PRODUCTION FORECAST AND METHODOLOGY
NUCLEAR

1.0 PURPOSE

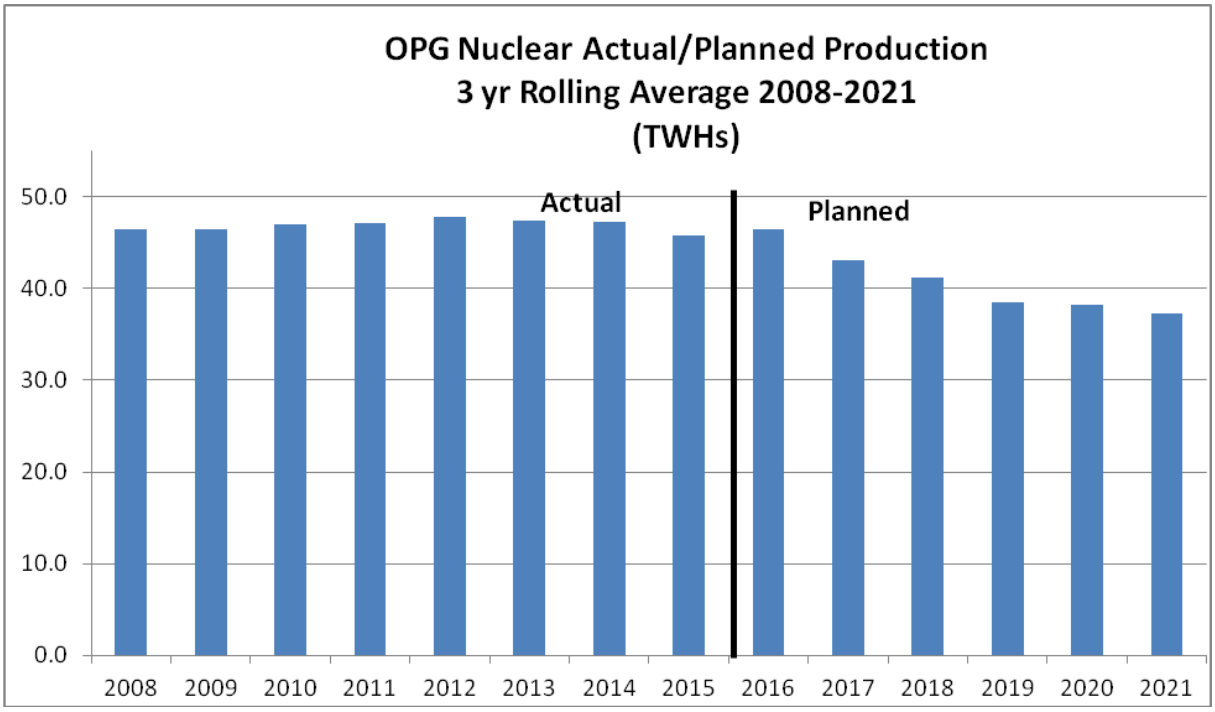
This evidence provides the production forecast for the nuclear facilities and a description of the methodology used to derive the forecast.

2.0 OVERVIEW

OPG is seeking approval of a nuclear production forecast of 38.1 terawatt-hours ("TWh") for 2017, 38.5 TWh for 2018, 39.0 TWh for 2019, 37.4 TWh for 2020 and 35.4 TWh for 2021. This amounts to a total 188.3 TWh nuclear production forecast for the 2017-2021 test period. The nuclear production forecast for the years 2013-2021 is presented in Ex. E2-1-1 Table 1. A monthly nuclear production forecast for 2017-2021 is presented in Ex. E2-1-1 Table 2. As discussed below, this represents a challenging production forecast for OPG's nuclear facilities during a period of significant and unprecedented change in OPG's nuclear operations due to the Darlington Refurbishment Program and Pickering Extended Operations.

Nuclear production (three year rolling average) over the 2008-2021 period peaked in 2012 as shown in Chart 1. From 2012 onward, actual and planned production primarily reflects the loss of generation due to the Darlington Vacuum Building Outage ("VBO") in 2015, the first unit outage for the Darlington Refurbishment Program in 2016, the Pickering VBO in 2021 and the increase in the number of planned outage days over the test period required for Pickering Extended Operations, and to address life cycle and aging equipment issues such as replacement of Primary Heat Transport ("PHT") pump motors at Darlington. OPG continues to pursue initiatives that focus on improving planned outage execution to meet planned outage days targets, and initiatives to improve plant equipment reliability and fuel handling to meet Forced Loss Rate ("FLR") targets. These initiatives are addressed in the discussion of OPG's gap closure initiatives in the Benchmarking and Business Planning evidence (Ex. F2-1-1).

Chart 1



The OEB approved nuclear production for the period 2008 to 2015 was greater than actual production. As shown on Chart 2 below, the average annual production shortfall for this period was 3.2 TWh. This resulted in an average negative revenue impact of $154.0M borne each year by OPG's shareholder. Consequently, in EB-2013-0321 OPG identified a change in OPG's approach in developing its nuclear production forecast. This change entailed increased scrutiny to more fully and realistically recognize the scope, risks and complexity of work performed during outages and where possible, basing the forecast on actual experience with similar work performed in the past at OPG and other organizations. In EB-2013-0321 the OEB accepted OPG's approach. The OEB noted, however, that the increased rigor had negated the need for adjustments for major unforeseen events going forward. OPG's methodology used to develop the 2017-2021 nuclear production forecast maintains the approach set out in EB-2013-0321. OPG's projected planned outage days, FLR, and

generation losses[1] during the test period reflect challenging targets. While any production forecast is subject to unplanned outcomes, OPG continues to be subject to unanticipated production disruptions due to events such as an unbudgeted planned outage in 2015 to replace PHT pump motors at Darlington. Smaller (albeit negative) production variances were achieved in 2014 and 2015 when compared to previous years, as shown on Chart 2.

