COMPARISON OF PRODUCTION FORECASTS
NUCLEAR

1.0 PURPOSE

This evidence presents period-over-period comparisons of actual and forecast nuclear production for 2016-2026, in support of the approval of OPG's nuclear production forecast for the IR term.

2.0 OVERVIEW

Variances between actual and forecast production in any year and period-over-period variances are typically the result of OPG experiencing more or fewer of: Darlington refurbishment ("DRP") days, planned outage ("PO") days,[1] forced outages ("FO"), planned or forced derates, forced extensions to planned outages ("FEPO") 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, Tables 1a and 1b, and are explained below.

3.0 PERIOD-OVER-PERIOD CHANGES – IR Term

2022 Plan versus 2021 Budget

The 2022 planned nuclear production of 33.2 TWh is 5.1 TWh lower than the 2021 Budget production of 38.3 TWh. The lower production for 2022 relative to 2021 is primarily due to a combination of the following:

- Lower production due to 320.0 additional refurbishment days at Darlington.

[1] Planned outage days excludes a) outage days for Darlington units out of service during refurbishment, and b) outage equivalent planned derate days.

- The increase in refurbishment days is the result of the overlapping refurbishments of Unit 1 and Unit 3 for most of 2022, whereas only Unit 3 is in refurbishment for all of 2021.

- Higher production due to 155.2 fewer PO days at Darlington, partially offset by 129.3 additional PO days at Pickering in 2022.
  - The fewer PO days at Darlington in 2022 are the result of there being no regular planned outages and one post-refurbishment planned outage at Darlington (43.0 days) as two units are being refurbished, compared with two regular planned outages and one post refurbishment outage in 2021 (228.2 days). OPG had to add a regular planned outage in 2021 to support Unit 4 operation until its start of refurbishment and to move a Unit 1 regular planned outage from 2020 to 2021, as a result of the deferred DRP schedule (Ex. E2-1-1).
  - The majority of additional Pickering PO days in 2022 are due to the Vacuum Building Outage ("VBO") in the fall of 2022 (one unit in planned outage and remaining five units scheduled for VBO inspections of 30 PO days each).
- Higher production due to 23.2 fewer Forced Loss Rate ("FLR") equivalent days (4.7 fewer FLR equivalent days at Pickering;[2] 18.4 fewer FLR equivalent days at Darlington)
  - The decrease in Darlington's FLR equivalent days is primarily due to a decline in Unit 2 FLR target as the unit enters its third year of operation post refurbishment.[3]

2023 Plan versus 2022 Plan

The 2023 planned nuclear production of 30.8 TWh is 2.4 TWh lower than the 2022 planned production of 33.2 TWh. The lower production for 2023 relative to 2022 is primarily due to a combination of the following:

- Lower production due to 153.0 additional refurbishment days at Darlington.
  - The additional refurbishment days are the result of refurbishing two units (Unit 3 and Unit 1) at the same time for all of 2023, along with a 3.5 month period where three units

[2] While the target FLR at Pickering remains consistent over the IR term at 3.5%, the number of FLR equivalent days depends on the number of operating days.

[3] The forecast FLR for Darlington units post refurbishment is 12% for the first year after they return to service, 6.0% for the second year, 2.0% for the third year, and returning to 1.0% thereafter.

are being refurbished (Unit 4 is scheduled to start refurbishment in September 2023). This is in comparison to refurbishing two units for most of 2022.

- Higher production due to 116.1 fewer PO days at Pickering, partially offset by 39.2 additional PO days at Darlington.
  - The fewer PO days at Pickering in 2023 compared to 2022 are primarily due to the VBO in 2022 (one unit in planned outage and remaining five units scheduled for VBO inspections of 30 PO days each), partially offset by Pickering undertaking three planned outages in 2023 compared to two planned outages in 2022.
  - The 39.2 additional PO days at Darlington occur because there is an 82.2 day regular planned outage at Darlington in 2023, compared to a 43.0 day post-refurbishment outage in 2022.
  - Higher production due to 4.3 fewer FLR equivalent days (8.5 fewer FLR equivalent days at Darlington partially offset by 4.2 additional FLR equivalent days at Pickering.)
    - The decrease in Darlington's FLR equivalent days is primarily due to a decline in Unit 2 FLR to 1.0% as the unit enters its fourth year of operation post refurbishment.

