OVERVIEW OF NUCLEAR FACILITIES

1.0 PURPOSE

The purpose of this evidence is to provide a description of the nuclear facilities, an overview of the nuclear mandate, objectives, organization, management framework, as well as key performance targets and benchmarking information.

2.0 OPG'S NUCLEAR GENERATING FACILITIES

OPG nuclear facilities consist of Pickering A Generating Station (Pickering A), Pickering B Generating Station (Pickering B), and Darlington Generating Station (Darlington) (collectively, the Nuclear Generating Stations). All of the nuclear generating stations are CANDU reactors, which are a pressurized-heavy-water, natural-uranium technology developed in Canada. CANDU is an acronym for Canada Deuterium Uranium. CANDU reactors are unique in their use of natural uranium, deuterium oxide (heavy water) as a moderator/coolant, on-line refueling capability and two shut down safety systems. These plants serve as base load resources since they have been designed to operate at full power. A photograph of Darlington is presented in Attachment A and a photograph of Pickering A and B is presented in Attachment B. Chart 1 below provides some basic information about the nuclear generating stations.

Chart 1
Nuclear Generating Stations Basic Information

	Pickering A	Pickering B	Darlington
In-service Dates	1971 to 1973	1983 to 1986	1989 to 1992
Net In-service Capacity	1,030 MW	2,064 MW	3,512 MW
Number of Units in service & size in MW's	2 x 540	4 x 540	4 x 934

While OPG's ten nuclear units are all CANDU reactors, they reflect three generations of design philosophy and technology with: Pickering A, Pickering B, and Darlington built in the 1960's, 1970's, and 1980's respectively. This results in significant variations among the three nuclear stations including technology and overall design. Darlington has a greater number of components located outside containment and are therefore more physically accessible for on-line maintenance versus Pickering A or Pickering B. Darlington units are larger generating capacity, but have fewer major components. More extensive use of digital equipment controls was made at Darlington versus a greater reliance on analog control technology at Pickering. This lack of standardization due to "generation of design" limits OPG's ability to integrate operations and apply uniform approaches across the stations. These differences also impact on the extent and nature of operations and maintenance activity at each station. In addition, the differences impact the ability to fully leverage fleet standardization potential and optimize/streamline infrastructure. Some examples of this are presented below - additional details are in Ex. F2-T2-S1:

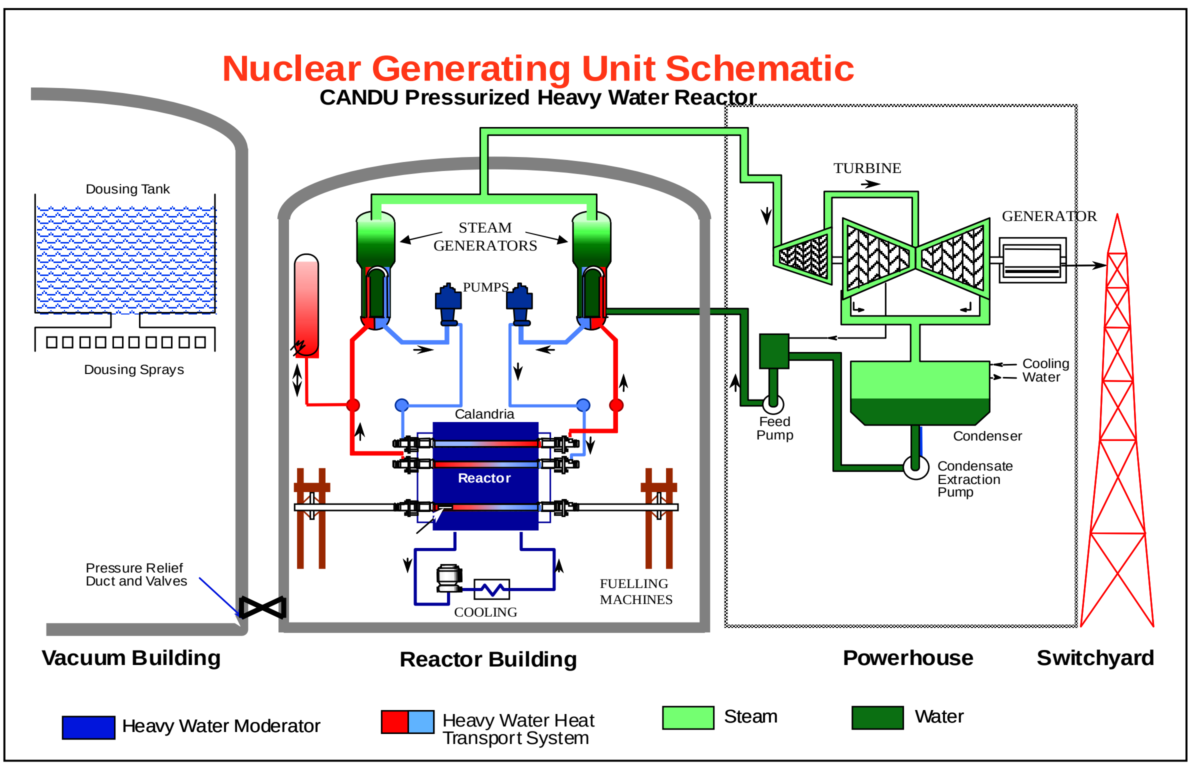
- Operator Requirements: Canadian Nuclear Safety Commission licenses are site specific, which means they are not readily transferable between plants. This affects both operating and outage flexibility with respect to demand for operators.
- Licensing Costs: Each station requires a fully separate licensing process, with associated costs.
- Training Costs: With the exception of basic skills training, the majority of technical training is not transferable between stations. The difference between stations necessitates station-specific staff training uses separate simulators to train control room operators.
- Other Costs: Differences between stations also mandate the need for station-specific technical procedures, and maintaining extensive inventories associated with station-specific parts.