Chart 2

OPG Nuclear Production Variance and Revenue Impact

Line No.		2008	2009	2010	2011	2012	2013	2014	2015	Average	Total
		(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)
1	**OPG Application - TWh**	**51.4**	**49.9**	**-**	**48.9**	**50.0**	**-**	**48.5**	**46.1**		
2	**OEB Approved - TWh+**	**51.4**	**49.9**	**50.7**	**50.4**	**51.5**	**51.0**	**49.0**	**46.6**		
3	**Actual -TWh**	**48.2**	**46.8**	**45.8**	**48.6**	**49.0**	**44.7**	**48.1**	**44.5**		
4	**Variance (TWh)** (line 3 - line 2)	**-3.2**	**-3.1**	**-4.9**	**-1.8**	**-2.5**	**-6.3**	**-0.9**	**-2.1**	**-3.2**	**-24.7**
5	**Revenue Impact - $M#**	**-159.9**	**-154.9**	**-242.4**	**-87.3**	**-121.3**	**-305.7**	**-45.9**	**-114.3**	**-154.0**	**-1231.8**

\+ 2010 is the average of 2008 and 2009 Board Approved; 2013 is average of 2011 and 2012 Board Approved.

\# At OEB-approved rates of $52.98/MWh for 2008-2010 less fuel cost, and $51.52/MWh for 2011-2013 less fuel cost.
For 2014, 10 months at OEB–approved rate of $51.52/MWh and 2 months at OEB approved rate of $59.29/MWh, less fuel cost (average $52.82/MWh).
For 2015, at OEB approved rate of $59.29/MWh less fuel cost

The test period production forecast takes into account the following:

- Darlington Refurbishment Program with Darlington Unit 2 being taken out of service in 2016, followed by Unit 3 in 2020, Unit 1 in 2021 (and Unit 4 in 2023). Each unit refurbishment project will take more than three years to complete. Two post-refurbishment mini-outages have been scheduled for Unit 2 to address equipment reliability issues that are expected to emerge post refurbishment. The need for these post-refurbishment outages is based on operating experience at other nuclear facilities that underwent major refurbishment. The first mini "warranty" outage of 55 days duration is scheduled for Unit 2 in 2020, within six months post refurbishment. The duration will allow sufficient time for anticipated equipment repair by the vendors. The second mini "warranty" outage of 31 days duration is scheduled for Unit 2 in 2021, within 18 months post-refurbishment. The shorter duration is due to an

[1] See Attachment 1 - Glossary of Outage and Generation Performance Term for definitions.

expectation that the majority of scope required to be addressed post-refurbishment will be completed during the first post refurbishment mini-outage in 2020.

- Eight mini-outages of approximately 20 days duration at Darlington over the period 2016-2021 are required to replace the high risk PHT pump motors. There are 16 operating PHT pump motors (four per unit) at Darlington. Failure of any one of the operating motors will result in a forced outage and could result in an extended outage, depending on availability of spare motors. Recent experience at OPG and operational experience from other utilities shows the expected service life of PHT pump motors to be 25 to 30 years, i.e., the approximate current service life of the Darlington facility. Based on operating experience to-date, including an unbudgeted planned outage to replace a failed PHT pump motor in 2015, OPG has an expedited program underway to purchase new or refurbished PHT pump motors and spares (Project #73566/80144 as described in Ex. D2-1-3) and mini outages have been included in the generation plan for their installation over the next five years.
- Darlington forecast FLR of 1.0 per cent for 2016 through 2019, 4.2 per cent for 2020 and 3.0 per cent for 2021. The increase in FLR in 2020 and 2021 reflects the return to service of Darlington Unit 2 from its refurbishment outage and is consistent with industry operating experience. Based on industry operating experience, the Darlington Refurbishment Program forecasts a Unit FLR of 12 per cent in the year of return to service and the year immediately following, 6 per cent in year two post-refurbishment, 2 per cent in year three post-refurbishment, and 1 per cent in year four and beyond post-refurbishment for the refurbished unit.
- Pickering's annual FLR stabilizing at 5.0 per cent for the period 2016 through 2021 reflecting expectations of reduced volatility in performance as a result of equipment reliability and fuel handling improvement initiatives.
- Undertaking 637 incremental planned outage days in 2016-2020 to enable the completion of various work activities required for Pickering Extended Operations as well as restoring normal planned outages and durations in 2020. These additional planned outage days reduce generation by 7.5 TWh over the period 2016-2020.

- Continuation of using mid-cycle planned outages on Pickering Units 1 and 4 each year during the 2016 to 2021 period to focus on preventive maintenance to maintain reliability and lessen the risk of forced outages.
- Maintaining a three year outage cycle for Darlington and a two year outage cycle for Pickering. Planned outage durations include production allowances, consistent with the approach described in EB-2013-0321, to reflect the risk of generation loss due to forced extensions to planned outages. These allowances more fully and realistically recognize the scope and complexity of planned outages in 2017-2021 that will be undertaken to address equipment reliability, equipment aging and parts obsolescence on OPG's aging reactors at Darlington and Pickering.

3.0 NUCLEAR PRODUCTION PLANNING PROCESS

3.1 Methodology

Except for updates to test period information, the following evidence is substantially unchanged from that filed in EB-2013-0321.

Nuclear facilities are designed as base load generators. OPG's annual nuclear production forecast is equal to the sum of the nuclear generating units' capacity multiplied by the number of hours in a year, less the number of hours for planned outages, forced production losses (i.e., unplanned outages and unplanned derates, as defined in Attachment 1 to this exhibit) and corrections for sources of generation losses (i.e., lake temperature, grid losses, consumption (station service), as defined in Attachment 1).

With the exception of increased rigour in assessing work scope as discussed in section 2.0, OPG's nuclear planning process has not changed since EB-2010-0008 and is focused on establishing annual planned outage schedules and calculating variances to planned generation due to forced production losses. Outage durations are determined based on the scope of work defined for each outage while considering recent benchmarking efforts, industry best practices and the nuclear commitment to continuous improvement. The

objective is to establish a realistic and accurate annual nuclear production forecast based on the Nuclear Generation and Outage Plan[2], with the following deliverables:

- A planned outage schedule for all stations that includes unit outage start dates, end dates, and durations, as well as a summary of major elements comprising the scope of work that will be executed during each outage.
- Operational reliability targets such as Unit Capability Factor ("UCF") and the level of forced production losses aligned with the FLR.
- Generation forecasts (in TWh) for individual nuclear units and an aggregated forecast for each station.

