BUSINESS PLANNING AND BENCHMARKING
NUCLEAR

1.0 PURPOSE

This evidence presents the business planning and benchmarking results for OPG's Nuclear Operations and provides a summary of nuclear operating costs from the 2020-2026 Business Plan in support of the application.

2.0 OVERVIEW

This application is based on OPG's 2020-2026 Business Plan, which was prepared reflecting the business planning process for the Nuclear Operations as outlined in Section 3.1 below. The methodology employed as part of that process is unchanged from the previous payment amounts application. This application reflects significant changes in OPG's Nuclear Operations, which pose unique challenges and opportunities in terms of business planning and benchmarking. Highlights of OPG's 2020-2026 Business Plan as it pertains to Nuclear Operations include the following:

- Ensuring the success of Pickering Optimized Shutdown of all six Pickering units, operating Unit 1 and Unit 4 to 2024 and Units 5-8 to 2025. Optimized shutdown will continue to provide Ontario with a clean and reliable source of baseload power while supporting summer capacity needs through to 2025. See Section 4.0 below.
- Ensuring an effective transition of OPG nuclear operations from a ten-unit fleet to four units at Darlington post-2025 in line with the corporate goal of mitigating the cost diseconomies of scale, where possible, while managing the risks and opportunities as part of the transition (Ex. F2-2-1).
- Executing site and fleet wide initiatives impacting people, processes and technology to drive station productivity, innovation and improve cost and operational performance over the IR term. See Section 3.4 below.
- Maintaining high standards of safety and environmental stewardship by targeting either best quartile performance or maximum Nuclear Performance Index ("NPI") points at both Pickering and Darlington relative to the company's Safety Cornerstone. See Section 3.3 below.

- Improving the identification and execution of project portfolio investments to enhance performance, reliability and overall value of the nuclear assets through a strengthened asset management program and Enterprise Project Management Office. (Ex. D2-1-1).
- Executing initial planning and preparation work in support of an investment decision for a proposed small modular reactor generating station at the Darlington site. This investment in clean and low-cost energy aligns with OPG's climate change goal of a net-zero carbon company by 2040 and will support Ontario's carbon reduction goals (Ex. F2-8-1).
- Investing in life cycle management and other sustaining infrastructure investments at Darlington, which will help to prepare the station for its second life and position Darlington towards the long-term goal of returning Darlington to top-quartile TGC post refurbishment. This will secure clean energy to supply over 20% of Ontario's electricity needs for the next 30-plus years (Ex. D2-1-3).

Achieving success on the business plan priorities will require building on the success of major programs undertaken within OPG over the past few years, which include; a) Unit 2 refurbishment completed and back in-service, b) safely extending the life of Pickering beyond its previously planned end of commercial operations date, c) the establishment of an Enterprise Project Management Office, which further enhanced the competency and process of managing and executing Nuclear Operations' capital and OM&A projects, and d) successful completion of various gap closure initiatives that have improved Nuclear operational and cost performance. These completed gap closure initiatives and their results are described in Attachment 1 to this exhibit.

A summary of actual and planned operating costs over the 2016-2026 period is presented in Ex. F2-1-1, Table 1.

OPG's 2020-2026 Business Plan reflects the implementation of an OPG-wide organizational realignment undertaken in the second half of 2020 with the goal of increasing cross-functional synergies and collaboration across the former Nuclear and Renewable Generation business units, which have been combined under an Enterprise Operations organization. The

realignment is realizing incremental operational efficiencies in management headcount in Nuclear Operations as it prepares for post-Pickering operations.

3.0 NUCLEAR BUSINESS PLANNING AND BENCHMARKING

3.1 Gap-Based Business Planning Process

The business planning cycle for OPG's Nuclear Operations is undertaken annually as part of the overall OPG business planning process (Ex. A2-2-1). This cycle is focused on establishing strategic and performance targets for the nuclear business, in alignment with OPG's corporate-wide objectives, and identifying the initiatives and resources required to achieve these targets.

Since 2009, OPG Nuclear has used a gap-based business planning process which consists of the following steps:

- **Benchmarking:** Using industry accepted performance metrics to compare nuclear performance against industry peers in order to identify areas with the greatest potential for improvement.
- **Target Setting:** Implementing a "top-down" approach to set operational and financial performance targets consistent with continuous improvement and informed by benchmarking.
- **Closing the Gap:** Developing various fleet wide and site-specific initiatives to close the performance gaps between current and targeted results.
- **Developing the Business Plan:** Preparing input for the corporate business plan i.e., the development of cost, generation, staff and investment plans to achieve targeted results in support of the company's strategic imperatives.

Once the detailed business plan is developed and approved, OPG uses operational and financial measures to track its performance against target.

3.2 Gap-Based Business Planning – Benchmarking

The 2020 Nuclear Benchmarking Report shows OPG's benchmarking performance against industry peers based on 2019 data and uses various indicators aligned with the cornerstone values of Safety, Reliability, Value for Money and Human Performance (Attachment 2).

The 2020 Nuclear Benchmarking Report uses the same methodology and format as the previous nuclear benchmarking reports filed with the OEB based on a benchmarking initiative undertaken by OPG in 2009 with the assistance of the ScottMadden, Inc. ("ScottMadden"), a consulting firm. OPG has from time to time advised the OEB of updates to its benchmarking metrics that were required to reflect changes in industry reporting or other factors (e.g., amalgamation of Pickering A and Pickering B). The 2020 Nuclear Benchmarking Report includes four material updates relative to the 2015 Nuclear Benchmarking Report filed in EB-2016-0152:

- The Total Recordable Injury Frequency ("TRIF") (number of injuries per 200k hours worked) is a new industry standard metric from the Canadian Electrical Association replacing the previous industry standard, the All Injury Rate ("AIR"). This measure is more widely accepted and utilized by other industries outside the electricity sector. In addition to all injuries calculated under AIR, TRIF includes restricted work injuries which improves the measure's utility as an assessment of safety performance.

- 1-year On-Line Deficient Critical Maintenance Backlogs and 1-year On-Line Corrective Critical Maintenance Backlogs are two new metrics that focus on the backlog of Critical Deficiencies, as opposed to Non-Critical Deficiencies. Critical Deficiencies have a more significant impact on reliability. OPG has added these two metrics to improve the benchmarking assessment of OPG's reliability performance. OPG continues to benchmark 1-Year On-Line Deficient Maintenance Backlogs and 1-Year Corrective Maintenance Backlogs, which reflect the sum of Critical and Non-Critical Deficiencies.

- OPG has included several normalization adjustments to the value for money metrics (Normalized 3-Year Total Generating Cost per MWh; Normalized 3-year Non-Fuel

Operating Costs per MWh; Normalized 3-Year Capital Cost per MW Design Electrical Rating ("DER")). These metrics normalize for refurbishment costs at Darlington as well as CANDU technology (including outage duration) and age-related impacts and are based on a recommended methodology from ScottMadden as described in Section 3.2.1 below.

