BUSINESS PLANNING AND BENCHMARKING
NUCLEAR

1.0 PURPOSE

This evidence presents the business plan and benchmarking results for OPG's Nuclear Operations and provides a summary of nuclear operating costs in support of the application.

2.0 OVERVIEW

OPG's 2017-2021 rate application for its nuclear facilities is based on OPG's 2016-2018 Business Plan, including an additional three-year financial projection for the later years of the test period (2019-2021) both prepared on the same basis and through a consistent process (see Ex. A2-2-1 Attachment 1, Appendix 5: Nuclear Financial Plan, Operational Targets, and Initiatives, for further details). It is also aligned to the guiding principles of Ontario's 2013 Long-Term Energy Plan as it pertains to cost-effectiveness, reliability, clean energy, and community engagement.[1] This application reflects unprecedented and significant changes in OPG's nuclear operations which pose unique challenges in terms of business planning and benchmarking. These include the implementation of the Darlington Refurbishment Program ("DRP") and Pickering Extended Operations ("Extended Operations").

OPG's 2016-2018 Business Plan continues to achieve a sustainable cost structure for the nuclear operations by building on the success of major programs undertaken by OPG over the past few years, including; a) Pickering Continued Operations, where the work program was completed on time, on budget and is on plan to achieve 4-6 additional years of station operation to 2020, b) Business Transformation, where staffing targets were fully realized through the successful implementation of the program, and c) completion of various fleet-wide and site initiatives (Fuel Handling Reliablity, 3k3 Equipment Reliablity and Days Based Maintenance) that were focused on improving operational and cost performance. These initiatives are described in greater detail in section 3.5 below.

[1] Executive Summary, Ontario 2013 Long-Term Energy Plan as found at http://www.energy.gov.on.ca/en/ltep/achieving-balance-ontarios-long-term-energy-plan/

Highlights of OPG's 2016-2018 Business Plan as it pertains to Nuclear Operations include the following:

- OPG has been successful in achieving Business Transformation targets through attrition. Higher than anticipated attrition has eliminated the gap associated with Goodnight[2] staffing benchmarks in 2016. The business plan and three-year financial projection address the challenges ahead and focus on addressing the emerging labour supply versus demand gap, leadership capability and key resource availability to ensure safe and efficient operations of OPG's nuclear facilities, while minimizing risks to the efficient execution of Pickering Extended Operations and the DRP.
- Maintaining high standards of safety and environmental stewardship with a focus on keeping Airborne Tritium Emissions as low as reasonably achievable.
- Implementation of Extended Operations to extend the life of all six Pickering units until 2022 and four units until 2024.
- Continued planning to develop a Pickering End of Commercial Operations and Decommissioning Strategy.
- An initiative to improve equipment reliability at both Pickering and Darlington with a particular focus on fuel handling to ensure that we achieve aggressive forced loss targets that improve generation efficiency.
- Implementation of human performance improvement plans at the nuclear fleet and station levels to focus on worker safety and plant operation, including increased supervisory effectiveness and field oversight, focusing on error prevention to reduce forced outages and improve production levels, thereby lowering Total Generating Cost per MWh ("TGC/MWh").
- Executing project portfolio investments to enhance the performance, reliability and overall value of OPG's Nuclear assets. This includes increased capital investment primarily at Darlington to undertake aging equipment projects and certain Facilities and Infrastructure Projects determined to be necessary to support Darlington operations before, during and post-refurbishment (see Ex. D2-2-10 and Ex. D2-1-2 section 3.1).

[2] See section 3.3 of this exhibit for further discussion of Goodnight staff benchmarking.

A summary of actual and planned operating costs in the nuclear revenue requirement over the 2013-2021 period is presented in Ex. F2-1-1 Table 1.

OPG continues to benchmark annual performance of Darlington and Pickering (Safety, Reliability, Value for Money and Human Performance) based on ScottMadden methodologies established in 2009, consistent with its obligations under the Memorandum of Agreement with the Shareholder (Ex. A1-4-1 Attachment 2). In 2015, ScottMadden validated the ongoing appropriateness of OPG's application of the benchmarking methodology (see Attachment 3 to this exhibit). Of the three key indicators of TGC/MWh, WANO Nuclear Performance Index ("NPI") and Unit Capability Factor ("UCF"), Darlington has achieved a combination of first quartile (TGC/MWh) and second quartile (WANO NPI; UCF) performance. Pickering continues fourth quartile performance for all three metrics. As discussed below, Pickering's performance on these three key indicators is reflective of its small unit size, first generation CANDU technology, and low capability factor for extensive planned outage programs tied to extending the life of Pickering to the benefit of ratepayers.

OPG recognizes that there are limitations in relying on benchmarking alone to measure and explain performance and highlight areas for improvement. These limitations were specifically addressed in ScottMadden's transmittal letter, attached to the Phase 1 Benchmarking Report (EB-2010-0008, Ex. F5-1-1), which noted the impact of factors influencing OPG's performance gap against best quartile, stating that:

> In our opinion, the comparisons provided in this report present a fair and balanced view of OPG operating and financial performance compared to other operators in the nuclear generation industry. However, it would be inappropriate to generalize regarding OPG's absolute performance based solely upon comparisons to industry averages. Differences in design technology, the number of reactors on site, the geographic size of the site, reactor age, operational condition and other factors all influence OPG's operational and financial performance. Benchmark data can be useful for highlighting performance gaps relative to other nuclear generation operators but prescriptive conclusions regarding OPG's ability to narrow such performance gaps will require further analysis.

Comparison of OPG's CANDU units to industry benchmarks is further complicated by differences that exist between Darlington and Pickering. While OPG's ten nuclear units are all heavy water moderated CANDU reactors, they reflect three generations of design philosophy and technology with Pickering Units 1 and 4, Pickering Units 5 to 8 and Darlington Units 1 to 4 built in the 1960's, 1970's, and 1980's respectively. This results in significant variations among the three nuclear stations including generating unit size (e.g., gross generating capacity of 934 MW at Darlington versus 540 MW at Pickering); technology (e.g., more extensive digital control at newer versus older stations), and overall design (e.g., the units at Pickering have more heat transport pumps and steam generators than units at Darlington, but operate at lower pressure and flow velocity).

CANDU units also have specific cost differences related to engineering, operating and maintenance costs as compared to Pressurized Water Reactors ("PWR")/Boiling Water Reactors ("BWR"). Examples of these cost differences include on-line fuel handling, heavy water management, and common station containment systems. ScottMadden established that these technology differences are fixed and "non-controllable" when compared to other potential controllable costs. While ScottMadden did not attempt to calculate the magnitude of the CANDU versus PWR/BWR technology cost gap, the Goodnight study in 2011 did quantify that OPG's ten CANDU units required significant additional staffing (400 Full-time Equivalents ("FTE")) relative to the PWR benchmark plants being benchmarked. In addition, Goodnight identified that there were 1,031 FTEs unique to CANDU design (e.g., heavy water management, fuel handling, and tritium removal) that have no equivalent in a similar sized PWR reactor unit plant (EB-2013-0321 Ex. F2-1-1, p. 11; Ex. F5-1-1, part a, slide 14). Given that approximately 70 per cent of OPG base OM&A is labour, additional staffing required for CANDU technology is a significant cost driver to the TGC ($/MWh) performance gap.

Darlington competes favourably in TGC/MWh against comparable PWR/BWR reactors in the United States despite the technology related cost difference in part because of its larger unit size, third generation CANDU technology improvements and lower fuel costs. Also, to maintain strong cost performance, OPG implemented various business transformation initiatives to achieve significant staff reductions. This has enabled OPG to eliminate the nuclear Goodnight staffing benchmark gap in 2016 for the fleet.

Pickering's TGC/MWh is high, compared to Darlington, reflecting its small unit size and first generation CANDU technology. To better understand Pickering's fourth quartile performance in TGC/MWh, OPG examined costs separately and compared TGC on a unitized basis in order to eliminate generation impacts due to extensive outage programs, reactor design and unit size. On a cost performance assessment, Pickering and Darlington compare very favourably to PWR/BWR reactors by reference to TGC per unit. Pickering's performance, similar to Darlington, is that it is among the lowest cost nuclear generators in North America, as shown in Chart 3. In addition, over the 2009-2014 review period, Pickering maintained a relatively stable cost profile, experiencing a compound annual growth rate of only 0.5 per cent while the industry median quartile experienced a compound annual growth rate of approximately 4.9 per cent over the same period (see Attachment 1 to this exhibit, Nuclear Benchmarking Report, page 67). Pickering's stable cost performance, similar to Darlington, also reflects OPG's implementation of various business transformation initiatives that allowed OPG to achieve significant staff reductions. Finally, when examining the performance of Pickering against other generation options as part of the "Extended Operations" plan, the IESO independently concluded that extending operations saved rate payers between $300M and $500M (see Ex. F2-2-3).

In summary, OPG believes that the nuclear operations OM&A (as shown on Ex. F2-1-1 Table 1 line 4, being the total of base, project and outage OM&A) included in the revenue requirements during the test period represent realistic and appropriate amounts to meet all nuclear safety and regulatory requirements, while demonstrating continuous improvement and executing the nuclear operations activities required to support ongoing nuclear operations and Pickering Extended Operations. OPG's 2016-2018 Business Plan limits the average annual increase in these costs to 0.9 per cent per year over the period 2015-2021. In addition, OPG's Custom IR proposal in this application includes a benchmarking-based stretch factor to drive continuous improvement in elements of the company's nuclear operations that can be implemented without jeopardizing safety, reliability or the execution of the multi-billion dollar nuclear capital work planned during the application period. In computing the nuclear payment amounts, OPG has applied a 0.3 per cent stretch-factor to the revenue requirement resulting from the company's Nuclear Base OM&A and corporate support services allocated to the Nuclear business (see Ex. A1-3-2).

3.0 NUCLEAR BUSINESS PLANNING AND BENCHMARKING

3.1 Gap-Based Business Planning Process

OPG's Nuclear business planning cycle is undertaken annually as part of and consistent with the overall OPG business planning process (see Ex. A2-2-1). The business planning process is focused on establishing strategic and performance targets for nuclear, in alignment with OPG's 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, compare nuclear performance against industry leaders 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:** By reference to OPG Nuclear's four cornerstone values of Safety, Reliability, Human Performance and Value for Money, developing various fleet wide and site specific initiatives to close the performance gaps between current and targeted results.
- **Resource Planning:** Preparing an OPG Nuclear business plan (i.e., the development of cost, staff and investment plans) that is based on the "top-down" targets and incorporates initiatives necessary to achieve targeted results.

3.2 Gap-Based Business Planning – Benchmarking

The 2015 Nuclear Benchmarking Report benchmarks OPG's performance against industry peers based on 2014 data and uses 20 indicators aligned with the cornerstone values of Safety, Reliability, Value for Money and Human Performance (see Attachment 1 to this exhibit). The 2015 Nuclear Benchmarking Report uses the same methodology and format as the report first filed in EB-2010-0008 and again in EB-2013-0321 based on a benchmarking initiative undertaken by OPG Nuclear in 2009 with the assistance of consulting firm ScottMadden, Inc ("ScottMadden"). Updates are required from time to time to reflect changes in industry reporting (e.g., on-line deficient and on-line corrective maintenance backlogs) and other factors (e.g., amalgamation of Pickering A and Pickering B). In 2015 OPG engaged ScottMadden to conduct an independent review of OPG Nuclear's 2014 benchmarking report and process to ensure continued accuracy of reporting and consistency with industry best practices. ScottMadden's assessment (Attachment 3 to this Exhibit) confirmed that the integrity of OPG's benchmarking process and the use of benchmarking in business planning as originally established in 2009 have been maintained, and that changes since 2009 as reflected in the 2014 report were reasonable and appropriate.

No changes were made to the methodology used in the 2015 Benchmarking Report compared to 2014 Benchmarking Report reviewed by ScottMadden.[3]

Chart 1 is a reproduction of Table 2 from OPG's 2015 Nuclear Benchmarking Report (Attachment 1 to this exhibit), and provides a summary of OPG's 2014 plant-level performance for each of the 20 key performance metrics benchmarked.

[3] In prior years, OPG calculated best quartile/median for on-line deficient and on-line corrective maintenance backlogs using individual plant data provided by INPO; for 2015 INPO provided best quartile/median directly and did not provide individual plant data.

Chart 1

Comparison of OPG Nuclear Performance to Industry Benchmarks

Metric	NPI Max	2014 Actuals			
		Best Quartile	Median	Pickering	Darlington
Safety					
All Injury Rate (#/200k hours worked)		0.66	N/A[1]	0.22	0.31
Rolling Average[2] Industrial Safety Accident Rate (#/200k hours worked)	0.20	0.00	0.02	0.03	0.06
Rolling Average[2] Collective Radiation Exposure (Person-rem per unit)	80.00	42.25	61.60	82.24	69.06
Airborne Tritium Emissions (Curies) per Unit[3]		1,014	2,410	2,390	1,831 ⇩
Fuel Reliability Index (microcuries per gram)	0.000500	0.000001	0.000001	0.001580 ⇩	0.000158 ⇧
2-Year Reactor Trip Rate (# per 7,000 hours)	0.50	0.00	0.05	0.36	0.00
3-Year Auxiliary Feedwater System Unavailability (#)	0.0200	0.0000	0.0015	0.0181	0.0000
3-Year Emergency AC Power Unavailability (#)	0.0250	0.0001	0.0024	0.0000	0.0000
3-Year High Pressure Safety Injection Unavailability (#)	0.0200	0.00000	0.00003	0.0000	0.0000
Reliability					
WANO NPI (Index)		92.9	85.8	64.3	92.1 ⇩
Rolling Average[2] Forced Loss Rate (%)	1.00	1.03	1.29	10.08	2.85
Rolling Average[2] Unit Capability Factor (%)	92.0	89.44	86.49	74.50	89.41
Rolling Average[2] Chemistry Performance Indicator (Index)	1.01	1.00	1.00	1.04 ⇧	1.00
1-Year On-line Deficient Maintenance Backlog (work orders per unit)		159	212	276 ⇩	176 ⇩
1-Year On-line Corrective Maintenance Backlog (work orders per unit)		11	20	160	20 ⇧
Value for Money					
3-Year Total Generating Cost per MWh ($ per Net MWh)		38.71	44.61	67.93	37.73
3-Year Non-Fuel Operating Cost per MWh ($ per Net MWh)		22.68	25.83	56.94	28.55
3-Year Fuel Cost per MWh ($ per Net MWh)		8.08	8.79	5.74	5.13
3-Year Capital Cost per MW DER (k$ per MW)		49.08	63.95	34.20	31.30
Human Performance					
18-Month Human Performance Error Rate (# per 10k ISAR and contractor hours)		0.00200	0.00400	0.00890	0.00620

Notes
1. No median benchmark available.
2. Indicates a 2-Year Rolling Average for Pickering and a 3-Year Rolling Average for Darlington.
3. 2012 data is used because 2013 and 2014 results were unavailable at the time of benchmarking.

Green = maximum NPI results achieved or best quartile performance
White = 2nd quartile performance
Yellow = 3rd quartile performance
Red = 4th quartile performance

⇩ Declining Benchmark Quartile Performance vs. 2013
⇧ Improving Benchmark Quartile Performance vs. 2013

Note to Chart 1: “DER” in “3-Year Capital Cost per MW” refers to Design Electrical Rating.

Detailed discussion on the performance trends and drivers by cornerstone is provided in the OPG 2015 Nuclear Benchmaring Report (Attachment 1), and is summarized as follows:

- **Safety**
  Overall, OPG's nuclear generating stations continue to demonstrate strong safety performance. Darlington achieved maximum NPI results or best quartile performance for all metrics. The Airborne Tritium Emissions declined in ranking due to an increase in heavy water management and the unavailability of the Tritium Removal Facility. Pickering's year-over-year performance improved in several Safety cornerstone metrics including Reactor Trip Rate, has significantly improved on Collective Radiation Exposure relative to 2013, and declined on Fuel Reliability Index.
- **Reliability**
  While Darlington's NPI performance in 2014 improved compared to 2013, its ranking declined from top quartile NPI rating in 2013 to second quartile in 2014 due to improving performance by industry peers. Darlington maintained its third quartile ranking for Forced Loss Rate ("FLR") and median quartile for Unplanned Capability Factor ("UCF"). Pickering's performance ranks in the 4th quartile for NPI, primarily due to 4th quartile performance for FLR and UCF. Pickering's Chemistry Performance Indicator has improved to third quartile.
- **Value for Money**
  Darlington maintained its top quartile TGC/MWh ranking in 2014, reflecting OPG's cost management and strong generation performance. Over the period 2009 to 2014, Darlington's TGC/MWh grew by $4.77/MWh (2.76 per cent), which compares favorably to industry best quartile growth of $7.88/MWh (4.7 per cent).

  Pickering's TGC/MWh remains in the fourth quartile. Total generating cost per MWh at Pickering is primarily affected by the size of the units and low capability factor due to extensive planned outage programs. Pickering's TGC/MWh increased by $1.51/MWh (0.5 per cent) over the period 2009 to 2014, while the industry median quartile growth rate was approximately $9.50/MWh (4.98 per cent) over the same period.

- **Human Performance**

  OPG Nuclear's human performance strategy focuses on and reinforces the correct behaviors during all phases of station operations and maintenance. Pickering and Darlington improved their Human Performance Error Rate ("HPER") in 2014 compared to 2013 but remained in the fourth and third quartiles respectively due to improving industry benchmark performance.

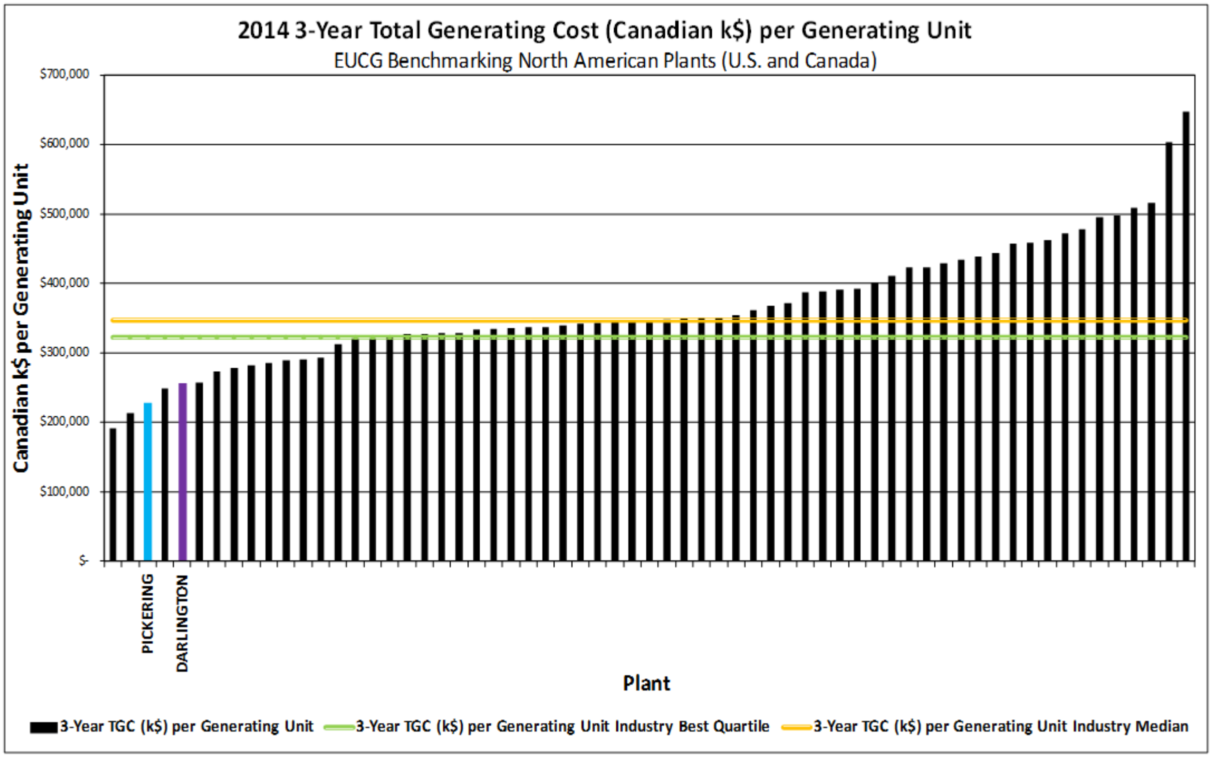
As noted above, OPG also benchmarks value for money performance on a $/generating unit basis in addition to $/MWh. The TGC/unit metric eliminates generation impacts due to extensive outage programs, reactor design and unit size. Chart 2 provides the value for money metrics on a per unit basis for 2014 with both Darlington and Pickering achieving best quartile performance for Total Generating Cost per unit.

Chart 2 – Plant Level Performance Summary

2014 Rolling Averages				
Metric	**Best Quartile**	**Median**	**Pickering**	**Darlington**
Value for Money				
3-Year Total Generating Cost per Generating Unit (Canadian k$ per Unit)	321,983	346,952	228,162	255,779
3-Year Non-Fuel Operating Cost per Generating Unit (Canadian k$ per Unit)	174,079	209,704	191,246	193,518
3-Year Fuel Cost per Generating Unit (Canadian k$ per Unit)	55,569	69,250	19,282	34,783
3-Year Capital Cost per Generating Unit (Canadian k$ per Unit)	50,331	59,478	17,634	27,478

Chart 3 shows that Darlington and Pickering are among the least expensive to operate on a per unit basis:

Chart 3



3.3 Gap-Based Business Planning – Nuclear Staffing Study

3.3.1 Overview

OPG continues to examine staffing levels as part of its benchmarking studies and anticipates that it will eliminate the Goodnight[4] staffing benchmark gap to industry peers in 2016.

The initial Goodnight study in 2011[5] indicated that OPG Nuclear was 17 per cent above its industry peers (normalized for CANDU technology differences), with a later update[6] by

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[4] In its Decision with Reasons in EB-2010-0008, the OEB directed OPG to conduct an examination of staffing levels as part of its benchmarking studies for its next application. The OEB also noted that "OPG may wish to consider whether a study of the major cost differences between CANDU and PWR/BWR would facilitate the review of its application on the issue of cost differences between the various technologies." To satisfy this directive, OPG retained Goodnight Consulting Inc. ("Goodnight"), an external consultant with extensive experience in nuclear industry staff benchmarking, and filed a staff benchmarking study in EB-2013-0321. A detailed discussion of the methodology used for the initial study, and which continues to be used subject to industry data updates, can be found in EB-2013-0321, Ex. F2-1-1, section 3.3.

[5] February 2012 report filed as EB-2013-0321, Ex. F5-1-1 Part a.

[6] May 2013 report filed as EB-2013-0321, Ex. F5-1-1 Part b.

Goodnight demonstrating that OPG Nuclear had narrowed the gap to less than eight per cent above benchmark (subsequently amended to 7.6 per cent per EB-2013-0321, Ex. JT1.13).