The Nuclear Generation and Outage Plan is approved as part of the OPG business planning process. As discussed in Ex. F2-4-1, outage resource requirements and cost estimates for the outage OM&A budget are also tied to the Nuclear Generation and Outage Plan.

3.1.1 Planned Outage Schedule

OPG's planned outage schedule identifies the number of days required for inspections and maintenance activities to ensure continued safe, reliable and long-term operation. The planned outage scheduled is prepared in accordance with OPG's aging and life cycle management programs and in compliance with OPG's nuclear operating licenses issued by the Canadian Nuclear Safety Commission ("CNSC").

Planned outages are complex, involving many OPG divisions and individuals working together. Outages require focus, expertise, high levels of coordination and a level of detail that exceeds that of major construction projects (due to regulatory complexity and constraints in work execution). The planned outage schedule also incorporates "lessons learned" from recent OPG outages and operating experience outside of OPG.

Planned outages consist of a combination of "routine" inspection and maintenance activities and "non-routine" activities specific to a particular outage. Examples of routine activities are

[2] The Nuclear Generation and Outage Plan summarizes OPG nuclear generation and outage targets and is an input to the overall OPG Business Plan

preventive maintenance, feeder inspections and water lancing of steam generators. Non-routine activities include corrective and deficient maintenance, and replacements or modifications to the equipment or plant configuration that can only be done when the unit is shut down. The majority of work in an outage typically is routine preventive maintenance and inspection activities, while the remaining work is non-routine breakdown maintenance and modifications.

Planned outages must be submitted to and be "time-stamped" by the IESO. In most cases, OPG submits its nuclear outage schedule early in order to secure an early time-stamp date; this date determines the outage advanced approval priority in the IESO's outage queue. In addition to an advance approval process, 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.

For the test period, there are single unit planned outages for routine maintenance at Darlington each year from 2016 to 2021. In addition, the first outage for the Darlington Refurbishment Program will commence in October 2016 with Unit 2 being taken out of service. Unit 2 is scheduled to return to service in 2020. Unit 3 refurbishment is scheduled to begin in 2020 and Unit 1 refurbishment is scheduled to begin in 2021. There are two short post-refurbishment mini "warranty" outages scheduled for Unit 2 in 2020 and 2021 as described in section 2.0 above.

The six Pickering units are on a two year planned outage cycle for routine maintenance, meaning that three units are subject to planned outages each year. Therefore Pickering will be subject to three planned outages per year in the 2016 to 2020 period. In addition there is one mid-cycle planned outage ("mid cycle" meaning mid-way through the two year planned outage cycle for Pickering as discussed above) for Pickering Unit 1, or Unit 4 every year in the test period, to allow for additional preventive maintenance which will lessen the risk of forced outages on those units.

There is no VBO or Station Containment Outage ("SCO") scheduled for Darlington during the test period. OPG conducted a combined VBO SCO outage in 2015. Although Darlington's next VBO was not required until 2021, OPG moved this outage forward to align with the SCO outage that was required to be done in 2015, eliminating the need for an additional outage in 2021 to perform a VBO. A six unit Pickering VBO is scheduled for 2021.

The planned outage durations include a station level allowance for uncertainty related to potential discovery work. They also include a nuclear fleet level allowance to address risks to the completion of the outage on schedule, risks that could emerge from fleet aging issues, or from complexity in fleet level activities (e.g., availability of Inspection Maintenance Service resources to service multiple outages).

3.1.2 Forced Loss Rate

Variances to planned generation result from forced production losses (i.e., unplanned outages and derates). OPG forecasts FLR targets that reflect the risk of forced production losses at Darlington and Pickering. The FLR targets are based on the plants' historical performance, any known improvements or plant material condition issues, and initiatives to improve equipment reliability.

Darlington's forced outage performance has shown significant volatility as set out in Chart 3 below:

Chart 3

Darlington Forced Loss Rate

	2010	2011	2012	2013	2014	2015	Avg
FLR (%)	**3.2**	**0.6**	**2.3**	**4.8**	**1.5**	**4.9**	**2.9**

The higher than planned FLR in 2015 is primarily attributable to PHT pump motor failures (PHT electrical protection trip; pressurized heater leak). Darlington's forecast FLR is 1.0 per cent for 2016 through 2019 and 4.2 per cent for 2020, then decreasing to 3.0 in 2021 (see Ex. E2-1-2 Table 1). While the forecast of 1.0 per cent for 2016 through 2019 is aggressive relative to the historical trend, it is achievable based on expectations that OPG executes

ongoing initiatives to improve equipment reliability that will stabilize Darlington's FLR. It is also based on a reasonable assumption that OPG will be able to install new PHT pump motors during the mini planned outages. Increased FLR in 2020 and 2021 is due to the refurbished Darlington Unit 2 returning to service.

Pickering's forced outage performance has also shown volatility as set out in Chart 4 below:

Chart 4

Pickering Forced Loss Rate

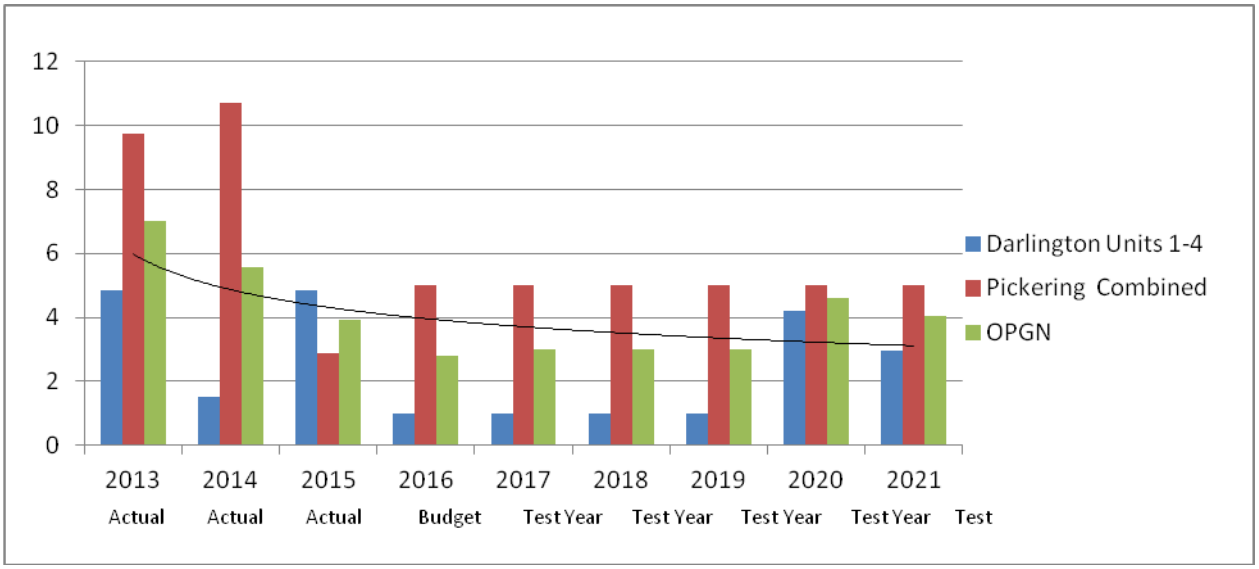
	2010	2011	2012	2013	2014	2015	Avg
FLR (%)	**9.3**	**11.6**	**7.0**	**9.7**	**10.7**	**2.9**	**8.5**

Pickering's forecast FLR is 5.0 per cent for each year from 2016 to 2021 (see Ex. E2-1-2 Table 1) reflecting an expectation that the FLR will stabilize as a result of ongoing equipment reliability improvement initiatives. Also, mid-cycle planned outages were introduced at Pickering Units 1 and 4 starting in 2012 to allow for additional preventive maintenance which will lessen the risk of forced outages. These mid-cycle outages are planned for each of 2016 through 2020.

Chart 5 presents historical and forecast FLR for the nuclear facilities for the period 2013-2021. The black line represents the three-year rolling average FLR.

Chart 5

OPG Nuclear FLR (2013-2021)



ATTACHMENTS

Attachment 1 Glossary of Outage and Generation Performance Terms

GLOSSARY OF
OUTAGE AND GENERATION PERFORMANCE TERMS

The following evidence is substantially unchanged from that filed in EB-2013-0321.

Consumption Losses: The electrical service energy consumed by a station and used to supply the electrical load for ancillary equipment and related on-site processes.

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, or environmental reasons.

Forced Extensions to Planned Outages ("FEPO"): 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"): Forced Loss Rate is a World Association of Nuclear Operators ("WANO") indicator of performance reliability. Forced Loss Rate is a measure of the percentage of energy generation that a plant is not supplying to the electrical grid during non-planned outage periods, because of forced production losses, i.e., forced outages or unplanned derates. This indicator excludes forced production losses due to high lake water temperatures, and forced extensions to planned outages.

Forced Outage: 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 and, per WANO industry performance reporting guidelines, for which OPG did not provide at least 28 days advance notice to the IESO for the start of the outage.

Forced Production Losses: Lost production due to forced outages and forced derates.

Generation Losses: The total generation losses that are outside the control of plant management, equal to the sum of "Consumption Losses" + "Grid Losses" + "Lake Temperature Losses".

Grid Losses: Generation losses due to a reduction in electrical power generation because the grid is unable to accept the available power (due to a problem outside of the station boundary) or because of demand limitations.

Lake Temperature Losses: High lake water temperature losses result when reduced condenser efficiency results in lower generation output.

Life Cycle Management: 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.

Maximum Continuous Rating: The design, or demonstrated higher, maximum power of a unit operating continuously (in MWs).

Planned Outage: 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.

Unbudgeted Planned Outage: An emergent outage that was not included in the approved integrated nuclear outage and generation plan that underpins the business plan, but for 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.

Unit Capability Factor ("UCF"): 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 the 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.

Numbers may not add due to rounding.

Table 1

Production Forecast Trend - Nuclear (TWh)

Line No.	Prescribed Facility	2013 Actual	2014 Actual	2015 Actual	2016 Budget	2017 Plan	2018 Plan	2019 Plan	2020 Plan	2021 Plan
		(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
1	**Darlington NGS**	25.1	28.0	23.3	26.0	19.0	19.3	19.7	17.7	16.6
2	**Pickering NGS**	19.6	20.1	21.2	20.8	19.1	19.2	19.4	19.6	18.8
3	**Total**	44.7	48.1	44.5	46.8	38.1	38.5	39.0	37.4	35.4

Numbers may not add due to rounding.

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EB-2016-0152
Exhibit E2
Tab 1
Schedule 1
Table 2