- OPG has included 3-year Total Generation Cost per unit (M$ per Unit) and Normalized 3-Year Total Generating Cost per unit (M$ per unit). Deriving a value for money metric on a unitized basis allows OPG to benchmark its cost performance on a capacity basis.

In 2019, OPG engaged ScottMadden to conduct an independent review of Nuclear's 2019 Benchmarking Report and process to ensure continued accuracy of reporting and consistency with industry best practices. ScottMadden's assessment found that OPG's current benchmarking methods align with previous guidance and current leading practices in the industry. The evaluation found no material issues with benchmarking report calculations or presentations of data and the review noted that OPG's nuclear business planning processes remain consistent with established OPG governance and industry leading practice. ScottMadden's assessment is filed as Attachment 3. The methodology underpinning OPG's 2020 Benchmarking Report is the same as the 2019 Benchmarking Report that ScottMadden assessed.

3.2.1 Benchmarking – Supporting Studies

In EB-2016-0152, OPG provided a calculation to normalize Total Generating Cost per MWh ("TGC/MWh") for Darlington by adding back the lost generation to account for the reduced unit output during the Darlington Refurbishment Program ("DRP"). The denominator in TGC/MWh declines because units are being refurbished but there is no corresponding decline in the numerator, as corporate support allocated, station and nuclear (now Operations and Project) support costs are largely fixed. The net impact, without adjustment, is to temporarily skew these metrics higher than would otherwise be the case.

In the EB-2016-0152 Decision and Order (p. 49), the OEB agreed that OPG's benchmarking methodology was appropriate with the exception of OPG's provided methodology for normalizing TGC/MWh. The OEB noted that ScottMadden had suggested that there were

alternative approaches to account for the impact of refurbishment on TGC/MWh and indicated an expectation that OPG would file a review from ScottMadden regarding OPG's nuclear benchmarking methodologies.

In addition, OPG was aware of prior studies by ScottMadden that indicated there are various differences between CANDU reactors and Pressurized Water Reactors ("PWR") and Boiling Water Reactors ("BWR") as well as age-related differences that impact value for money performance comparisons with peers. OPG has consistently identified these factors in its Benchmarking Reports as contributing to the benchmarking gap, but was previously unable to quantify their impact.[1] While OPG's gap-based business planning process relies upon benchmarking to compare OPG's nuclear performance against industry leaders in order to identify areas with the greatest potential for improvement, OPG understands that there are limitations in assessing benchmarking results. The OEB has also recognized the limitations of benchmarking (EB-2016-0152, Decision and Order, p. 49).

Based on the OEB's expectations and in an effort to improve the usefulness of benchmarking results and address the benchmarking limitations described above, OPG engaged ScottMadden to undertake two independent studies to normalize OPG's value for money metrics to enable closer comparisons with peers. The two studies were:

a) OPG Nuclear Cost Performance Benchmarking – Methodology to Adjust for Refurbishment and Validation of Implementation (Attachment 4).

b) OPG Nuclear Cost Performance Benchmarking – A Study of Factors Impacting TGC/MWh Performance with Normalizing Adjustments to Facilitate Closer Comparison (Attachment 5).

In addition, in the EB-2016-0152 Decision and Order (p. 84), the OEB directed OPG to file a staffing benchmarking study following the Goodnight methodology. OPG engaged Goodnight Consulting Inc. ("Goodnight") to undertake this Nuclear Staffing Benchmarking Study (Attachment 6).

[1] EB-2016-0152, Ex. F2-1-1, Attachment 1, 2015 Benchmarking Report, p. 72.

Each of the three supporting studies referenced above are discussed in greater detail below.

3.2.1.1 OPG Nuclear Cost Performance Benchmarking - Methodology to Adjust for Refurbishment and Validation of Implementation

The purpose of ScottMadden's Methodology to Adjust for Refurbishment and Validation of Implementation study was to facilitate useful comparisons to past performance and industry peers for the operating plant at Darlington during the extended time periods in which certain units will be offline due to the DRP.

ScottMadden's views on adjusting TGC/MWh for DRP are summarized below:

- DRP is a unique "mega-program" and there is no established practice for normalizing cost metrics for this unique program.
- Normalization is necessary to facilitate benchmark comparisons to past performance and industry peers.
- OPG should continue to report unadjusted (i.e., not normalized) version of the cost metrics along with any normalized version.
- A more strongly supported and conventional approach to normalization of cost metrics is to adjust actual costs in the numerator while using unadjusted actual MWhs generated in the denominator.

ScottMadden examined various OPG cost items and OPG's corporate and nuclear support cost attributions in order to identify costs that should be adjusted to create a normalized TGC/MWh and Non-Fuel Operating Cost per MWh ("NFOC/MWh") while maintaining generation. ScottMadden's methodology indicated how each type of Darlington Station, Nuclear Support (now Operations and Project Support), allocated corporate support OM&A costs and sustaining capital expenditures could be removed for the purpose of normalizing TGC/MWh and its applicable sub-components for refurbishment. The study ultimately established a methodology to allow OPG to adjust the distribution of OM&A and capital costs while using actual generation to estimate what TGC/MWh and NFOC/MWh would be if Darlington was operating less than four units.

OPG independently applied ScottMadden's methodology to normalize TGC/MWh and its sub-components based on 2017 data. ScottMadden then reviewed OPG's work on the 2017 data (Attachment 3, Section 4) and validated that the approach OPG followed was in accordance with ScottMadden's guidance and that OPG accurately performed the calculations. ScottMadden found that OPG correctly interpreted and implemented the guidance provided.

OPG continued to apply ScottMadden's normalization methodology in deriving Darlington's Value for Money metrics in subsequent years. The 2019 results are shown in Chart 1 below.

3.2.1.2 OPG Nuclear Cost Performance Benchmarking – A Study of Factors Impacting TGC/MWh Performance with Normalizing Adjustments to Facilitate Closer Comparison

The objective of ScottMadden's Study of Factors Impacting TGC/MWh Performance with Normalizing Adjustments to Facilitate Closer Comparison was to determine whether and to what extent certain site characteristics of OPG's CANDU units influence TGC/MWh performance relative to industry peers and if possible, quantify and adjust these characteristics to produce normalized TGC/MWh values. ScottMadden's CANDU and age-related normalization methodology included:

- an econometric analysis of Electric Utility Cost Group ("EUCG") data; and
- a custom nuclear outage benchmarking study that sought to determine and normalize expected impacts on generation between CANDU and non-CANDU plants.

In its econometric analysis, ScottMadden analyzed nine years of EUCG data (from 2009 to 2017) for OPG and its industry peers to understand which site characteristics most influence TGC over a sustained period and to what extent. ScottMadden's analysis indicated that CANDU technology increases predicted TGC by over $250 million per year relative to non-CANDU plants and each month of average unit age increases predicted TGC by $346,000 per year. ScottMadden then adjusted the EUCG data to normalize for these factors.[2]

[2] In addition, the ScottMadden analysis found that site capacity was a driver of TGC variability. However, ScottMadden did not adjust for site capacity to be conservative and to ensure that adjustments were easy to understand as such an adjustment would also have required a complex adjustment to generation.

