PRODUCTION FORECAST AND METHODOLOGY – NUCLEAR

1.0 PURPOSE
This evidence provides a description of the methodology used to forecast nuclear production, and presents the nuclear production forecast for 2011 - 2012.

2.0 OVERVIEW
OPG is seeking approval of a production forecast of 98.9 TWh for the 2011 - 2012 test period for the nuclear facilities, which is an improvement of 3.9 TWh over the actual production achieved during 2008 - 2009.

OPG operates its nuclear generating stations in compliance with all applicable regulations, requisite licences and approvals in a safe, efficient, and cost effective manner. OPG, in accordance with its Nuclear Safety Policy, conservatively implements unit shutdowns in all circumstances when, in OPG’s assessment, the safe operation of the station could be at risk.

Section 3.0 provides a description of the nuclear production planning process which produces an integrated nuclear outage and generation plan (“Integrated Plan”). Section 4.0 presents the nuclear production forecast trend for 2007 - 2012 and describes the key factors impacting each year’s production forecast.

During the test period, OPG forecasts improved production performance across its entire nuclear fleet, as a result of a reduction in the number of planned outage days and improvements in forced loss rate (“FLR”) at Pickering A and B.

3.0 NUCLEAR PRODUCTION PLANNING PROCESS
3.1 Integrated Nuclear Outage and Generation Plan
Through the nuclear production planning process, OPG seeks to establish accurate and reliable annual production forecasts for its individual nuclear units and an aggregated forecast for each station. Nuclear facilities are designed as base load generators; meaning
generator output is not intended to vary with market demand. Therefore, the annual nuclear
production forecast is equal to the sum of the generating units’ capacity multiplied by the
number of hours in a year, less the number of hours for planned outages or forced
production losses (i.e., unplanned outages and derates). As such, the production planning
process is focused on establishing annual planned outage schedules, in accordance with
established outage scheduling guidelines, and on estimating forced production losses.

OPG is a member of the World Association of Nuclear Operators (“WANO”) and uses WANO
performance indicators to plan, track and assess the performance of its nuclear units. For the
purpose of this evidence, forced production losses and planned outages are defined as per
WANO (see Attachment 1). Phase 1 of the ScottMadden Report (see Ex. F5-T1-S1) provides
additional background on standard industry benchmarks used to plan and track nuclear
generation performance.

The objectives of the production planning process are to:

- Provide a key input into the annual OPG business planning process.
- Ensure availability and optimal deployment of the internal and external resources needed
to execute the inspection, modification, and maintenance programs.
- Provide long-term operational plans to allow coordination of nuclear outages across OPG
so that reactor outages are planned to occur in periods that have minimal impact on the
Ontario electrical grid.
- Comply with the IESO Market Rules by providing information on OPG’s nuclear
production, capacity, and reliability assumptions.

The nuclear production planning process generates an annual Integrated Plan, with the
following deliverables:

- A five-year planned outage schedule for all stations that includes unit outage start dates,
end dates, and durations.
- A summary of major elements comprising the scope of work that will be executed during
each outage, with a higher level of specificity for scope elements occurring in outages
during the first two years of the Integrated Plan.
• Operational reliability performance targets such as unit capability factor and the level of targeted forced production losses represented by the forced loss rate (“FLR”). The process for setting these performance targets is discussed at Ex. F2-T1-S1.

• Outage resource requirements and cost estimates for inclusion in the outage OM&A budget. Further discussion of the outage OM&A forecast can be found at Ex. F2-T4-S1.

• Five-year generation forecasts in terawatt-hours (“TWh”) for individual nuclear units and an aggregated forecast for each station.

3.2 Generation Planning Methodology

The outage and generation planning process mandates three formal planning and review sessions over a 12-month period, culminating in a final Integrated Plan. The process reflects the dynamic nature of outage planning and ensures that all regulatory, operational or maintenance issues that have arisen since the prior period are incorporated into the plan, including:

• “Lessons learned” from recent OPG outages, internal operating experience, emergent discovery work, or short-term updates to life cycle management programs.

• Operating experience from others in the nuclear industry.

• Unanticipated regulatory orders/decisions/requirements (e.g., Canadian Nuclear Safety Commission, (“CNSC”) Technical Standards and Safety Authority), or a failure to obtain regulatory concurrence for plans, such that OPG must undertake unanticipated work activities.

The timing of the three planning and review sessions is as follows:

• In the late fall, the then current five-year Integrated Plan is reviewed and material updates, if any, to the outage schedule are identified.

• In the spring, the first draft of the new Integrated Plan is produced and any material updates to the current outage schedule are identified.

• In the summer, the final Integrated Plan is produced. It is incorporated into the OPG Nuclear business plan which is approved by the Chief Nuclear Officer (“CNO”) and then
submitted as part of OPG’s business planning process (see Ex. A2-T2-S1 for a
discussion of the corporate business planning process).