The latest report,[7] the 2014 Goodnight Nuclear Staffing Benchmarking Analysis published in December 2014 (Attachment 2 to this exhibit), shows that staff reductions had further narrowed the gap to 4.1 per cent, and as stated above, OPG has eliminated the gap in 2016.

The main conclusions of the 2014 Goodnight Nuclear Staffing Study are as follows:

- As of March 2014, OPG Nuclear was above the comparable benchmark by 213 FTEs or approximately 4.1 per cent;
- OPG was above benchmark staffing in 17 job functions, and at or below benchmark in 23 functions.
- OPG's variance above the benchmark had narrowed from 17 per cent in 2011 to 4.1 per cent due to initiatives undertaken by OPG, including the centre-led initiative (i.e., Business Transformation) and the Pickering station amalgamation, that have allowed OPG to manage staff resources primarily through attrition and modest increases in the industry peer benchmark.
- The initial Goodnight study in 2011 excluded 2,101 OPG employees that could not be benchmarked to PWR/BWR industry peers for various reasons (see EB-2013-0321, Ex. F5-1-1 Part a, Slides 14-16). The 2014 Goodnight Study excluded from benchmark 2,036 OPG Nuclear Personnel (see Attachment 2, Sllde 14). This 65 headcount reduction or 3.1 per cent decline in non-benchmarkable resources between 2011 and 2014 is futher indication of the efficiencies acheived through the Business Transformation initiative. This reduction increased to 3.8 per cent by the end of 2015.

3.3.2 OPG's Response to the Goodnight Nuclear Staffing Studies

OPG has accepted the methodology and observations of the Goodnight studies as reasonable for the purpose of benchmarking staff levels (in total and by function) between OPG CANDU units and U.S. PWR units. OPG agrees with the conclusion from the

[7] OPG advised during EB-2013-0321 (Ex J6.1) that another report was being prepared and provided a preliminary update that OPG Nuclear was above benchmark by 4.7 per cent as of March 2014.

application of the Goodnight methodology that technology/design/regulatory differences exist between CANDU and PWR units and that such factors drive differences in staffing levels.

OPG has since 2011 implemented nuclear staffing plans that implement staff reductions through attrition in response to the conclusions of the Goodnight studies that OPG Nuclear staffing was above comparable benchmark. Achieving the business plan targets for staff numbers required continuous monitoring, controls and initiative development and implementation to streamline processes and find efficiencies to offset staff reductions.

In 2015, actual FTEs were below budgeted FTEs primarily due to higher than planned attrition of Nuclear Operations regular staff, which, because of hiring lags, was managed through the use of non-regular staff, overtime and purchased services. While OPG was below benchmark in 2015 (by virtue of nuclear operations regular staff being significantly below budget), the planned increase in FTEs in 2016 reflects completion of hiring to levels required to sustain Nuclear Operations and undertake Extended Operations at Pickering as well as increased staffing for the Darlington Refurbishment Program. The planned FTEs in 2016 would restore staff levels to sustainable levels while ensuring OPG is still at benchmark. Darlington Refurbishment Program staffing is expected to be relatively stable during 2017-2021 while there is a downward trend in Nuclear Operations FTEs reflecting continuous monitoring and controls as well as initiative development and implementation to streamline processes and find efficiencies to offset expected staff attrition.

OPG has pursued a measured approach in staff management that does not compromise safety or ongoing initiatives to improve reliability and implement industry best practices. Safe and reliable operations remain OPG's top priority. OPG has not and will not put at risk its efforts to safely improve reliability performance by moving too quickly to reduce staffing levels. OPG believes that this is a prudent manner in which to operate its nuclear facilities, also recognizing that improved plant reliability will improve OPG's TGC ($/MWh) and TGC ($/unit) metrics.

3.4 Gap Based Business Planning: Target Setting

Top-down targets are performance improvement targets designed to demonstrate continuous improvement and drive OPG nuclear operations closer to top quartile industry performance over the duration of a business plan. The Chief Nuclear Officer ("CNO"), in consultation with OPG's Nuclear Executive Committee ("NEC"), provided direction on top-down performance targets for each nuclear station for the business planning period. The top-down approach establishes operational, staff and financial targets informed by historical performance, targets set in prior years and the latest benchmarking results.

Chart 4 sets out detailed OPG nuclear operational and financial targets for the 20 benchmark performance indicators for the 2016-2018 period. These targets represent challenging but achievable targets, cognizant of the current reality that Darlington and Pickering are aging facilities, which will require significant investment and operational excellence to achieive the desired outcome of low cost, safe and reliable generation.

Chart 4
Operational and FinancialTargets

Benchmarking Indicators	WANO Max NPI	Best Quartile[+]	Median Quartile[+]	Pickering – Annual Targets			Darlington – Annual Targets		
				2016	2017	2018	2016	2017	2018
Safety									
All Injury Rate (#/200k hours worked)		0.66	N/A	0.24	0.24	0.24	0.24	0.24	0.24
Industrial Safety Accident Rate (#/200k hours worked)	0.20	0.00	0.02	0.1	0.1	0.1	0.1	0.1	0.1
Collective Radiation Exposure (person-rem per unit)	80.00	42.25	61.60	111.5	126.9	137.3	65	87.8	72.1
Airborne Tritium Emissions (Curies) per Unit		1,014	2,410	2,333	2,333	2,333	1,014	1,014	1,014
Fuel Reliability (microcuries per gram)	0.000500	0.000001	0.000001	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Reactor Trip Rate (# per 7,000 hours)	0.50	0.00	0.05	0.5	0.5	0.5	0.5	0.5	0.5
Auxiliary Feedwater System Unavailability (#)	0.0200	0.0000	0.0015	0.02	0.02	0.02	0.02	0.02	0.02
Emergency AC Power Unavailability (#)	0.0250	0.0001	0.0024	0.025	0.025	0.025	0.025	0.025	0.025
High Pressure Safety Injection Unavailability (#)	0.020	0.00000	0.00003	0.02	0.02	0.02	0.02	0.02	0.02
Reliability									
WANO NPI (Index)		92.9	85.8	72.3	71.1	71.1	87.3	84.3	93
Forced Loss Rate (%)	1.00	1.03	1.29	5	5	5	1	1	1
Unit Capability Factor (%)	92.0	89.4	86.5	77.6	71.5	72	91.1	85.1	86
Chemistry Performance Indicator (Index)	1.01	1.00	1.00	1.03	1.03	1.03	1.01	1.01	1.01
On-line Deficient Critical and Non-Critical Mtce Backlog (work orders/unit)		159	212	196	196	196	175	159	150
On-Line Corrective Critical and Non-critical Mtce Backlog (work orders/unit)		11	20	55	28	28	20	15	10
Value for Money									
Normalized Total Generating Cost per MWh ($/Net MWh)[++,^]		41.78	48.15	N/A	N/A	N/A	48.09	48.16	47.68
Total Generating Cost per MWh ($/Net MWh)[++,^]		41.78	48.15	71.79	77.36	76.91	48.09	65.23	64.36
Normalized Non-Fuel Operating Cost per MWh ($/Net MWh)[++]		24.48	27.88	N/A	N/A	N/A	33.84	35.36	33.69
Non-Fuel Operating Cost per MWh ($/Net MWh)[++]		24.48	27.88	60.10	66.89	69.34	33.84	49.50	46.99
Fuel Cost per MWh ($/Net MWh)		8.72	9.49	5.78	6.00	6.02	5.41	5.54	5.53
Capital Cost per MW DER (k$/MW)^^		52.97	69.02	39.70	27.52	9.62	65.54	55.19	64.99
Human Performance									
Human Performance Error Rate (# per 10k ISAR hours)		0.0020	0.0040	0.003	0.003	0.003	0.003	0.002	0.002

+ Best Quartile and Median Quartile for Value for Money metrics are forecast 2018 (2014 actual 3-year rolling average escalated).

++ TGC/MWh and Non-Fuel Operating Cost per MWh exclude centrally held pension and OPEB costs and asset service fees to align with the industry standard.

^ Targets for selected metrics presented in Appendix 5 to the 2016-2018 Business Plan document (Ex. A2-2-1 Attachment 1) represent initial estimates that were subsequently finalized based on updated cost allocations, as anticipated in footnote 2 in Appendix 5.

^^ Design Electrical Rating (DER)

The TGC/MWh for Darlington has been calculated on a normalized and non-normalized basis for 2017 and 2018 to account for the impact of reduced unit output during Darlington Refurbishment. The denominator in TGC/MWh, i.e., MWh, declines because units are being refurbished but there is not a corresponding decline in the numerator, as corporate allocated costs and station costs are largely fixed. The net impact will be to temporarily skew these metrics higher than would otherwise be the case. Nuclear Operations has set internal performance targets for TGC/MWh on a non-normalized basis, but for benchmarking against industry peers, will continue to compare Darlington's performance using a normalized TGC metric.

The following summarizes the targets set for each of the four cornerstones for the period 2016-2018, specifically:

- For the safety cornerstone, OPG is targeting either best quartile performance or maximum NPI points at both stations with a focus on improving Collective Radiation Exposure at Pickering and the Fuel Reliability Index at Darlington.
- For the realiablity cornerstone, OPG is targeting best quartile (1.0 per cent) at Darlington over the test period despite an actual FLR of 4.86 per cent in 2015. Darlington's UCF is targeted to improve (UCF exludes impact of unit outages for DRP). OPG is targeting a FLR of 5.0 per cent at Pickering across the test period which compares favourably to an average FLR of 8.5 per cent over the period 2010-2015 (See Ex. E2-1-1 section 3.1.2). OPG is targeting a lower FLR at Pickering based on past and expected future improvements in equipment reliability. Improvements are also targeted at both Pickering and Darlington to reduce Online Deficient and Corrective Maintenance backlogs. Pickering's UCF is targeted to be lower, reflecting the extensive additional planned outage days for Pickering Extended Operations.
- For the value for money cornerstone, OPG is targeting an increase in the normalized TGC/MWh for Darlington in 2016 and 2017 before slight decline in 2018. This is driven by expectation of a minimal increase in operating costs primarily reflecting labour escalation and higher capital investment. OPG is also targeting an increase in Pickering's TGC/MWh over the 2016-2018 planning period primarily due to lower

MWh associated with extensive additional planned outages for Pickering Extended Operations.

- For the human performance cornerstone, OPG is targeting improvement at Darlington, as indicated in the target reductions in the HPER over the 2016-2018 planning period. Pickering HPER is targeted to remain unchanged over this period.

Projected targets for the three key metrics of TGC/MWh, FLR and UCF for 2019-2021 are provided in Chart 5. These are challenging targets, which will require OPG to establish new initiatives based on future outcomes and operating conditions in order to achieve them.

Chart 5

Projected Targets for Key Metrics

Benchmarking Indicators	Pickering – Annual Targets			Darlington – Annual Targets		
	2019	2020	2021	2019	2020	2021
Safety						
Forced Loss Rate (%)	5.0	5.0	5.0	1.0	4.2	3.0
Unit Capability Factor (%)	72.6	73.4	70.6	87.8	79.4	90.9
Normalized Total Generating Cost per MWh ($/Net MWh)*	N/A	N/A	N/A	51.68	52.04	39.80
Total Generating Cost per MWh ($/Net MWh)*	78.36	74.93	81.16	64.61	73.82	64.90

* TGC/MWh and Non-Fuel Operating Cost per MWh exclude centrally held pension and OPEB costs and asset service fees to align with the industry standard.

Darlington's FLR in 2020 and 2021 is impacted by the assumed FLR for refurbished Unit 2 returning to service and is consistent with the assumptions that underpin the Darlington Refurbishment Execution Phase Business Case (Ex. D2-2-8 Attachment 1). The decline in Darlilngton's TGC/MWh in 2021 is largely explained by the expectation that two units will be subject to refurbishment in 2021. As a result there will be signficantly lower outage OM&A as there are no planned outages with the excepton of a short post refurbishment outage as described in Ex. E2-1-1.

3.5 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, the site and support groups establish and pursue improvement initiatives to close performance gaps to targets over the business planning period. The initiatives are either site specific or fleet-wide to improve efficiencies and reduce costs through process streamlining.

Among the most successful prior site specific or fleet wide initiatives were Fuel Handling Reliability, 3K3 Equipment Reliability, and the implementation of Days Based Maintenance. Attachment 4 to this exhibit provides details of these three prior initiatves and benefits realized.

Another key prior initiative was Business Transformation, which enables OPG nuclear to eliminate the gap associated with Goodnight staffing benchmarks in 2016. Business Transformation implemented a centre-led matrix organization design with centre-led functions supporting the Nuclear business unit. Organizational changes were also made within OPG Nuclear as part of the adoption of the matrix organization. Through Business Transformation, OPG Nuclear streamlined processes and identified efficiencies to manage regular headcount reductions through attrition while ensuring its facilities operate safely and reliably. Examples of such nuclear initiatives include Automate System and Component Health Reports; Stop In House Drawing Revisions; and Reduction of Non-Regulated Security Services.

OPG has experienced significant volatility in generation over the period 2008 to 2015 as discussed in Ex. E2-1-1, primarily as a result of forced outages/forced derates and forced extension of planned outages. This has resulted in annual production shortfalls and negative revenue impacts. OPG has identified fuel handling reliability, human performance errors, equipment reliability (both nuclear and conventional systems) and execution of planned outages as the primary contributors impacting reliability. The 2016-2018 Business Plan includes four key fleet wide initiatives to mitigate these primary contributors in order for OPG to achieve its generation and total generating cost per MWh targets in the Nuclear business unit. These four initiatives are as follows:

(i.) **Human Performance Initiative**: This initiative is focused on preventing human performance errors that propagate into events that have a consequential (unfavorable) impact on safety and reliability. A key focus is improving supervisory effectiveness and leadership oversight.

OPG Nuclear benchmarks its human performance against peers using an industry standard metric referred to as the 18-month Human Performance Error Rate (“HPER”) (number per 10k Industrial Safety Accident Rate hours (# per 10k ISAR hours)) (see 2015 Benchmarking Report - Attachment 1 to this exhibit). The expected benefit of improving Human Performance will be to reduce lost generation due to human error. For the 2016-2018 Business Plan, OPG is targeting a significant improvement in human performance by achieving reductions in human errors. Improved human performance as measured by HPER will contribute to enabling OPG to achieve its 2016-2018 Business Plan targeted FLR and UCF.

(ii.) **Equipment Reliability Initiative**: This initiative is focused on improving equipment reliability, which has been a major contributor to OPG’s historical FLR. The initiative is a multi-faceted Equipment Reliability Plan that focuses on People, Equipment and Processes and is measured by a new industry Equipment Reliability Index (“ERI”) to drive key performance indicators. The ERI is the North American benchmark for assessing overall equipment reliability performance. The index is an effective instrument for measuring the longer term trend of improvements and uses key leading indicators projecting degradation in plant operations or reliability of key station equipment.

(iii.) **Outage Performance Initiative**: This initiative is focused on improving planned outage performance in order to achieve business plan duration targets. The major deliverables from this initiative include seeking reduced outage durations. This will be accomplished in part by the successful completion of the Machine Delivered Scrape

("MDS"), which is the deployment of new tooling with the Universal Delivery Machine ("UDM") at Pickering. Further description of the MDS project is found in the Business Case Summary included in Ex. D2-1-3. Other deliverables are focused on improved outage execution and scheduling performance, and undertaking a feasibility study on Pickering's outage cycle.

The Outage Performance improvement initiative seeks to eliminate the potential for the occurrence of Forced Extension to a Planned Outage ("FEPO") days in the test period, to eliminate loss of production and avoid additional outage OM&A costs OPG must successfully execute this initiative in order to achieve targeted production levels.

(iv.) **Parts Improvement Initiative:** Parts availability performance directly impacts OPG's ability to schedule and execute online, outage and project work in a consistent and predictable manner. The consequences of poor parts availability could be low scope completion rates, longer outages, higher assessing, planning, and maintenance backlogs, lower equipment reliability, and ultimately, reduced capacity factors. The initiative focuses on obtaining the right parts on time, reducing churn in OPG's work management system to ultimately improve equipment reliability. The initiative targets completion of 19 deliverables by cross-functional teams involving Supply Chain, Engineering, Fleet Operations & Maintenance, and Work Management over a period of three years.

Key indicators of the initiative's overall effectiveness are Work Order with Material Request Execution, which measures the percentage of work with parts that was actually executed vs. planned for online work, and Need to Use Cycle Time (Plan to Complete) for Work Orders with Material Request, which measures the overall duration it takes to complete a job that requires a part.

Through the Parts Improvement initiative, OPG is addressing many issues contributing to cycle time and expects to see improvement in the trend in the overall duration it takes to complete a job that require parts.

The 2016-2018 Business Plan also includes two fleet wide initiatives that address additional challenges, as summarized below:

- **Inventory Reduction Initiative:** Annual station materials and supply inventory targets and surplus inventory targets have been established to optimize inventory and reduce costs by targeting half the historical growth rate for 2016. An Inventory Management Organization will be established for each station with cross-functional support provided by Engineering, Supply Chain and Finance.

  A reduction in the growth of the inventory reduces the capital invested in the inventory and reduces the potential for additional obsolescence provision. This also reduces warehousing requirements and related expenses.

- **Workforce Planning and Resourcing Initiative:** The Workforce Planning and Resourcing Initiative is designed to implement a fleet-wide resourcing strategy to meet the challenge of the widening gap between labour demand and supply, leadership capability and key resource availability to ensure safe and efficient operations of OPG's nuclear facilities, while minimizing risks to the efficient execution of Pickering Extended Operations and the DRP.

OPG's 2016-2018 Business Plan (Ex. A2-2-1 Attachment 1) sets out in its Appendix 5 the resource requirements (cost, staff and investment plans) for the Nuclear operations. The plan maintains a sustainable cost structure for OPG's Nuclear operations through cost efficiencies while focusing on initiatives to ensure safe and reliable performance.

ATTACHMENTS

Attachment 1: OPG 2015 Nuclear Benchmarking Report

Attachment 2: 2014 Goodnight Nuclear Staffing Benchmarking Analysis

Attachment 3: ScottMadden Evaluation of OPG Nuclear Benchmarking

Attachment 4: Prior Gap Closure Initiatives

Note: Attachment 2 is marked "Confidential", however, OPG has determined it to be non-confidential in its entirety or with redactions as indicated.

November 2015

ONTARIO POWER GENERATION




ONTARIO POWER GENERATION NUCLEAR

2015 NUCLEAR BENCHMARKING REPORT

Non-Confidential – For General Release

Nuclear Finance – Business Planning and Benchmarking

Table of Contents

1.0 EXECUTIVE SUMMARY

Background

This report presents a comparison of Ontario Power Generation (OPG) Nuclear's performance to that of nuclear industry peer groups both in Canada and worldwide. The report was prepared as part of OPG Nuclear's commitment to "performance informed" business management. The results of this report are used during business planning to drive top-down target setting with business improvement as the objective.

Benchmarking involves three key steps: (a) identifying key performance metrics to be benchmarked, (b) identifying the most appropriate industry peer groups for comparison, and (c) preparing supporting analyses and charts. OPG Nuclear personnel responsible for specific performance metrics assisted in the development of the supporting analyses by providing insight into the factors contributing to current OPG Nuclear performance.

Performance Indicators

Good performance indicators used for benchmarking are defined as metrics with standard definitions, reliable data sources, and utilization across a representative portion of the industry. Good indicators allow for benchmarking to be repeated year after year in order to track performance and improvement. Additionally, when selecting an appropriate and relevant set of metrics, a balanced approach covering all key areas of the business is essential. In accordance with these criteria, 20 key performance indicators have been selected for comparison to provide a balanced view of performance and for which consistent, comparable data is available. These indicators are listed in Table 1 and are divided into four categories aligned with OPG Nuclear's four cornerstones of safety, reliability, value for money, and human performance.

Industry Peer Groups

Peer groups were selected based on performance indicators widely utilized within the nuclear industry with consideration for plant technology to ensure suitable comparisons. Overall, six different peer groups were used as illustrated in Table 1 and panel members are detailed in Tables 7-12 of Section 7.0.

Table 1: Industry Peer Groups

	WANO / COG CANDUs	All North American PWR and PHWRs (WANO)	INPO AP-928 Workgroup	INPO	CEA	EUCG North American Plants (U.S. and Canada)
Safety						
All Injury Rate					X	
Rolling Average Industrial Safety Accident Rate*		X				
Rolling Average Collective Radiation Exposure*	X					
Airborne Tritium Emissions per Unit	X					
Fuel Reliability Index*	X					
2-Year Reactor Trip Rate*	X					
3-Year Auxiliary Feedwater System Unavailability*	X					
3-Year Emergency AC Power Unavailability*	X					
3-Year High Pressure Safety Injection Unavailability*	X					
Reliability						
WANO NPI	X					
Rolling Average Forced Loss Rate*	X					
Rolling Average Unit Capability Factor*	X					
Rolling Average Chemistry Performance Indicator*	X					
1-Year On-line Deficient Maintenance Backlog			X			
1-Year On-line Corrective Maintenance Backlog			X			
Value for Money						
3-Year Total Generating Cost / MWh						X
3-Year Non-Fuel Operating Cost (OM&A) / MWh						X
3-Year Fuel Cost / MWh						X
3-Year Capital Cost / MW DER						X
Human Performance						
Human Performance Error Rate				X		

* Sub-indicator of WANO NPI

Data provided by the World Association of Nuclear Operators (WANO) is the primary source of benchmarking data for operational performance (Safety and Reliability) indicators. Eleven out of the twenty benchmarking metrics have been compared to the WANO/COG CANDU panel. All WANO performance indicators are presented at the unit and plant levels except the Industrial Safety Accident Rate and Emergency AC Power Unavailability which are only measured at the plant level.

Different peer groups were used for a few of the specialized operating metrics which are not tracked through WANO. For maintenance work order backlogs, the peer group consisted of all plants participating in the Institute of Nuclear Power Operations (INPO) AP-928 working group. For human performance comparisons, data was obtained from INPO and the Canadian Electricity Association (CEA) panel was used for the All Injury Rate.

For financial performance comparisons, data compiled by the Electric Utility Cost Group (EUCG) was used. EUCG is a nuclear industry operating group and the recognized source for cost benchmark information. EUCG cost indicators are presented at the plant level and compared on a net megawatt hour generated basis (to be referred to as MWh subsequently) and on a per megawatt (MW) design electrical rating (DER) basis. The only CANDU operators reporting data to EUCG in 2014 were OPG Nuclear and Bruce Power which is not a sufficiently large panel to provide a basis for comparison; hence, the data sets were not limited to a CANDU specific panel. Should more CANDU operators choose to join EUCG in the future, comparisons to a CANDU specific panel will be reconsidered.