ScottMadden also undertook a custom nuclear outage benchmarking study, including a confidential direct survey of nuclear operators representing 47 nuclear plants. As explained more fully in Attachment 5, the custom nuclear outage benchmarking study methodology quantified and adjusted for the impact of regularly recurring, planned maintenance outages on power generation, taking steps to arrive at an average annual value for days offline due to these planned outages. ScottMadden's analysis found that CANDU plants exhibited 4 to 22 more outage days per year compared to BWR and PWR plants, depending on the outage cycle frequency. ScottMadden adjusted for these incremental outage days by adding them back to total production for each year.

Chart 1 below summarizes the application of normalization methodologies for refurbishment (described in Section 3.2.1.1), and CANDU and age-related factors (described in Section 3.2.1.2), to the main 2019 Value for Money metrics. OPG does not apply CANDU and age-related normalization, consistent with ScottMadden's methodology, to the sub-components of TGC/MWh (i.e., Non-fuel Operating Cost per MWh or Capital Cost per MW DER). OPG accepts ScottMadden's normalization methodologies as described above as this achieves a closer comparison of OPG's TGC/MWh performance to peers.

Chart 1: Summary of Normalization Methodology Adjustments to Value for Money Metrics (2019)

Indicator	Non-Normalized	Refurbishment Normalization	CANDU and age-related Normalization	Combined Normalization
3-year Total Generation Cost per MWh	PN: $62.39 DN: $67.00	PN: N/A DN: $54.18	PN: $44.85 DN: $50.99	PN: $44.85 DN:$38.84
3- year Total Generating Cost per Unit	PN: $228.27 DN: $442.14	PN: N/A DN: $357.53	PN: $176.31 DN: $355.07	PN: $176.31 DN: $270.46
3- Year Non-Fuel Operating Cost per MWh	PN: $53.85 DN: $47.10	PN: N/A DN: $37.85	N/A	N/A
3-year Capital Cost per MW DER	PN: $30.66 DN: $116.67	PN: N/A DN: $89.78	N/A	N/A

3.2.1.3 Nuclear Staffing Benchmarking Study

At the direction of the OEB,[3] a Nuclear Staffing Benchmarking Study was undertaken by Goodnight and is included as Attachment 6.

The main conclusions of the 2019 Goodnight Nuclear Staffing Study are as follows:

- Goodnight compared OPG Nuclear staffing levels to other North American nuclear operators using an approach consistent with the methodology Goodnight used to evaluate OPG in 2011, 2013 and 2014.
- The analysis showed that OPG, as of August 2019, is 239 Full-Time Equivalents ("FTEs") (4.5%) below the total North America nuclear operator benchmark of 5,255 FTEs.
- 5,016 OPG Nuclear staff and long-term contractors were benchmarked; 2,404 OPG Nuclear personnel were excluded from benchmarking consistent with the methodology applied in prior studies.
- OPG is above benchmark staffing in 14 job functions, and below benchmark staffing in 28 functions.

OPG staffing levels have shown significant improvement by closing the gap identified initially by Goodnight in 2011[4] and then continuing to improve even after the gap was eliminated in 2016.[5] The latest study completed by Goodnight in 2019 confirms that actions taken by OPG have been effective in achieving favourable performance compared to benchmarked nuclear operators.

3.2.2 Benchmarking Results

Chart 2 is a reproduction of Table 1 from OPG's 2020 Nuclear Benchmarking Report (Attachment 1), and provides a summary of OPG's 2019 plant-level performance for each of the key performance indicators benchmarked.

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[3] EB-2016-0152, Decision and Order, p. 84.
[4] EB-2013-0321, Ex. F5-1-1, Part a.
[5] In 2011, Goodnight indicated that OPG Nuclear was 17% above its industry peers, with a later update by Goodnight demonstrating that OPG Nuclear had narrowed the gap to 7.6% per EB-2013-0321, Ex. JT1.13). The Goodnight Nuclear Staffing Benchmarking Analysis published in December 2014 (EB-2016-0152, Ex. F2-1-1 Attachment 2), showed that staff reductions had further narrowed the gap to 4.1%, and as stated in EB-2016-0152, Ex. F2-1-1, OPG had eliminated the gap in 2016.

Chart 2

Comparison of OPG Nuclear Performance to Industry Benchmarks

Metric	NPI Max	2019 Actuals			
		Best Quartile	Median	Pickering	Darlington
Safety					
Total Recordable Injury Frequency (#/200k hours worked) [3]		0.81	N/A	0.11	0.00
Rolling Average[2] Industrial Safety Accident Rate (#/200k hours worked)[1]	0.20	0.00	0.01	0.02	0.04
Rolling Average[2] Collective Radiation Exposure (Person-rem per unit)[1]	80.00	38.54	70.32	70.32	83.23
Airborne Tritium Emissions (Curies) per Unit [3]		982	2,772	2,517	1,213
Fuel Reliability (microcuries per gram)[1]	0.000500	0.000001	0.000007	0.000187	0.000295
2-Year Reactor Trip Rate (# per 7,000 hours)[1]	0.50	0.00	0.00	0.24	0.00
3-Year Auxiliary Feedwater System Unavailability (#)[1]	0.0200	0.0000	0.0000	0.0039	0.0000
3-Year Emergency AC Power Unavailability (#)[1]	0.0250	0.0008	0.0016	0.0003	0.0026
3-Year High Pressure Safety Injection Unavailability (#)[1]	0.0200	0.000000	0.000000	0.00013	0.00000
Reliability					
Rolling Average[2] WANO NPI (Index)[1]		92.68	87.64	82.50	88.90
Rolling Average[2] Forced Loss Rate (%)[1]	1.00	1.08	2.43	3.39	2.56
Rolling Average[2] Unit Capability Factor (%)[1]	92.00	87.06	86.14	83.31	87.06
Rolling Average[2] Chemistry Performance Indicator (Index)[1]	1.01	1.00	1.00	1.02	1.03
1-Year Online Deficient Maintenance Backlog (work orders per unit)[1]		30	39	114	110
1-Year Online Deficient Critical Backlog (work orders per unit) [1]		0	0	5	3
1-Year Online Corrective Maintenance Backlog (work orders per unit) [1]		2	3	9	4
1-Year Online Corrective Critical Backlog (work orders per unit) [1]		0	0	1	0
Value for Money[4]					
3-Year Total Generating Costs per MWh ($ per Net MWh)[1]		34.63	41.85	62.39	67.00
Normalized 3-Year Total Generating Cost per MWh ($ per Net MWh)[1]		30.83	36.12	44.85	38.84
3-Year Total Generating Cost per Unit (M $ per Unit)[1]		275.21	310.29	228.27	442.14
Normalized 3-Year Total Generating Cost per Unit (M $ per Unit)[1]		239.49	290.39	176.31	270.46
3-Year Non-Fuel Operating Costs per MWh ($ per Net MWh)[1]		20.84	24.65	53.85	47.10
3-Year Normalized Non-Fuel Operating Cost per Net MWh ($/MWh)[1]		20.84	24.65	--	37.85
3-Year Fuel Costs per MWh ($ per Net MWh)[1]		7.03	7.69	4.22	4.38
3-Year Capital Costs per MW DER (k$ per MW)[1]		38.82	53.64	30.66	116.67
Normalized 3-Year Capital Cost per MW DER (k$ per MW)[1]		38.82	53.64	--	89.78
Human Performance					
18-Month Human Performance Error Rate (# per 200k ISAR and contractor hours)[1]		0.0000	0.0530	0.0200	0.0360

1. Best Quartile, Median and Third Quartile are from Q4 2019 best available information.
2. Indicates a 2-Year Rolling Average for Pickering and a 3-Year Rolling Average for Darlington.
3. Best Quartile, Median, Third Quartile are from the Q4 2018, which is the most current available benchmark for these metrics.