The nature of the technology and the nuclear regulatory environment impacts operations and costs in other ways. While more detailed information is provided in Ex. F2-T2-S1, some of the more significant items are:

- <u>Aging Technology</u>: OPG's nuclear stations contain the first large CANDU units built, the result being that many of the technological issues OPG faces are being addressed for the first time in the nuclear industry.

- Evolving/Escalating Regulatory Standards: To conform to changing regulatory standards often stations must be retrofitted which involves significant cost (e.g., the second, enhanced shutdown system retrofitted at Pickering A). These requirements are largely mandated by the Canadian Nuclear Safety Commission as described in Ex. A1-T6-S1 with oversight through on-site Canadian Nuclear Safety Commission staff. Frequently changes to standards occur as a result of incidents or experience elsewhere in the nuclear industry, and this is a constant ongoing process. Additionally, recent world events have significantly changed security requirements.

- Advancements in Technology: Research and development activities lead to advancements that improve the operability and safety of the stations, with various impacts on cost. For example, specialized diagnostic tools and improved inspection capabilities make it possible to inspect an increasing range of components to a higher degree of precision. These new techniques are essential to the long term health of the units, but can increase the cost of OM&A.



3.0 NUCLEAR GOVERNANCE FRAMEWORK

The Chief Nuclear Officer Charter contains all the key aspects of the governance framework embodied in nuclear facility operations. OPG's Nuclear Safety Policy is derived from this Charter, and defines the principles, objectives, and responsibilities governing the safe operation of OPG's nuclear facilities. It requires that the Board of Directors regularly review nuclear safety performance. It also requires the Chief Nuclear Officer establish a Nuclear Oversight Committee and enlist the World Association of Nuclear Operators to provide independent advice regarding OPG nuclear activities that may impact on nuclear safety.

In addition, OPG is subject to various federal and provincial legislation and regulations including:

<u>Federal</u>

- Canadian Nuclear Safety Commission – All nuclear construction requirements, equipment, safety systems, operating limits, licences, emergency response, decommissioning and waste management are subject to Canadian Nuclear Safety Commission approval. The requirement to meet nuclear safety regulations and standards is imposed by the *Nuclear Safety and Control Act*.
- Environmental legislation includes the *Canadian Environmental Protection Act*, the *Fisheries Act*, and the *Canadian Environmental Assessment Act.*

<u>Provincial/Municipal</u>

- OPG is subject to provincial and municipal legislation including Ontario's *Environmental Protection Act* and the *Ontario Water Resources Act*.

4.0 NUCLEAR ORGANIZATION

The Nuclear business unit is comprised of Nuclear Operations, Nuclear Generation Development and Services, and the Nuclear Waste Management Division (per OPG's organizational chart shown in Ex. A1-T5-S1).

<u>Nuclear Operations</u>

Nuclear Operations under the direction and leadership of the Chief Nuclear Officer, is focused on the operation, maintenance, and performance of OPG's Pickering A, Pickering B and Darlington nuclear generating stations, along with oversight of various nuclear support services, which include:

- Engineering and Modifications
- Nuclear Programs and Training
- Nuclear Supply Chain
- Performance Improvement and Oversight

The description of the roles and responsibilities of the generating stations along with Nuclear Support Services is provided at Ex. F2-T2-S1.

<u>Nuclear Generation Development and Services</u>

The Senior Vice President Nuclear Generation Development and Services is responsible for the development work associated with consideration of life extension of Pickering B and Darlington, for undertaking the federal approvals process for new nuclear units in accordance with the shareholder direction, as well as for managing existing nuclear commercial services. This group also includes Inspection and Maintenance Services and Commercial Services (i.e., isotope sales as well as management of the Bruce Power lease), which are discussed in greater detail at Ex. G2-T1-S1.

<u>Nuclear Waste Management Division</u>

The Nuclear Waste Management Division is responsible for managing OPG's obligation for the ongoing long-term management of nuclear waste produced at the nuclear stations as well as the decommissioning of its nuclear generating stations after the end of their useful lives.

The Chief Nuclear Officer, the Senior Vice President Nuclear Generation and Development Services and the Senior Vice President of Nuclear Waste Management Division report to the Executive Vice President and Chief Operating Officer.