Table 2
Monthly Production - Nuclear (TWh)
Test Period

Line No.	Prescribed Facility	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
		(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)
	2017 Plan:													
1	**Darlington NGS**	1.9	1.2	1.2	1.2	1.4	1.8	1.8	1.8	1.8	1.5	1.4	1.9	19.0
2	**Pickering NGS**	1.7	1.3	1.4	1.4	1.4	1.6	1.8	1.8	1.7	1.4	1.6	1.8	19.1
3	**Total**	3.6	2.5	2.6	2.6	2.8	3.3	3.6	3.7	3.5	2.9	3.0	3.8	38.1
	2018 Plan:													
4	**Darlington NGS**	1.9	1.7	1.7	1.2	1.3	1.2	1.8	1.8	1.8	1.5	1.4	1.9	19.3
5	**Pickering NGS**	1.9	1.6	1.7	1.4	1.4	1.5	1.4	1.7	1.7	1.4	1.6	1.8	19.2
6	**Total**	3.8	3.4	3.4	2.6	2.7	2.6	3.2	3.5	3.5	2.9	3.0	3.8	38.5
	2019 Plan:													
7	**Darlington NGS**	1.9	1.7	1.5	1.2	1.3	1.4	1.8	1.8	1.8	1.4	1.9	1.9	19.7
8	**Pickering NGS**	1.9	1.6	1.7	1.4	1.4	1.4	1.5	1.8	1.7	1.4	1.6	1.8	19.4
9	**Total**	3.8	3.4	3.2	2.6	2.7	2.8	3.3	3.6	3.5	2.8	3.4	3.8	39.0
	2020 Plan:													
10	**Darlington NGS**	1.9	1.7	1.0	0.6	0.8	1.4	1.8	1.8	1.7	1.4	1.8	1.8	17.7
11	**Pickering NGS**	1.7	1.3	1.4	1.4	1.4	1.5	1.9	2.1	1.8	1.4	1.6	2.0	19.6
12	**Total**	3.6	3.1	2.4	2.0	2.2	2.9	3.6	3.9	3.5	2.9	3.4	3.8	37.4
	2021 Plan:													
13	**Darlington NGS**	1.9	1.7	1.8	1.3	1.9	1.4	1.2	1.2	1.1	0.8	1.1	1.2	16.6
14	**Pickering NGS**	1.9	1.6	1.6	1.4	0.0	1.4	1.7	2.0	1.7	1.8	1.7	1.9	18.8
15	**Total**	3.8	3.3	3.4	2.7	1.9	2.8	2.9	3.2	2.9	2.6	2.8	3.1	35.4

COMPARISON OF PRODUCTION FORECASTS
NUCLEAR

1.0 PURPOSE

This evidence presents period-over-period comparisons of nuclear production forecasts for 2013-2021 in support of the approval of OPG's nuclear production forecast for the test period.

2.0 OVERVIEW

Variances between actual and forecast production in any year or period-over-period variances are typically the result of OPG experiencing more or fewer forced outages ("FO") or derates, forced extensions to planned outages ("FEPO"), planned outage days or unbudgeted planned outages. Variances may also arise due to station consumption, grid losses and lake water temperature.

Period-over-period variances are presented in Ex. E2-1-2 Table 1 and are explained below.

PERIOD-OVER-PERIOD CHANGES – TEST YEARS

2017 Plan versus 2016 Budget

The nuclear production forecast for 2017 of 38.1 TWh is 8.7 TWh lower than the 2016 Budget of 46.8 TWh. The lower forecast production for 2017 relative to 2016 forecast production is primarily due to the following:

- There are 287 additional planned outage refurbishment days[1] for Darlington as Unit 2 refurbishment continues for the entire year.
- There are 182.4 additional planned outage days[1] for the combined nuclear fleet (additional 42.4 planned outage days for Darlington and additional 140 planned outage days for Pickering). The increase in planned outage days for Darlington is a result of a Single Fuel Channel Replacement on Unit 1, planned derates on Unit 3

[1] Darlington "planned outage refurbishment days" includes outage days for units out of service during refurbishment. "Planned outage days" excludes outage days for units out of service during refurbishment.

and 4 due to Unit 2 bulkhead installation, and a mini-outage to install Primary Heat Transport ("PHT") pump motors. The increase of planned outage days for Pickering reflects the additional scope required Pickering Extended Operations.

- There are 10.6 fewer equivalent days in the combined nuclear fleet Forced Loss Rate ("FLR"). While the forecast FLR is maintained year-over-year for Darlington (1.0 per cent) and Pickering (5.0 per cent), with additional planned outage days at both stations, this results in fewer equivalent FLR days.

2018 Plan versus 2017 Plan

The nuclear production forecast for 2018 of 38.5 TWh is 0.4 TWh higher than the 2017 Plan of 38.1 TWh. The higher forecast production for 2018 relative to 2017 forecast production is primarily due to the following:

- There are 20.9 fewer planned outage days for the combined nuclear fleet (10.1 fewer planned outage days for Darlington and 10.8 fewer planned outage days for Pickering). The reduction of planned outage days for Darlington is due to no Single Fuel Channel replacement and Planned Derates in 2018 versus 2017. The reduction in planned outage days for Pickering reflects the scope being undertaken in 2018 versus 2017 for Pickering Extended Operations.
- There is no change in the combined nuclear fleet FLR. With a total of 20.9 fewer planned outage days, this results in 0.6 additonal equivalent FLR days.
- There is no change in planned outage refurbishment days for Darlington as Unit 2 refurbishment continues for the entire year.

2019 Plan versus 2018 Plan

The nuclear production forecast for 2019 of 39.0 TWh is 0.6 TWh higher than the 2018 Plan of 38.5 TWh. The slightly higher forecast production for 2019 relative to 2018 forecast production is primarily due to the following:

- There are 32.9 fewer planned outage days for the combined nuclear fleet (19.2 fewer planned outage days for Darlington and 13.7 fewer planned outage days for Pickering). The reduction of planned outage days for Darlington is a result of one fewer mini-outage to install PHT pump motors, and reduced scope in the Unit 4

outage, offset by additional planned derates. The reduction of planned outage days for Pickering reflects the scope for Pickering Extended Operations.

- There is no change in the combined nuclear fleet FLR. With a total of 32.9 fewer planned outage days, this results in 0.9 additional equivalent FLR days.
- No change in planned outage refurbishment days for Darlington as Unit 2 refurbishment continues for the entire year.

2020 Plan versus 2019 Plan

The nuclear production forecast for 2020 of 37.4 TWh is 1.7 TWh lower than the 2019 Plan of 39.0 TWh. The lower forecast production for 2020 relative to 2019 forecast production is primarily due to the following:

- There are 45.8 additional planned outage days for the combined nuclear fleet (64.1 additional planned outage days for Darlington offset by 18.3 fewer planned outage days for Pickering). The increase in planned outage days for Darlington is a result of a Single Fuel Channel replacement during the Unit 1 outage and a planned mini-outage post-refurbishment for Unit 2 to allow vendors to address equipment reliability issues after the Unit 2 refurbishment. The reduction of planned outage days for Pickering reflects the scope for Pickering Extended Operations.
- There is a 1.6 per cent increase (29.6 more equivalent FLR days) in the FLR for the combined nuclear fleet. The FLR for Darlington increases from 1.0 per cent to 4.2 per cent due to post-refurbishment FLR (as discussed in Ex. E2-1-1, section 2.0). This results in 28.4 additional equivalent FLR days at Darlington. The FLR for Pickering remains constant at 5.0 per cent. With a total of 18.3 fewer planned outage days, this results in 1.2 additonal equivalent FLR days at Pickering.
- There is one additional planned outage refurbishment day for Darlington due to the leap year. While Unit 2 Refurbishment ends in February 2020, the Unit 3 Refurbishment is scheduled to start immediately thereafter such that planned outage days for the combined units cover the entire year.