Legend

4th Quartile Performance	3rd Quartile Performance	2nd Quartile Performance	Maximum NPI points achieved or Best Quartile

Detailed discussion of the 2019 performance trends and drivers by cornerstone is provided in the OPG 2020 Nuclear Benchmarking Report (Attachment 1), and is summarized as follows:

- **Safety**

  Overall, OPG's nuclear generating stations continue to demonstrate strong safety performance. Darlington and Pickering continued to demonstrate first quartile performance in Total Recordable Injury Frequency ("TRIF"), with OPG achieving its lowest TRIF in the history of the company in 2019. OPG was the top TRIF performer in 2019 compared to its peer group.

  Darlington achieved maximum NPI results or best quartile performance for six of seven NPI safety sub-metrics, while Pickering achieved similar results on seven of seven safety sub-metrics.

  The Collective Radiation Exposure improved for Pickering resulting in maximum NPI points, and improved for Darlington while remaining in the third quartile. Positive gains were seen from site innovations such as leveraging technology to avert dose using robotic equipment and remote monitoring of systems, and the early completion of planned outages.

  The Airborne Tritium Emissions remained in the second quartile for Darlington while Pickering has improved from third to second quartile due to emission reduction initiatives that included dedicated teams to ensure daily emissions monitoring, sustaining and improving dryer performance, heavy water leak minimization, tritium program development and innovations.

  Pickering's Fuel Reliability Index ("FRI") improved in 2019 achieving maximum NPI points due to improved methods to reduce fuel bundle defects as well as elimination of the possibility of foreign materials entrance into the Heat Transport System due to Fuel Handling and Outage practices. Darlington's FRI performance continued to achieve maximum NPI points.

- **Reliability**

  Several key reliability indicators at both stations noted sustained or improved quartile performance in 2019.

  Significant improvements were recorded for On-line Deficient Maintenance Backlogs, and On-line Corrective Maintenance Backlogs for both stations relative to 2018. Pickering's On-line Deficient Maintenance Backlogs registered a 59% reduction compared to the previous year, while Darlington improved by 11%. In addition Pickering achieved a 47% improvement in On-line Corrective Maintenance Backlogs.

  Darlington's unit capability factor ("UCF") improved to first quartile while its NPI ranking remained in the second quartile relative to 2018 and its forced loss rate ("FLR") remained consistent at third quartile. Pickering improved to the third quartile and achieved its best ever NPI value as a combined six-unit station. Pickering's FLR and UCF also improved with the station achieving its best ever performance for those metrics as a combined six-unit station. While Pickering's FLR remains above the median quartile, it has shown considerable improvement year-over-year, from double digit values in 2014 to single digits currently.

  Darlington's Chemistry Performance Indicator experienced some challenges in 2018 due to Unit 3 condenser tube leaks which caused an increase in boiler conductivity and feedwater iron levels during start-ups following the unit outages. As Chemistry Performance Indicator is a 3-year rolling average, the event from 2018 continued to impact 2019 performance. A number of initiatives are being implemented to further improve performance. Pickering improved from fourth quartile to third and has shown an improving trend since 2014.

- **Value for Money**

  Darlington's TGC per MWh performance was in third quartile in 2019 after normalizing for refurbishment costs, CANDU technology and age-related factors (as described in Section 3.2.1.1 and Section 3.2.1.2). Darlington's TGC/MWh performance (non-normalized) was in the fourth quartile. These non-normalized results were driven largely by significant capital

expenditures, which are necessary for reliable post-refurbishment operation, and, reduced generation during the DRP. Darlington achieved top quartile performance in Fuel Cost per MWh.

Pickering's normalized TGC per MWh improved in 2019 by $4.44/MWh and was in fourth quartile (normalized and non-normalized). Pickering's performance was partly impacted by requirements for Pickering Extended Operations. Pickering units are the smallest in the peer group with a capacity of 540 MW per unit compared to the peer group average of 1,026 MW. Improved performance in 2019 reflects higher generation and associated OM&A cost reduction due to fewer outage days as well as decreased capital investment and improved Fuel Costs/MWh. Pickering maintained best quartile performance in Fuel Cost per MWh and Capital Cost per MW DER.

Pickering's TGC per generating unit continued to demonstrate strong performance, placing among the best in the peer group in the first quartile, while Darlington's normalized TGC per generating unit was second quartile.

- **Human Performance**

  OPG Nuclear's human performance strategy focuses on and reinforces the correct behaviors during all phases of station operations and maintenance. Darlington improved its Human Performance Error Rate ("HPER") in 2019 as compared to 2018 and remained in second quartile. Pickering improved to second quartile in 2019 from fourth quartile in 2018. OPG is targeting building industry-leading Human Performance practices through a Mobile Observation and Coaching Application analysis tool for early detection of signs of decline in Human performance, and specialized training with the use of a simulator to teach Human Performance concepts and behaviours.

OPG has made improvements in many areas and continues to identify and implement opportunities for further improvement as discussed in Section 3.4 below

3.3 Gap-Based Business Planning – Target Setting

Top-down targets are designed to demonstrate continuous improvement and drive OPG Nuclear Operations closer to top quartile industry performance. Targets are set for each year of the business plan and are measured annually to assess performance for the given year.

2022-2026 Targets

OPG's Chief Nuclear Officer ("CNO"), in consultation with OPG's Nuclear leadership team, provided direction on top-down performance targets for each nuclear station for the 2020-2026 business planning period, based on the applicable corporate targets. The top-down targets for this business plan recognize the following drivers of operating costs and generation, including:

a) Lost generation due to the refurbishment of four units at Darlington.
b) The need for capital expenditures within the Nuclear Operations' project portfolio to position Darlington for strong performance post refurbishment (as discussed at Ex. D2-1-2).
c) Pickering investments that are being optimized and planned outages are being undertaken to ensure it safely runs to planned shutdown in 2024 for Pickering Units 1 and 4 and to end of 2025 for Pickering Units 5-8.
d) In alignment with OPG-wide initiatives, the need to implement wide scale cost efficiencies to achieve the base operating cost reductions set out in the Business Plan. These cost reductions will mitigate, to a significant extent, the diseconomies of scale that will result within OPG as a result of the planned Pickering shutdown. (Ex. A2-2-1). Initiatives in support of these demanding targets are being developed in such areas as: optimization of maintenance work programs, resource optimization leveraging attrition, streamlining processes, and maximizing viable technology innovations, including increased use of artificial intelligence. OPG's specific nuclear fleet-wide initiatives are described below in Section 3.4.