5.0 OPG NUCLEAR WASTE MANAGEMENT AND DECOMMISSIONING

As they operate, OPG's nuclear reactors produce used nuclear fuel bundles, which are a form of high-level radioactive waste. Nuclear operations also give rise to other material that has come into close contact with the reactors, but which is less radioactive than used fuel. These materials include ion exchange resins and other structural material and reactor equipment, including pressure tubes (collectively, intermediate-level radioactive waste). Certain other material used in connection with station operation, but which is neither highly radioactive nor of an intermediate level of radioactivity, such as tools and protective clothing, are referred to as low-level radioactive waste. OPG is responsible for the ongoing long-term management of each of these categories of wastes. In addition, OPG will have to manage radioactive waste associated with the decommissioning of its nuclear generating stations (including the Bruce Generating Stations) after the end of their useful lives.

The liabilities of OPG's predecessor, Ontario Hydro, associated with nuclear waste management and decommissioning were transferred to OPG in April 1999. The responsibility for funding these liabilities is described in the Ontario Nuclear Funds Agreement between the Province of Ontario and OPG. The key provisions of the Ontario Nuclear Funds Agreement are:

- For OPG to establish two segregated funds, comprising the used fuel segregated fund (to fund future costs of nuclear used fuel waste management) and the decommissioning segregated fund (to fund the future cost of nuclear fixed asset removal and low and intermediate level waste management).
- For the Ontario Electricity Financial Corporation to be responsible for making a payment to the decommissioning segregated fund as specified within Ontario Nuclear Funds Agreement.
- For the Province to limit OPG's financial exposure in relation to the cost of used fuel management.
- For the Province to support financial guarantees to the Canadian Nuclear Safety Commission for OPG's nuclear waste management and decommissioning responsibilities by providing a provincial guarantee in return for an annual guarantee fee.

Details on nuclear waste management and decommissioning including the funding of nuclear liabilities are provided in Exhibit H.

6.0 NUCLEAR MANDATE AND OBJECTIVES

With respect to the nuclear facilities, the Memorandum of Agreement with the shareholder states:

> OPG's key nuclear objective will be the reduction of the risk exposure to the Province arising from its investment in nuclear generating stations in general and, in particular, the refurbishment of older units. OPG will continue to operate with a high degree of vigilance with respect to nuclear safety.
>
> OPG will seek continuous improvement in its nuclear generation business and internal services. OPG will benchmark its performance in these areas against nuclear plants worldwide as well as against the top quartile of private and publicly-owned nuclear electricity generators in North America. OPG's top operational priority will be to improve the operation of its existing nuclear fleet.

Consistent with this mandate and OPG's corporate objectives, OPG Nuclear established the following objectives with the purpose of making Nuclear a more dependable, predictable, and cost effective operating entity:

- Safety: Continued focus on high performance.
- Human Performance: Continued improvements in human performance and leadership and continue to address demographics/knowledge transfer issues.
- Reliability: Maintain progress on improving material condition of the operating units and sustaining the improvements. Deliver improved outage performance with reduced duration.
- Value for Money: Improve cost structure by getting the right work and parts to the line to improve efficiency and lowering support costs.

The operating units are being maintained to ensure that OPG retains all options for extending the life of the units. OPG will continue to maintain and invest in these facilities to ensure consistent, safe, and reliable performance over the current planned asset life, regardless of whether a decision is made to refurbish these plants in order to extend their lives further.

Pickering B and Darlington Refurbishment Projects

Based on current plans, Pickering B's estimated end of life is 2014 - 2016 while Darlington estimated end of life is 2018 - 2020. In June 2006, the Ontario government directed OPG to begin economic feasibility studies on refurbishing its existing nuclear plants, and to begin an environmental assessment.

OPG has initiated phase 1 of the Pickering B and Darlington refurbishment projects, consisting of:

- Assessing options for refurbishment and continuing to operate nuclear units beyond their currently-predicted end of service life.
- Preparing a recommendation to the OPG Board with respect to Pickering B refurbishment.

New Nuclear Project

Also in June 2006, OPG was directed by its shareholder to begin investigating new nuclear generation. Specifically, OPG was directed to begin a federal approvals process, including an environmental assessment for new nuclear units at an existing site. OPG is conducting the initial planning of the work required to obtain the necessary federal approvals, including planning for an environmental assessment under the *Canadian Environmental Assessment Act* and initiating a review of available reactor designs (collaboratively with Bruce Power). Further information on these projects is provided in Ex. D2-T1-S3.

7.0 BACKGROUND ON PERFORMANCE

Beginning in 1997, OPG Nuclear began a series of programs to address a prior lack of investment in many aspects of its operations including maintaining the material condition of its nuclear assets. In 2003, concerns remained for OPG Nuclear's future performance capabilities. The most significant risk identified was that the material condition of the plants was deteriorating as the plants entered the mid-points of their respective plant lives, with the oldest plants exhibiting greater deterioration.

Pickering A Return to Service

In August 1999, OPG's Board of Directors approved a plan to restart the four units at Pickering A which had been laid up in 1997. The project to restart the units was the Pickering A return to service project.

The project commenced with Unit 4, which was declared commercially available in September 2003. With the direction and agreement of the shareholder, OPG commenced the return to service of Unit 1. In November 2005, Unit 1 was declared commercially available for service.