As noted by ScottMadden (see Ex. F5-T1-S2 page 16), the gap-based business planning
process introduced in 2009 as part of the Phase 2 Nuclear Benchmarking Initiative was
overlaid on the nuclear planning process already underway. The final Integrated Plan
generated in the summer of 2009 and used in the 2010 - 2014 nuclear business plan
therefore reflects the combination of the “bottom-up” analysis from the draft Integrated Plan
prepared in the spring and the performance targets (i.e., forced loss rate and unit capacity
factor) generated during the gap-based, top down, target setting process. Further discussion
of the process by which target setting impacted the development of the final Integrated Plan
can be found in section 3.2.1.2.

In addition to the three formal planning and review sessions, non-routine meetings are also
convened when developments in program assumptions or outage schedules need to be
addressed. On limited occasions, significant developments may necessitate updates to the
current outage schedule, if they impact the immediate two year outage planning horizon.

The final Integrated Plan and all non-routine updates are approved by the CNO.

At each stage of the planning process, material updates are communicated to the IESO.
Planned outages must be registered with and “time-stamped” by the IESO. OPG files its
nuclear outage schedule in order to secure an early “time-stamp” date for its outages, which
determines their standing in the IESO’s outage queue. All outages in the queue are subject
to final approval by the IESO, which can deny this approval at any time up to the start of the
outage.

The following describes in greater detail the stages in the preparation of the final Integrated
Plan:
3.2.1 Integrated Plan Development

In the fall of each year, each station submits an initial outage outlook for the five-year period commencing in January of the next calendar year. For example, the generation plans reviewed during 2009 covered the 2010 – 2014 timeframe. The initial outage outlook will reflect any regulatory, operational or maintenance issues that have arisen since the finalization of the prior Integrated Plan. Often outage durations are amended to reflect analysis of data obtained from recent outages experienced at OPG or other nuclear stations.

Outages during the first two years of the five year planning cycle are subject to the most extensive review and planning.

At the end of this stage, OPG Nuclear has identified:

- An updated, five-year planned outage schedule for each unit in the nuclear fleet, with the addition of a fifth year, as described below.
- Forced production loss and Unit Capability Factor (“UCF”) targets, as described below.
- Generation targets and the underlying rationale for the changes from the prior Integrated Plan.

3.2.1.1 Planned Outage Schedule

Planned outage scope and duration are primarily determined by the station’s life cycle plan (as discussed below). This plan identifies the inspections and maintenance necessary to ensure the continued safe, reliable, long-term operation of the plant and compliance with regulatory requirements. With regard to the scope of regulatory requirements, the nuclear industry stands apart from other regulated industries and other forms of electrical generation due to the complex nature of its technology, the criticality of safety in its operations and nuclear regulations. Consequently, the key drivers associated with OPG’s nuclear operations (i.e., safety, complexity, training, material standards, work environment, non-standard fleet, aging technology, evolving regulatory standards, and achievements in technology) that are outlined in the base OM&A exhibit (Ex. F2-T2-S1) are equally applicable to outage scope, duration, and cost.
The outage scheduling guidelines considered during the planning process are:

- Eliminate/minimize overlap of planned outages.
- Minimize the scheduling of planned outages during peak seasonal periods.
- Ensure outage changes impact minimally on planned production targets.
- Proactively minimize the probability of inter-site work and schedule conflicts related to shared resources and tooling (e.g., inspection maintenance services campaigns and feeder replacement projects; optimize use of roving maintenance crews).
- Ensure standard intervals are applied between planned outages at each unit.

Outages involve many OPG divisions and individuals working together, and as such they require high levels of coordination. Outages require focus, expertise, and a level of detail that exceeds major construction projects. They require careful preparation and the safe execution of a well-developed plan that accounts for nuclear, radiological, and industrial safety, as well as, the efficient achievement of production goals and cost controls.

Outages consist of a combination of “routine” inspection and maintenance activities and “non-routine” activities specific to a particular outage. They involve thousands of work tasks, representing many person-hours of labour, sequenced in the optimal order to ensure safe and effective execution. As an example of the complexity of outage planning, Attachment 3 includes a Level 1 schedule for the Pickering B Unit 6 2009 planned outage.

Examples of routine activities would be preventive maintenance programs, feeder inspections and water lancing of steam generators, to maintain performance and reliability. Non-routine activities include corrective and elective maintenance programs and could include upgrades, replacements or modifications to the equipment or plant configuration that can only be done when the unit is shut down, such as single fuel channel replacement or low level drain state.