2024 Plan versus 2023 Plan

The 2024 planned nuclear production of 33.3 TWh is 2.5 TWh higher than the 2023 planned production of 30.8 TWh. The higher production for 2024 relative to the 2023 is primarily due to a combination of the following:

- Higher production due to 105.0 fewer refurbishment days at Darlington.
  - As discussed above, while both 2023 and 2024 have two units being refurbished in parallel for the entire year, in 2023 there is a 3.5 month period where a third unit is undergoing refurbishment.
- Higher production due to 100.9 fewer PO days at Pickering and 57.2 fewer PO days at Darlington.
  - At Pickering, there is one less planned outage in 2024 versus 2023.
  - Darlington has a post-refurbishment outage in 2024 (55.0 days), while there is a regular planned outage in 2023 (82.2 days).

- While there is an Equipment Aging PO at Darlington in 2023, there is no Equipment Aging PO in 2024 as all Darlington units are either undergoing refurbishment or will have returned to service after refurbishment.

- Lower production due to 35.8 additional FLR equivalent days (32.1 additional FLR equivalent days at Darlington and 3.7 additional FLR equivalent days at Pickering).
  - The additional FLR equivalent days at Darlington are primarily due to forecasting a higher FLR for Unit 3 in 2024 after it returns to service.

2025 Plan versus 2024 Plan

The 2025 planned nuclear production of 30.2 TWh is 3.2 TWh lower than the 2024 planned production of 33.3 TWh. The lower production for 2025 relative to 2024 is primarily due to a combination of the following:

- Lower production in 2025 due to the planned shutdown of Pickering Units 1 and 4 in 2024 (Unit 1 on September 30, 2024 and Unit 4 on December 31, 2024).
- Higher production due to 261.0 fewer refurbishment days at Darlington.
  - Only Darlington Unit 4 will be undergoing refurbishment for the entire year, as Unit 1 is scheduled to return to service in April. This will mark the first time in more than three years where only one unit is being refurbished.
- Lower production due to 213.0 additional PO days at Darlington, partially offset by 235.2 fewer PO days at Pickering.
  - The 213.0 additional PO days at Darlington are primarily due to a 182.0 day turbine generator controls upgrade planned outage for Unit 2 in 2025 (Ex. E2-1-1).[4]
  - There are no regular planned outages for Pickering Units 5-8 in their final year of operation.
- Higher production due to 9.2 fewer FLR equivalent days, with 17.5 fewer days at Pickering due to two units not operating and 8.2 more days at Darlington due to a higher forecast FLR as Unit 1 returns to service.

[4] This planned outage has a total duration of 190.1 days of which 182.0 days are in 2025 and the remaining 8.1 days are in January 2026.

2026 Plan versus 2025 Plan

The 2026 planned nuclear production of 21.5 TWh is 8.7 TWh lower than the 2025 planned production of 30.2 TWh. The lower production for 2026 relative to the 2025 is primarily due to a combination of the following:

- Lower production due to the planned shutdown of Pickering Units 5-8 in 2025. As of January 1, 2026, no units at Pickering are planned to be producing power.
- Higher production in 2026 due to 184.0 fewer refurbishment days at Darlington. Darlington Unit 4, the last unit to undergo refurbishment, is scheduled to return to service in October 2026, after which all four units will be operational. During 2025, there are scheduled refurbishment days on Unit 1 (3.5 months) and Unit 4 (full year).
- Higher production due to 208.9 fewer PO days at Darlington.
    - There are no regular Darlington planned outages in 2026, compared to 181 days for the turbine generator controls upgrade planned outage in 2025.[5]