All data provided by the peer groups (WANO, INPO, CEA, and EUCG) is confidential. As a result, the names of comparator companies have been redacted in this non-confidential version of the 2015 Nuclear Benchmarking Report.

Of the 20 metrics listed in Table 1, three are used to provide important information regarding major operator performance. These are the WANO Nuclear Performance Index (NPI), Unit Capability Factor (UCF), and Total Generating Cost (TGC) per MWh.

Further information on benchmarking of major operators is provided in Section 6.0 of this report.

Benchmarking Results – Plant Level Summary

Table 2 provides a summary of OPG Nuclear's performance compared to benchmark results.

Table 2: Plant Level Performance Summary

Metric	NPI Max	2014 Actuals: Best Quartile	Median	Pickering	Darlington
Safety					
All Injury Rate (#/200k hours worked)		0.66	N/A[1]	0.22	0.31
Rolling Average[2] Industrial Safety Accident Rate (#/200k hours worked)	0.20	0.00	0.02	0.03	0.06
Rolling Average[2] Collective Radiation Exposure (Person-rem per unit)	80.00	42.25	61.60	82.24	69.06
Airborne Tritium Emissions (Curies) per Unit[3]		1,014	2,410	2,390	1,831 ⇩
Fuel Reliability Index (microcuries per gram)	0.000500	0.000001	0.000001	0.001580 ⇩	0.000158 ⇧
2-Year Reactor Trip Rate (# per 7,000 hours)	0.50	0.00	0.05	0.36	0.00
3-Year Auxiliary Feedwater System Unavailability (#)	0.0200	0.0000	0.0015	0.0181	0.0000
3-Year Emergency AC Power Unavailability (#)	0.0250	0.0001	0.0024	0.0000	0.0000
3-Year High Pressure Safety Injection Unavailability (#)	0.0200	0.00000	0.00003	0.0000	0.0000
Reliability					
WANO NPI (Index)		92.9	85.8	64.3	92.1 ⇩
Rolling Average[2] Forced Loss Rate (%)	1.00	1.03	1.29	10.08	2.85
Rolling Average[2] Unit Capability Factor (%)	92.0	89.44	86.49	74.50	89.41
Rolling Average[2] Chemistry Performance Indicator (Index)	1.01	1.00	1.00	1.04 ⇧	1.00
1-Year On-line Deficient Maintenance Backlog (work orders per unit)		159	212	276 ⇩	176 ⇩
1-Year On-line Corrective Maintenance Backlog (work orders per unit)		11	20	160	20 ⇧
Value for Money					
3-Year Total Generating Cost per MWh ($ per Net MWh)		38.71	44.61	67.93	37.73
3-Year Non-Fuel Operating Cost per MWh ($ per Net MWh)		22.68	25.83	56.94	28.55
3-Year Fuel Cost per MWh ($ per Net MWh)		8.08	8.79	5.74	5.13
3-Year Capital Cost per MW DER (k$ per MW)		49.08	63.95	34.20	31.30
Human Performance					
18-Month Human Performance Error Rate (# per 10k ISAR and contractor hours)		0.00200	0.00400	0.00890	0.00620

Notes
1. No median benchmark available.
2. Indicates a 2-Year Rolling Average for Pickering and a 3-Year Rolling Average for Darlington.
3. 2012 data is used because 2013 and 2014 results were unavailable at the time of benchmarking.

Green = maximum NPI results achieved or best quartile performance
White = 2nd quartile performance
Yellow = 3rd quartile performance
Red = 4th quartile performance

⇩ Declining Benchmark Quartile Performance vs. 2013
⇧ Improving Benchmark Quartile Performance vs. 2013

Since achievement of maximum WANO Nuclear Performance Index (NPI) results is recognized within the industry as a measure of desirable performance, performance gaps are assessed against full WANO NPI result thresholds in addition to median and best quartile performance. Green shaded boxes indicate that maximum WANO NPI performance results were achieved or that performance is at or better than the best quartile threshold. White shaded boxes indicate that performance is between the best quartile and is at or better than median thresholds. Yellow shaded boxes indicate that performance is between the median and is at or better than worst quartile thresholds. Red shaded boxes indicate that performance is below the worst quartile threshold. Table 2 also identifies, by Nuclear cornerstone, where there has been either improving or declining benchmarking quartile performance relative to 2013 benchmarking results.

For Safety, overall, OPG's nuclear generating stations continue to demonstrate strong performance. OPG Nuclear continues to demonstrate strong performance for the All Injury Rate and the Industrial Safety Accident Rate. Pickering improved in several Safety cornerstone metrics such as the All Injury Rate, Reactor Trip Rate, Emergency AC Power Unavailability and the High Pressure Safety Injection Unavailability. Although the Pickering station ranked in the last quartile for Collective Radiation Exposure, its performance has drastically improved since the 2012 results. Darlington achieved maximum NPI results or best quartile performance for all NPI sub-metrics under the Safety cornerstone. The Airborne Tritium Emissions indicator saw a decline in industry benchmark ranking due to an increase in heavy water leaks and the unavailability of the Tritium Removal Facility. Pickering and Darlington continue to improve their Reactor Trip Rate performance.

For Reliability, Pickering remained in the fourth quartile in 2014 when compared to other CANDU plants for the WANO Nuclear Performance Index, Forced Loss Rate (FLR) and Unit Capability Factor (UCF) but improved to third quartile for the Chemistry Performance Indicator. Industry best quartile performance for NPI results significantly improved in 2014. Although Darlington NPI performance improved overall, the station ranking fell from industry top quartile in 2013 to second quartile in 2014. Darlington FLR performance remained in the third quartile and second quartile for UCF when compared to 2013. The Darlington Chemistry Performance Indicator once again remained in the top quartile and achieved maximum NPI points. As for the On-line Deficient Maintenance Backlogs, Darlington fell to the second quartile ranking due to the improved best quartile in 2014 while Pickering fell to the third quartile ranking. Darlington improved to second quartile ranking for the On-line Corrective Maintenance backlogs in 2014.

Under the Value for Money cornerstone, Pickering remained in the worst quartile for performance in Total Generating Cost (TGC) per MWh and Non-Fuel Operating Cost (NFOC) per MWh. Pickering sustained best quartile performance in Fuel Cost per MWh and Capital Cost per MW DER. Darlington's TGC per MWh maintained best quartile performance in 2014. Third quartile performance in NFOC per MWh was offset by sustained top quartile performance in Fuel Cost per MWh and Capital Cost per MW DER at Darlington in 2014. Darlington had the second lowest Fuel Cost per MWh in its industry peer group, followed by Pickering (third lowest).

In the area of Human Performance, Pickering and Darlington improved their human performance error rate in 2014 and remained in the same quartiles as in 2013.

Report Structure

Sections 2.0 to 5.0 of the report focus on the four OPG Nuclear cornerstone areas, with detailed comparisons at the plant, and where applicable, unit level. Each indicator is displayed graphically from best to worst plants/units (in bar chart format) for the most recent year in which data is available. Zero values are excluded from all calculations except where zero is a valid result.

Next, the historical trend is graphed (in line chart format) using data for the last few years (depending upon availability and metric). Each graph also includes median and best quartile results, and for some WANO operating metrics, the values required to achieve full WANO NPI results.

Following the graphical representation, performance observations are documented as well as insights into the key factors driving performance at OPG's nuclear generating stations.

Section 6.0 of the report provides an operator level summary across a few key metrics. The operator level analysis looks at fleet operators, primarily across North America, utilizing a simple average of the results (mean) from each of their units/plants. Operations related (WANO NPI and UCF) results were averaged at the unit level and cost related (TGC per MWh) results were averaged at the plant level. The list and ranking of operators, for the Nuclear Performance Index and Unit Capability Factor, have been updated to reflect industry developments.

Section 7.0 provides an appendix of supporting information, including common acronyms, definitions, panel composition details and a WANO NPI plant level performance summary of OPG nuclear stations against the North American panel.

2.0 SAFETY

Methodology and Sources of Data

The majority of safety metrics were calculated using data from WANO. Data labelled as invalid by WANO was excluded from all calculations. Indicator values of zero are not plotted or included in calculations except in cases where zero is a valid result. Current data is obtained and consolidated with previous benchmarking data.

The All Injury Rate was calculated using data from the Canadian Electricity Association (CEA). Median information and individual company information was not available for this metric; therefore, only trend and best quartile information is presented. The peer group for this metric is limited to Group I members of CEA for 2011-2014 and Group I and II members for the 2009-2010 period (Section 7.0, Table 10).

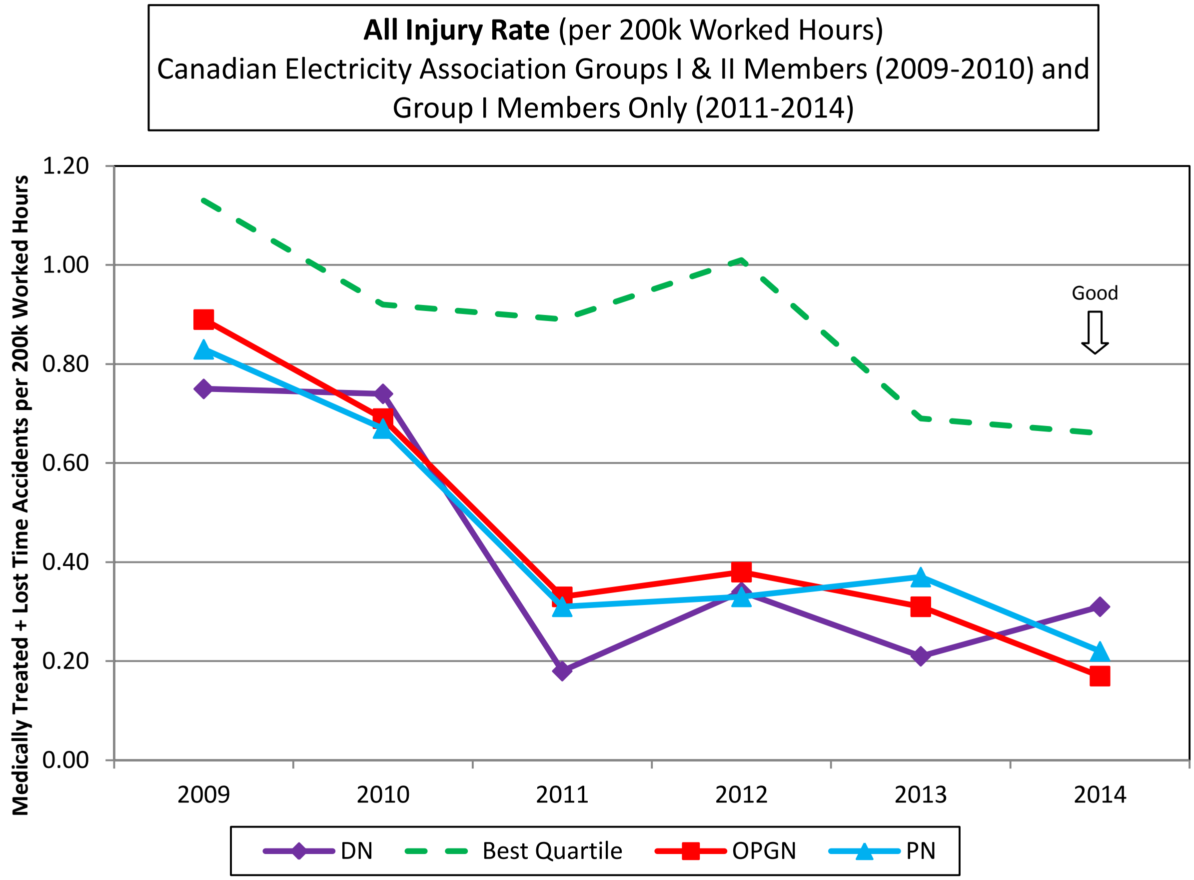
Airborne Tritium Emissions per unit data was collected from the CANDU Owners Group (COG) for 2009 to 2012 as displayed in the historical trend line chart. Industry data for 2013 and 2014 was unavailable at the time of benchmarking. The peer group for this metric is all CANDUs who are members of COG. The bar chart associated with this metric displays graphically the plant performance from best to worst results using 2014 data for OPG stations and 2012 data (most recent benchmark data) for all other benchmarked stations that were in service over that period of time.

Discussion

Nine metrics are included in this benchmarking report to reflect safety performance, including seven of the ten metrics which comprise the WANO Nuclear Performance Index: Industrial Safety Accident Rate, Collective Radiation Exposure, Fuel Reliability Index, Unplanned Automatic Reactor Trips, Auxiliary Feedwater Safety System Unavailability, Emergency AC Power Safety System Unavailability, and High Pressure Safety Injection Unavailability. The remaining WANO NPI metrics are included in Section 3.0 under the Reliability cornerstone. In addition to the WANO sub-indicators listed above, the CEA All Injury Rate and the COG Airborne Tritium Emissions per unit are included in this section of the report.

In 2014, OPG Nuclear's performance for the All Injury Rate (AIR) was excellent, achieving the lowest AIR in the history of the company while also achieving top quartile performance. Pickering continued to show maximum WANO NPI results or top quartile performance for five other metrics under the Safety cornerstone, second quartile performance for one indicator, and worst quartile performance for the Collective Radiation Exposure and the Fuel Reliability Index. Darlington showed very strong performance, achieving maximum NPI results (and/or best quartile ranking for 2014) for all NPI safety metrics. Darlington Airborne Tritium Emissions declined to second quartile in 2014 (previously top quartile in 2013) due to an increase in heavy water leaks and the unavailability of the Tritium Removal Facility.

All Injury Rate



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Attachment 1
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Observations – All Injury Rate (AIR) (Canadian Electricity Association – CEA)

2014 (Annual Value)

- Pickering, Darlington, and OPG Nuclear as a fleet all performed better than the CEA top quartile by a significant margin.
- In 2014, OPG Nuclear achieved its lowest AIR in the history of the company.
- Pickering's AIR injuries decreased from seven in 2013 to four in 2014.
- Darlington's AIR injuries slightly increased from three in 2013 to four in 2014.
- OPG benchmarks against CEA Group 1 (a sub-set of all CEA members), which incorporates 13 organizations, including most provincial utilities with more than 1500 employees.

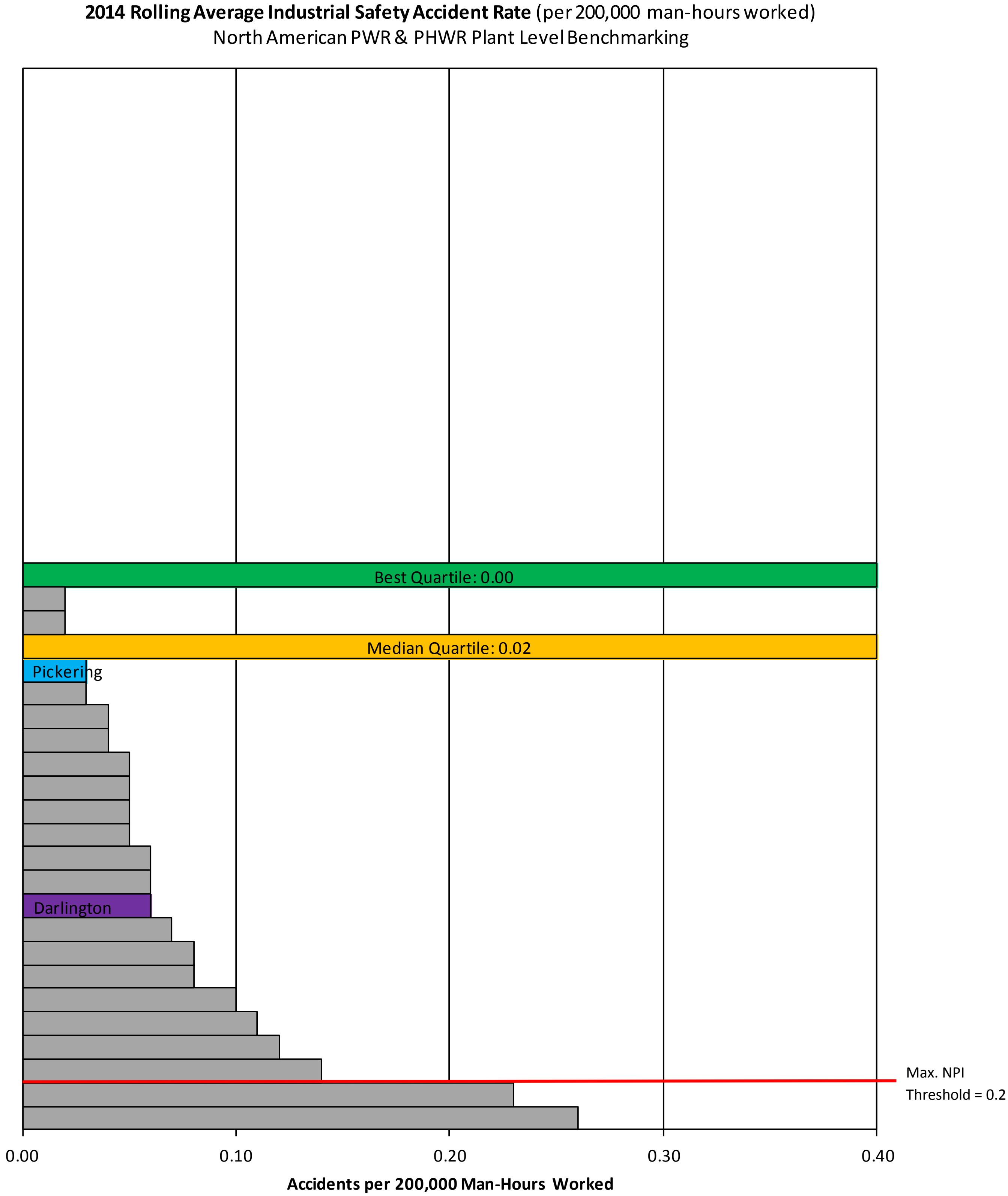
Trend

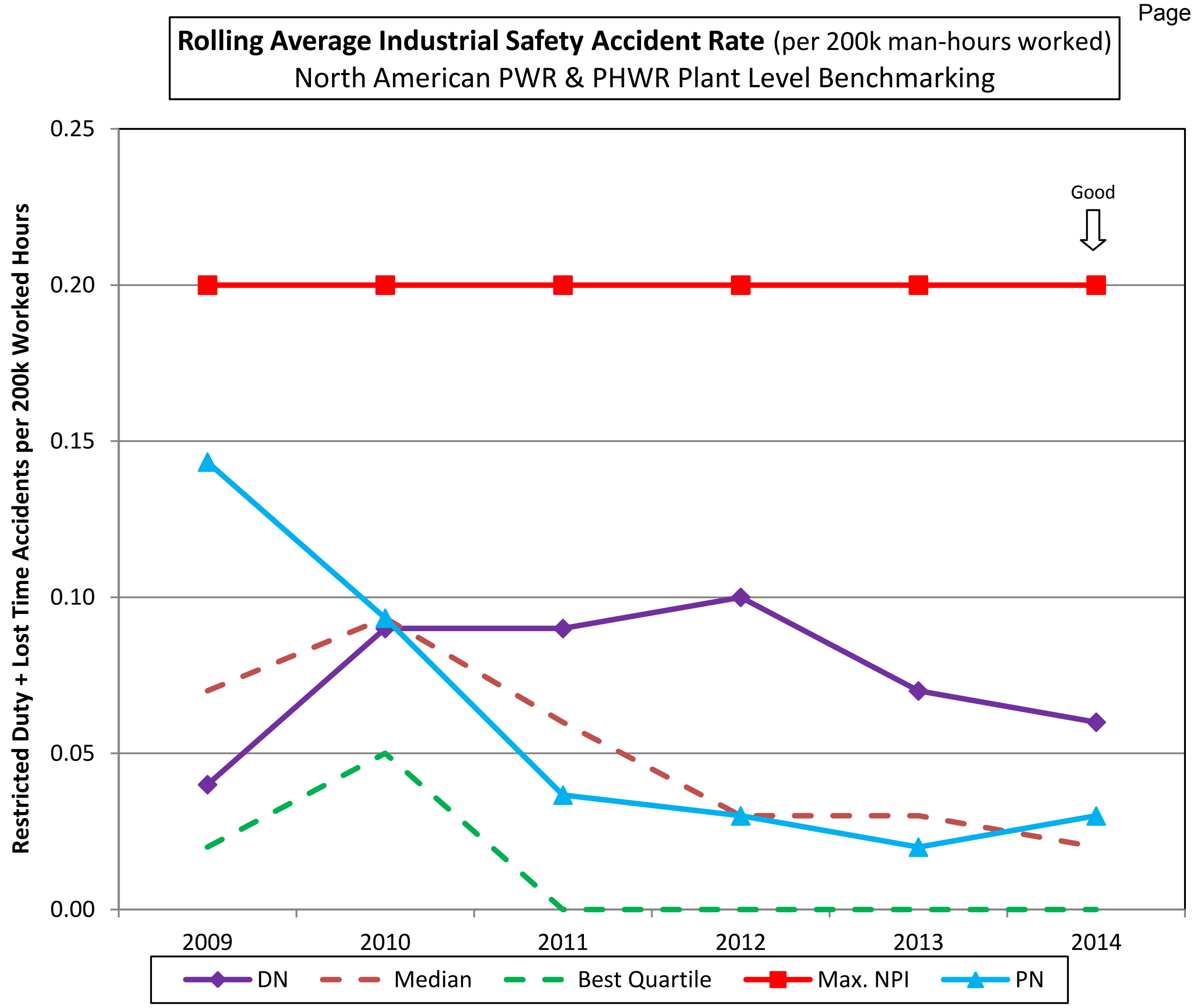
- Pickering, Darlington and OPG Nuclear as a fleet have all shown significant step improvements in performance over the last six years.
- OPG Nuclear recorded its best AIR results ever in 2014, with performance continually improving each year since 2012.
- Industry best quartile has overall improved over the last six years, though not to the same degree as OPG Nuclear.

Factors Contributing to Performance

- OPG encourages a proactive reporting culture that seeks to identify hazards and address them, before they lead to employee injuries. Proactive reporting is tracked, trended and managed via the Station Condition Record process.
- OPG Nuclear largely attributes its favourable AIR performance in the past five years to a significant reduction in the number of musculoskeletal disorder (MSD) injuries, also known as repetitive strain injuries. As a result, OPG Nuclear's MSD reduction program has been benchmarked by other industry peers.
- OPG Nuclear implemented a similar program to improve "Situational Awareness" which works to support employees in identifying and addressing changing and/or distracted work conditions that could lead to hazardous situations. Since its inception in 2013, OPG Nuclear's AIR has dropped by 39% (0.31 down to 0.17).
- To complement its successful Safety Program, OPG launched the Total Health Program in 2014. This program supports employees and their families in their efforts to achieve an optimal level of health and functioning, primarily through health education, health promotion, disease and injury prevention, and crisis intervention. The Total Health Program incorporates mental health as a key component.