Even though OPG Nuclear is transitioning to standard baseline outage templates as discussed in Attachment 2, any outage will have unique aspects based on its specific scope. Approximately 60 per cent of the work activities in an outage typically relate to routine
preventative maintenance and inspection activities while the remaining 40 per cent relate to work activities for non-routine upgrades and modifications. Within this split, the planned outage scope would primarily consist of pre-defined work activities and related work tasks. However, approximately 15 per cent of planned outage scope is contingency work activities that are anticipated to arise from discovery work during the routine inspection and preventive maintenance activities. These contingency activities are carefully selected based on risk assessments and historical experience. This approach allows OPG to proactively plan for, and be in a position to quickly respond to, such discovery work as it is identified over the course of the outage. Including contingency work activities within the planned outage scope minimizes the potential disruption to the outage schedule due to critical path and bulk work delays, as well as improving the accuracy of the Integrated Plan.

In addition, in order to avoid a significant disruption to the outage schedule, OPG may postpone completion of non-critical, non-safety related discovery work until after the outage. A decision to postpone work can lead to reduced production reliability during the post-outage period and require that future planned outages include the deferred items. By providing for a prudent level of contingency work activity in the planned outage scope, OPG balances the risk of outage extension due to discovery work against post-outage production reliability (i.e., the risk of more and longer force outages which impacts FLR).

Though outage duration is determined by the critical path of outage inspections and maintenance, it is also impacted by CANDU design (i.e., fuel is not offloaded during the outage) and the availability of the mandatory minimum equipment required for protection of the reactor fuel. Historically, the bulk of the outage critical path duration has been fuel channel and steam generator work. Recently, feeder piping inspections and maintenance are emerging as an additional critical path driver on some units. Pickering B Continued Operations, as discussed at Ex. F2-T2-S3, will result in additional planned outage days in 2010 - 2012 due to the need to perform additional Spacer Location and Relocation ("SLAR") work as well as other work activities.
The following steps outline the process that yields each station’s planned outage schedule:

- Each station identifies the inspection and maintenance activities required to comply with the aging and life cycle management programs and to ensure the safe and reliable operation of the facilities for the duration of their planned lives. The aging and life cycle management programs outline specific objectives for the major plant components (e.g., fuel channels, steam generators, feeders). The programs detail the frequency and nature of inspections, and the recurring preventive maintenance work required to ensure fitness for service and to maintain the reliability and safety of the plant. While outages will always include routine inspections and maintenance activities, the equipment affected will vary from one outage to the next, in accordance with the schedule specified in the aging and life cycle management programs. The variation in the scope of outages comes from corrective maintenance, projects and other non-routine activities. These variations are required to respond to issues specific to a station or to a unit(s) within a station, as units do not necessarily age according to the same pattern or at the same rate. The critical path of an outage can be impacted by these variations.

- OPG’s nuclear operating licenses issued by the Canadian Nuclear Safety Commission (“CNSC”) (further described in Ex. A1-T6-S1) require that a number of tests and maintenance activities be performed at specified intervals to ensure continued safety. In some instances, the requirement necessitates the shut down of all the units within the station because the test or the work involves a common safety system or component (e.g., vacuum building outage at Darlington in 2009 and in Pickering in 2010). The stations develop high level planned outage schedules with the input of several organizations, including Engineering, Inspection Maintenance and Commercial Services (“IM&CS”), and Projects and Modifications. To accommodate constraints around inter-site sharing of certain resources and tooling, this input is a significant factor in determining both the scheduled outage dates and the sequencing of major critical path activities. It helps ensure effective deployment of inspection and maintenance resources between the units on outage, particularly in those instances where overlapping, multi-site outages occur. For example, IM&CS staff will review the outage schedule to ensure that the planned activities can be completed with the available resources and external commitments. This review is critical due to the limited availability of highly specialized
nuclear tooling and personnel. Efforts are also made to schedule outages at different sites sequentially to facilitate the sharing of operations and maintenance resources. As well, the planned outage schedule is reviewed to identify and resolve potential conflicts between stations over the use of shared specialty resources such as project crews, contract staff, and major component spares such as turbine spindles or feeder replacement tooling. At this stage, the outage OM&A costs are estimated based on several factors including historical experience, projected contractors’ costs, parts and projected equipment costs, and staffing requirements. Further discussion about outage OM&A costs can be found at Ex. F2-T4-S1. Station staff prepare resource, duration, and cost estimates at a detailed level for the outages. This allows the stations to prioritize work activities and examine the economic justification for necessary but non-essential activities, relative to other competing needs. The outage schedules involve development of detailed logic diagrams that identify the start and end dates for individual activities within each outage. The critical path for upcoming outages is also determined at this stage of the planning.

- Each station’s planned outage schedule includes an allowance for uncertainty in the outage duration related to potential discovery work. The allowance for uncertainty reflects a station level assessment of past outages, known and unknown technological risks specific to the outage, the number of inspections that may result in discovery work and resource capability and availability.

3.2.1.2 Forced Production Losses and Unit Capability Targets

All generating units face the risk of unscheduled equipment problems that may require unplanned shutdowns or a derating of the generating unit. Accordingly, the stations develop forced loss rate (“FLR”) targets that reflect the risk of such forced production losses for all units in the station.