4.0 PERIOD-OVER-PERIOD CHANGES – BRIDGE YEAR

2021 Budget versus 2021 OEB Approved

The 2021 planned nuclear production budget of 38.3 TWh is 2.9 TWh higher than the 2021 OEB approved production of 35.4 TWh. The higher production for 2021 is primarily due to a combination of the following:

- Higher production due to 200.0 less refurbishment days at Darlington.
    - The OEB Approved production forecast assumed a six month period when two units would be refurbished in parallel. Following revisions to the DRP schedule, this overlap will not begin until February 2022, when Unit 1 begins its refurbishment. (Ex. D2-2-5)
- Lower production due to 177.0 more PO days at Darlington, partially offset by 204.9 fewer days at Pickering.
    - The Pickering VBO was moved to 2022 after CNSC approval, accounting for 120.0 fewer PO days at Pickering (Ex. E2-1-1).[6]

[5] There are 9.0 planned outage days in 2026 at Darlington to complete the turbine generator controls planned outage.

[6] As noted in Ex. E2-1-1, OPG expects to seek the CNSC's approval for use of innovative technology to perform vacuum building inspection work in a more efficient manner that may reduce the planned VBO's duration in 2022.

- The number of planned outages at Pickering has been reduced from three to two due to the transition from a 24 month to a 30 month outage cycle.
- At Darlington, the OEB Approved forecast had a post-refurbishment outage and a Primary Heat Transport ("PHT") pump motor replacement mini outage, and no regular planned outages. In comparison, the 2021 Budget has two regular planned outages (total 183.8 days), plus a post-refurbishment outage. As a result of the deferred DRP schedule, OPG had to move a Unit 1 regular planned outage from 2020 to 2021 and also add a regular planned outage in 2021 to support Unit 4 operation until its start of refurbishment.

- Higher production due to 17.8 fewer FLR equivalent days at Pickering due to a change in the FLR target to 3.5% compared to 5.0% in the 2021 OEB Approved forecast.

2021 Budget versus 2020 Budget

The 2021 planned nuclear production of 38.3 TWh is 3.7 TWh lower than the 2020 production budget of 42.0 TWh. The lower production for 2021 relative to 2020 is primarily due to a combination of the following:

- Lower production due to 66.7 more refurbishment days at Darlington.
  - Unit 3 will be refurbished for all of 2021, whereas the 2020 Budget reflects an approximate two month gap between the refurbishments of Unit 2 and Unit 3.[7]
- Lower production due to 195.2 more PO days at Darlington, partially offset by 99.6 fewer PO days at Pickering.
  - At Darlington, there are two regular planned outages in 2021 (93.5 days and 90.3 days) and one post-refurbishment outage (44.4 days), versus no regular planned outages in 2020 and a 33-day Single Fuel Channel Replacement ("SFCR") outage in advance of the Unit 3 refurbishment. As noted above, the two regular planned outages in 2021 result from the deferred DRP schedule.
  - At Pickering, there are two regular planned outages in 2021 versus three in 2020.

OPG will update the application for any resulting material changes during the course of the proceeding. Without regulatory approval from the CNSC, OPG must plan for and execute the 2022 VBO.

[7] The 2020 Budget reflects the revised high confidence return to service date for Unit 2 of June 25, 2020 reforecast in August 2019 (Ex. D2-2-2) and incorporated into the 2020-2026 Business Plan.