The top-down approach that established the operational and financial targets was also informed by historical performance, targets set in prior years and the latest benchmarking results. Charts 3 (Pickering) and Chart 4 (Darlington) set out OPG's nuclear operational and financial targets for 27 benchmark performance indicators for the 2020-2026 period. OPG views these targets as challenging but achievable.

Chart 3

Annual Operational and Financial Targets for Pickering

Benchmarking Indicators	WANO Max NPI	Best Quartile [1]	Median Quartile [1]		Pickering – Annual Targets					
					2020	2021	2022	2023	2024	2025
Safety										
Total Recordable Injury Frequency(#/200k hours worked)		0.81	N/A		0.20	0.13	0.1	0.09	0.09	0.08
Industrial Safety Accident Rate (#/200k hours worked)	0.20	0.00	0.01		0.10	0.10	0.10	0.10	0.10	0.10
Collective Radiation Exposure (person-rem per unit)	80.00	38.54	70.32		121.7	94.5	101	99.5	72.7	19.5
Airborne Tritium Emissions (Curies) per Unit		982	2,772		2,333	2,250	2,200	2,200	2,070	2,000
Fuel Reliability (microcuries per gram)	0.000500	0.000001	0.000007		0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Reactor Trip Rate (# per 7,000 hours)	0.50	0.00	0.00		0.5	0.5	0.5	0.5	0.5	0.5
Auxiliary Feedwater System Unavailability (#)	0.02	0.0000	0.0000		0.02	0.02	0.02	0.02	0.02	0.02
Emergency AC Power Unavailability (#)	0.025	0.0008	0.0016		0.025	0.025	0.025	0.025	0.025	0.025
High Pressure Safety Injection Unavailability (#)	0.02	0.00000	0.00000		0.02	0.02	0.02	0.02	0.02	0.02
Reliability										
WANO NPI (Index)		92.7	87.6		77.6	74.7	76.9	75.7	80.3	85.6
Forced Loss Rate (%)	1.00	1.08	2.43		3.5	3.5	3.5	3.5	3.5	3.5
Unit Capability Factor (%)	92.0	87.06	86.14		76.0	80.0	74.1	79.4	83.3	93.2
Chemistry Performance Indicator (Index)	1.01	1.00	1.00		1.02	1.01	1.03	1.01	1.01	1.00
On-line Deficient Mtce Backlog (work orders/unit)		30	39		115	57	52	46	39	39
On-line Deficient Critical Mtce Backlog (work orders/unit)		0	0		7	0	0	0	0	0
On-Line Corrective Mtce Backlog (work orders/unit)		2	3		10	2	2	2	2	2
On-Line Corrective Critical Mtce Backlog (work orders/unit)		0	0		0	0	0	0	0	0
Value for Money										
Normalized Total Generating Cost per MWh ($/Net MWh),**2		30.83	36.12		50.37	44.31	46.15	40.77	36.32	23.73
Total Generating Cost per MWh ($/Net MWh)**		34.63	41.85		70.57	63.24	67.06	60.10	55.42	46.62
Normalized Total Generating Cost per Unit (M$ per Unit)**2		239.49	290.39		183.79	170.04	164.64	155.26	139.41	70.15
Total Generating Cost per Unit (M$ per Unit)**2		275.21	310.29		238.30	225.46	220.97	212.52	197.61	129.31
Non-Fuel Operating Cost per MWh ($/Net MWh) **		20.84	24.65		63.02	56.24	60.78	54.60	50.03	40.87
Fuel Cost per MWh ($/Net MWh)		7.03	7.69		4.02	3.83	3.90	4.01	4.17	4.52
Capital Cost per MW DER (k$/MW) ***2		38.82	53.64		23.10	21.93	15.17	10.18	8.39	6.60
Human Performance										
Human Performance Error Rate (# per 200k ISAR hours)		0.0000	0.0530		0.06	0.066	0.066	0.04	0.04	0.04

** TGC/MWh and Non-Fuel Operating Cost per MWh exclude OPEB, Pension and Corporate Asset Service Fees to align with the industry standard.

*** Design Electrical Rating (DER)

Note 1: Best Quartile and Median Quartile for Value of Money metrics are based on 2019 year end

Note 2: Normalization methodologies are applied as described in section 3.2.1 and summarized in Chart 1

Note 3: Nuclear Performance Index (NPI) is a Composite index of ten WANO indicators related to safety and production performance. NPI is calculated using a 2 year rolling average for PN and a 3 year rolling average for DN.

Note 4: Value for money targets are indicative and will be updated for final cost allocations reflected in this application (Ex. A2-2-1, Attachment 1, p. 49).

Chart 4
Annual Operational and Financial Targets for Darlington

Benchmarking Indicators	WANO Max NPI	Best Quartile [1]	Median Quartile [1]		Darlington – Annual Targets						
					2020	2021	2022	2023	2024	2025	2026
Safety											
Total Recordable Injury Frequency(#/200k hours worked)		0.81	N/A		0.20	0.17	0.1	0.09	0.09	0.08	0.08
Industrial Safety Accident Rate (#/200k hours worked)	0.20	0.00	0.01		0.10	0.10	0.10	0.10	0.10	0.10	0.10
Collective Radiation Exposure (person-rem per unit)	80.00	38.54	70.32		30.63	126.2	21.1	73.9	40	78.2	31.8
Airborne Tritium Emissions (Curies) per Unit		982	2,772		970	970	970	970	970	970	970
Fuel Reliability (microcuries per gram)	0.000500	0.000001	0.000007		0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Reactor Trip Rate (# per 7,000 hours)	0.50	0.00	0.00		0.5	0.5	0.5	0.5	0.5	0.5	0.5
Auxiliary Feedwater System Unavailability (#)	0.02	0.0000	0.0000		0.02	0.02	0.02	0.02	0.02	0.02	0.02
Emergency AC Power Unavailability (#)	0.025	0.0008	0.0016		0.025	0.025	0.025	0.025	0.025	0.025	0.025
High Pressure Safety Injection Unavailability (#)	0.02	0.00000	0.00000		0.02	0.02	0.02	0.02	0.02	0.02	0.02
Reliability											
WANO NPI (Index)		92.7	87.6		93.7	84.3	93.1	77.54	86.9	84.75	85
Forced Loss Rate (%)	1.00	1.08	2.43		2.85	3.79	2.12	1.2	5.99	6.42	4.27
Unit Capability Factor (%)	92.0	87.06	86.14		91.06	76.0	85.8	78.1	81.8	68.2	89.4
Chemistry Performance Indicator (Index)	1.01	1.00	1.00		1.02	1.01	1.01	1.01	1.01	1.01	1.01
On-line Deficient Mtce Backlog (work orders/unit)		30	39		101	90	75	65	60	41	30
On-line Deficient Critical Mtce Backlog (work orders/unit)		0	0		2	0	0	0	0	0	0
On-Line Corrective Mtce Backlog (work orders/unit)		2	3		2	2	2	2	2	2	2
On-Line Corrective Critical Mtce Backlog (work orders/unit)		0	0		0	0	0	0	0	0	0
Value for Money											
Normalized Total Generating Cost per MWh ($/Net MWh),**2		30.83	36.12		39.05	58.74	47.45	62.71	44.81	60.27	40.65
Total Generating Cost per MWh ($/Net MWh)**		34.63	41.85		62.16	94.26	106.15	153.88	115.53	108.41	65.45
Normalized Total Generating Cost per Unit (M$ per Unit)**2		239.49	290.39		274.78	352.45	324.33	392.99	292.79	325.81	286.41
Total Generating Cost per Unit (M$ per Unit)**2		275.21	310.29		416.40	531.18	670.80	865.68	691.61	542.19	438.86
Normalized Non-Fuel Operating Cost per MWh ($/Net MWh) **2		20.84	24.65		34.52	55.45	47.55	71.30	52.71	63.75	41.64
Non-Fuel Operating Cost per MWh ($/Net MWh) **		20.84	24.65		40.51	66.14	69.92	109.07	80.29	79.60	48.61
Fuel Cost per MWh ($/Net MWh)		7.03	7.69		4.74	4.08	4.10	4.35	5.15	5.11	4.89
Normalized Capital Cost per MW DER (k$/MW) ***2		38.82	53.64		109.68	125.42	149.82	155.25	106.03	104.27	78.49
Capital Cost per MW DER (k$/MW) ***2		38.82	53.64		129.03	154.33	231.31	259.24	205.17	135.00	91.29
Human Performance											
Human Performance Error Rate (# per 200k ISAR hours)		0.0000	0.0530		0.033	0.039	0.039	0.019	0.019	0.019	0.019