Rolling Average Industrial Safety Accident Rate




Rolling Average Industrial Safety Accident Rate (per 200k man-hours worked)
North American PWR & PHWR Plant Level Benchmarking
Restricted Duty + Lost Time Accidents per 200k Worked Hours
0.25
0.20
0.15
0.10
0.05
0.00
Good
2009
2010
2011
2012
2013
2014
DN
Median
Best Quartile
Max. NPI
PN

Observations – Rolling Average Industrial Safety Accident Rate (ISAR) (World Association of Nuclear Operators - WANO)

2014 (Rolling 2 Year Average Pickering, Rolling 3 Year Average Darlington)

- The Industrial Safety Accident Rate (ISAR) incorporates all lost time injuries and restricted work injuries incurred by OPG employees working on the site.
- For reporting the ISAR, a 2-year rolling average was used for all panel members with the exception of the Darlington station which follows a 3-year outage cycle. This is consistent with the World Association of Nuclear Operators (WANO) Nuclear Performance Index (NPI) reporting guidelines.
- WANO top quartile in 2014 remained unchanged from 2013 at 0.00 (i.e. zero ISAR events). Median performance was 0.02, which was a decrease from 0.03 in 2013.
- Both Pickering and Darlington achieved maximum NPI points for the ISAR in 2014.
- Pickering ISAR performance degraded from 2013 to 2014 (0.02 to 0.03).
- Darlington ISAR performance improved from 2013 to 2014 (0.07 to 0.06).
- Darlington and Pickering ISAR did not meet the WANO median or top quartile in 2014.

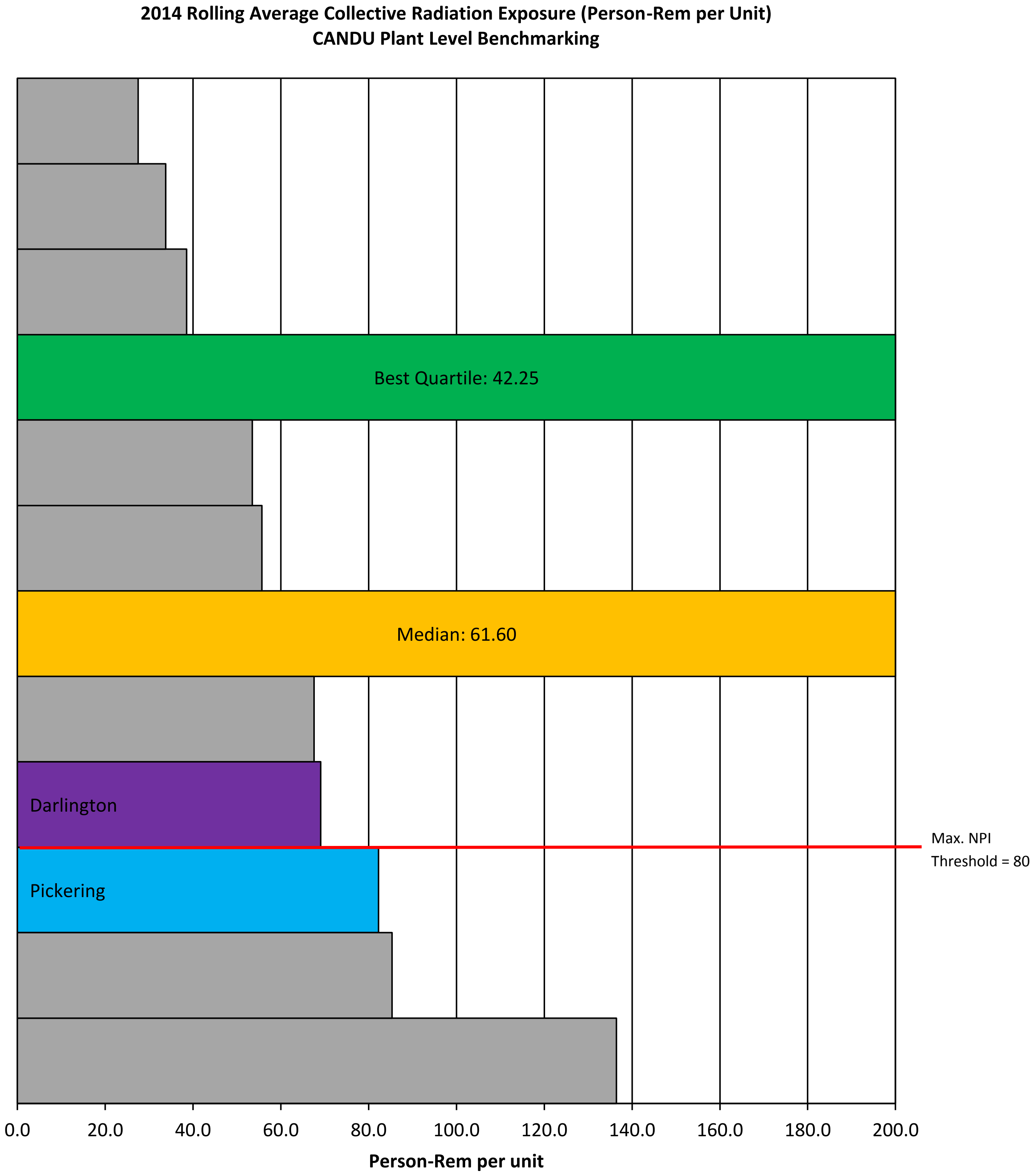
Trend

- The ISAR median has steadily improved over the past six years. The industry best quartile has been at zero for the past four years.
- Darlington’s ISAR rolling average has slightly decreased over the past 2 consecutive years, and currently stands at 0.06. This is attributed to lower/same number of injuries and higher personnel hours worked.
- Darlington had only 1 ISAR injury in 2014, contributing to an improvement in the ISAR rolling average from 2013 to 2014.
- Pickering’s ISAR rolling average increased slightly from 0.02 in 2013 to 0.03 in 2014 but has overall trended downward (i.e. improved) in the past four years. This is attributed to additional personnel hours worked and an overall reduction in the number of ISAR injuries in 2012 and 2013.

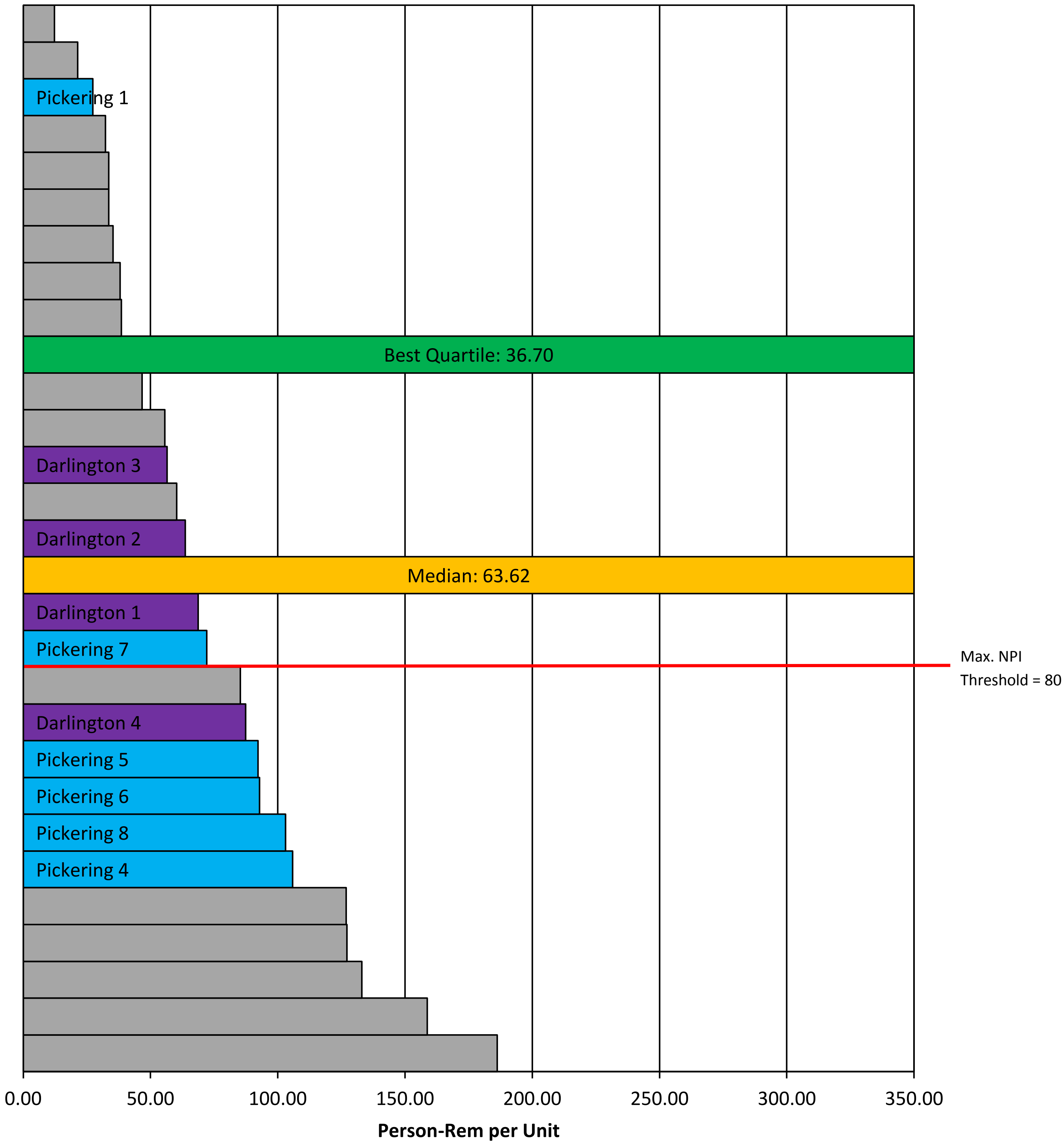
Factors Contributing to Performance

- ISAR is a measure of “permanent utility personnel” and does not include contractors. Many of the utilities in the benchmarking group utilize contractors to a greater extent than OPG Nuclear for higher risk work activities (e.g. outages). Therefore this can negatively impact OPG Nuclear’s ISAR in comparison to the reported industry benchmark quartiles.
- OPG Nuclear continues to monitor performance trends in the area of conventional safety and implements action plans to support continuous improvement. An ongoing major initiative is to improve “Situational Awareness”, which works to support employees in identifying and addressing changing and/or distracted work conditions that could lead to hazardous situations.

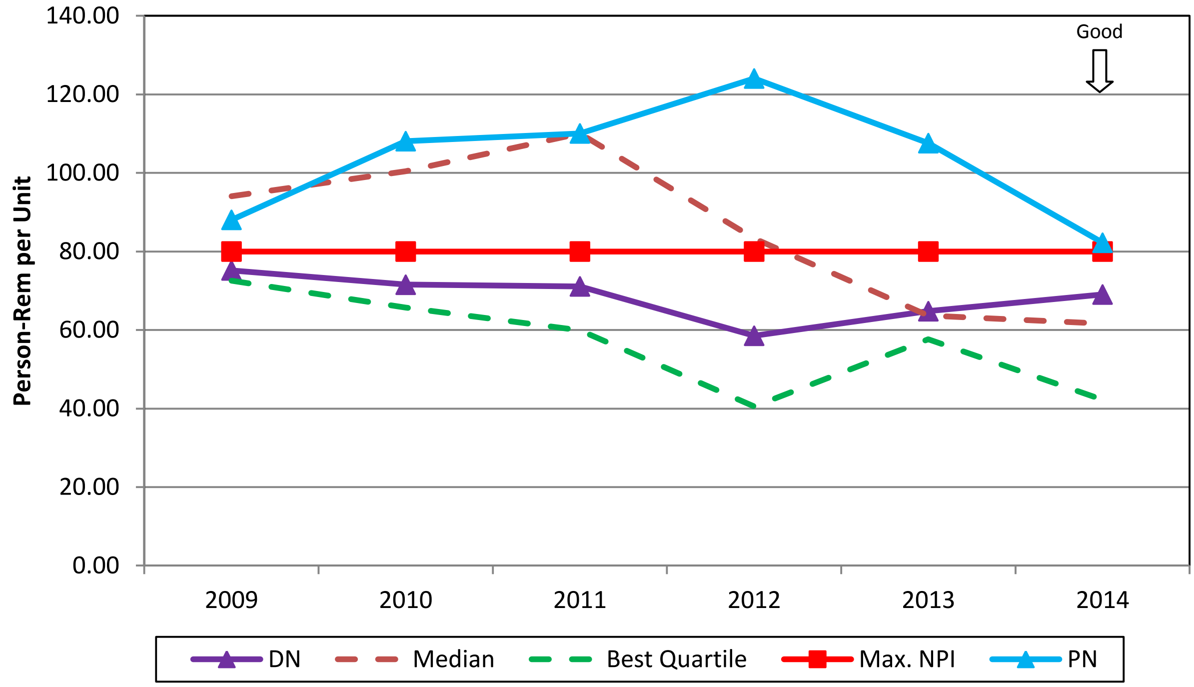
Rolling Average Collective Radiation Exposure



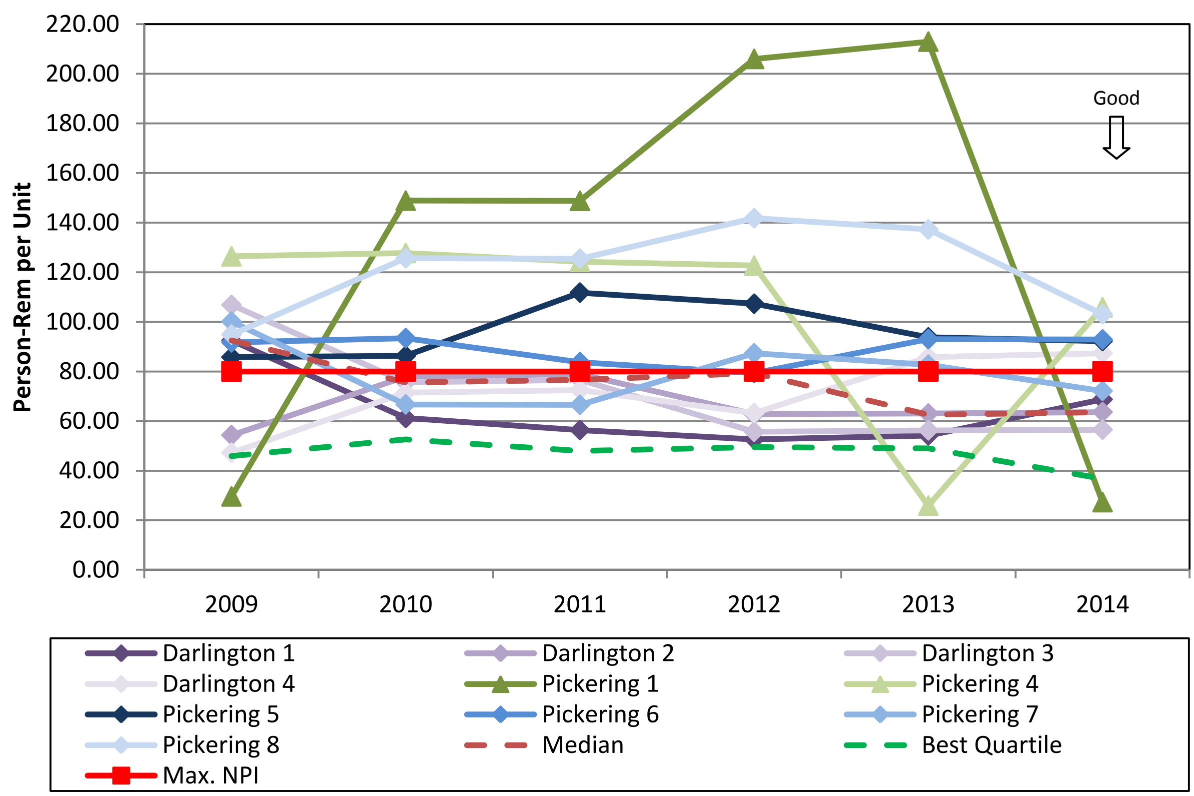
2014 Rolling Average Collective Radiation Exposure (Person-Rem per Unit)
CANDU Unit Level Benchmarking



Rolling Average Collective Radiation Exposure (Person-Rem per Unit)
CANDU Plant Level Benchmarking



Rolling Average Collective Radiation Exposure (Person-Rem per Unit)
CANDU Unit Level Benchmarking



Observations – Rolling Average Collective Radiation Exposure (CANDU)

- Collective Radiation Exposure (CRE) is an industry composite indicator encompassing external and internal collective whole body radiation dose.
- Darlington follows a 3-year outage cycle and Pickering and other panel members are on a 2-year outage cycle to define the CRE performance for a given year. The following factors play a significant role in the CANDU reactors' CRE performance: planned outage scope and duration, tritiated ambient air in accessible and access controlled areas, effectiveness of mitigation measures and initiatives being implemented to reduce identified sources of radiological hazards, and human performance during execution of radiological tasks.

2014 (Rolling 2 Year Average Pickering, Rolling 3 Year Average Darlington)

- The Pickering plant level rolling average dose performance of 82.24 person-rem/unit was worse than the industry median of 61.60 person-rem/unit.
- The Pickering unit level rolling average performance was better than best quartile for Unit 1 but worse than the industry median of 63.62 person-rem/unit for Units 4, 5, 6, 7 and 8.
- Planned outage scope and duration significantly contributed to this level of plant and unit rolling average CRE performance. There was no major planned outage on Unit 1 in 2013 and 2014. In general, Pickering has three major planned outages per year; Darlington averages 1.3 outages per year over the three year outage cycle.
- The Darlington plant level rolling average dose performance was 69.06 person-rem/unit achieving maximum NPI points. This result is worse the industry median value of 61.60 person-rem/unit.
- The Darlington unit level rolling average dose performance was better or equal to the industry median value of 63.62 person-rem/unit with 63.62 person-rem/unit for Unit 2 and 56.52 person-rem/unit for Unit 3. Units 1 and 4 were worse than the median with 68.73 and 87.36 person-rem/unit respectively.

Trend

- Industry median performance has been steadily improving since 2011 whereas the best quartile performance during the same time period has trended around an average value of 50 person-rem/unit.
- Pickering plant level performance has improved sharply since 2012. The gap between Pickering performance and median has been cut by > 50% since 2012. The rolling average is still worse than median due to scope increases during outages and long outage duration.
- Pickering unit level performance has remained relatively flat with the following exceptions: Unit 1 rolling average CRE has improved sharply since 2013 due to no major planned outage on that unit in 2013 and 2014. Unit 8 rolling average CRE has improved since 2013 due to good dose performance and lower than expected dose rates during the 2014 Pickering Unit 8 outage.

Factors Contributing to Performance - Rolling Average Collective Radiation Exposure (CANDU)

- The Darlington plant level dose performance has been increasing since 2012 and because the median value has significantly decreased (i.e. improved) in the same time period, Darlington now finds itself above the industry median. This performance is due to increased outage scope, including both planned and unplanned outages. Units 1-3 have performed near the industry median, while Unit 4, for both 2013 and 2014, has been well over due to dose from planned and unplanned outages.

Best Practices

- The following list represents common practices that demonstrate continuous improvement and help maintain good CRE performance for CANDU type reactors:
    - Robust Site As Low As Reasonably Achievable (ALARA) Committee, chaired by Facility Senior Vice President
    - Reactor face shielding to reduce dose rates
    - Use of full size vault platforms to improve workflow
    - Teledosimetry
    - Process fluid detritiation
    - Use of Munters driers to enhance existing measures to minimize ambient airborne tritium levels
    - Optimization of Fuelling Machine purification using Ion Exchange with annual resin replacement and/or sub-micron filters
    - Sub-micron filtration in the Primary Heat Transport system
    - Use of independent radiological oversight for higher risk work to improve human performance during execution of radiological tasks
    - Daily accounting of dose, and work group focus on Radiation Protection Fundamentals.
- OPG establishes internal administrative dose limits to ensure that dose to each exposed individual is managed and maintained well below individual regulatory limits.

Initiatives

- OPG Nuclear fleet-wide and site specific initiatives have been implemented to incorporate the industry best practices noted above.
- Specific key site initiatives are described below.

Pickering

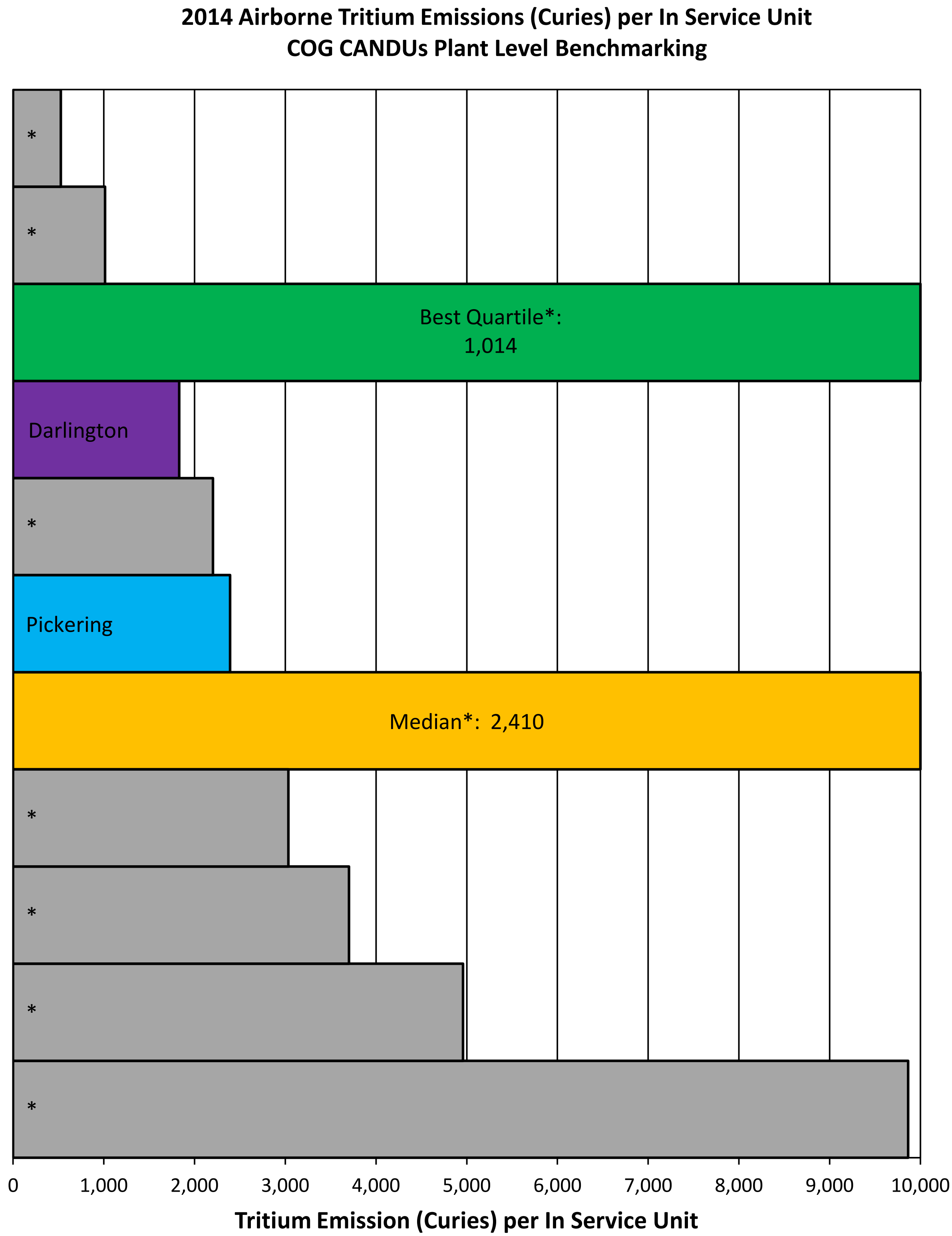
- Source term reduction, including improvements to process fluid filtration, a dose reducing resin trial, and detritiation.
- Source term mitigation, including optimization of shielding for reactor face work, improvements to the shielding canopy for reactor face work, and dryer modifications for improved performance and reliability.
- Human performance, including involvement and oversight by Radiation Protection staff of work with elevated radiation risk.