2020 Budget versus 2020 OEB Approved

The 2020 nuclear production budget of 42.0 TWh is 4.7 TWh higher than the 2020 OEB Approved production of 37.4 TWh. The higher production is primarily due to a combination of the following:

- Higher production due to 67.7 fewer refurbishment days at Darlington.
  - The 2020 Budget has a two month gap between the return to service of Unit 2 and the start of the refurbishment of Unit 3 as a result of revisions to the DRP schedule in response to COVID-19. In the 2020 OEB Approved, there was no planned gap between these refurbishments.
- Higher production due to 41.4 fewer PO days at Pickering and 150.2 fewer PO days at Darlington.
  - At Pickering, both the 2020 Budget and the 2020 OEB Approved include three regular planned outages. However, the combined duration of the three planned outages in the 2020 Budget declined relative to the durations assumed in the 2020 OEB Approved due to changes in outage scope (the 2020 OEB Approved assumed outages on Units 4, 7 and 8, while the 2020 Budget assumes outage on Units 1, 4 and 6; as noted in F2-4-1, outage scope will vary by unit). In addition, the mid-cycle outage included in the 2020 OEB Approved is not required (see Ex. E2-1-1).
  - At Darlington, the PHT pump motor replacement mini outage included in the 2020 OEB Approved has been cancelled, as the work was completed earlier in the period (see Ex. E2-1-1). Additionally, the later return to service date for Unit 2 (June 2020 versus February 2020) results in the first Unit 2 post-refurbishment outage moving from 2020, as was assumed in the 2020 OEB Approved, to 2021. As discussed above, the deferred DRP schedule also required that OPG move a Unit 1 regular planned outage from 2020 to 2021. This is partly offset by the SFCR outage that was added in advance of the Unit 3 refurbishment.[8]
- Higher production due to 31.5 fewer FLR equivalent days (24.6 fewer FLR equivalent days at Pickering; 6.9 fewer FLR equivalent days at Darlington). The 24.6 fewer FLR equivalent

[8] In EB-2016-0152, this work was intended to be included as part of the Unit 1 regular planned outage in spring 2020. The subsequent delay to the Unit 1 outage to fall 2020 (before being moved to 2021 in connection with the deferred DRP schedule) created the need for a separate 33 day SFCR outage earlier in the year.

days at Pickering is due to a change in the FLR target to 3.5% compared to 5.0% in the 2020 OEB Approved. The 6.9 fewer FLR equivalent days at Darlington is due to the higher Unit 2 post-refurbishment FLR assumption being applied to fewer operating days as the planned return to service date for Unit 2 is later than in the 2020 OEB Approved.

2020 Budget versus 2019 Actual

The 2020 nuclear production budget of 42.0 TWh is 1.4 TWh lower than the 2019 actual production of 43.5 TWh. The lower production for 2020 relative to the 2019 actual production is primarily due to a combination of the following:

- Higher production due to 66.7 fewer refurbishment days at Darlington.
  - There is a two month gap in 2020 between Unit 2 return to service and the start of Unit 3 refurbishment, whereas in 2019 Unit 2 was undergoing refurbishment for the entire year.
- Lower production due to 224.2 more PO days at Pickering, offset by 51.9 fewer PO days at Darlington, and a 40.1 day planned derate at Darlington.
  - There are three regular planned outages at Pickering in 2020, versus two in 2019.
  - There are no regular planned outages at Darlington in 2020, versus one in 2019. The only planned outage for 2020 is the 33 day SFCR outage in advance of Darlington Unit 3 refurbishment.
  - Planned derates for bulkhead removal and installation due to Unit 2 refurbishment lead-out and Unit 3 lead-in account for 40.1 days less generation in 2020. These derates were not required in 2019 as no units were transitioning into or out of refurbishment.
- Lower production due to 12.0 additional FLR equivalent days (29.1 additional days at Pickering and 17.1 fewer days at Darlington). The 2020 Budget reflects a 3.5% FLR target at Pickering, whereas the 2019 Actual FLR was 1.6%. At Darlington, the 2020 Budget assumes a 2.9% FLR taking into account the return to service of Unit 2, whereas the 2019 Actual FLR was 4.8%, as described below.