** TGC/MWh and Non-Fuel Operating Cost per MWh exclude OPEB, Pension and Corporate Asset Service Fees to align with the industry standard.
*** Design Electrical Rating (DER)
Note 1: Best Quartile and Median Quartile for Value of Money metrics are based on 2019 year end
Note 2: Normalization methodologies are applied as described in section 3.2.1 and summarized in Chart 1
Note 3: Nuclear Performance Index (NPI) is a Composite index of ten WANO indicators related to safety and production performance. NPI is calculated using a 2 year rolling average for PN and a 3 year rolling average for DN.
Note 4: Value for money targets are indicative and will be updated for final cost allocations reflected in this application (Ex. A2-2-1, Attachment 1, p. 49).

The following summarizes the rationale for the targets set for each of the four cornerstones for the period 2020-2026, specifically:

- **Safety Cornerstone:** For the safety cornerstone, OPG is targeting either best quartile performance or maximum NPI points at both stations, except for Collective Radiation Exposure and Airborne Tritium at Pickering, where the focus will be on improvement, while recognizing that both metrics are significantly impacted by the number of planned outage days.

- **Reliability Cornerstone:** For the reliability cornerstone, OPG is targeting a FLR of 3.5% at Pickering across 2020-2026, based on past improvements and expected sustained equipment reliability, which compares favourably to an average FLR of 8.5% over the period 2010-2015, an average of 4.0% over the period 2016-2019 and the target of 5.0% in EB-2016-0152 (Ex. E2-1-1, Section 3.3). Pickering's UCF is targeted to improve from 2022 onwards. Darlington's UCF and FLR fluctuate over the IR term due to the expected increase in FLR after each unit is returned to service post-refurbishment. Based on industry operating experience, post-refurbishment FLR is assumed to be 12% in year one following return to service, 6% in year two and 2% in year three, before return to the top-quartile target of 1%. Prior to refurbishment, OPG continues to target 1% FLR at each Darlington unit in order to drive continuous improvement. Online Deficient and Corrective Maintenance backlogs will remain a focus for continued improvements at both Pickering and Darlington. The online corrective critical and deficient critical maintenance backlog metrics are expected to be in the top quartile throughout 2020-2026.

- **Value for money:** As Pickering progresses toward the planned shutdown, the station is expected to improve significantly to first quartile normalized TGC per MWh performance by 2025, reflecting improved reliability and reduced capital investment requirements. By 2025, Pickering's normalized TGC per MWh measure is planned to have improved by over $15/MWh compared to 2019 results. For Darlington, the TGC per MWh over the period 2020-2026 is expected to be temporarily affected by the increased capital spending supporting continued preparation for Darlington second life operations and reduced generation. By 2026, Darlington is expected to achieve second quartile normalized TGC/MWh performance, reflecting the cost

targets set in the 2020-2026 Business Plan for mitigating the reallocation of shared costs to Darlington and other operations following the Pickering shutdown. With the achievement of these cost targets, the 2026 goal for normalized TGC/MWh performance is expected to be a stepping stone toward further improvement in the station's value for money metrics as it enters steady-state post refurbishment operations and returns the sustaining capital program to prior levels.

- **Human Performance:** For the human performance cornerstone, OPG is targeting an improved HPER at Darlington, while remaining in the second quartile. Pickering HPER is targeting improvements during the business planning period and is expected to achieve median quartile from 2023 onwards.

3.4 Gap Based Business Planning - Gap Closure and Resource Plan

The operational and financial targets established by the target setting process are the basis for site and support group business planning. As part of that process, fleetwide and site improvement initiatives are established to close performance gaps to targets over the business planning period. The fleetwide improvement initiatives, which are described in Section 3.4.2, are intended to improve efficiency, operational performance and cost effectiveness.

3.4.1 Prior Gap Closure Initiatives

In its EB-2016-0152 submission, OPG identified six Nuclear gap closure initiatives: i) Parts Improvement, (ii) Outage Improvement, (iii) Equipment Reliability, (iv) Human Performance, (v) Nuclear Inventory, and (vi) Workforce Planning and Resourcing. Attachment 1 provides details about these prior initiatives and benefits realized.

3.4.2 Current Fleetwide Improvement Initiatives

OPG's 2020-2026 Business Plan (Ex. A2-2-1, Attachment 1) sets out the resource requirements (cost, staff and investment plans) for Nuclear. As stated above and in Ex. A2-2-1, OPG's operating cost profile in the 2020-2026 Business Plan is based on challenging but achievable OM&A targets that will position Darlington towards top-quartile TGC performance, post refurbishment.

The Nuclear business remains focused on continuously improving its operational performance and cost effectiveness at the Darlington and Pickering stations. The 2020-2026 targeted cost structure for the business, builds on productivity improvements and cost savings accomplished to date as well as a range of change strategies over the planning period This includes initiatives aimed at continuing to drive better outage performance, improving equipment reliability, reducing maintenance backlogs, implementing integrated asset management planning, enhancing maintenance programs and strengthening the digital infrastructure.