2021 Plan versus 2020 Plan

The nuclear production forecast for 2021 of 35.4 TWh is 2.0 TWh lower than the 2020 Plan of 37.4 TWh. The lower forecast production for 2021 relative to 2020 forecast production is primarily due to the following:

- There are 199 additional planned outage refurbishment days for Darlington due to the overlap of the refurbishment of Unit 1 and Unit 3 (starting June 2021).
- There are 68.1 fewer planned outage days for the combined nuclear fleet (131.9 fewer planned outage days for Darlington, offset by 63.9 additional planned outage days for Pickering). The reduction of planned outage days for Darlington is a result of no scheduled planned outages (two units are being refurbished) and the shorter duration of the second planned mini-outage post-refurbishment for Unit 2 in 2021 compared to the similar mini-outage in 2020. The increase in planned outage days for Pickering in 2021 includes the requirement to complete a planned Vacuum Building Outage in addition to the normal planned outages scheduled for that year. There are no planned outage days for Pickering Extended Operations in 2021 as this work will be completed in 2020.
- A 0.6 per cent decrease (16.6 fewer equivalent FLR days) in the combined nuclear fleet FLR. The FLR for Darlington declines from 4.2 per cent to 3.0 per cent due to post refurbishment FLR (as discussed in Ex. E2-1-1, section 2.0). With a reduction of 131.9 planned outage days at Darlington, this results in 13.1 fewer equivalent FLR days. The FLR for Pickering remains constant at 5.0 per cent. With a total of 63.9 additional planned outage days at Pickering, this results in 3.5 fewer equivalent FLR days.

3.0 PERIOD-OVER-PERIOD CHANGES – BRIDGE YEAR

2016 Budget versus 2015 Actual

The nuclear production forecast for 2016 of 46.8 TWh is 2.3 TWh higher than the 2015 actual of 44.5 TWh. The higher forecast production for 2016 relative to 2015 actual production is primarily due to the following:

- There are 78 additional planned outage refurbishment days for Darlington as Unit 2 refurbishment starts in October 2016.

- There are 104.3 fewer planned outage days for the combined nuclear fleet (155.9 fewer planned outage days for Darlington, offset by 51.5 addititional planned outage days for Pickering). The reduction of planned outage days for Darlington in 2016 reflects that 2015 had a four unit Vacuum Building Outage as well as an unbudgeted planned outage to replace the PHT pump motors on Unit 1. The increase in planned outage days for Pickering reflects the scope addition of a Single Fuel Channel replacement, Machine Delivery Scrape commissioning and Reactor Building Pressure Test, as well as two unbudgeted planned outages on Unit 1 and Unit 8 offset by a cancellation of a Unit 4 mid-cycle outage.
- There were 48.3 FEPO days in 2015 for the combined nuclear fleet (7.7 FEPO days for Darlington and 40.6 FEPO days for Pickering). The 2016 generation plan assumes outages will be completed on plan resulting in an year-over-year reduction in FEPO days.
- A 1.1 per cent decrease (6.7 fewer equivalent FLR days) in the combined nuclear FLR (a decrease of 3.9 per cent for Darlington and an increase of 2.1 per cent for Pickering).

4.0 PERIOD-OVER-PERIOD CHANGES – HISTORICAL YEARS

2015 Actual versus 2015 OEB Approved

The actual nuclear production of 44.5 TWh for 2015 was 2.1 TWh lower than the 2015 OEB Approved forecast of 46.6 TWh[2]. The lower actual production for 2015 relative to 2015 OEB Approved was primarily due to the following:

- There were 48.3 FEPO days in 2015 for the combined nuclear fleet (7.7 FEPO days for Darlington and 40.6 FEPO days for Pickering). The 2015 OEB approved generation plan assumed outages would be completed on plan resulting in a variance between 2015 actual and 2015 OEB approved. The 2015 actual FEPO days for Darlington occurred during the Unit 1 planned outage that followed the Vacuum Building Outage, the Unit 3 planned outage, and the Unit 1 unbudgeted planned outage. The 2015 actual FEPO days at Pickering occurred during the planned Unit 1, Unit 5 and Unit 7 outages.

[2] EB-2013-0321 Decision With Reasons, November 20, 2014, p 39.

- There were 141 additional planned outage days for the combined nuclear fleet (78.9 additional planned outage days for Darlington and 62.2 additonal planned outage days for Pickering). The increase in planned outage days was due to the three unbudgeted planned outages to address equipment related issues on Units 1 and 8 at Pickering and on Unit 1 at Darlington, partially offset by fewer planned outage days for the Unit 2 and Unit 4 Vacuum Building Outage and the cancellation of the Pickering Unit 4 mid-cycle outage.
- There was a 0.8 per cent increase (8.1 fewer equivalent days) in the combined nuclear FLR (an increase of 3.9 per cent for Darlington and a decrease of 2.6 per cent for Pickering).