5.0 PERIOD-OVER-PERIOD CHANGES – Historical Years

2019 Actual versus 2019 OEB Approved

The 2019 nuclear production of 43.5 TWh is 4.5 TWh higher than the 2019 OEB Approved production of 39.0 TWh. The higher actual production in 2019 is primarily due to a combination of the following:

- Higher production due to 283.9 fewer PO days at Pickering and 34.2 fewer PO days at Darlington.
  - At Pickering, the transition from a 24 month to a 30 month outage cycle resulted in two regular planned outages being executed in 2019, compared to three such outages in the OEB Approved plan. A mid-cycle outage was also cancelled. In addition, more efficient outage execution resulted in the planned outages being completed ahead of schedule.[9]
  - At Darlington, the 2019 regular planned outage was completed ahead of schedule. Additionally, as discussed in Ex. E2-1-1, OPG was able to replace two PHT pump motors during the planned outage. As such, the planned mini-outages to replace two PHT pump motors as set out in the OEB Approved forecast were not required.

- Higher production due to 13.9 fewer FLR equivalent days (52.5 fewer FLR equivalent days at Pickering partially offset by 38.6 additional FLR equivalent days at Darlington). Pickering's actual 2019 FLR was 1.6% versus 2019 OEB Approved of 5.0%. Darlington FLR was 4.8% versus 2019 OEB Approved of 1.0%. The 2019 actual FLR at Darlington includes the following forced outages:
  - On Unit 3, to repair a heat transport system leak (19.2 days); and
  - On Unit 4, to repair a process leak on the turbine side (19.7 days).

[9] See Ex. E2-1-1 and Ex. F2-1-1, Attachment 1, Outage Improvement Initiative, for discussion on various efficiency initiatives focused on improvements to the outage planning process, tooling, scope of work, and training.

2019 Actual versus 2018 Actual

The 2019 nuclear production of 43.5 TWh is 2.7 TWh higher than the 2018 actual production of 40.9 TWh. The higher production for 2019 relative to the 2018 production is primarily due to a combination of the following:

- Higher production due to 115.8 fewer PO days at Pickering and 22.4 fewer PO days at Darlington.
  - At Pickering, there was one less regular planned outage executed in 2019 versus 2018, partially offset by an unbudgeted planned outage in March 2019 to replace a high pressure turbine rupture disc (7.9 days).
  - At Darlington, there was no PHT pump motor replacement mini outage in 2019 whereas there was a 24.6 day PHT pump motor replacement mini outage in 2018.
- Higher production due to 28.8 fewer FLR equivalent days in 2019 versus 2018 (66.1 fewer days at Pickering partially offset by 37.3 additional days at Darlington). The FLR at Pickering in 2019 was 1.6% versus 5.3% in 2018, offset by FLR at Darlington in 2019 of 4.8% versus 1.1% in 2018.

2018 Actual versus 2018 OEB Approved

The 2018 nuclear production of 40.9 TWh is 2.4 TWh higher than the 2018 OEB Approved production of 38.5 TWh. The higher production for 2018 relative to the 2018 OEB Approved production is primarily due to a combination of the following:

- Higher production due to 181.7 fewer PO days at Pickering and 36.0 fewer PO days at Darlington.
  - The fewer PO days at Pickering were attributed to:
    - a boiler scope reduction on the Unit 4 regular planned outage in 2018 based on further inspection and analysis;
    - outage optimization through the implementation of a 30-month outage cycle in 2018, which resulted in the deferral of a Unit 7 regular planned outage to 2019. This was partially offset by the deferral of a Unit 6 regular planned outage from 2017 into 2018. The duration and scope of this 2018 Unit 6 outage was reduced as the low level drain was replaced during ongoing maintenance activities;

        - improved efficiencies in outage execution, and
        - the cancellation of the Pickering mid-cycle outage in 2018.
    - The fewer PO days at Darlington were attributed to improved outage execution efficiencies on the single regular planned outage, as well as the execution of one 24.6 day mini outage for PHT pump replacement, rather than the original expectation of two such 20 day mini outages.
- Lower production due to 15.8 additional FLR equivalent days in 2018 Actual versus 2018 OEB Approved. There was a slight increase in FLR at Pickering (5.3% actual in 2018 relative to 5.0% in the 2018 OEB Approved) and Darlington (1.1% actual in 2018 relative to 1.0% in the 2018 OEB Approved).