In 2010, FLR targets were developed by station management with input from the Outage and Strategic Planning Departments, Engineering, and Nuclear Finance. FLR targets are based on the plants’ recent performance, any known improvements or deterioration in plant material
condition, past and future investment in reducing corrective and elective maintenance
backlogs to improve reliability and other performance improvement initiatives, as well as
known risks.

As part of the Phase 2 Nuclear Benchmarking initiative (Ex. F2-T1-S1), OPG introduced a
change to its production forecast methodology related to the use of gap-based target setting
to establish top-down, station FLR and Unit Capability Factor targets. The targets were
initially set for the fifth year (2014) of the Nuclear business plan. The stations then reviewed
their bottom-up FLR and Unit Capability Factor ("UCF") targets for the prior years (2010 -
2013) for reasonableness and consistency with the 2014 operational targets.

3.3 Initial Draft Integrated Plan
Using each station’s initial planned outage schedule and the FLR and UCF target
assumptions, Nuclear Finance prepares a draft five-year Integrated Plan. The draft
Integrated Plan includes monthly and annual generation targets (TWh), planned outage
days, and corresponding generation performance indicators at the unit, station and fleet
level, for each of the five years of the Integrated Plan.

Included in the draft Integrated Plan is a fleet-level uncertainty adjustment. The fleet level
adjustment recognizes the potential for events that are not predictable from a station level
perspective. These events could impact the duration of a planned outage resulting in forced
extensions of planned outages. The fleet level adjustment is intended to address planned
outage risks including those that could emerge from fleet aging issues, or the complexity in
fleet level activities (e.g., traveling crews and IM&CS) in support of outages. The fleet level
adjustment is implemented by applying adjustments to the planned outage duration for each
station’s planned outage schedule. The combined fleet level uncertainty adjustment directly
applied to the station production targets is 0.3 TWh in 2011 and 0.35 TWh in 2012.

3.4 Final Integrated Plan Approval
The Integrated Plan is finalized after the CNO reviews the station’s nuclear generation
targets, planned station outage schedules, and generation performance indicators included
in the draft Integrated Plan. This review identifies revisions to the generation plan to reflect the latest generation-related information from across Nuclear or any changes in the overall nuclear program direction. The final Integrated Plan is incorporated into OPG’s overall business planning process. Once approved through the OPG business planning process, the Integrated Plan will not change until the completion of the subsequent business planning cycle.

3.5 Forecast for Major Unforeseen Events

On average from 2005 - 2008, OPG’s actual nuclear production has been less than the approved nuclear business plan forecast by approximately 3.5 TWh. An analysis of these production shortfalls revealed that they were largely the result of Nuclear’s experience with forced outages and forced extensions to planned outages due to major unforeseen events. Accordingly, OPG has adjusted its production forecast methodology in the 2010 - 2014 Business Plan to include a 2.0 TWh per year allowance for major unforeseen events on the expectation that these types of events will occur in the future. (see Attachment 4 for analysis).

The Nuclear business unit strives to maximize nuclear production while ensuring safe and reliable operations. In order to incent and challenge the nuclear organization, OPG has established a stretch performance target that is 2.0 TWh higher than the 2010 - 2014 Business Plan production forecast. The performance of OPG Nuclear’s management will be assessed in part against its ability to achieve this stretch target (including payouts under the Annual Incentive Plan).

4.0 OPG NUCLEAR PRODUCTION FORECAST TREND

The expected trend in nuclear production starting from 2007 is for production to decline over the period 2008 - 2010 followed by an increase in 2011 and a further increase in 2012. This data is provided in Ex. E2-T1-S1 Table 1.

The major factors influencing the trend in production over 2007 - 2012 are:
An expectation of improved performance at the Pickering units. The performance improvements at Pickering B during 2009 reflect the impact of various initiatives that have been undertaken since 2004. Improvements at Pickering A are expected by the end of the test period as a result of the Pickering A Equipment Reliability program. In addition, both stations will be positively impacted by new programs arising from the 2009 Nuclear Benchmarking initiative, designed to improve outage performance as discussed below in Attachment 1.

- A vacuum building outage at Darlington in 2009 which required all four Darlington units to be shut down for approximately four weeks.
- A vacuum building outage at Pickering in 2010 that will require all four Pickering B units and the two Pickering A units to be shut down for approximately four weeks.
- Extended scope and duration of planned outages at Pickering B over the period 2010 - 2012 as a result of the Pickering B Continued Operations initiative. There are 167 additional planned outage days in the test period for Continued Operations corresponding to a reduction of 1.9 TWh in the production forecast in the test period.
- An improvement in the forecast FLR at Pickering A starting in late 2009 reflecting recent CNSC concurrence with OPG’s shutdown system trip setpoint methodology resulting in the elimination of the three per cent derate that was imposed in 2007.