In August 2005, OPG made the decision not to proceed with the return to service of Units 2 and 3 on the basis that it would not be financially viable. OPG is in the process of placing Units 2 and 3 at Pickering A into safe store condition for the remaining life of the station and an additional 30-year period prior to dismantlement. This project involves de-fueling the reactors, removing all heavy water and reconfiguring the station, including the control room, as a two unit station.

Evidence on the relevant costs of the Pickering A return to service project can be found at Ex. J1-T1-S1. Evidence on the reconfiguring of the station to achieve isolation of Pickering A Units 1 and 4 from Pickering A Units 2 and 3, as well as relocation of common system controls that are currently located in Unit 2, can be found at Ex. D2-T1-S1.

Operating Units: Pickering B, Darlington, and Pickering A Unit 1 and 4

Since 2004, OPG Nuclear has focused on increased investment in the material condition of the units, while maintaining the focus on safety performance, with an expectation that over the long-term, performance and reliability of the stations will improve resulting in increased production. During the period 2004 - 2007, the investment in improved material conditions of the nuclear generating stations has focused on completing life cycle plans and addressing known life limiting issues on major components at Pickering B and Darlington.

The 2004 plan was to ensure that Darlington, the station with the most advanced design, would not deteriorate in performance due to material condition issues but rather would sustain its high capability performance. This increased investment was incorporated into the 2004 business plan.

Pickering B was performing at poor reliability levels and was entering into major component maintenance (e.g., pressure tube and steam generators work). The plan was to drive improvements in the system and component health programs by significant and focused investment so that by the time the major component outage work was complete in 2007, the plant's overall material condition will have been restored and the effort would then go towards sustaining the performance at the improved levels. The result is that material condition of Pickering B has trended positive with significant reduction in forced losses due to material condition, and lower backlogs. Forced losses and high backlogs are indicative of poor asset health.

The Pickering A units as they came back into service over 2003 - 2005 were subject to unplanned outages, which is typical of units that have been out of service for many years. The plan was to ensure that Pickering A operated at the high standards of backlog levels for top performing plants. However, reliability has continued to be a problem due to a series of emergent issues relating to material condition of the units.

In 2007, Pickering A and Pickering B performance was negatively impacted by two major one-time extraordinary events; the inadvertent release by a third party contractor of resin into the demineralized water system, and Pickering A electrical supply system (inter-station transfer bus) problems. These events are unrelated to overall plant material condition.

OPG has also incorporated significant safety improvements over this period, which enables OPG to more effectively to address material condition issues. Other issues related to physical aspects of safety include the completion of the auxiliary power system at Pickering. These major safety related achievements provide a strong foundation for achieving predictability in operations. These key elements are recognized by international standard agencies as standards of safe operation. OPG is the first nuclear generator in Canada to achieve certification from Technical Standards and Safety Association for pressure boundary work (safe operations issue). Other factors for sound, sustainable and good performance include addressing our long standing major destiny issues such as feeders, steam generator, turbine and pressure tube (spacer relocation) issues. These are all very complex, long duration and high cost efforts. The business has also heavily invested in material condition improvements driving down backlogs in corrective and elective maintenance. Overall, the business is not yet at the industry standard, but has made considerable progress in achieving this goal.

The business has also reconstituted its security requirements as per requirements of the CNSC, following world events.

Key Initiatives

A number of measures and initiatives have been undertaken or are in the process of starting up, in support of the objectives, specifically:

- Increasing the effort to reduce elective and corrective maintenance backlogs and focus additional resources on preventive maintenance programs. A new equipment performance improvement strategy will be implemented that is designed to ensure cost effective maintenance by better integrating the roles of (1) station work management with responsibility for programming work to be done within the station and outage planning, (2) station operations and maintenance with responsibility for planned, preventive and corrective maintenance of structures, systems, components or equipment, and (3) Nuclear Supply Chain with responsibility for procurement of materials and services.
- Improving outage planning and execution processes to minimize unanticipated production shortfalls and transition OPG to a more sustainable, reliable, and predictable performance state. Components of this initiative include improvements to outage scope control, outage planning, and resource allocation.
- Implementing a three-year cycle for planned outages at Darlington (compared to current two-year cycle) and transitioning at Pickering to outage durations of 45 to 50 days from the recent life cycle outages of up to 130 days.

- At Pickering B, evaluating requests for project investments in the context of an impending decision on refurbishment. An exception to this are current large, one-of-a-kind projects (security, used fuel disposal, and auxiliary power) which are nearing completion.
- Increasing and sustaining the level of generation. Expected generation ranges from 50 to 51 TWh throughout the test period, reflecting an increase in the combined fleet output over the 2005 - 2007 period.
- Improved project review and monitoring process. This initiative includes examining the project portfolio to ensure that the number of planned projects is reasonable, that estimates of benefits are duly challenged, taking into account the ability to deliver the work (resource availability, scheduling and access to plant/equipment) as well as manage the projects both in-house and through third parties.
- Supply Chain is part way through their performance improvement plan which commenced in 2005, with a focus on three broad program objectives that include: improving material availability, establishing a competent nuclear supply chain organization, and re-establishing commercial leverage.
- Improving organizational effectiveness by taking initiatives to develop and enhance capable leadership in OPG Nuclear, addressing the aging demographics of the OPG Nuclear workforce and focusing on human operational improvements, while ensuring an effective and engaged workforce.
- Ongoing review of key processes (using an industry based peer team approach), to increase efficiency and effectiveness.