2015 Actual versus 2014 Actual

The actual nuclear production for 2015 of 44.5 TWh was 3.5 TWh lower than the 2014 actual nuclear production of 48.1 TWh. The lower actual production for 2015 relative to 2014 actual production was primarily due to the following:

- There were 7.1 fewer FEPO days for the combined nuclear fleet (7.7 more FEPO days for Darlington offset by 14.8 fewer FEPO outage days for Pickering).
- There were 239.9 additional planned outage days for the combined nuclear fleet (174.8 additonal planned outage days for Darlington and 65.2 additional planned outage days for Pickering). The increase in planned outage days for Darlington in 2015 was mainly due to the Vacuum Building Outage. The increase in planned outage days for Pickering reflects the scope increase in the planned outages, the unbudgeted Unit 1 planned outage to repair Calandria Inlet Valves, and the unbudgeted Unit 8 Planned outage to repair the Liquid Injection Shutdown System in 2015, offset by the cancellation of the planned mid-cycle outages in 2014 and 2015.
- There was a 1.6 per cent decrease (109.4 fewer equivalent days) in the combined nuclear FLR (an increase of 3.4 per cent for Darlington and a reduction of 7.8 per cent for Pickering).

2014 Actual versus 2014 OEB Approved

The actual nuclear production of 48.1 TWh for 2014 was 0.9 TWh lower than the 2014 OEB Approved forecast of 49.0 TWh[3]. The lower actual production for 2014 relative to 2014 OEB Approved was primarily due to the following:

- There were 55.4 additional FEPO days for the combined nuclear fleet (all at Pickering). For Pickering, 7.5 FEPO days were due to the Unit 7 planned outage being extended to address Heat Transport pressurization and warm up oscillations, 13.6 FEPO days were due to the Unit 8 outage being extended for Fuel Handling reliability program maintenance, and 34.3 FEPO days were due to the Unit 4 planned outage being extended to repair a section of the heat transport system.
- There were 7.0 additional planned outage days in 2014 compared to the OEB approved plan for the combined nuclear fleet (15.0 more planned outage days for Darlington offset by 8.0 less planned outage days for Pickering).
- There was a 1.5 per cent increase (56.9 more equivalent days) in the combined nuclear fleet FLR (an increase of 0.3 per cent for Darlington and an increase of 3.0 per cent for Pickering).

2014 Actual versus 2013 Actual

The actual nuclear production for 2014 of 48.1 TWh was 3.4 TWh higher than the 2013 actual nuclear production of 44.7 TWh. The higher actual production for 2014 relative to 2013 was primarily due to the following:

- There were 152.0 fewer FEPO days for the combined nuclear fleet (39.8 fewer FEPO days for Darlington and 112.2 fewer FEPO days for Pickering).
- There were 11.7 additional planned outage days for the combined nuclear fleet (52.4 fewer planned outage days for Darlington offset by 64.1 additional planned outage days for Pickering). The reduction in planned outage days for Darlington was due to a single planned outage at Darlington in 2014, compared to two outages in 2013, consistent with the 3 year outage cycle at Darlington. The increase in planned outage days for Pickering resulted from the deferral of the Pickering Unit 4 outage from 2013 to January 2014. The deferral was slightly offset by the mid-cycle outages being

[3] EB-2013-0321 Decision With Reasons, November 20, 2014, p 39.

cancelled on Unit 1 and Unit 5.

- There was a 1.5 per cent decrease (16.8 fewer equivalent FLR days) in the combined nuclear fleet FLR (a decrease of 3.3 per cent for Darlington and an increase of 1.0 per cent for Pickering).

2013 Actual versus 2013 Budget

The actual 2013 nuclear production of 44.7 TWh was 3.3 TWh lower than the 2013 Budget of 48.0 TWh. The lower actual production for 2013 relative to 2013 Budget was primarily due to the following:

- There were 207.4 FEPO days for the combined nuclear fleet (39.8 FEPO days at Darlington and 167.6 FEPO days at Pickering). At Darlington, 19.7 FEPO days were due to the Unit 2 outage being extended for Primary Heat Transort activities and 20.1 FEPO days were due to Unit 4 outage being extended to repair Generator Seal Oil Heat Exchanger 1 and 2. At Pickering, 4.5 FEPO days were due to Unit 6 outage being extended to perform repairs on Steam Relief Valves, 53.4 FEPO days due to Unit 5 outage being extended to repair problems with the Main Output Transformer Isolated Phase Bus, and 109.7 FEPO days were due to the Unit 1 outage being extended from 2012 into 2013 due to a fire in the Lube Oil Purifier system.
- There were 82.6 fewer planned outage days for the combined nuclear fleet (almost no change to the planned outage days for Darlington and 82.7 fewer planned outage days for Pickering). The reduction of planned outage days for Pickering was a result of the deferral of the Pickering Unit 4 outage to January 2014.
- There was a 2.5 per cent increase (63.2 more equivalent FLR days) in the combined nuclear fleet FLR (an increase of 3.3 per cent for Darlington and an increase of 1.6 per cent for Pickering).

Numbers may not add due to rounding.