The Nuclear production forecast for the 2011 - 2012 period does not include a specific provision for reduced production due to surplus baseload generation. OPG was not subject to material reductions in nuclear generation due to surplus baseload generation situations in 2008 or 2009 and is currently not anticipating a significant impact on its nuclear facilities during the test period.
LIST OF ATTACHMENTS

1. Attachment 1: Glossary of Outage and Generation Performance Terms
3. Attachment 3: Level 1 Planned Outage Schedule - Pickering B Unit 6
4. Attachment 4: Forecast for Major Unforeseen Events
ATTACHMENT 1

GLOSSARY OF OUTAGE AND GENERATION PERFORMANCE TERMS

**Calandria Tubes:** Tubes that span the calandria and separate the pressure tubes from the moderator. Each calandria tube contains one pressure tube.

**Corrective Maintenance:** Activities associated with the repair or replacement of plant systems, equipment, components, etc., which are found to be defective, and repairing, altering, adjusting, or bringing them into conformity or making them operable. This means any work on power block equipment that has failed or is significantly degraded to the point that failure is imminent prior to the next scheduled maintenance window. Such equipment no longer conforms to, or is incapable of, performing its design function.

**Critical Path:** The longest series chain of work which determines the outage duration based on the concept that you cannot start some activities until others are finished. These activities need to be completed in a specified work sequence, with each stage being more-or-less completed before the next stage can begin. **Bulk Work** activities are activities that do not drive the critical path and can be completed “in parallel” thus not impacting outage duration.

**Derate:** A derate is where a unit is delivering a portion but not all of its full electrical power. Derates include:

- **Planned Derate**, a planned reduction in available power generation, scheduled with the IESO at least 28 days in advance.
- **Forced Derate**, an unplanned reduction in available power generation, which can include deratings due to equipment, safety, environmental reasons, or Canadian Nuclear Safety Commission requirements.

**Discovery Work:** Work required to correct a deficiency that is discovered in the field after an outage begins.
**Elective Maintenance:** Any work on power block equipment that is deficient or degraded that needs to be remedied but which does not represent a loss of functionality of a major component or system.

**Feeder:** There are several hundred fuel channels in the reactor that contain fuel. The feeders are pipes attached to each end of the channels used to circulate heavy water coolant between the fuel channels and the steam generators.

**Feeder Replacement:** OPG will inspect feeders to assess the condition of feeder wall thickness relative to Technical Standard and Safety Authority standards; OPG will replace feeders which, in OPG's assessment, encroach on the Technical Standard and Safety Authority standard; with such assessments reviewed by the Canadian Nuclear Safety Commission (“CNSC”) for their concurrence and approval.

**Forced Extensions to Planned Outages:** An extension to a planned outage which is not scheduled with the IESO at least 28 days in advance, and is unavoidable because the unit is not capable of safe operation at the scheduled outage completion time (e.g., an unexpected condition discovered during the scheduled outage which drives critical path).

**Forced Loss Rate (“FLR”):** FLR is a WANO indicator of performance reliability. FLR is a measure of the percentage of energy generation during non-planned outage periods (non-planned outage periods exclude forced extensions of planned outages) that a plant is not capable of supplying to the electrical grid because of forced production losses, such as forced outages or unplanned derates.

**Forced Outage:** As per WANO industry performance reporting guidelines, a forced outage is a generator outage for which OPG did not provide at least 28 days advance notice to the IESO. For purposes of clarification, the IESO defines a forced outage as an unplanned electricity system component failure (e.g., immediate, delayed, postponed, startup failure) or other condition that requires the unit be removed completely from service immediately. For the purposes of the filing, the WANO definition has been used unless otherwise stated.
Under certain infrequent circumstances (e.g., protection of equipment or the public), a utility is permitted by the IESO market rules to force a unit offline even though a request for a planned outage has been declined by the IESO. This would be classified a forced outage by OPG, and is subject to follow-up investigation by the IESO at their discretion.

**Forced Production Losses:** Forced production losses represent lost production due to forced outages and forced derates.

**Lessons Learned Review:** At the completion of an outage, a review of areas for improvement is conducted and documented. The review includes an analysis of actual performance against scheduled performance for the purpose of improving schedule and performance for similar work in the future. The focus of the review includes: (1) scope control, (2) schedule accuracy, adherence, and stability, (3) organization effectiveness and communication, (4) work package readiness, (5) strengths, (6) improvement areas, including action plans for resolution, (7) resource availability and utilization, and (8) contingency plans.

**Level I Schedule:** An outage schedule produced at a summary level of detail, identifying major activities within a scheduled period of unavailability for a particular system or sub-system, with a pre-defined start and end date.