8.0 NUCLEAR TARGETS

Nuclear establishes performance targets to support its business objectives and benchmarks its performance against a number of these targets. Benchmarking information is presented in section 9.0. The targets for the Nuclear Generating Stations for 2008 and 2009 are shown in the chart below.

Chart 2

Nuclear Generating Station Targets

MEASURE	2008	2009
Generation (TWH)		
Pickering A	7.1	7.3
Pickering B	15.7	16.0
Darlington	28.6	26.5
Total Nuclear	51.4	49.8
Production Unit Energy cost (PUEC) – ($/MW/h)		
Pickering A	76	77
Pickering B	50	50
Darlington	30	34
Nuclear Avg.	43	46
Unit Capability Factor - %		
Pickering A	79.0	81.4
Pickering B	86.6	88.6
Darlington	92.7	86.2
Nuclear Avg.	89.0	86.0
Nuclear Performance Index (NPI)		
Pickering A	61.5	65.5
Pickering B	67.5	78.8
Darlington	95.7	92.9
Nuclear Avg.	78.0	82.0
Elective Maintenance Backlogs (per unit)		
Pickering A	425	375
Pickering B	700	575
Darlington	350	325
Nuclear Avg.	505	435

Nuclear production unit energy cost ("PUEC") is a measure of the cost of generating one megawatt-hour of electricity. It is derived by dividing OM&A costs plus nuclear fuel costs by total energy produced. Standard industry practice is to include in OM&A costs, the allocated corporate costs and variable costs related to used fuel disposal and the disposal of low and intermediate level radioactive waste materials. However, the costs do not include the total cost of service, e.g., PUEC excludes costs such as depreciation, taxes, and capital costs.

Unit capability factor is a standard World Association of Nuclear Operators ("WANO") indicator of performance reliability. Unit capability factor is the percentage of maximum energy generation that a unit or plant is capable of supplying to the electrical grid, limited only by factors within control of plant management. Unit capability factor is derived as the ratio of generation available from a unit over a specified time period divided by the maximum generation that the unit is able to produce under ambient conditions and at maximum reactor power during the same period. The available generation is reduced by planned and unplanned production losses deemed under station management's control. However, the derivation of available generation is not affected by losses due to events not under station management's control, including environmental conditions (e.g., loss of transmission capability, lake water temperature derates, labour disputes and low demand periods). While these events do impact actual production, they do not penalize unit capability factor as the units themselves are considered available to produce at these times. A high unit capability factor is indicative of excellence in plant physical asset condition, adherence to effective plant programs and practices to minimize unplanned energy losses and to optimize planned outages. Unit capability factor is usually presented as an average over a multi-year period in order to smooth out differing outage patterns etc.

The nuclear performance index ("NPI") is a weighted average of ten WANO indicators. It provides an overall measure of plant safety and reliability performance (70/30, safety related/reliability split) based on a number of reliability and safety measures. It is a measure of operational excellence. Plants with high NPI values have historically proven to be industry's top performers in costs and capacity factor. The inputs used are multi year data to provide a more consistent view (e.g., unit capability factor is averaged over two years.)

Elective maintenance backlogs measures pro-active investment in maintenance of plant equipment to maintain plant condition and enhance future reliability. A lower number indicates that plant equipment is being well maintained. Industry data indicate that well performing plants maintain backlogs at 350 - 400 per unit.

9.0 NUCLEAR FACILITIES BENCHMARKING

9.1 Establishing Industry Peer Groups

Nuclear benchmarks performance against CANDU nuclear plants as well as against the U.S. nuclear generators to assess and drive performance of its stations, as well as to identify opportunities for improvement from others. However, there are limits to OPG's ability to benchmark Pickering A and B due to lack of appropriate peer groups.

As reactor designs evolved from the late 1960's to the early 1990's, reactors tended to become larger, growing from 400 MW electrical output to 1300 MW electrical output. They also began to be grouped into multi-unit sites, generally in pairs in North America. Only OPG built four-unit stations. There was also a trend to greater complexity, more redundancy, more regulatory requirements such as seismic qualification, environmental qualification, and greater defense against accidents.

Darlington falls into the latest generation of North American reactors. Its large unit size and its multi-unit site are typical of U.S. stations built in the 1980s, although Darlington contains more common interconnected station systems. Cost and performance comparisons with those stations therefore, are reasonably valid.

Pickering A and Pickering B however are non-typical. At approximately 2100 MW, Pickering B falls into the mid range of U.S. stations in terms of total size. However the small size of its reactors places it at the bottom of the reactor size range. In fact, there are only five stations out of 72 in North America (U.S. and Canada) with smaller reactors and one of them is Pickering A. The four American reactors are all single unit stations with an average age of 35 years. Pickering A and Pickering B are older vintage and design. The two plants being of different designs but connected together (vacuum building, common services) adds to the complexity (cost) of operation of this facility.