Factors Contributing to Performance - Rolling Average Collective Radiation Exposure (CANDU) (CONT'D)

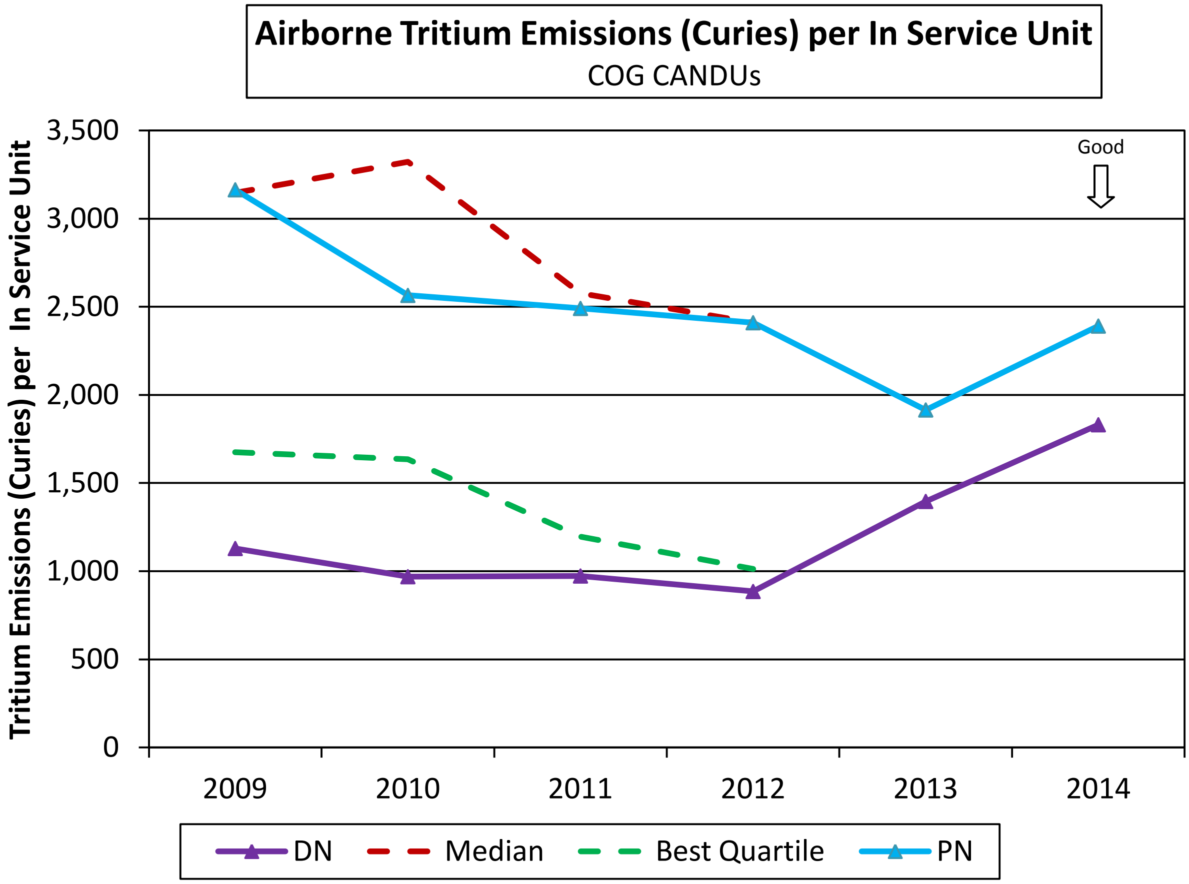
Darlington

- The early efforts in source term reduction are generating lasting effects. A reduction of coolant pH factors from 10.8 to 10.1 minimizes crud migration from boilers to inlet feeders. The installation of sub micron heat transport filters effectively reduces the dose rates in the heat transport system and has contributed to the success of Darlington's external dose.
- Developed and implemented a reactor face shielding strategy to reduce dose while at the same time minimize the risks of personnel injury during shielding installation.
- Implemented an improved feeder ice jacket including the application of long handled tools for jacket installation and remote data acquisition.
- Effectively utilized Teledosimetry to reduce Radiation Protection Coordinator dose. Utilized Teledosimetry as a coaching tool to improve worker radiation protection practices and reduce dose.
- Tritium mitigation strategies have been developed and implemented to reduce air-borne tritium concentrations inside containment.
- Work Group specific dose reduction initiatives have been developed and implemented by line management.

Airborne Tritium Emissions per In Service Unit



* Industry data based on 2012 as it is the best available information at the time. Pickering and Darlington results are 2014.



Note: Median and Best Quartiles are plotted till 2012 as the 2013 and 2014 results were unavailable at the time of benchmarking.

Observations – Airborne Tritium Emissions (Curies) per In Service Unit

2014 (Annual Value)

- The 2012 industry results collected from the CANDU Owners Group (COG) for non-OPG facilities are included in this report as the most up to date figures available for benchmarking performance.
- Tritium emissions from each OPG facility for 2014 are compared per in service reactor unit.
- Curies per in service unit at top quartile CANDU plants was 1,014 or lower.
- Both Pickering and Darlington performed better than the industry median threshold of 2,410 Curies per in service unit.
- Darlington’s results include emissions from the Tritium Removal Facility averaged over the 4 units at Darlington.

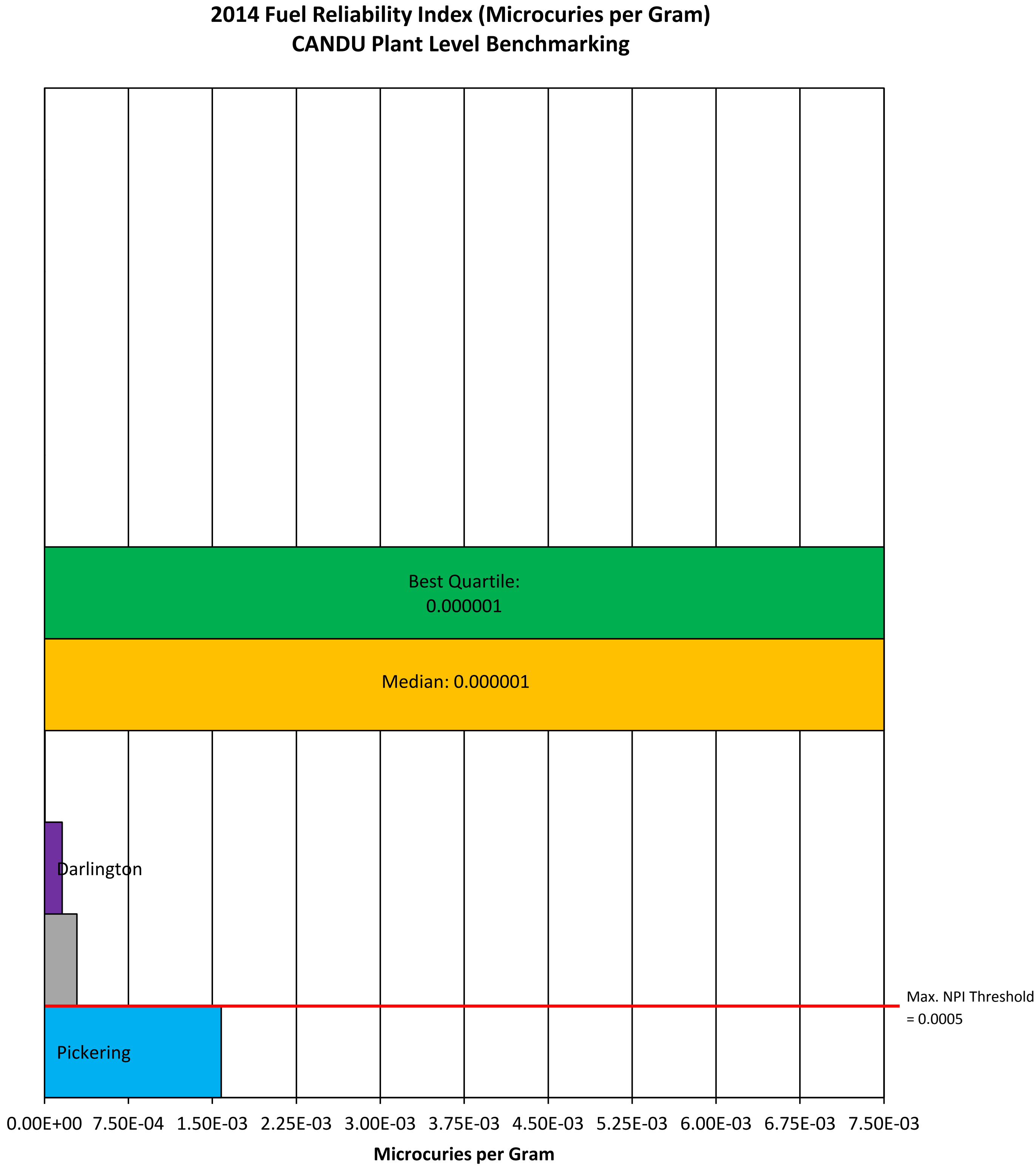
Trend

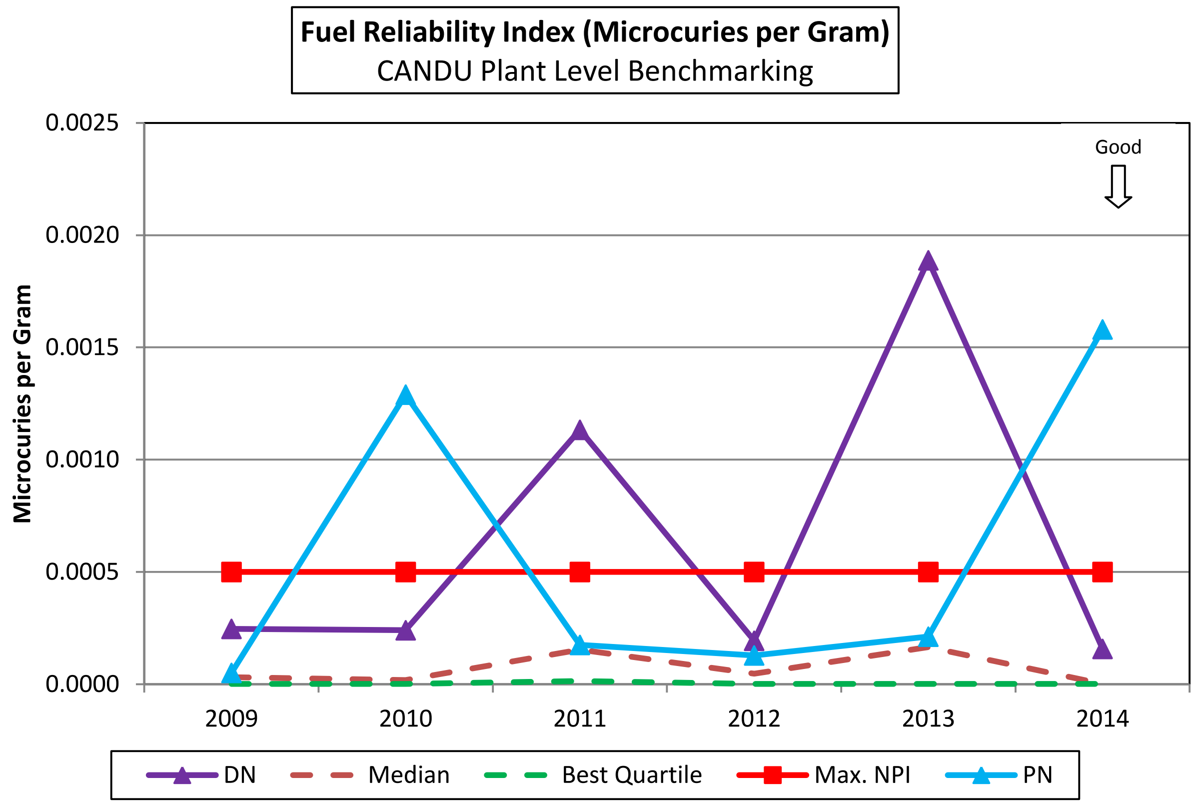
- Pickering achieved best Airborne Tritium Emissions performance in 2013 as a result of increased focus on dryer performance, leak management and source term reduction.
- In 2014, an upward trend in performance at both Pickering and Darlington was observed due to heavy water leaks, poor vapour recovery dryer performance and unavailability of the Tritium Removal Facility (see below).
- Tritium emissions to air continue to be less than one per cent of the regulatory limit.
- The industry trend line graph to 2012 shows that industry best quartile performance continues to trend downward.
- The industry median improved in 2011 largely due to major reductions in emissions from a COG CANDU plant.

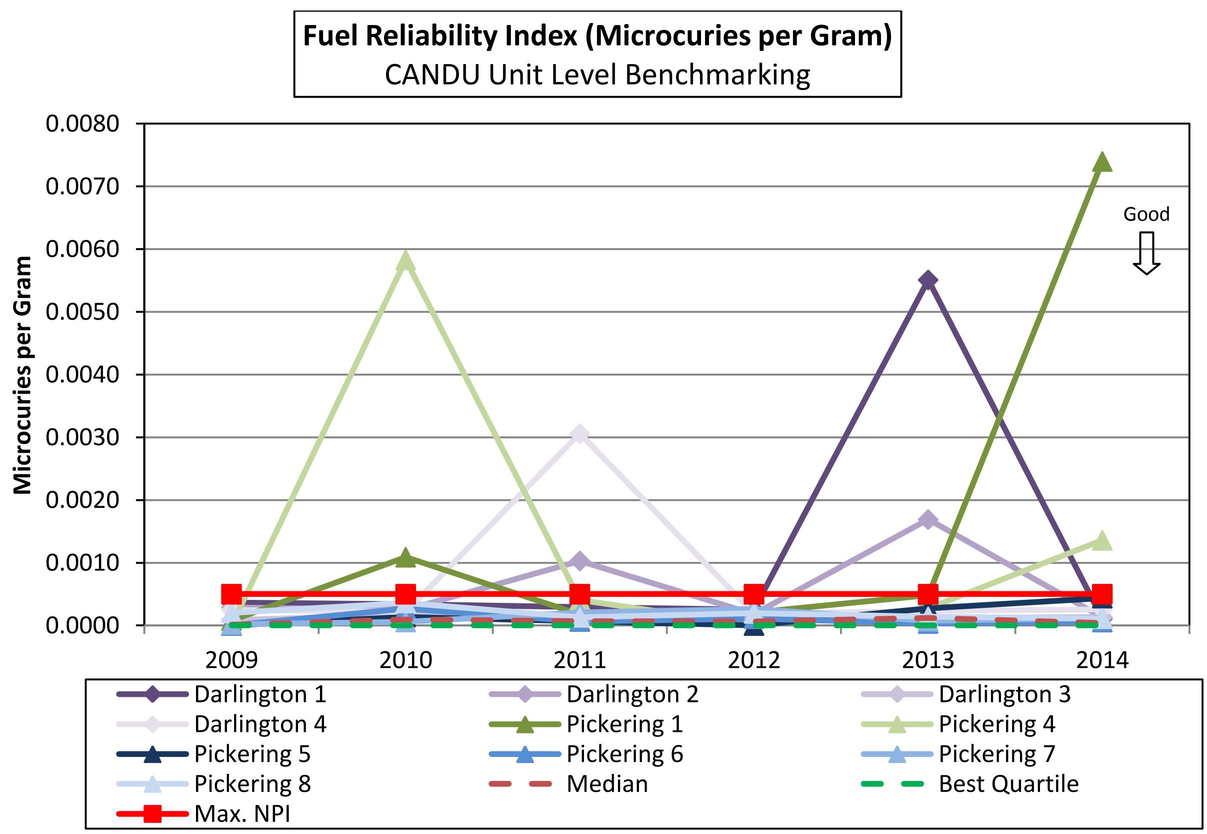
Factors Contributing to Performance

- Key factors affecting performance at Pickering and Darlington include the following:
    - leaks within containment requiring outages for repair,
    - poor vapour recovery dryer performance,
    - operational issues of the Tritium Removal Facility impacting its availability,
    - increased unit source term.
- Station focus on tritium emission reduction initiatives include dedicated teams to ensure daily emissions monitoring, heat exchanger cleaning and continuous operation of confinement dryers, heavy water leaks minimization, and improved availability and performance of releases from the Tritium Removal Facility at the Darlington site.
- Other improvement initiatives include OPG’s participation in COG environmental benchmarking of selected CANDU stations to determine the best environmental practices.

Fuel Reliability Index




Fuel Reliability Index (Microcuries per Gram)
CANDU Plant Level Benchmarking
Microcuries per Gram
0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
2009
2010
2011
2012
2013
2014
Good
DN
Median
Best Quartile
Max. NPI
PN


Fuel Reliability Index (Microcuries per Gram)
CANDU Unit Level Benchmarking
Microcuries per Gram
0.0080
0.0070
0.0060
0.0050
0.0040
0.0030
0.0020
0.0010
0.0000
2009
2010
2011
2012
2013
2014
Good
Darlington 1
Darlington 2
Darlington 3
Darlington 4
Pickering 1
Pickering 4
Pickering 5
Pickering 6
Pickering 7
Pickering 8
Median
Best Quartile
Max. NPI

Observations – Fuel Reliability Index (CANDU) (FRI)

2014 (Most Recent Operating Quarter)

- The CANDU plant and unit Fuel Reliability Index (FRI) median and top quartile values are 0.000001 microcuries per gram.
- The Pickering plant level of performance for the most recent quarter was worse than the CANDU plant median FRI (0.00158015 vs 0.000001).
- The Darlington plant level of performance for the most recent quarter was worse than the CANDU plant median FRI (0.0001575 vs 0.000001) but still achieved maximum NPI points.
- At Darlington, four fuel defects manifested in early 2014. A team was formed to investigate the issue and actions to improve fuel performance margins were developed and are being progressed. The station has been defect free since September 2014. The major actions to improve fuel performance margins are to manage the fueling of heavier bundles, to reduce the fuel density by a small amount and to increase internal pellet-to-clad clearances by a small amount.

Trend

- The Pickering station FRI score trended higher (worsening performance) due to increasing incidents of fuel defects occurring at Pickering in the fourth quarter of 2014. Defects were observed in three units overall through the year.
- The Darlington station FRI score trended lower (improved performance) in the fourth quarter of 2014 as the reactors have been defect free since September 2014 achieving maximum NPI points in the process.

Factors Contributing to Performance

- Fuel defects existed in three units in Pickering in 2014. A team has been formed to investigate the fuel defects incidents and a corrective action plan has been prepared to address the problem.
- Pickering and Darlington employ common practices used by top operating plants to improve fuel performance:
    - Reduction of foreign material in the heat transport system.
    - Conservative operation of fuel power and power ramping.
    - Quality practices during fuel manufacture.
    - Careful monitoring via inspection programs and continuous improvement programs.