**Life Cycle Plan:** Life cycle management is the integration of safety management, ageing management and business management decisions, together with economic considerations over the life of a nuclear power plant in order to:

- Maintain an acceptable level of performance including safety.
- Optimize the operation, maintenance and service life of structures, systems, and components.
- Maximize returns on investment over the operational life of the nuclear power plant.
- Take account of strategies for life cycle funding (including decommissioning), fuel management, and waste management.
MegaWatt (MW = $10^6$ watt): The productive capacity of electrical generators operated by utility companies. For reference, about 10,000 100-watt lightbulbs or 5,000 computer systems would be needed to draw 1 megawatt.

**Maximum Continuous Rating:** A station’s maximum capacity measured in MW.

**Operating Capacity Factor ("OCF"):** A standard WANO indicator of performance reliability, OCF is a measure of the percentage of energy generation that a plant is capable of supplying to the electrical grid during non-planned outage periods (e.g., OCF = 100-FLR).

**Planned Outage:** A planned outage is an outage which has been scheduled with the IESO at least 28 days in advance of the start date. It is subject to final approval by the IESO, the starting time of which could be postponed up to the scheduled hour of shutdown. The schedule must include the planned completion date. The planned outage duration cannot be revised (increased or decreased) after the planned outage has commenced.

**Planned Outage Extension:** An extension to a planned outage which has been scheduled with the IESO at least 28 days in advance of the planned outage extensions occurrence. A planned outage extension may be approved by the IESO, although the unit could be made capable of safe operation at the scheduled outage completion time, if it is more economical to continue the existing outage than to have another outage later.

**Pressure Tubes:** Tubes that pass through the calandria and supports the fuel bundles. Pressurized heavy water flows through the tubes, cooling the fuel.

**Preventive Maintenance:** The activities associated with forestalling or preventing anticipated problems or the breakdown of a system, part, etc. For example:

- Overhaul
- Testing
- Calibrations
- Lubrication programs
- Elastomer replacements
Steam Generator: A heat exchanger that transfers heat from the heavy water coolant to light water. The light water boils, producing steam to drive the turbine.

TeraWatt (TW = 10^6 MW): The productive capacity of electrical generators operated by utility companies.

Unbudgeted Planned Outages: An unbudgeted planned outage is an emergent outage that was not included in the approved integrated nuclear outage and generation plan that underpins the business plan, but which OPG had sufficient time to notify the IESO at least 28 days prior to the start date. Although unbudgeted, this allows the outage to be categorized as 'planned' for performance reporting purposes as per WANO industry guidelines. If OPG moves forward with the outage but is unable to so notify the IESO within the 28 days timeframe, the outage would be designated a forced outage.

Unit Capability Factor (“UCF”): Unit capability factor is a standard WANO indicator of performance reliability. Unit capability factor is the percentage of maximum energy generation that a unit 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, lake water temperature derates, labour disputes, and potential low demand periods). While these events do impact production, they do not penalize unit capability factor as the units are considered available to produce at these times.

World Association of Nuclear Operators (“WANO”): An internationally recognized body with standardized performance indicators for nuclear reactors (against which OPG Nuclear benchmarks).
ATTACHMENT 2

OPG NUCLEAR INITIATIVES TO IMPROVE OUTAGE AND PRODUCTION PERFORMANCE

Since 2004, OPG Nuclear has instituted a series of programs to invest in aspects of its operations, including: i) improving the material condition of its nuclear assets, and ii) improving outage planning procedures and processes to increase productivity and reduce outage duration.

Since 2006, the success of the improved plant material condition and improved outage planning procedures and processes initiatives is beginning to emerge. As noted by ScottMadden in the 2009 Benchmarking Phase 1 report, Darlington’s forced loss rate (“FLR”) was within the best quartile (Ex F5-T1-S1 page 86). Positive results also emerged in 2009 for Pickering B, with the successful completion of the Unit 6 fall outage ahead of schedule. The actual FLR for Pickering B in 2009 was 5.8 per cent as compared to the two-year trend of 12.5 per cent in 2007 and 24.2 per cent in 2008. At Pickering A, Unit 1 achieved best quartile performance with a UCF of 91.4 per cent in 2009, an improvement compared to 39.0 per cent in 2007 and 62.3 per cent in 2008. The Unit Capacity Factor (“UCF”) best quartile benchmark is 91.0 per cent (see Ex F5-T1-S1). Pickering A Unit 1’s FLR in 2009 was 8.1 per cent which is an improvement from the two-year trend of 50.8 per cent in 2007 and 37.2 per cent in 2008.

The following provides additional details on past and future initiatives to improve outage and production performance:

i) **Improving the Material Condition of the Nuclear Units**

Improving the material condition of the nuclear units is expected to improve the long-term performance and reliability of OPG’s nuclear generating stations. Investments are focused on completing life cycle programs for major components such as feeder replacement, steam generator inspections, and the completion of the Spacer Location and Relocation program (“SLAR”). Another initiative relates to the plant reliability list program. The plant reliability list is a comprehensive, prioritized list of critical work orders based on system and component
health assessments. The plant reliability list integrates a number of initiatives into one plan where previously such initiatives had been managed separately. This allows OPG Nuclear to focus on the highest priority, most critical work. The execution of the plant reliability list program, which is continuous and ongoing, is expected to result in improved system health, plant material condition, and improved plant reliability.