Pickering B therefore, as a large station with small reactors, has no appropriate peer group. Benchmarking Pickering B with small reactors disregards the significant cost-benefit of a multi-unit site. On the other hand, comparing it with similar size stations places it at a disadvantage because of its small unit size. However, OPG uses the latter approach while incorporating correction factors, where appropriate, for reactor size.

Pickering A, as a multi-unit station with small reactors, also has no appropriate peer group.

It is worth noting that the size of units primarily impacts on cost, and not on performance.

9.2 Benchmarking Results

The measures that are benchmarked are: unit capability factor, NPI, PUEC, and elective maintenance backlogs (see section 8.0 above for additional information on these measures). These measures represent essential parameters of good and sustainable nuclear performance.

Nuclear uses two sources for benchmarking:

- World Association of Nuclear Operators - for non-cost performance data
- Electric Utility Cost Group (“EUCG Inc.”) - for cost performance data

Information on the two organizations and the facilities included in their benchmarking is provided in Appendix A.

Benchmarking results are presented in Chart 3 and then discussed in additional detail below:

Chart 3
Nuclear Benchmarking Results

Measure		Value*	Comparison	Source and Peer Group
Production Unit Energy Costs "PUEC" ($/MWh Can$)	Pickering A	68	US industry median is 24 $/MWh, US top quartile is 20 $/MWh. PA/PB U.S size peer group median 32 $/MWh DN U.S. size peer group median 23 $/MWh	EUCG** for 2006 (CANDU worldwide PUEC data is not available) U.S. – Can. $ Fx rate 0.88
	Pickering B	50		
	Darlington	26		
	Nuclear	48		
Unit Capability Factor (%)	Pickering A	69.6	CANDU : Median: 86.4 Top quartile: 92.4.	OPG/WANO data: three year average. CANDU unit capability factor scores include OPG
	Pickering B	74.3		
	Darlington	89.2		
	Nuclear	81.4		
Nuclear Performance Index (NPI)	Pickering A	56.6	CANDU: Median: 74.6; Top quartile: 85.8	OPG/WANO NPI data: up to 3 year averages for various components CANDU NPI scores exclude OPG
	Pickering B	56.9		
	Darlington	92.7		
	Nuclear	68.7		
Elective Maintenance Backlogs (# outstanding per unit)	Pickering A	450	US industry median: 348; US top quartile: 304	Sourced from WANO working group but not standard WANO measure. One year data for OPG/WANO.
	Pickering B	850		
	Darlington	400		
	Nuclear avg.	590		

*OPG benchmark data are based on current business plan information provided to the Shareholder.
**EUCG cost data are always in U.S. dollars of the year, and are not normalized in any way for unit size, age, or technology differences.

1.0 Production Unit Energy Cost

External information is collected via EUCG, a non-profit organization whose membership includes 99 percent of U.S. nuclear operators, as well as many others outside of the U.S. The organization collects, validates, and publishes blinded cost and production data to members. It is standard industry practice to benchmark costs by comparing the cost of production.

Darlington continues to perform very well, relative to its peer group, at $26/MWh. OPG has budgeted adequate OM&A and capital investments to ensure that Darlington's material plant condition and performance is sustained**,** as is further discussed in Exhibits D and F. Darlington is expected to further improve on this as its generation output improves.

The 2006 PUEC for Pickering B is $50/MWh. This is high for its peer group, mainly due to lower production levels and higher costs as the plant elective backlogs are reduced and life cycle outages completed. Pickering B is also an older vintage plant with smaller size units – both representing negative impacts for unit energy costs.

OPG currently does not use PUEC to benchmark Pickering A since it is not yet a meaningful measure. For completeness it has been included in this benchmarking data presentation, although it is not factored into the overall Nuclear PUEC benchmark. The plant was idle from 1997 until the restart of Units 1 and 4. Because of the transition from four to two unit operation, Pickering A has not yet achieved a stable cost profile so as to allow for the meaningful use of PUEC for benchmarking. OPG expects that Pickering A will be in a position to be effectively benchmarked in 2008, when it is more firmly established in a steady state of operation.

In addition to costs, PUEC is also impacted by generation output. Overall, the U.S. industry (pressurized water reactors/boiling water reactors) has achieved a stable "high level" of generation performance. The U.S. nuclear industry began improvement programs earlier and have achieved a steady state of top level performance in cost and output. OPG is moving in the same direction, but with the exception of Darlington, has not yet achieved this level.

The Pickering plants are making significant investments to improve the level of performance (e.g., improving material condition of plant, reducing corrective and elective maintenance backlogs). It is therefore difficult to make a meaningful comparison based solely on unit cost.