2-Year Unplanned Automatic Reactor Trips

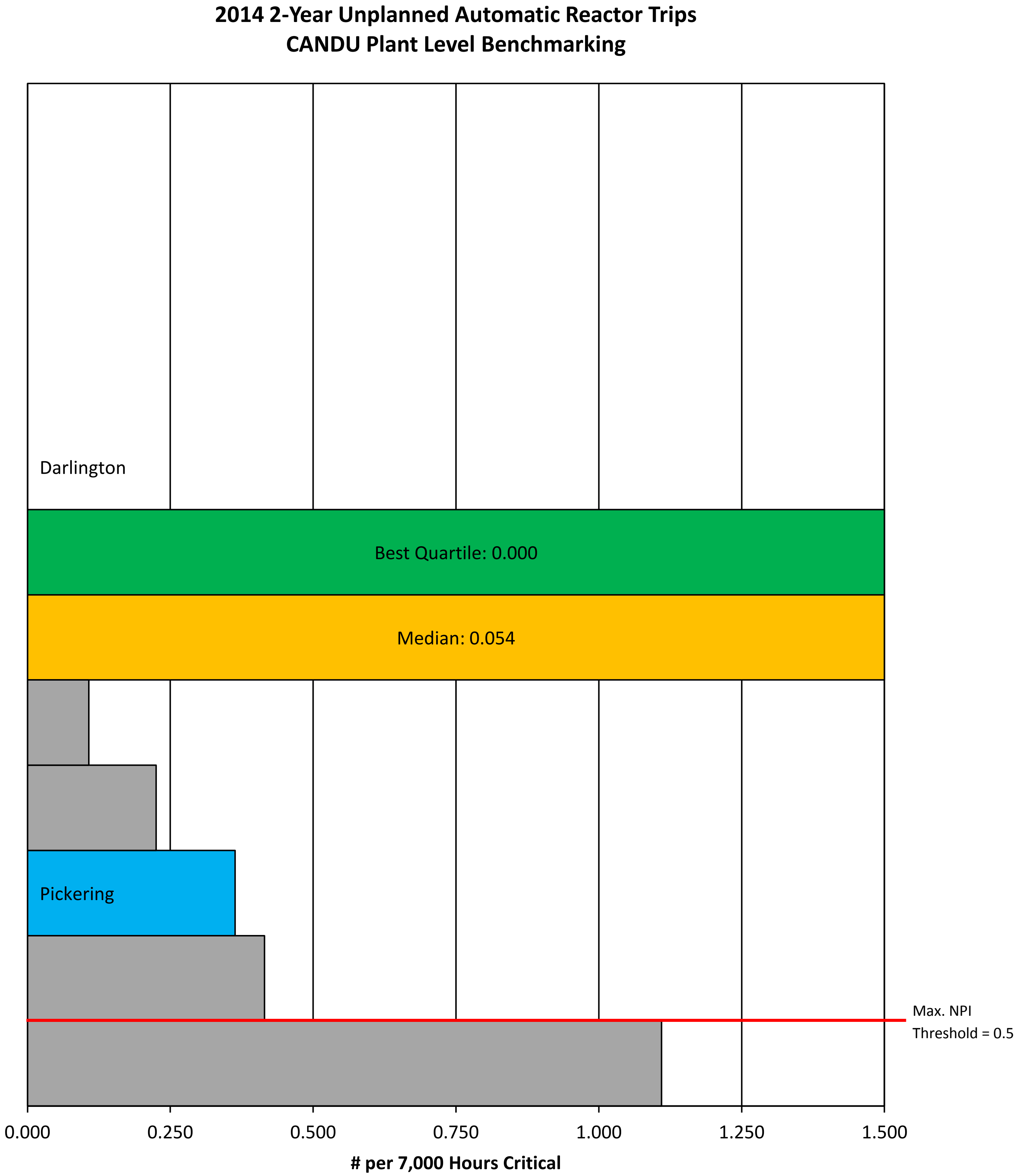


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Exhibit F2-1-1
Attachment 1
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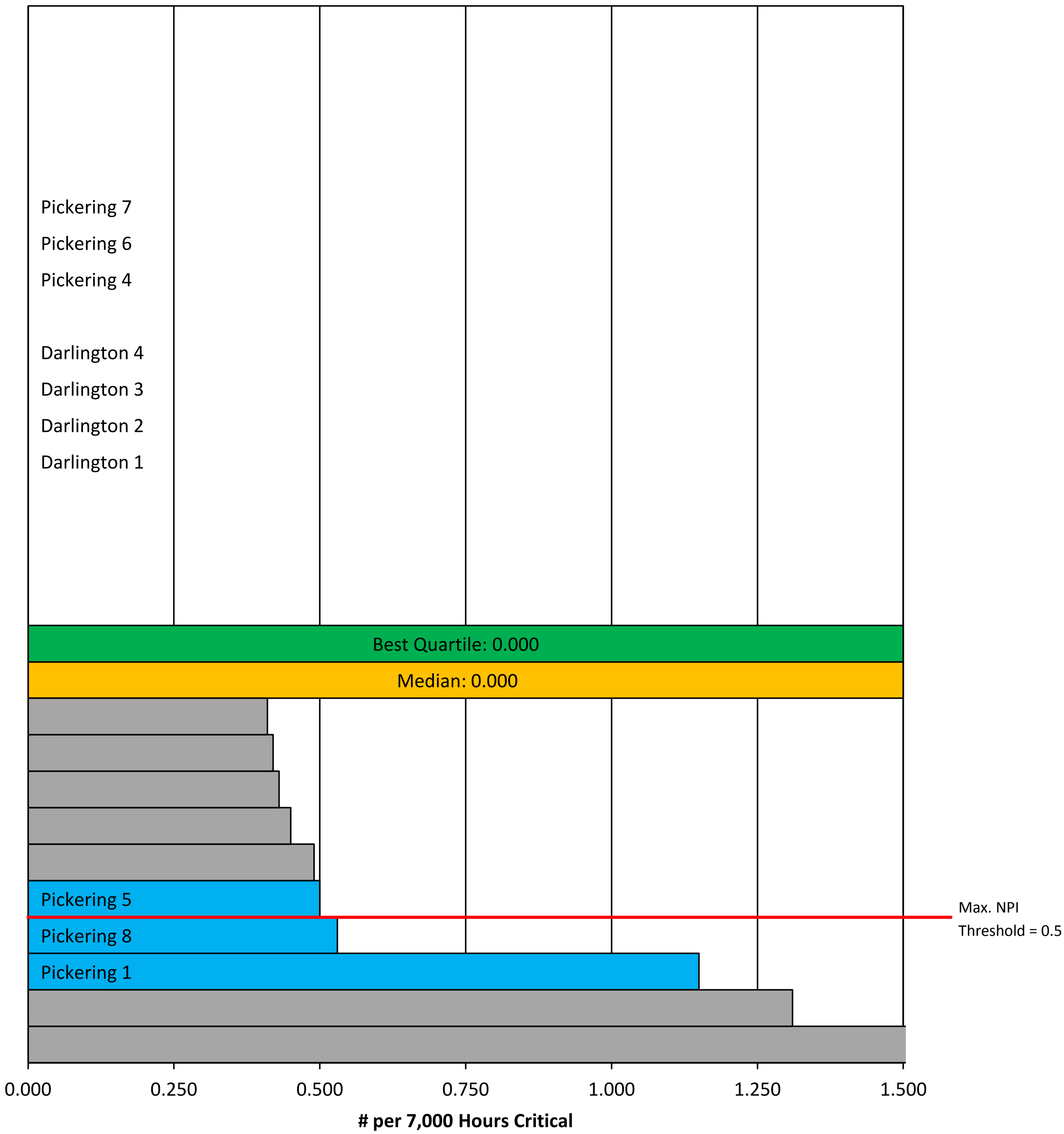
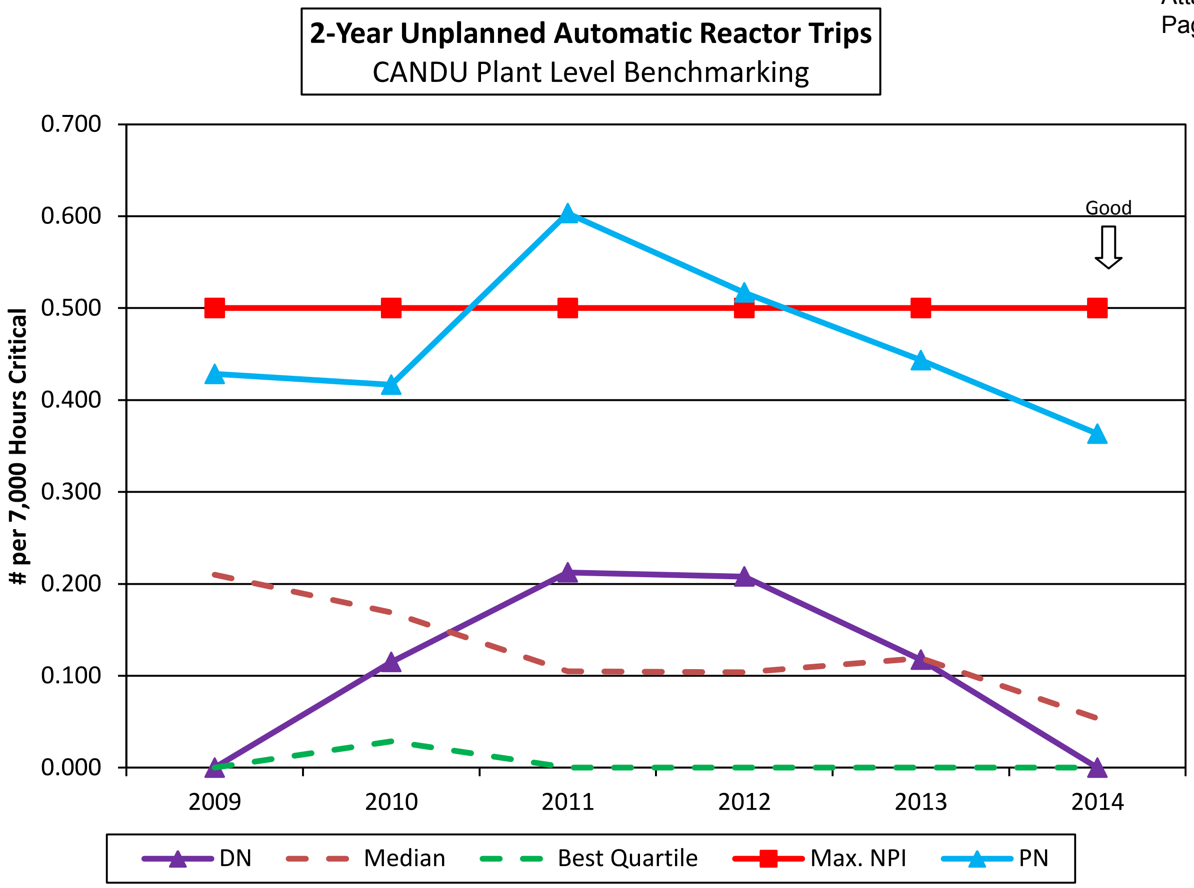
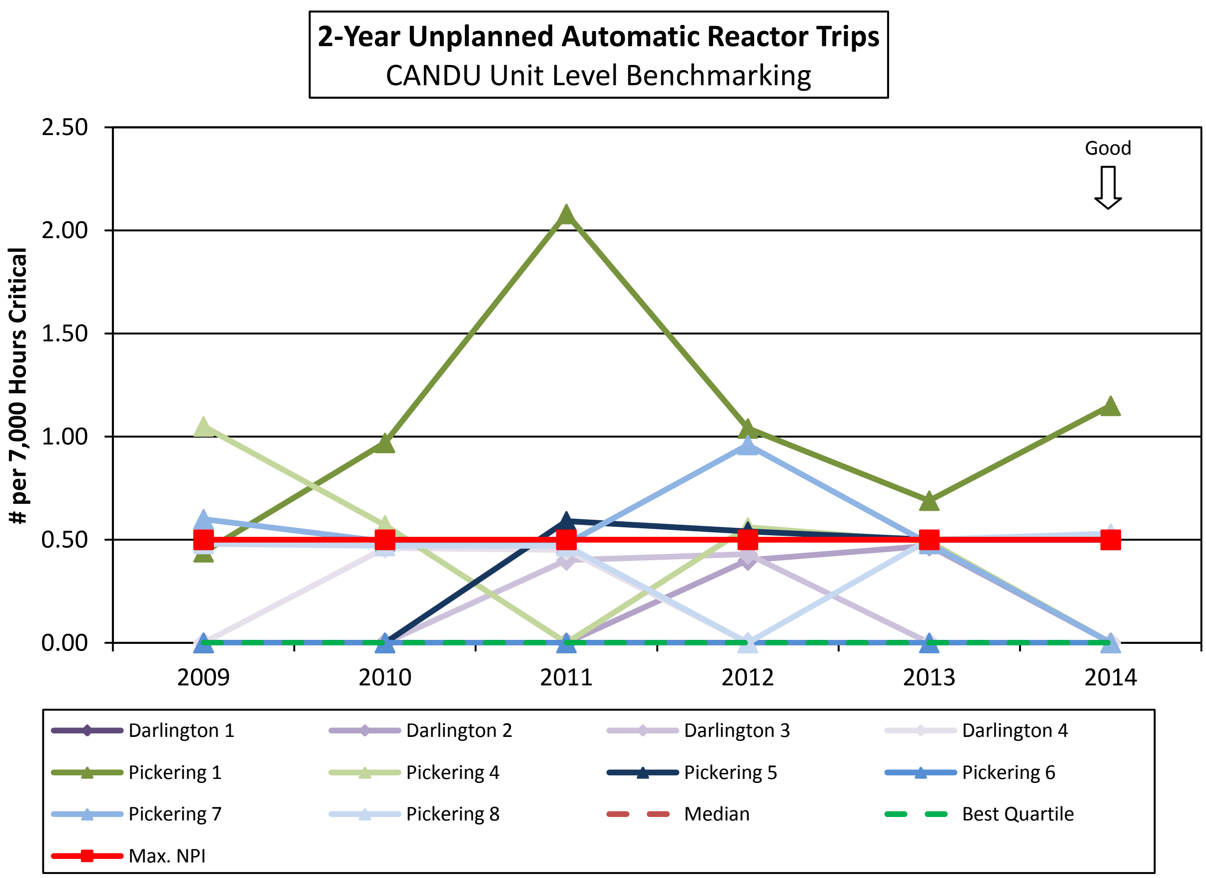
2014 2-Year Unplanned Automatic Reactor Trips
CANDU Unit Level Benchmarking




2-Year Unplanned Automatic Reactor Trips
CANDU Plant Level Benchmarking
per 7,000 Hours Critical
0.700
0.600
0.500
0.400
0.300
0.200
0.100
0.000
2009
2010
2011
2012
2013
2014
Good
DN
Median
Best Quartile
Max. NPI
PN


2-Year Unplanned Automatic Reactor Trips
CANDU Unit Level Benchmarking
per 7,000 Hours Critical
2.50
2.00
1.50
1.00
0.50
0.00
2009
2010
2011
2012
2013
2014
Good
Darlington 1
Darlington 2
Darlington 3
Darlington 4
Pickering 1
Pickering 4
Pickering 5
Pickering 6
Pickering 7
Pickering 8
Median
Best Quartile
Max. NPI

Observations – 2-Year Unplanned Automatic Reactor Trips (CANDU)

2014 (2-Year Rolling Average)

- The 2-year rolling average unplanned automatic reactor trip best quartile for CANDU plants was zero while the median was 0.054. For individual CANDU units, the best quartile and median values for unplanned reactor trip were zero.
- At the plant level, Pickering's trip rate of 0.363 was below the maximum NPI threshold value of 0.500. On an individual unit basis, Units 4, 6 and 7 with trip rate of zero, were at best quartile. Unit 5 achieved maximum NPI points. Unit 8, with trip rate of 0.530 was worse than the third quartile threshold of 0.440. Unit 1, with trip rate of 1.150, was worse than the third quartile threshold of 0.440.
- At the plant level Darlington's trip rate of 0.000 reached best NPI results. On an individual unit basis, Units 1, 2, 3 and 4, with trip rates of zero, performed at the best quartile level.

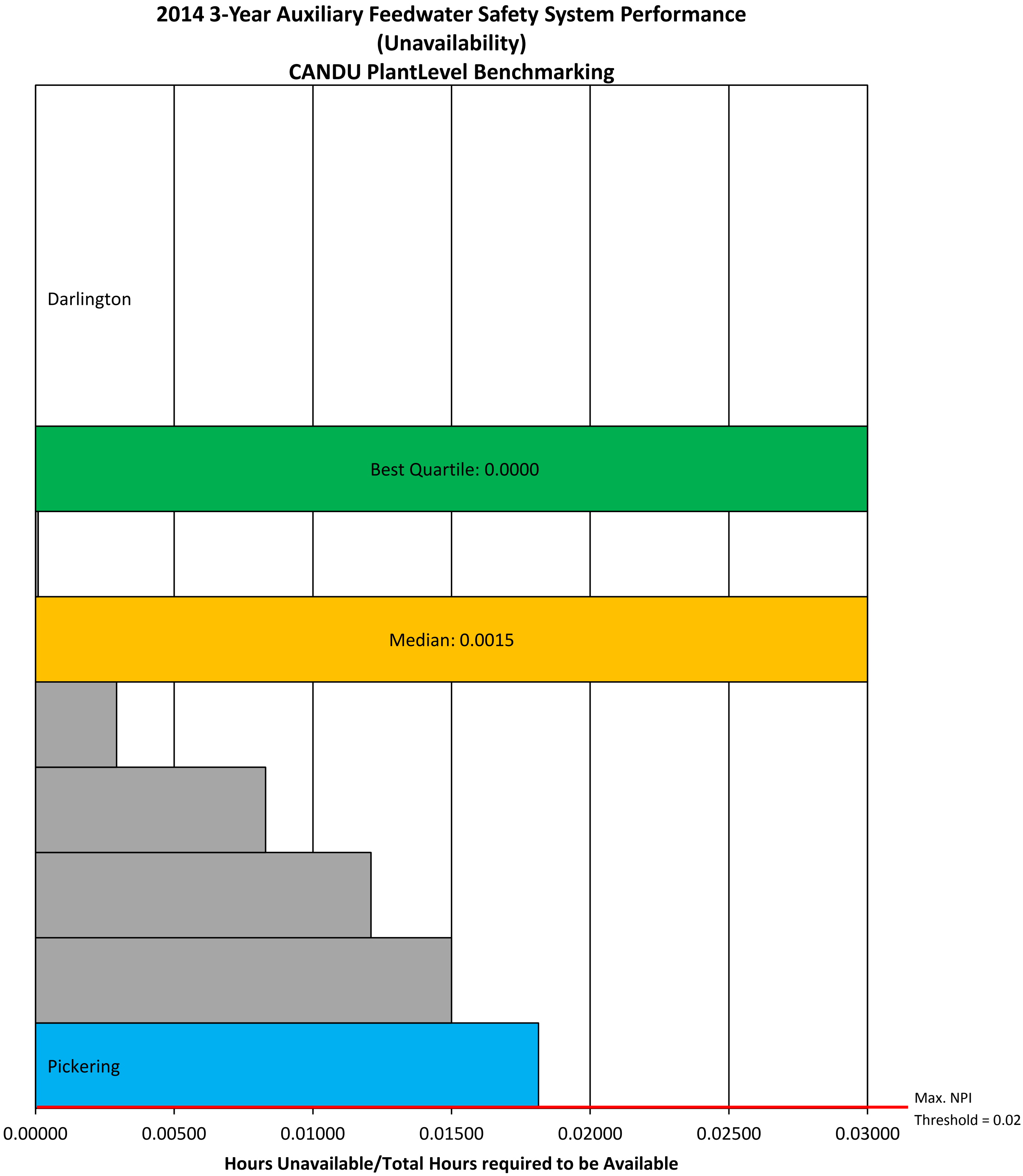
Trend

- The unplanned automatic reactor trip best quartile for CANDU plants has been zero since 2011. The median value improved from 2009 to 2012, performance declined in 2013 but improved in 2014. On an individual unit basis, the industry best quartile and median has remained at zero since 2009.
- At the plant level, Pickering station performance continues to improve for the third year running from a 0.603 trip rate in 2011 to 0.363 in 2014. On an individual unit basis, Unit 1 performance has improved from 2011 to 2013 but decreased in 2014. Unit 4 performance has decreased from 2011 to 2012, slightly improved in 2013 and achieved best performance in 2014 with a zero trip rate. Unit 5 performance improved from 2011 to 2013 and remained at a constant trip rate between 2013 and 2014. Unit 6 has consistently performed at a zero trip rate since 2009. Unit 7 performance improved from 2012 and 2013 achieving the best performance in 2014 with a zero trip rate. Unit 8 performance remained flat hovering around 0.5 since 2009.
- At the plant level, Darlington station performance has been improved since 2011 achieving a zero trip rate in 2014. On an individual unit basis, Unit 1 has consistently performed at a zero trip rate since 2009. Units 3 and 4 performed at a zero trip rate in 2013 and 2014 with both units improving from previous years' performance. Unit 2 performance has been significantly improved in 2014 from 2012 and 2013, achieving a zero trip rate in the process.

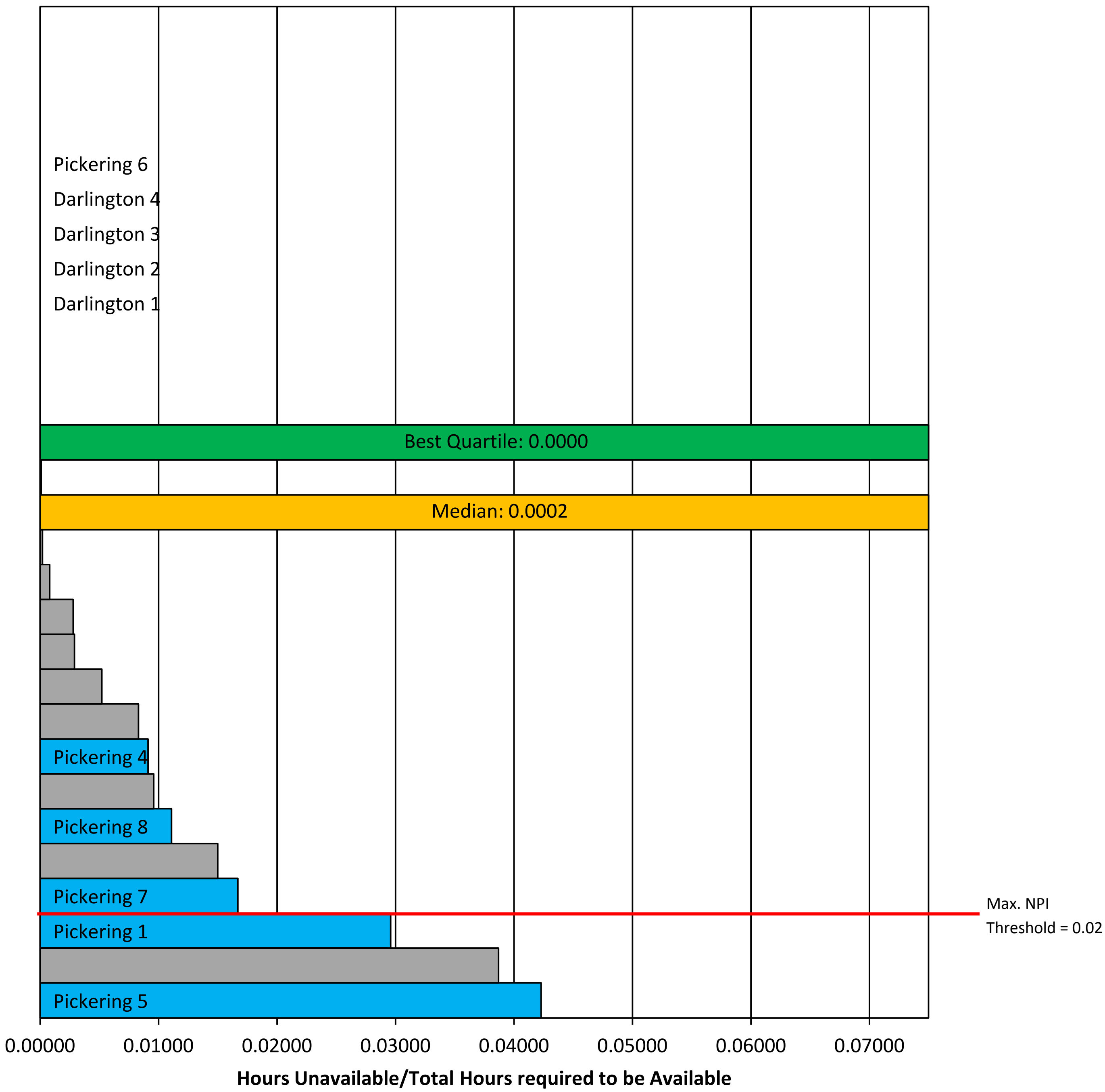
Factors Contributing to Performance

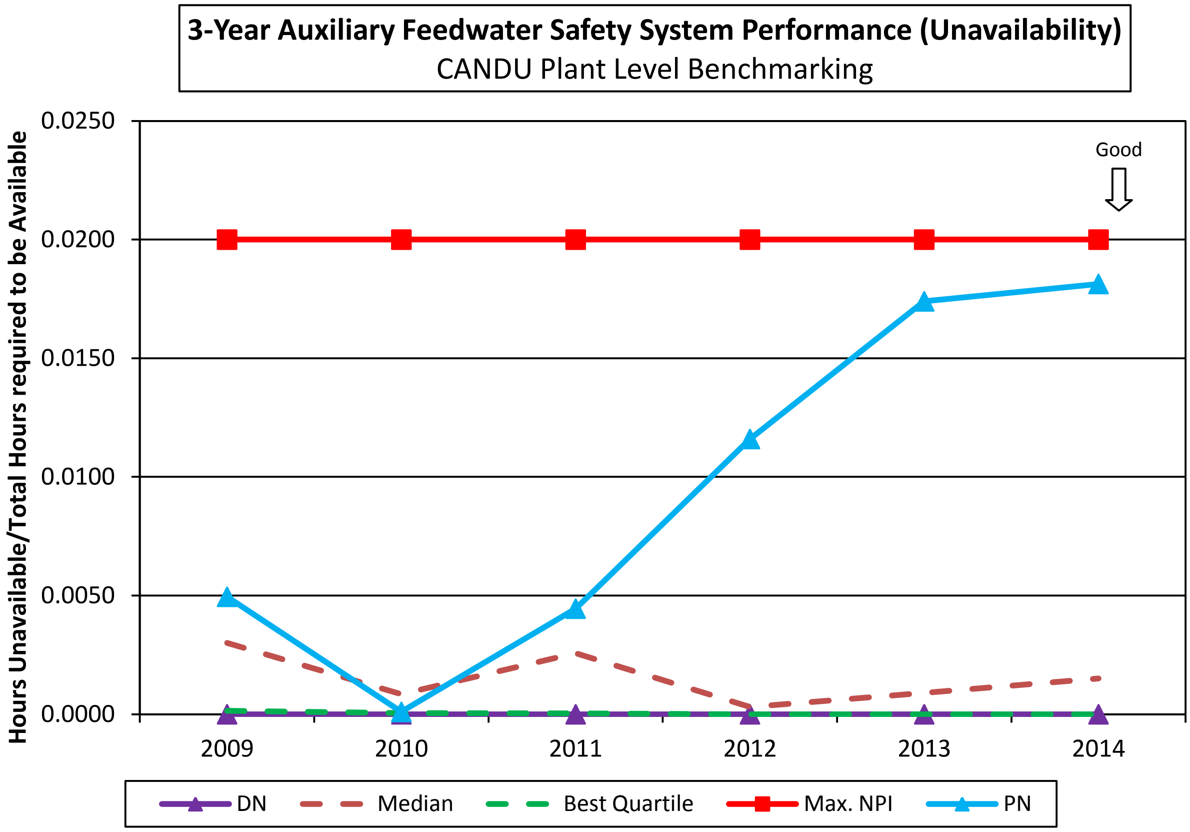
- Key performance drivers for this metric include: general equipment reliability, material condition, and human performance.
- On-going due diligence by Station Operations, Engineering and Maintenance organizations. Operating Experience (OPEX) from each event has been shared at Pickering, Darlington and at external summits. Where necessary, training material has been revised based on OPEX. To improve human performance, technical procedures have been revised. To improve equipment reliability, where possible, like-for-like parts replacement has taken place. System health teams are involved in obsolescence issues.
- In 2014, Pickering had 1 unplanned automatic reactor trip (1 on Unit 1).
  There were no unplanned automatic reactor trips at Darlington in 2014.