At Darlington, the focus is on completing life cycle programs for major components such as feeder replacements. At Pickering B, the focus is on completing major life cycle programs including the completion of the SLAR program. At Pickering A, the focus since 2005 has been on the return to service of its units after their extended shut-down. Starting in 2009, Pickering A introduced the Pickering A Equipment Reliability program. The objective of this program is to restore Pickering A’s plant performance to the historically achieved levels, reduce forced losses and improve generation performance. Discussion of the Pickering A Equipment Reliability program is found at Ex F2-T2-S1 Attachment 2.

OPG’s efforts to maintain and improve the material condition of its plants are also focused on reducing the number of corrective and elective maintenance backlogs at all three stations. Maintenance backlogs represent deficiencies at the plant and are an indicator of station health. Prior to 2004, OPG reduced its investment in reducing maintenance backlogs. Moving forward, OPG is refocusing its resources on elective and corrective maintenance programs to reduce backlogs and improve station health, thereby improving reliability and reducing the potential for forced production losses.

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<td>Pickering A</td>
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<td>558</td>
<td>428</td>
<td>420</td>
<td>333</td>
<td>350</td>
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<td>17</td>
<td>14</td>
<td>17</td>
<td>11</td>
<td>10</td>
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<tr>
<td>Darlington</td>
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<td>584</td>
<td>373</td>
<td>313</td>
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<td>275</td>
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<td>235</td>
</tr>
<tr>
<td>Corrective</td>
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<td>14</td>
<td>13</td>
<td>8</td>
<td>7</td>
<td>9</td>
<td>8</td>
<td>7</td>
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<tr>
<td>OPG</td>
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<td>699</td>
<td>605</td>
<td>482</td>
<td>400</td>
<td>380</td>
<td>337</td>
<td>318</td>
</tr>
<tr>
<td>Corrective</td>
<td>69</td>
<td>37</td>
<td>17</td>
<td>16</td>
<td>13</td>
<td>16</td>
<td>13</td>
<td>13</td>
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</table>
As reported in the Phase 1 Benchmarking Report, all three OPG stations are worse than median for both elective and corrective maintenance backlogs compared to North American peers. As part of the gap-based target setting process introduced as part of the Phase 2 Nuclear Benchmarking Initiative (Ex F2-T1-S1), five-year elective and corrective backlog targets were set to narrow this performance gap by reducing the level of elective backlogs at all three sites, and stabilizing the level of corrective backlogs at Pickering.

ii) Outage Planning Procedures and Processes - Station Led Initiatives
OPG’s nuclear stations have undertaken steps since 2006 to introduce robust outage planning procedures and processes designed to improve outage performance. These initiatives include:

- Improving Outage Planning: OPG Nuclear is planning for shorter duration, “routine” planned outages, supported by the following initiatives:
  - Implementing improved industry-standard outage planning milestones in the planned outage process, to transition to industry best practices. Improving processes to better manage outage scope so as to reduce the number of planned outage days.
  - Establishing standard outage templates. Internal benchmarks detailing the amount of time and resources required for “routine” outage work activities. Implementing the recommendations from “lessons learned” reviews following planned outages.

- Improving Outage Execution: Improve outage execution performance to reduce outage duration and costs including the following steps:
  - Creating an Outage Control Centre: Using industry best practices, OPG centralized the oversight and project management of outage execution at each site into an Outage Control Centre in 2006. The centre is staffed with senior line management who have the authority to make the immediate decisions necessary to keep outages on schedule.
  - Developing Specialized Teams: As noted above, outage scope consists of routine and non-routine work activities. OPG has recently initiated a process to create specialized work teams and provide them with advanced preparation and training.
  - Co-ordination of Operations and Maintenance: Operations staff performs activities associated with preparing and placing systems and components in-service and out of
service for maintenance, while maintenance staff perform all activities directly related to the preventative, elective, and corrective maintenance. Consequently, maintenance staff cannot initiate maintenance activity until operations staff had completed their work. Recent initiatives have been directed at improving co-ordination between operations and maintenance staff as well as allocating more operations staff to support the outage thereby increasing productivity and reducing inefficiencies.

• Improving Forced Outage Readiness: OPG has reviewed and adopted best industry practices related to forced outage management readiness to quickly respond to, and more effectively manage, forced outages.