In addition, there are other factors which must be considered when assessing benchmarks for OPG plants. These include fluctuations in the Canada – U.S. currency exchange rate, accounting differences, and technology differences. While performance data across the industry are standard, the same cannot be said for the cost data. Although the EUCG strives for consistency, openness and accuracy in reporting cost data through various data audit reviews, it relies on the integrity of the data submitters. In addition, varying accounting models (e.g., allocation of corporate overhead and capitalization policies) can affect the way costs are interpreted. These aspects of variability include:

a. Canada – U.S. Dollar Exchange Rate Distortion

The cost comparisons and trending currently being used covers the years 2003 - 2006. The Canadian dollar has appreciated by almost 25 percent against the U.S. dollar during this four year period (almost 40 percent since 2002). All other things remaining equal, this has tended to show OPG costs as rising against the U.S. industry, thus distorting the comparison. The large shift in the Canadian – U.S. dollar exchange rate impacts the ability to trend costs over this time period.

b. Accounting Differences

When looking at operating costs, there are differences created by capitalization policies which vary between companies. Some companies allow more costs to be capitalized than others. This alters the costs which go into the production cost calculation. Also the way corporate costs are allocated to the plants can effect the cost calculation.

c. Technology Differences between CANDU and Pressurized Water Reactors/Boiling Water Reactors

The principal differences between reactor types are presented below. The emphasis is on differences that result in different costs. Of the world reactor fleet of 436 units, 265 or 61 percent are pressurized water reactors. Ninety-two or 21 percent are boiling water reactors, and 39 or 9 percent are CANDU type. The remaining units are mainly gas cooled reactors.

Chart 4

Technology Differences between CANDU and Pressurized Water Reactors/ Boiling Water Reactors

Components	Pickering A	Pickering B	Darlington	Pressurized Water Reactor	Boiling Water Reactor
Reactor	Horizontal pressure tubes	Horizontal pressure tubes	Horizontal pressure tubes	Pressure vessel	Pressure vessel
Reactor coolant and associated systems	Heavy water	Heavy water	Heavy water	Light water	Light water
Generator Output	540MW	540MW	934MW	500-1400 MW	500 – 1400 MW
Steam Generators (SG)/unit	12	12	4	2 - 4	NA
Main Coolant Pumps/unit	16	16	4	2 - 4	2
Large Isolation Valves Main Circuit	40/unit	40/unit	0	0	4/unit
Standby Generators & Emergency Power Generator	6 for 4 units	8 for 4 units	6 for 4 units	2/unit	2/unit
Computers/unit	2	2	8	1	1
Shut Down Systems/unit	2	2	2	2	2
On line Fuelling Machines	8 for 4 units	8 for 4 units	6 for 4 units	NA	NA
Tritium Removal Facility	0	0	1	NA	NA
Heat Transport System	Carbon steel	Carbon steel	Carbon steel	Stainless steel	Stainless steel

The major difference between OPG's CANDU and light water reactors (typical U.S. reactors) designs is that CANDU reactors use natural uranium for fuel, while U.S. reactors use uranium that has been enriched to higher levels of the fissile isotope, Uranium-235. This difference in fuel types necessitates major differences in technology used to support operations. This in turn drives economic differences. Examples are discussed below.

- CANDU units must use heavy water instead of light water in the moderator and heat transport systems. Management of the reactor coolant is more costly in a CANDU since the heavy water itself is more costly and also since it is more radioactive than the U.S. light water coolant due to the presence of tritium – creating a “costlier” work environment (e.g., work in plastic suits, increased monitoring etc.).
- In the OPG CANDU design, units are connected to each other by a common vacuum building containment system (safety feature at some CANDU sites). This common containment system necessitates that all units be taken off-line at the same time once every 10 to 12 years to conduct required inspections of these components. At Darlington this applies to four units while at Pickering it applies to all six operating units. These are typically complex major outages and have a significant impact on generation output.
- CANDU units must use on-line fuelling, with a consequent cost premium for sophisticated robotics and a permanent fuelling organization.
- CANDU units must have the fuel contained in pressure tubes to allow on-line fuelling. This requires additional inspection and maintenance which pressurized water reactors pressurized water reactors/boiling water reactor reactors do not have to undergo.
- The generally larger equipment inventory in a CANDU unit compared to the pressurized water reactor’s/boiling water reactor’s units represents a net increase in maintenance and operations workload.

The disadvantages above are offset to some extent by the advantage in the cost of fuel since natural uranium is less expensive than enriched. In addition, with on-line refueling, CANDU units should be capable of longer operating intervals between outages. The pressurized water reactors / boiling water reactors, without on-line fueling, are limited by fuel “burn-up”. They must shut down to refuel every 18 to 24 months, whereas CANDU units may operate up to 36 months between outages.

There are some economic "spin-offs" from operating with natural uranium and heavy water which the other reactors do not have. These include tritium and cobalt sales (see Exhibit G2). Finally, irradiated natural uranium ("spent fuel") is less hazardous to handle and store than enriched uranium.

2.0 Unit Capability Factor

With reference to unit capability factor, Darlington has continued to perform as one of the better CANDU plants world wide. Pickering B performance is below equivalent world wide CANDU due to major fuel channel outages and unplanned production losses. The performance of the Pickering A units, which came back into service over 2003-2005, has also been below equivalent world wide CANDU.

In 2007, Pickering A and Pickering B unit capability factors were also negatively impacted by two major one-time extraordinary events: the inadvertent release by a third party contractor of resin into the demineralized water system, and Pickering A electrical supply system (inter-station transfer bus) problems.

