating nuclear facility**. Over the past two years we’ve gone from four bus tours a week to 12 just to meet demand.

Bruce Power believes education is the key to a supportive community.

**We’re also very active on social media, join us at:**

- [www.facebook.com/BrucePowerNGS](http://www.facebook.com/BrucePowerNGS)
- [Twitter @Bruce_Power](http://Twitter @Bruce_Power)
- [www.linkedin.com/company/bruce-power](http://www.linkedin.com/company/bruce-power)
- [www.youtube.com/user/brucepower4you](http://www.youtube.com/user/brucepower4you)
- [Instagram@brucepowerngs](http://Instagram@brucepowerngs)

Bruce Power’s app includes several energy calculators and information about nuclear energy and Ontario’s supply mix.

We also have an iPad and iPhone App available for download at the iTunes store or [www.brucepowerapp.com](http://www.brucepowerapp.com). We also collaborated with EnergyMobile to develop the GridWatch App, which provides up-to-the-minute electricity supply mix information on your phone or online at [www.gridwatch.ca](http://www.gridwatch.ca).

Visit [www.brucepower.com](http://www.brucepower.com) for more information or to sign up for a tour.