• Improving Material Availability: OPG is seeking to minimize delays in the completion of outages by ensuring materials and replacement parts are available as required. Nuclear Supply Chain is focusing on reducing the average cycle time required to deliver materials and replacement parts to the stations.

iii) Outage Planning Procedures and Processes – Fleet-wide Initiatives

With the benefits from the outage improvement initiatives at the station level emerging since 2006, OPG believes that additional improvements in outage performance and costs can be obtained by moving towards an integrated, fleet-wide approach. Outage planning and execution are station accountabilities. As a result, past outage improvement initiatives were generally implemented separately by each station. OPG uses peer teams composed of representatives from each station to provide a forum for the sharing and implementation of best practices.

During Phase 2 of the 2009 Benchmarking Initiative, a new fleet-wide initiative (“Outage Improvement Strategy”) was identified as one of seven top priorities for implementation. The Outage Improvement Strategy represents the consolidation of various actions to improve outage execution and planning and it will be implemented through an integrated fleet approach. The objective is to develop an integrated Outage Improvement Plan that looks at the performance gaps across the fleet and addresses key drivers and program changes on a fleet-wide basis, necessary to drive improved outage performance and lower cost. This approach is similar to the process used successfully by Exelon Corporation, which operates the largest fleet of nuclear stations in the United States.
The Outage Improvement Strategy that was developed during the 2009 Phase 2 Benchmarking is comprised of the following sub-initiatives:

- Improve Contractor Management Process
- Improve Outage Scoping Process
- Implement Outage Duration Improvement Program
- Standardize Outage Control Centre across fleet
- Formalize Continuous Fleet Outage Improvement Program
- Outage Training Performance Improvement Initiative
- Execution Rate Improvement Plan

The Outage Improvement Strategy builds upon past work at the sites to introduce optimal fleet-wide processes and procedures. OPG will focus on improving fleet contractor management procedures (how work is managed, what work is performed, when the work is scheduled, what support is available), improving contractor productivity/efficiency by increasing the amount of work done each day. Other key areas targeted are the scoping process where OPG is committed to improving the timely identification and assessment of the planned outage work prior to the scope freeze milestone date. Improving OPG’s ability to pre-plan and assess the level of work and resources required will avoid delays in execution of the outage and/or higher costs. Another component of the Outage Improvement Strategy is to review and implement fleet-wide standards for minimum staffing requirements based on best in fleet organizational practices.

Another separate initiative aimed at improving outage planning and processes is the roll-out of the Primavera P6 software planning tool. Primavera P6 is a construction project management product created for prioritizing, planning, scheduling, managing and executing projects. Primavera P6 enhances OPG’s ability to model and optimize resource usage for outage execution on a fleet-wide basis, thereby increasing outage productivity and reducing outage duration.
Attachment 4

Forecast for Major Unforeseen Events

This attachment describes the derivation and rationale for the 2.0 TWh forecast for major unforeseen events described in section 3.5.

On average from 2005 to 2008, OPG’s actual nuclear production has been less than the approved business plan forecast by approximately 3.5 TWh. An analysis undertaken in 2009 revealed that these unplanned variances were largely the result of high forced loss rates due to major unforeseen events (2.05 TWh, on average) and forced extensions to planned outages (1.19 TWh, on average) (Table 1). Examples of major unforeseen events include losses due to feeder thinning (2005); the inter-station transfer bus issue (2007); the resin release issue (2007) and calandria tube deterioration (2008).

Table 1

Average TWh Variance to Business Plan, 2005 to 2008

<table>
<thead>
<tr>
<th>Station</th>
<th>Planned Outage Variances</th>
<th>Forced Losses</th>
<th>Forced Extension to Planned Outages</th>
<th>Other Losses¹</th>
<th>Total Average Variance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Major Unforeseen Events</td>
<td>Balance</td>
<td>Major Unforeseen</td>
<td>Balance</td>
</tr>
<tr>
<td>Pickering A</td>
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<td>-1.18</td>
<td>-0.51</td>
<td>0.00</td>
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</tr>
<tr>
<td>Pickering B</td>
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<td>-0.87</td>
<td>-0.05</td>
<td>-0.09</td>
<td>-0.64</td>
</tr>
<tr>
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<td>0.00</td>
<td>0.54</td>
<td>0.00</td>
<td>-0.28</td>
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<tr>
<td>Total Fleet</td>
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<td>-2.05</td>
<td>-0.02</td>
<td>-0.09</td>
<td>-1.19</td>
</tr>
</tbody>
</table>

A forecast for major unforeseen events was not included in the nuclear generation forecast presented in EB-2007-0905. For the 2010 - 2014 Business Plan, a forecast of generation

¹ Other losses are comprised of grid losses, net lake losses and consumption (i.e. station operating and outage)
losses due to major unforeseen events has been included in the nuclear production forecast. This reflects OPG’s recent actual experience as well as OPG’s expectation that there will be future production losses due to these major unforeseen events. The average amount (2.0 TWh) incurred over the last 4 years is considered a realistic projection of the expected losses.

The adjustment to the nuclear production forecast of 2 TWh for major unforeseen events results in a more accurate and reasonable production forecast for OPG.