The expectation for 2008 and 2009, as a result of improvements made in plant material condition, is that performance will rebound at both the Pickering A and Pickering B stations. The target unit capability factor for Pickering B in 2008 and 2009 will place Pickering B within median CANDU equivalent. Pickering A unit capability factor is also expected to improve but will remain below the median CANDU equivalent.

3.0 Elective Maintenance Backlogs

With a large elective backlog, OPG's nuclear fleet continues to lag in comparison to similar performance indicators for U.S. nuclear generating facilities, reflecting a lack of past investment in plant material condition. OPG will be increasing investments to help reduce elective maintenance backlogs. There is a consensus within the U.S. nuclear industry with regard to the acceptable level of elective maintenance backlogs for a well run plant. It is usually 350 to 400 per unit.

4.0 Nuclear Performance Index

The world CANDU median score (excluding OPG units) for Q1 2007 is 74.6, while the top quartile is 85.8. Darlington at 92.7, is thus in the upper end of the top quartile for world CANDU reactors. Pickering B is at 56.9 and Pickering A is at 56.6.

As noted previously, NPI is a weighted average of several WANO indicators. It provides an overall measure of plant safety and reliability performance (70/30, safety/reliability split) based on a number of reliability and safety measures. The low NPI scores at Pickering A and Pickering B are driven by generation performance results. The stations are recovering from lengthy planned outages to address major life cycle and backlog issues. The results also reflect the high forced loss rates due to the poor material condition, which are expected to reduce as the backlog reduction and material condition improvement work takes effect. It is important to underline that OPG Nuclear's NPI safety-related indicators average considerably better than the generation areas. Thus it is largely the generation scores that are lowering total NPI score.

Output

Generation performance is heavily weighted in NPI calculations:

- Unit capability factor (weight 15 percent)
- Forced loss rate (weight 15 percent)

Safety Related

Nuclear Safety:

- Unplanned automatic scrams (weight: 10 percent).
- High pressure injection (weight: 10 percent).
- Auxiliary boiler feedwater (weight: 10 percent).
- Emergency AC power (weight: 10 percent).

Asset Health:

- Chemistry performance index (weight: 5 percent)
- Fuel reliability (weight: 10 percent).

<u>Worker Safety:</u>

- Collective radiation exposure (weight: 10 percent)
- Industrial safety accident rate (weight: 5 percent).

The chart, below, shows a breakdown of the NPI index into its components and compares OPG to world fleet of CANDU reactors. It is calculated over a two year period.

Chart 5

NPI Index

		Out of points	Excluding OPG CANDU Benchmarks Q1-2007		Total Points OPG Q2 2007		
			TOP Q avg	World Median	PA	PB	DN
Output	UCF FLR	**30**	**29.2**	**20.5**	**0.0**	**0.8**	**22.9**
Nuclear Safety	RTR HPSI ABFW EACP	**40**	**40.0**	**40.0**	**34.4**	**38.6**	**40.0**
Asset Health	CPI FRI	**15**	**15.0**	**15.0**	**7.2**	**10.2**	**14.8**
Worker Safety	CRE ISAR	**15**	**15.0**	**7.8**	**15.0**	**7.3**	**15.0**
				Total	**56.6**	**56.9**	**92.7**

Source: WANO

At Pickering B, the NPI score is negatively impacted by a low collective radiation exposure score. This is a result of lengthy, extensive planned outages in 2005, 2006 and 2007. Despite this, it is important to note that all plants remain well below prescribed limits.

At no time have any of the three OPG plants exceeded either Canadian Nuclear Safety Commission mandated dose limits, or the more restrictive OPG corporate limits.

LIST OF ATTACHMENTS

Appendix A: Benchmarking Sources

Attachment A: Photo of Darlington Generating Station

Attachment B: Photo of Pickering Generating Station

APPENDIX A
Benchmarking Sources

Nuclear uses primary two sources for benchmarking:

- World Association of Nuclear Operators
- Electric Utility Cost Group

World Association of Nuclear Operators

OPG Nuclear participates in the World Association of Nuclear Operators database, which is updated quarterly by utilities across the world. The database does not contain cost data, but it does encompass industry standard performance indicators, including unit capability factor, unplanned capability loss factor, forced loss rate, safety performance etc.

Electric Utility Cost Group

This is an industry association which shares “blinded” historical cost information amongst members in fossil, hydro-electric and nuclear forms of generation. The EUCG nuclear membership currently includes 99 percent of the commercial operators in the U.S., as well as many overseas. OPG, Bruce Power, and Hydro Quebec are the Canadian members. EUCG cost data are used to compare Nuclear’s production costs to industry peers (on a fleet, site or unit basis). The EUCG affords the opportunity to compare functional costs and activity based costs.

The primary goal of the EUCG is to enable member companies to optimize costs and reliability performance of participating plants through economic comparison and benchmarking studies. To achieve these objectives, the EUCG operates a database for comparing nuclear plant costs, staffing, and performance data. This database was originally developed in 1986.

ATTACHMENT A

Photo of Darlington Generating Station

ATTACHMENT B

Photo of Pickering Generating Station