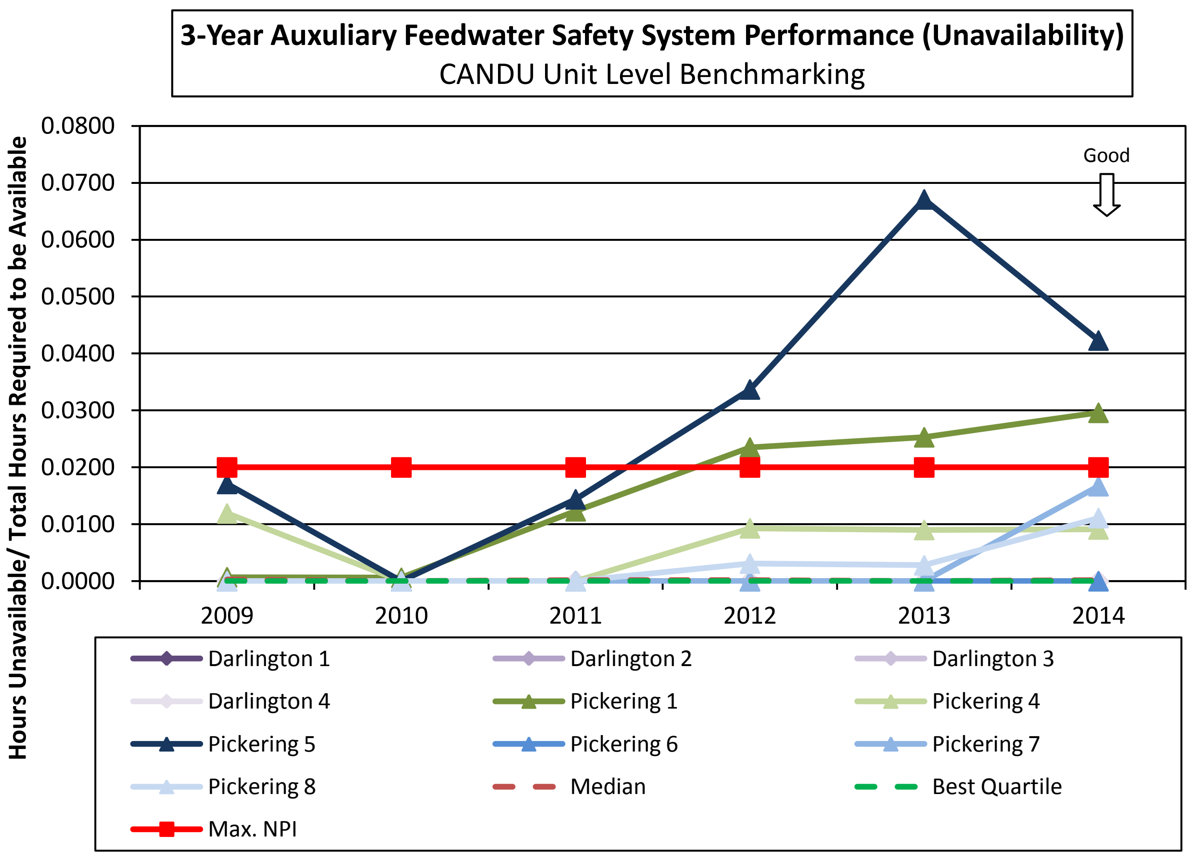
3-Year Auxiliary Feedwater Safety System Unavailability



2014 3-Year Auxiliary Feedwater Safety System Performance (Unavailability)
CANDU Unit Level Benchmarking




3-Year Auxiliary Feedwater Safety System Performance (Unavailability)
CANDU Plant Level Benchmarking
Hours Unavailable/Total Hours required to be Available
0.0250
0.0200
0.0150
0.0100
0.0050
0.0000
Good
2009
2010
2011
2012
2013
2014
DN
Median
Best Quartile
Max. NPI
PN


3-Year Auxuliary Feedwater Safety System Performance (Unavailability)
CANDU Unit Level Benchmarking
Hours Unavailable/ Total Hours Required to be Available
0.0800
0.0700
0.0600
0.0500
0.0400
0.0300
0.0200
0.0100
0.0000
Good
2009
2010
2011
2012
2013
2014
Darlington 1
Darlington 2
Darlington 3
Darlington 4
Pickering 1
Pickering 4
Pickering 5
Pickering 6
Pickering 7
Pickering 8
Median
Best Quartile
Max. NPI

Observations – 3-Year Auxiliary Feedwater System (CANDU)

2014 (3-Year Rolling Average)

- The best quartile CANDU plants Auxiliary feedwater (AFW) safety system performance was zero with a median value of 0.0015. For individual CANDU units, the best quartile was zero with a median of 0.0002.
- At the plant level, Pickering station, with an unavailability of 0.0181 reached maximum NPI threshold value of 0.0200. On an individual unit basis, all Pickering units achieved maximum NPI points for AFW unavailability except for Units 1 and 5. Units 1 and 5 unavailability is above the NPI maximum threshold. Even though Units 7 and 8 AFW were declared unavailable during 2014 their NPI values are below the NPI maximum threshold.
- Darlington station achieved best quartile performance of zero unavailability at both the station and unit levels in 2014.

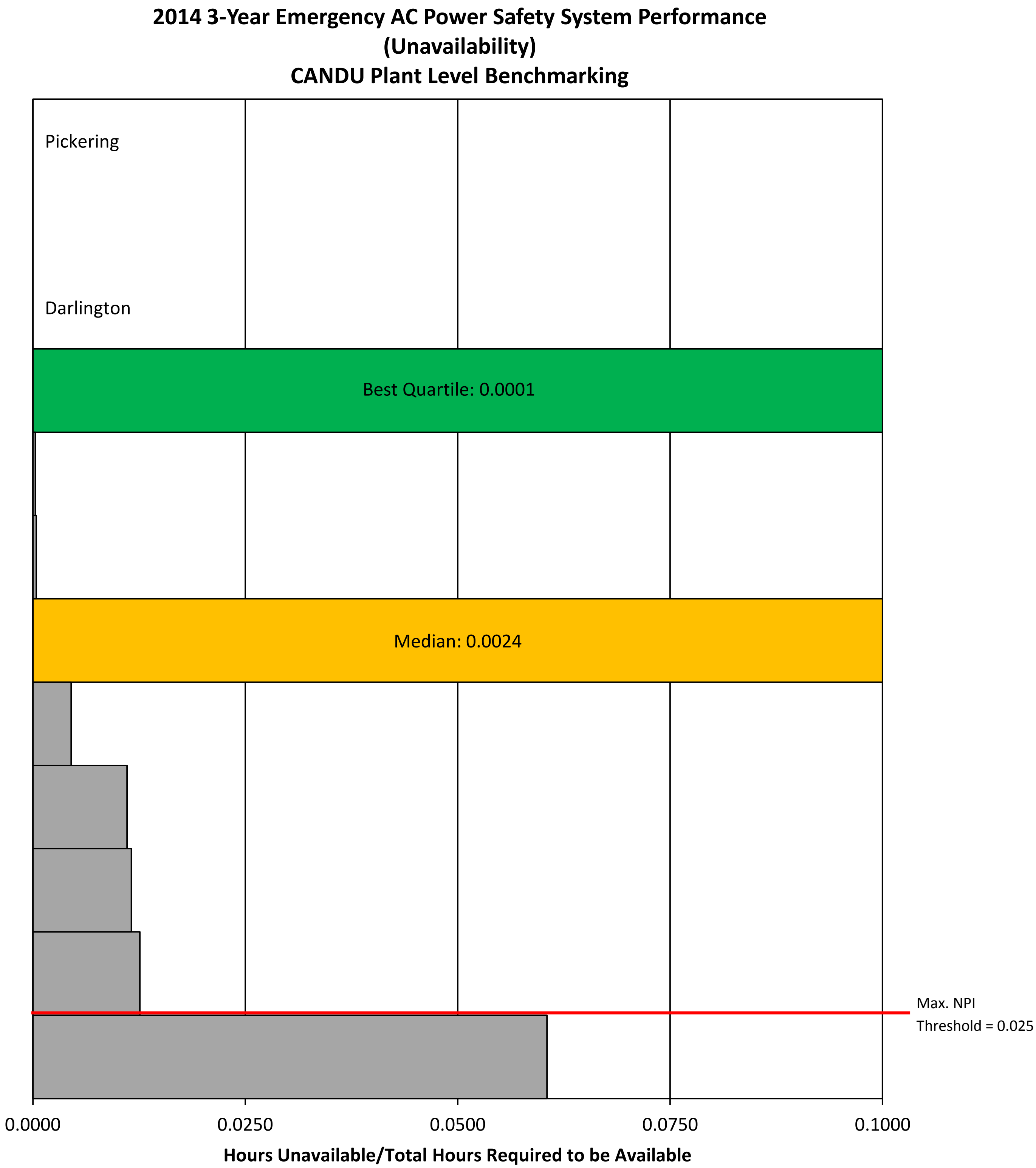
Trend

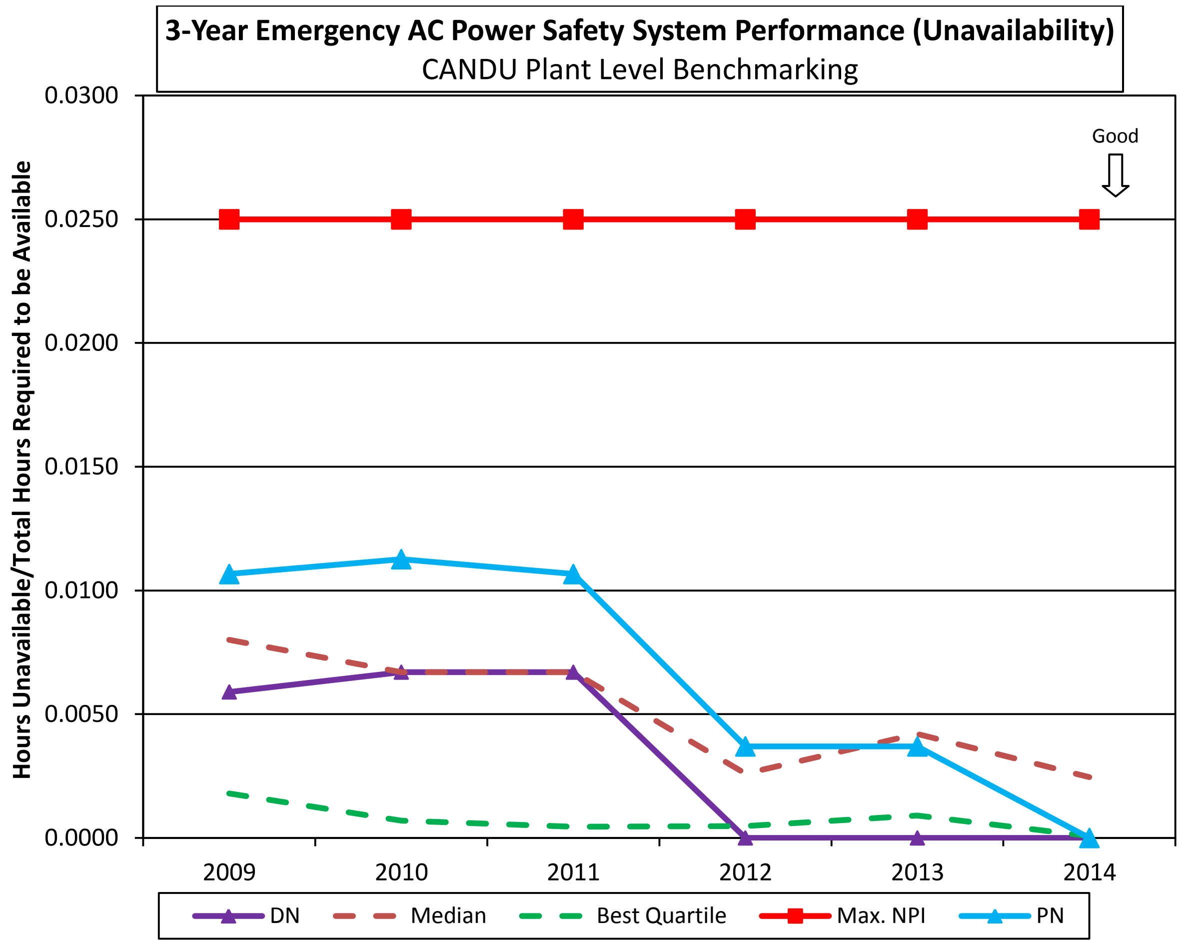
- The 3-Year Auxiliary Feedwater unavailability best quartile performance of CANDU plants improved from 2010 and maintained zero unavailability from 2011 to 2014. The plant level industry median value has fluctuated slightly over the review period but has remained well below the NPI maximum threshold. At the unit level, the industry best quartile has remained at zero over the review period and the median value at or close to zero over the review period.
- At the plant level, Pickering station performance has declined since 2010 and is approaching the NPI maximum threshold. On an individual unit basis, Unit 6 has consistently performed at a zero unavailability rate over the review period. All Pickering units have achieved maximum NPI points over the review period except for Units 1 and 5. Unit 1 performance declined in 2014, while Unit 5 performance improved from 2013 but still exceeded the maximum NPI threshold. Unit 7 performances has consistently performed at a zero unavailability rate since 2009 but recently declined in 2014.
- Darlington station and unit performance has been at zero unavailability since 2009.

Factors Contributing to Performance

- Key performance drivers for this metric include: general equipment reliability, material condition, and human performance.
- On May 31, 2014 Pickering Unit 7 Auxiliary Condensate Extraction Pump (ACEP) and on September 13, 2014 Pickering Unit 8 ACEP failed to start during ACEP test execution, which resulted in system unavailability on both units. The issue has since been resolved.
- On October 29, 2014 Pickering Unit 1 Auxiliary Boiler Feedwater (ABFW) control valve failed to control the feedwater discharge pressure during test execution, which resulted in system unavailability. The issue has since been resolved.
- Pickering Auxiliary Feedwater System Unavailability performance is partly attributed to the design of the system where there is only one ABFW pump per unit. However, most of the unavailability has been caused by water contaminating the oil. Current contamination limits assume a very small amount of water in the oil, in the range of a few hundred parts per million (ppm), would result in the pump being unavailable. However, recently conducted tests confirm that the pumps remain available with 10,000 ppm of water in the oil. Most of the past unavailability would not have occurred with these higher limits in effect. This is therefore expected to result in a significant improvement in future availability numbers.

3-Year Emergency AC Power Safety Unavailability




3-Year Emergency AC Power Safety System Performance (Unavailability)
CANDU Plant Level Benchmarking
Hours Unavailable/Total Hours Required to be Available
0.0300
0.0250
0.0200
0.0150
0.0100
0.0050
0.0000
Good
2009
2010
2011
2012
2013
2014
DN
Median
Best Quartile
Max. NPI
PN

Observations – 3-Year Emergency AC Power Safety System (CANDU)

2014 (3-Year Rolling Average)

- 3-Year Emergency AC Power Safety System performance at best quartile CANDU plants was 0.0001. The industry median value was 0.0024.
- Both Pickering and Darlington were amongst the best performing stations in the CANDU peer group, achieving zero unavailability, best quartile performance and maximum NPI results.

Trend

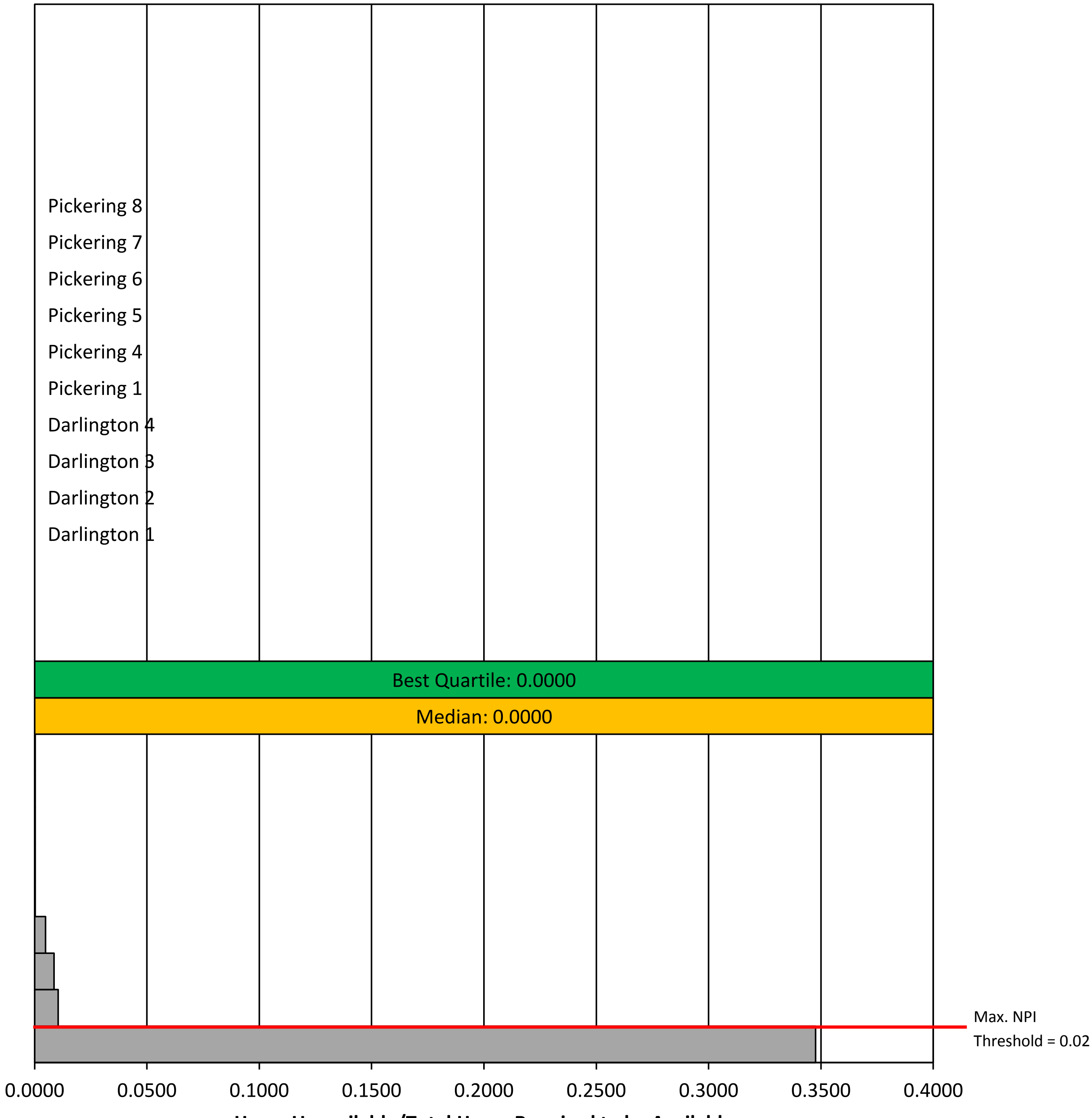
- The 3-year Emergency AC Power Safety System unavailability industry best quartile for CANDU plants has steadily improved since 2009, with a slight decline in 2013 and improved in 2014. The industry median value improved over the review period, with a slight decline in 2013 but improved in 2014.
- Pickering station performance has improved over the review period until reaching its best performance in 2014 achieving zero unavailability.
- Darlington station and unit performance improved from 2011, achieving zero unavailability in the last three years 2012, 2013 and 2014.