In addition to managing improvements, OPG will make greater use of innovation, leveraging proven technologies in the nuclear industry to change how work programs are executed. This will be enabled by OPG's Digital Strategy (see Ex. D3-1-1). Investing in technology to create efficiencies is consistent with customer feedback as obtained through the customer engagement process (see Ex. A2-2-1). In order maximize the value of these initiatives, OPG will focus on empowering leaders and strengthening an overall innovation mindset to help drive business efficiencies.

Consistent with the above, the key nuclear initiatives discussed below are designed to bring improvements across a range of areas broadly characterized as people, processes and technology. The initiatives will strengthen operational performance and cost effectiveness of the nuclear fleet, helping to drive the cost savings needed to meet the 2020-2026 Business Plan commitments. The initiatives are also designed to mitigate risks to enable a successful transition from a ten unit fleet to a four unit fleet. In recognition of the transformational period for the organization that is the next IR term, OPG will adopt an agile approach to achieving its performance goals by pursuing a range of potential opportunities, building on successes, and developing alternative plans and mitigation actions as required. As discussed in Ex. A2-2-1, the targets for this business plan recognize that a "check and adjust" approach will be necessary to advance the significant changes in the organization, while ensuring continued safe and reliable fleet operations.

3.4.2.1 <u>Nuclear Specific Initiatives</u>

Investments are integrated to ensure improvements are executed and sequenced appropriately. Initiatives focus on changing how we execute our work programs by leveraging proven

technology that is used in the Nuclear industry. Investing in technology to create efficiencies is also consistent with customer feedback as obtained through the customer engagement process (see Ex. A2-2-1).

The initiatives discussed below will help OPG to successfully transition from a ten unit fleet to a four unit fleet with the planned shutdown of Pickering in 2024/2025 and support achievement of Nuclear cost savings and business plan targets. OPG will adopt an agile approach to achieving its financial and operational performance goals by pursuing a range of opportunities, building on successes, and developing alternative plans and mitigation actions as required.

Right Work, Right Time, Right Value

The Right Work, Right Time, Right Value ("RWRTRV") initiative focusses on improving plant reliability by improving maintenance productivity. Another key area of focus is on improving work management performance by transitioning to the use of digital work management tools and artificial intelligence in work management and outage planning processes. Key improvement actions and anticipated results for this initiative are:

- Expanding the "Fix it Now" maintenance team and optimizing assessment of minor maintenance. The benefit of the Fix-it-Now team is increased agility in executing priority work. This team is empowered with cross-functional members to tackle urgent issues more efficiently. Similarly, minor maintenance work is being optimized to ensure assessment is based on a graded approach, which improves efficiency and reduces the comprehensive requirements that are applied to complex work. These are industry best practices and trends that are being further expanded at OPG, improving work management performance, reducing backlogs, and supporting improved plant reliability. Maximizing the Fix It Now team will improve minor maintenance execution and drive reductions in both targeted critical and deficient maintenance backlogs.

- Utilizing the Monitoring and Diagnostic Center ("M&D Center") to develop predictive failure models and transitioning components of its time-based maintenance program to condition-based maintenance. The objective of condition-based maintenance is to establish

continuous equipment condition monitoring through the use of high performance diagnostic tools that can combine the power of on-line process and equipment performance data acquisition with advanced diagnostic methodologies, including advanced pattern recognition technology (a form of artificial intelligence ("AI")), to avoid operations and maintenance costs and improve plant performance. As part of the continued evolution of the M&D Center, sensors and remote monitoring technologies are being installed on plant equipment, which will provide real time data and analysis to ensure maintenance is done promptly and resource utilization is maximized (see also Ex. D2-1-3, Section 3.1, Project #83828). This will allow the prioritization of maintenance activities and optimal use of resources to ensure high plant reliability.

- As part of continuous improvement and in keeping with industry best practices, a collaborative review of the preventative maintenance ("PM") program will be performed by Engineering, Maintenance, Operations, and Work Management staff to ensure that Maintenance resources are focused on execution of the highest-value activities. Lower risk/lower value work will be removed from the PM program and similar tasks or related activities will be bundled together to increase efficiencies in execution.

- Along with the AI modelling in the M&D Centre, OPG will continue to explore opportunities for using AI to improve work management. The use of AI for work management is a new concept for the nuclear industry and is enabling both Pickering and Darlington to continually drive improvements to their work management programs. OPG is leveraging new technologies and processes as they are adopted in the nuclear industry and applying successes to future work. This includes using AI to maximize maintenance resources by effectively coordinating on-line and outage shift schedules, assisting in the assessment of work packages, and logging and monitoring of foreign material exclusion. OPG has already realized improvements in the outage scoping process with batch work assessing capabilities that reduce human performance issues as errors are automatically corrected. OPG will continue to seek further opportunities to apply AI to support planning of outage scope and the efficient execution of outage work.

The RWRTRV initiative's improvements support cost effectiveness as well as improved operational performance and efficiencies in areas of maintenance, outage performance, backlog reductions and equipment reliability.

Leaders Driving Business Results

The Leaders Driving Business Results initiative focusses on managers driving business efficiencies through innovation. The initiative provides managers with tools and training to make sound decisions that will improve the performance of their teams and support improvement in value for money metrics through readily available information. Key improvements and anticipated results include:

- Established automated centralized business data and reports providing managers with more efficient reporting and access to information to make better informed and more timely decisions. As an example, OPG has implemented a suite of online reporting dashboards providing managers with the ability to see up-to-date operational and cost information, including overtime trend data to better manage their budgets. These dashboards also support building broader awareness of business acumen and how decisions impact TGC per MWh.

- To support this transition, training and workshops will continue to ensure that all managers have the required knowledge and skills to use these tools and manage their teams to drive and sustain innovation and performance improvement.

People Powering the Future

As discussed in Ex. F4-3-1, the planned shutdown of Pickering will result in a transformational change to OPG's workforce, with an expected reduction of over 3,000 employees. The People Powering the Future initiative focusses on ensuring work programs are resourced appropriately in accordance with the 2020-2026 Business Plan while minimizing the organizational and financial impacts associated with the transition to post-Pickering operations.

In preparing for this transition, OPG is developing strategies to ensure there is proper knowledge retention and transfer in order to minimize any impact to work programs and operations. These changes are also expected to support a leaner organization post planned Pickering shutdown, in line with the business plan cost targets. As the organization makes these changes, it is important to ensure that the right individuals and skills are available, within the provisions of collective agreements. OPG is also ensuring that workforce strategies are designed to manage the financial cost of the downsizing process.

Key improvement actions and anticipated results for this initiative include:

- Implement the changes required to support the organizational design for OPG post-Pickering shutdown, including streamlining and reducing demand for engineering support as already demonstrated thorough the organizational realignment and the centralization of the engineering function.

- Continue to leverage headcount reductions through attrition, where possible, retain vacancy controls and implement targeted staffing plans.

- Optimize the resource mix and utilization of staff to support an effective transition to a post-Pickering organization while ensuring safe and reliable operations, including for post-shutdown activities at Pickering.