Table 1
Comparison of Production Forecast - Nuclear

Line No.	Business Unit	2013 Budget	(c)-(a) Change	2013 Actual	(g)-(c) Change	2014 OEB Approved[1]	(g)-(e) Change	2014 Actual	(k)-(g) Change	2015 OEB Approved[2]	(k)-(i) Change	2015 Actual
		(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)
	Darlington NGS											
1	**TWh**	26.9	(1.8)	25.1	2.9	27.1	0.9	28.0	(4.7)	25.0	(1.7)	23.3
2	**Unit Capability Factor (%)**	88.8	(5.9)	82.9	9.0	93.5	(1.6)	91.9	(15.0)	86.3	(9.4)	76.9
3	**PO Days**	144.4	0.1	144.5	(52.4)	77.1	15.0	92.1	174.8	188.0	78.9	266.9
4	**FEPO Days**	0.0	39.8	39.8	(39.8)	0.0	0.0	0.0	7.7	0.0	7.7	7.7
5	**FLR (%)**	1.5	3.3	4.8	(3.3)	1.3	0.3	1.5	3.4	1.0	3.9	4.9
6	**FLR Days Equivalent**	19.7	41.8	61.5	(41.0)	14.6	5.9	20.5	36.9	12.7	44.7	57.4
	Pickering NGS											
7	**TWh**	21.1	(1.5)	19.6	0.5	21.9	(1.8)	20.1	1.1	21.6	(0.4)	21.2
8	**Unit Capability Factor (%)**	79.2	(5.5)	73.7	1.6	79.9	(4.6)	75.3	4.1	82.1	(2.8)	79.4
9	**PO Days**	303.5	(82.7)	220.8	64.1	292.9	(8.0)	284.9	65.2	287.9	62.2	350.1
10	**FEPO Days**	0.0	167.6	167.6	(112.2)	0.0	55.4	55.4	(14.8)	0.0	40.6	40.6
11	**FLR (%)**	8.1	1.6	9.7	1.0	7.8	3.0	10.7	(7.8)	5.5	(2.6)	2.9
12	**FLR Days Equivalent**	152.4	21.4	173.8	24.2	147.0	51.0	198.0	(146.3)	104.5	(52.8)	51.7
	Totals											
13	**Unit Capability Factor (%)**	84.3	(5.7)	78.6	5.7	87.6	(3.3)	84.3	(6.3)	84.0	(6.0)	78.0
14	**PO Days**	447.9	(82.6)	365.3	11.7	370.0	7.0	377.0	239.9	475.9	141.0	616.9
15	**FEPO Days**	0.0	207.4	207.4	(152.0)	0.0	55.4	55.4	(7.1)	0.0	48.3	48.3
16	**FLR (%)**	4.5	2.5	7.0	(1.5)	4.1	1.5	5.6	(1.6)	3.1	0.8	3.9
17	**FLR Days Equivalent**	172.1	63.2	235.3	(16.8)	161.6	56.9	218.5	(109.4)	117.2	(8.1)	109.1
18	**Total TWh**	48.0	(3.3)	44.7	3.4	49.0	(0.9)	48.1	(3.5)	46.6	(2.1)	44.5

Line No.	Business Unit	2015 Actual	(c)-(a) Change	2016 Budget	(e)-(c) Change	2017 Plan	(g)-(e) Change	2018 Plan	(i)-(g) Change	2019 Plan	(k)-(i) Change	2020 Plan
		(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)
	Darlington NGS											
19	**TWh**	23.3	2.7	26.0	(7.0)	19.0	0.2	19.3	0.4	19.7	(1.9)	17.7
20	**Unit Capability Factor (%)**	76.9	14.2	91.1	(5.9)	85.1	0.9	86.0	1.7	87.8	(8.4)	79.4
21	**PO Days**[3]	266.9	(155.9)	111.0	42.4	153.4	(10.1)	143.3	(19.2)	124.1	64.1	188.2
22	**FEPO Days**	7.7	(7.7)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23	**FLR (%)**	4.9	(3.9)	1.0	0.0	1.0	(0.0)	1.0	0.0	1.0	3.2	4.2
24	**FLR Days Equivalent**	57.4	(44.7)	12.7	(3.3)	9.4	0.1	9.5	0.2	9.7	28.4	38.1
	Pickering NGS											
25	**TWh**	21.2	(0.4)	20.8	(1.7)	19.1	0.1	19.2	0.2	19.4	0.3	19.6
26	**Unit Capability Factor (%)**	79.4	(1.7)	77.6	(6.1)	71.5	0.5	72.0	0.6	72.6	0.8	73.4
27	**PO Days**	350.1	51.5	401.6	140.0	541.6	(10.8)	530.8	(13.7)	517.2	(18.3)	498.9
28	**FEPO Days**	40.6	(40.6)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
29	**FLR (%)**	2.9	2.1	5.0	0.0	5.0	(0.0)	5.0	0.0	5.0	0.0	5.0
30	**FLR Days Equivalent**	51.7	38.0	89.7	(7.2)	82.4	0.5	83.0	0.7	83.6	1.2	84.9
	Totals											
31	**Unit Capability Factor (%)**	78.0	6.6	84.6	(6.8)	77.8	0.7	78.5	(39.5)	39.0	37.2	76.2
32	**PO Days**[3]	616.9	(104.3)	512.6	182.4	695.0	(20.8)	674.1	(32.9)	641.3	45.8	687.1
33	**FEPO Days**	48.3	(48.3)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
34	**FLR (%)**	3.9	(1.1)	2.8	0.2	3.0	(0.0)	3.0	(0.0)	3.0	1.6	4.6
35	**FLR Days Equivalent**	109.1	(6.7)	102.4	(10.6)	91.8	0.6	92.5	0.9	93.4	29.6	122.9
36	**Total TWh**	44.5	2.3	46.8	(8.7)	38.1	0.4	38.5	0.6	39.0	(1.7)	37.4

Line No.	Business Unit	2020 Plan	(c)-(a) Change	2021 Plan
		(a)	(b)	(c)
	Darlington NGS			
37	**TWh**	17.7	(1.1)	16.6
38	**Unit Capability Factor (%)**	79.4	11.5	90.9
39	**PO Days**[3]	188.2	(131.9)	56.2
40	**FEPO Days**	0.0	0.0	0.0
41	**FLR (%)**	4.2	(1.2)	3.0
42	**FLR Days Equivalent**	38.1	(13.1)	25.0
	Pickering NGS			
43	**TWh**	19.6	(0.8)	18.8
44	**Unit Capability Factor (%)**	73.4	(2.8)	70.6
45	**PO Days**	498.9	63.9	562.8
46	**FEPO Days**	0.0	0.0	0.0
47	**FLR (%)**	5.0	(0.0)	5.0
48	**FLR Days Equivalent**	84.9	(3.5)	81.4
	Totals			
49	**Unit Capability Factor (%)**	76.2	2.8	79.0
50	**PO Days**[3]	687.1	(68.1)	619.0
51	**FEPO Days**	0.0	0.0	0.0
52	**FLR (%)**	4.6	(0.6)	4.0
53	**FLR Days Equivalent**	122.9	(16.6)	106.3
54	**Total TWh**	37.4	(2.0)	35.4

Notes:

1 OEB Approved nuclear production in 2014 is 49.0 TWh per EB-2013-0321 Decision with Reasons p. 39.

2 OEB Approved nuclear production in 2015 is 46.6 TWh per EB-2013-0321 Decision with Reasons p. 39.

3 PO days excludes planned outage days for Darlington units out of service during Darlington refurbishment.