2018 Actual versus 2017 Actual

There was no significant period-over-period change between the 2017 and 2018 nuclear production. The 2018 nuclear production of 40.9 TWh is consistent with the 2017 nuclear production of 40.7 TWh.

2017 Actual versus 2017 OEB Approved

The 2017 nuclear production of 40.7 TWh is 2.6 TWh higher than the 2017 OEB Approved production of 38.1 TWh. The higher production for 2017 relative to 2017 OEB Approved production is primarily due to a combination of the following:

- Higher production due to 217.1 fewer PO days at Pickering and 37.5 fewer PO days at Darlington.
    - The fewer PO days at Pickering were primarily due to the deferral of the regular planned Unit 6 outage to 2018 in order to address resource availability. A new planned Unit 4 outage was added in the spring of 2017 to address emergent Steam Generator issues identified in the prior Unit 4 2016 regular planned outage. This required a shift of the 2017 Unit 1 regular planned outage from the spring to the fall, and a shift of the 2017 Unit 6 regular planned outage to 2018. The cancellation of the mid-cycle outage was offset by an unbudgeted planned outage for Unit 8 to inspect and replace a high pressure turbine spindle.

- The fewer PO days at Darlington were primarily due to deferral of the two PHT pump motor replacement mini outages to 2018.

- Lower production due to 20.2 additional FLR equivalent days in 2017 Actual versus 2017 OEB Approved. Pickering's actual FLR of 5.2% was 0.2% above the OEB Approved FLR of 5.0%, and Darlington's actual FLR of 1.7% was 0.7% above the OEB Approved FLR of 1.0%.

2017 Actual versus 2016 Actual

The 2017 nuclear production of 40.7 TWh is 4.9 TWh lower than the 2016 production of 45.6 TWh. The lower production for 2017 relative to 2016 production is primarily due to a combination of the following:

- Lower production due to 287 additional refurbishment days at Darlington as Unit 2 refurbishment continued for all of 2017.
- Higher production due to 44.8 fewer PO days at Pickering, slightly offset by 0.8 more PO days at Darlington, and 81.9 fewer FEPO days.
  - The fewer PO days at Pickering were due to the 2017 Unit 6 regular planned outage deferral into 2018, along with a partial deferral into 2018 of the Unit 1 regular planned outage, as discussed above. In addition, improved outage execution resulted in fewer planned outage days and 81.9 fewer FEPO days compared to 2016. These factors were partially offset by a 40.6 day unbudgeted planned outage for Unit 8 to inspect and replace a high pressure turbine spindle.
  - At Darlington, there was an unbudgeted planned outage in November 2017 to replace ACU Vault Coils (10 days).

  Lower production due to 12.1 additional FLR equivalent days (25.6 additional FLR days at Pickering partially offset by 13.5 fewer FLR days at Darlington). Pickering's actual FLR was 5.2% in 2017 versus 4.1% in 2016, and Darlington's actual FLR was 1.7% in 2017 versus 2.3% in 2016.The 25.6 additional FLR days at Pickering are attributable to a single forced outage caused by the Unit 7 fueling machine becoming lodged in a tilted position.

2016 Actual versus 2016 Budget

The 2016 nuclear production of 45.6 TWh is 1.2 TWh lower than the 2016 budget production of 46.8 TWh. The lower production for 2016 relative to 2016 budget production is primarily due to a combination of the following:

- Lower production due to 93.5 FEPO days at Pickering. The majority of the FEPO days were due to the extension of the Unit 4 and Unit 8 regular planned outages as a result of resourcing issues associated with the two parallel outages, and the large amount of in-scope work.
- Higher production due to 32.3 fewer PO days at Pickering due to cancellation of a mid-cycle outage, and due to 0.9 fewer PO days at Darlington