4.0 PICKERING OPTIMIZED SHUTDOWN

4.1 OVERVIEW

In EB-2016-0152, OPG presented the Pickering Extended Operations initiative aimed at operating Pickering Units 1 and 4 to 2022 and Pickering Units 5-8 to 2024 (EB-2016-0152, Ex. F2-2-3). OPG expects this initiative will be completed by 2021 at a total cost of $307M, consistent with the forecast presented in EB-2016-0152.

This application reflects OPG's plans to safely optimize the shutdown of Pickering by operating all six units until September 2024, five of the six units through 2024 and the remaining four units until December 2025, as per the 2020-2026 Business Plan ("Optimization"). OPG will require CNSC approval to operate the remaining four units past 2024 until December 2025.

On August 14, 2020, the Province of Ontario issued a press release announcing its support of OPG's plan to pursue Optimization (Attachment 7). The IESO's Annual Planning Outlook published in December 2020 also assumes Pickering shutdown in 2024/2025. Optimizing the shutdown of Pickering mitigates capacity uncertainties during the refurbishments of the Darlington and Bruce stations.

4.2 WORK AND COSTS REQUIRED FOR OPTIMIZATION

The work related to the Pickering Extended Operations initiative demonstrates that it is feasible for Pickering to safely operate to the optimized shutdown plan of 2024/2025.

Optimization involves incremental activities to demonstrate to the CNSC the station's continued fitness of service to safely and reliably operate to the planned shutdown dates through to 2025, and to make other necessary improvements in support of this plan. The estimated cost of this work, which is incremental to normal operating costs, is $50M over 2020-2024 ("Enabling Costs"). Further details on the Pickering Optimized Shutdown work and Enabling Costs are described below.

4.2.1 Pickering Optimized Shutdown Work

In advance of recommending Optimization, OPG completed an initial technical assessment of the Pickering units' continued ability to operate to the Optimization's proposed shutdown dates. The initial technical assessments serve as the basis for the detailed scope for the Enabling Costs. The main elements of this scope of work are for: 1) the Periodic Safety Review ("PSR") revision; 2) the Fuel Channel Life Cycle Management Plan ("FC-LCMP"), and 3) Component Condition Assessments.

Periodic Safety Review Revision

The current Power Reactor Operating Licence for Pickering was issued in August 2018 for a 10 year term and is set to expire on August 31, 2028. As part of Pickering's re-licensing in 2018, a PSR was completed to evaluate the plant against the requirements that would apply to a newly-built nuclear power plant. The evaluation identified potential nuclear safety enhancements to the plant design or programs. The safety enhancements were then assessed to identify the alternatives that can be reasonably and practicably implemented to improve safety, and these results were documented in the Integrated Implementation Plan ("IIP"). The licence issued in August 2018 will allow OPG to operate all Pickering units until 2024 with a commitment by OPG to implement the results of the IIP to ensure the station's continued safe and reliable commercial operation, to be followed by the safe storage project (i.e., until the units are placed in a safe-stored state). The CNSC also approved fuel channel operation past 247,000 Equivalent Full Power Hours ("EFPH") up to 295,000 EFPH.[6]

While 295,000 EFPH is sufficient to allow OPG to operate the Pickering Units 5-8 to 2025, for the units to operate beyond 2024, OPG is also required to complete a reassessment of the continued validity of the PSR, revise the IIP actions as required, and notify the CNSC of the results of both by December 31, 2022, in support of an application for a licence amendment. OPG will continue, leading up to the CNSC submission, to validate of technical analysis (Fuel Channel Life Cycle Management; Component Condition Assessments) to support CNSC approval to operate Pickering units to 2025. The PSR results would then be reviewed by the CNSC.

Fuel Channel Life Cycle Management Plan

The major limiting component for operations is the life expectancy of the fuel channels. Technical assessments on the fuel channels' fitness-for-service continue through the FC-LCMP and ongoing inspections, and include incremental fuel channel scope required to address known degradation in order to enable operation to the planned shutdown dates through to 2025. The ongoing work program consists of analysis and work activities to assess

[6] Work undertaken through the Fuel Channel Life Extension project and the Pickering Extended Operations initiative underpinned OPG's successful application to the CNSC to allow Pickering to operate to 295,000 EFPH.

fuel channel fitness-for-service for the planned operating durations and to develop methods for assuring that each Pickering unit can meet its extended service life target. This work program builds on the Fuel Channel Life Management and Fuel Channel Life Extension projects in support of Pickering Extended Operations.

Component Condition Assessments

While the technical fitness-for-service of other major components, separate from the fuel channels, is not considered life limiting, Component Condition Assessments will be conducted to validate their fitness-for-service to the planned shutdown dates in 2024 and 2025. Planned outages will involve maintenance and inspection of steam generators, feeders, and "balance of plant" components (including fueling machine maintenance). Examples of the work expected to be performed include steam generator water-lancing, feeder thickness inspections and feeder replacements.

4.2.2 Enabling Costs

The costs associated with completing the above work are included within OPG's Nuclear Base, Outage and Project OM&A exhibits and associated tables, as summarized in Chart 5 below.

Chart 5: Optimization – Enabling Costs ($M)

Line No.	Cost Item	2020 Budget	2021 Budget	2022 Plan	2023 Plan	2024 Plan	2025 Plan	Total	Reference
		(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)
1	Base OM&A	2.2	4.6	5.8	2.7	4.8	0.0	20.1	Ex. F2-2-1 Table 1
2	Outage OM&A	0.1	1.2	2.6	2.2	13.5	0.0	19.7	Ex. F2-4-1 Table 1
3	Project OM&A	0.2	2.0	7.8	0.0	0.0	0.0	10.0	Ex. F2-3-1 Table 1
4	Total Pickering Optimization	2.5	7.9	16.2	5.0	18.4	0.0	50.0	

Numbers may not add due to rounding

Further details are found in each of the referenced exhibits above.

Normal operating activities and their associated costs will continue through to 2025 with amounts forecast for 2022 through 2025 included in the IR term costs. There are no costs to operate Pickering post 2025 in the 2020-2026 Business Plan.

Any differences between forecast and actual Enabling Costs incurred to achieve Optimization will be recorded in the Capacity Refurbishment Variance Account for disposition in a future proceeding. This variance account is discussed in Ex. H1-1-1, Section 5.6.

ATTACHMENTS

Attachment 1:	Prior Gap Closure Initiatives
Attachment 2:	OPG 2020 Nuclear Benchmarking Report
Attachment 3:	ScottMadden Evaluation of OPG Nuclear Benchmarking
Attachment 4:	OPG Nuclear Cost Performance Benchmarking – Methodology to Adjust for Refurbishment and Validation of Implementation (ScottMadden)
Attachment 5:	OPG Nuclear Cost Performance Benchmarking – A Study of Factors Impacting TGC/MWH Performance with Normalizing Adjustments to Facilitate Closer Comparison (ScottMadden)
Attachment 6:	2019 Goodnight Nuclear Staffing Benchmarking Analysis
Attachment 7:	Province of Ontario Press Release dated August 14, 2020

Note: Attachments 1-7 may be marked “Confidential”, however, OPG has determined all Attachments to be non-confidential in their entirety.