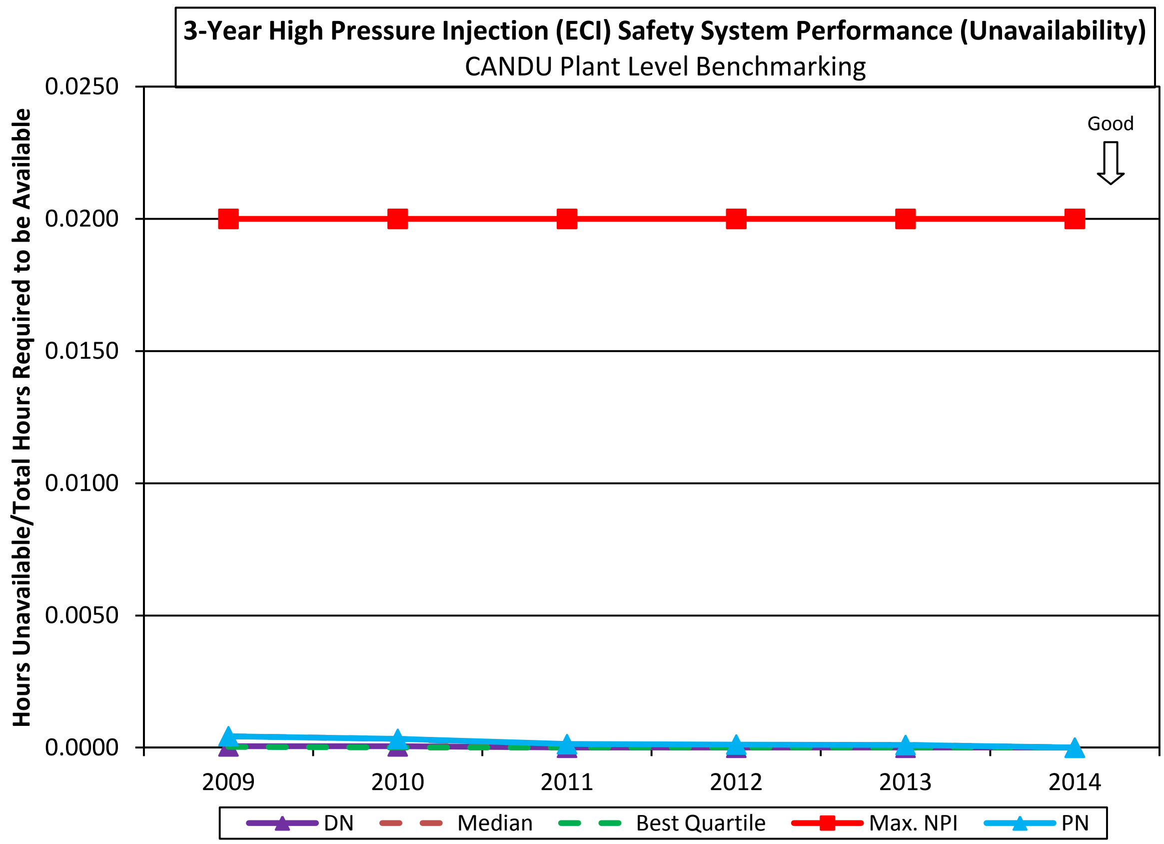
Factors Contributing to Performance

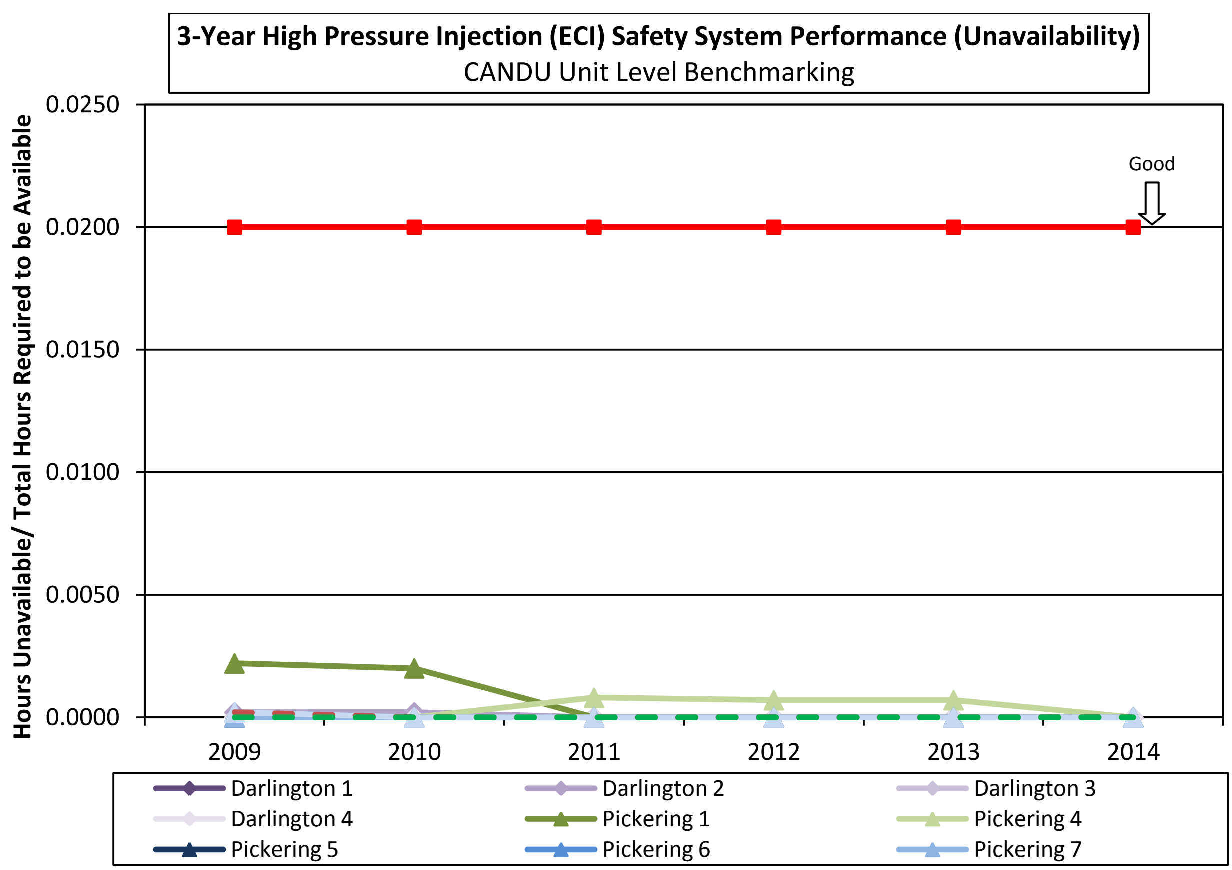
- Key performance drivers for this metric include: general equipment reliability, material condition, and human performance.
- A 2012 revision (as approved by WANO) to the calculation methodology of the Emergency AC Power System Unavailability; where penalties have been eliminated for the unavailability of redundant/installed spares; has also been a driver towards the improved OPG unavailability numbers.

3-Year High Pressure Safety Injection

2014 3-Year High Pressure Injection (ECI) Safety System Performance (Unavailability)
CANDU Unit Level Benchmarking




3-Year High Pressure Injection (ECI) Safety System Performance (Unavailability)
CANDU Plant Level Benchmarking
Hours Unavailable/Total Hours Required to be Available
0.0250
0.0200
0.0150
0.0100
0.0050
0.0000
2009
2010
2011
2012
2013
2014
Good
DN
Median
Best Quartile
Max. NPI
PN


3-Year High Pressure Injection (ECI) Safety System Performance (Unavailability)
CANDU Unit Level Benchmarking
Hours Unavailable/ Total Hours Required to be Available
0.0250
0.0200
0.0150
0.0100
0.0050
0.0000
2009
2010
2011
2012
2013
2014
Good
Darlington 1
Darlington 2
Darlington 3
Darlington 4
Pickering 1
Pickering 4
Pickering 5
Pickering 6
Pickering 7

Observations – 3-Year High Pressure Safety Injection Unavailability (CANDU)

2014 (3-Year High Pressure Safety Injection Unavailability)

- The best quartile and median values for the 3-Year High Pressure Safety Injection Unavailability performance for CANDU plants were zero. For individual CANDU units, both the best quartile and median value were zero.
- Pickering achieved best quartile performance of zero unavailability at both the station and unit levels in 2014.
- Darlington achieved best quartile performance of zero unavailability at both the station and unit levels in 2014.

Trend

- The 3-Year High Pressure Safety Injection unavailability best quartile performance of CANDU plants has been zero since 2009. The plant level industry median performance improved from 2009 to 2011, declined slightly in 2012 and achieved zero unavailability in 2014. At the unit level, the industry best quartile has remained at zero over the review period. The median value has remained at zero since 2010.
- At the plant level, Pickering station performance has consistently improved over the review period achieving zero unavailability in 2014. On an individual unit basis, Unit 1 has improved from 2009 to 2010, achieving zero unavailability from 2011 to 2014. Unit 4 performance remained at zero unavailability in 2009 and 2010, slightly declined from 2010 to 2013 but achieved zero unavailability in 2014. Units 5 and 7 have been at the best quartile since 2009. Units 6 and 8 remained at the best quartile since 2010.
- At the plant level, Darlington station performance has improved since 2009 and has maintained best quartile performance from 2011 to 2014. On an individual unit basis, Units 1, 3 and 4 have been at the best quartile since 2009. Unit 2 has improved from 2009 before achieving the best quartile from 2011 to 2014.

Factors Contributing to Performance

- On January 15, 2014 Pickering Unit 1 High Pressure Safety Injection system was declared unavailable for 5 minutes and 18 seconds due to power lost to Unit 1 Motor Control Centres. This does not impact the numerical value of the NPI because the system unavailability was declared for very short period of time.
- Key performance drivers for this metric include the continuous implementation and utilization of:
  - Modifications and key initiatives such as the Parts Improvement Initiative ensuring parts availability.
  - Plant Reliability Lists work programs to drive work execution.
  - Dashboard at Plant Health to provide coordination and support work completion from a cross-functional team.
  - Procedural Updates to continuously incorporate Operating Experience and to mitigate human performance events.
  - Enhanced System Health Team Focus and Effectiveness.

3.0 RELIABILITY

Methodology and Sources of Data

The majority of reliability metrics were calculated using the data from WANO. Any data labelled as invalid by WANO was excluded from all calculations. Indicator values of zero are not plotted or included in calculations except in cases where zero is a valid result. Complete data for the review period was obtained and averages are as provided by WANO.

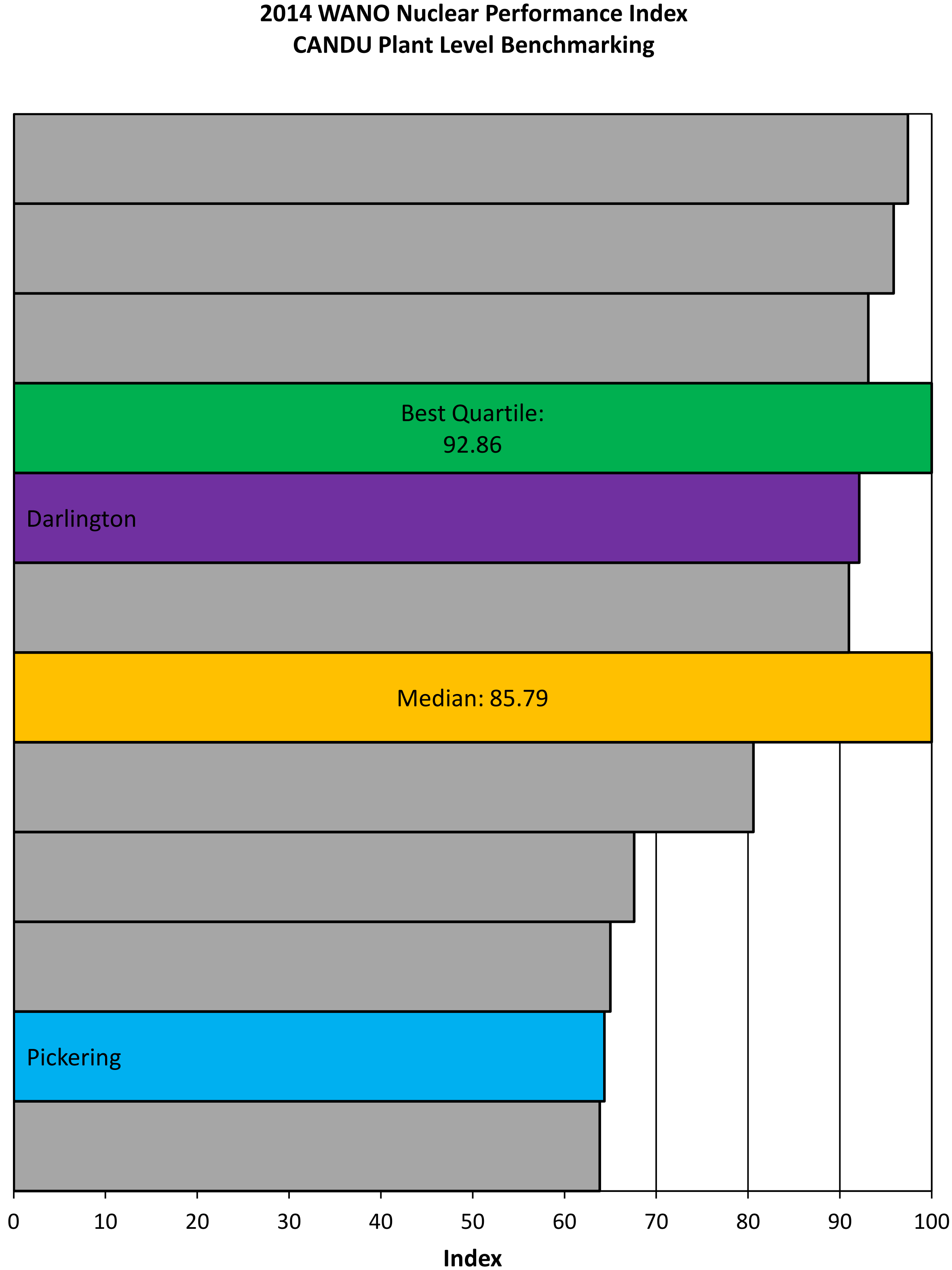
The two backlog metrics, Deficient and Corrective maintenance, are also included within this section and the data comes from an industry sponsored INPO AP-928 subcommittee. Data points benchmarked on backlogs are a single point in time, not a rolling average. All of the data is self-reported. Industry backlog benchmark standards changed with Revision 3 of AP-928 Work Management Practices at INPO in June of 2010. The new standard created an alignment between engineering criticality coding and backlog classification that allows improved focus on the more critical outstanding work. This standard also sets a more consistent foundation for classification of backlogs such that comparisons between utilities will be more meaningful. All OPG nuclear stations converted to the new standard on January 24, 2011. The latest 2014 industry backlog benchmark data was collected for December 31, 2014. The results and supporting analysis associated with the backlog metrics reflect this industry development.

Discussion

The primary metric within the reliability section is the WANO Nuclear Performance Index (NPI). The WANO NPI is an operational performance indicator comprised of 10 metrics, three of which are analyzed in this section: Forced Loss Rate, Unit Capability Factor, and Chemistry Performance Indicator. The remainder of the WANO NPI components are analyzed in the safety section (Section 2.0).

Darlington improved quartile rankings for the Corrective Maintenance Backlogs moving to the second quartile compared to 2013. Industry best quartile performance for NPI and the Deficient Maintenance Backlogs metrics significantly improved in 2014. Although Darlington’s scores for either metric improved overall, the station ranking fell from top quartile in 2013 to second quartile in 2014 for both indicators. The Pickering station performed at the same quartile rankings when compared to 2013 except for the Chemistry Performance Indicator and the Deficient Maintenance Backlogs. The Chemistry Performance Indicator ranking improved to the third quartile while the Deficient Maintenance Backlogs declined to the third quartile in 2014. All other Pickering Reliability metrics are in the fourth quartile.

WANO Nuclear Performance Index



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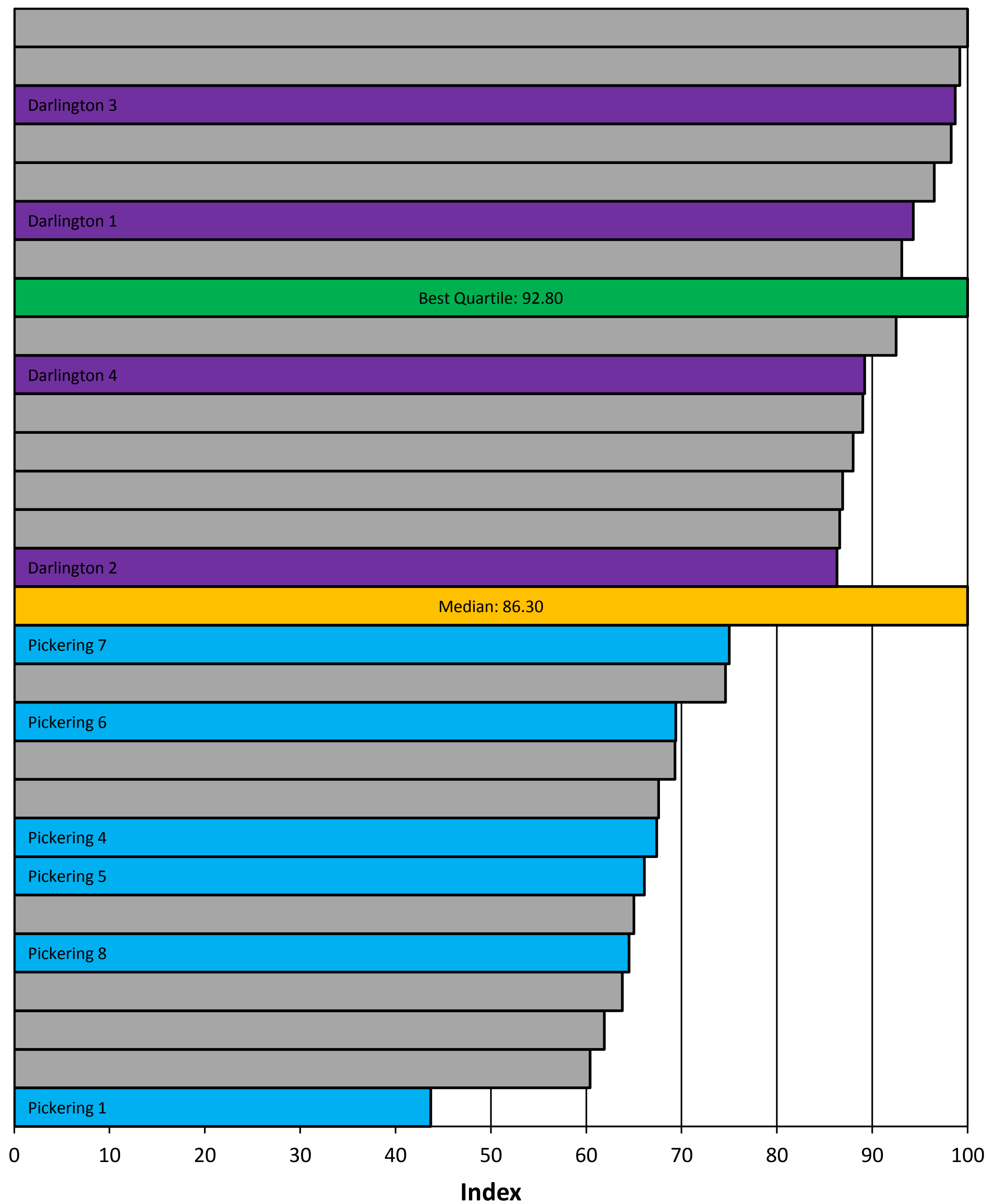
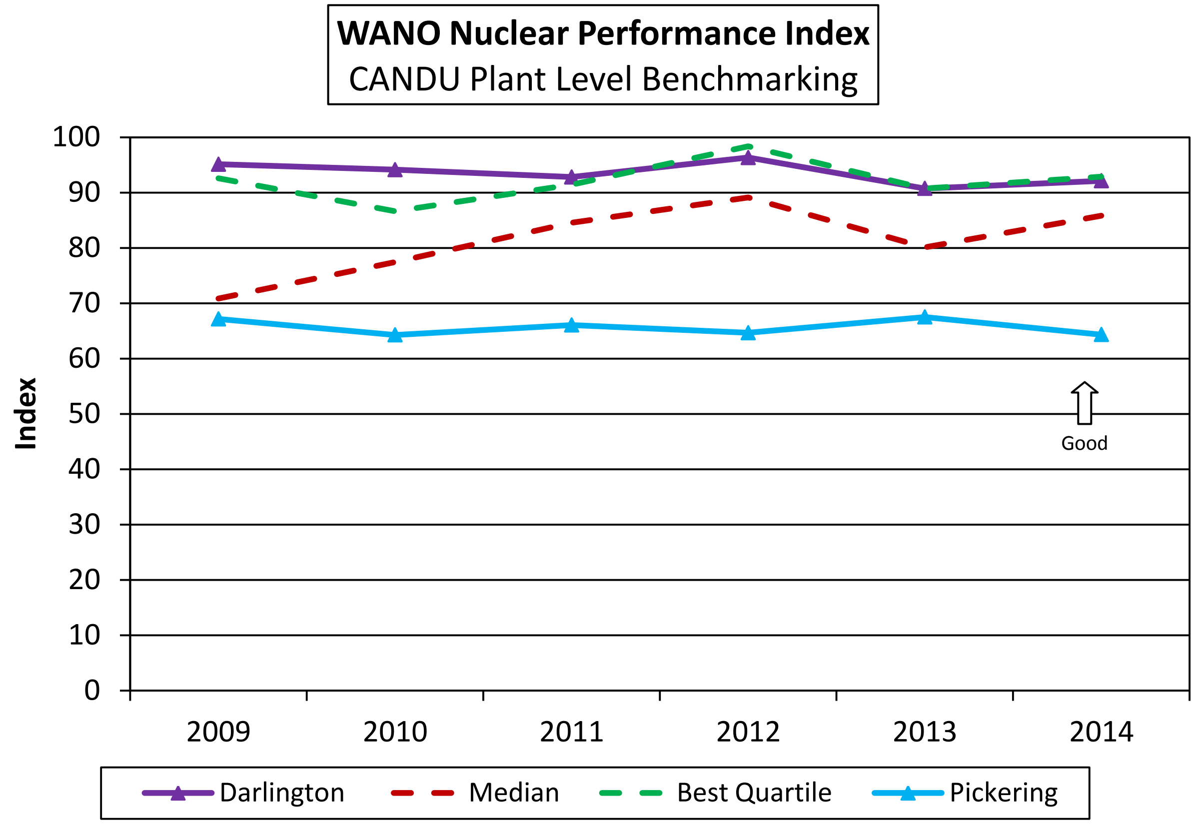
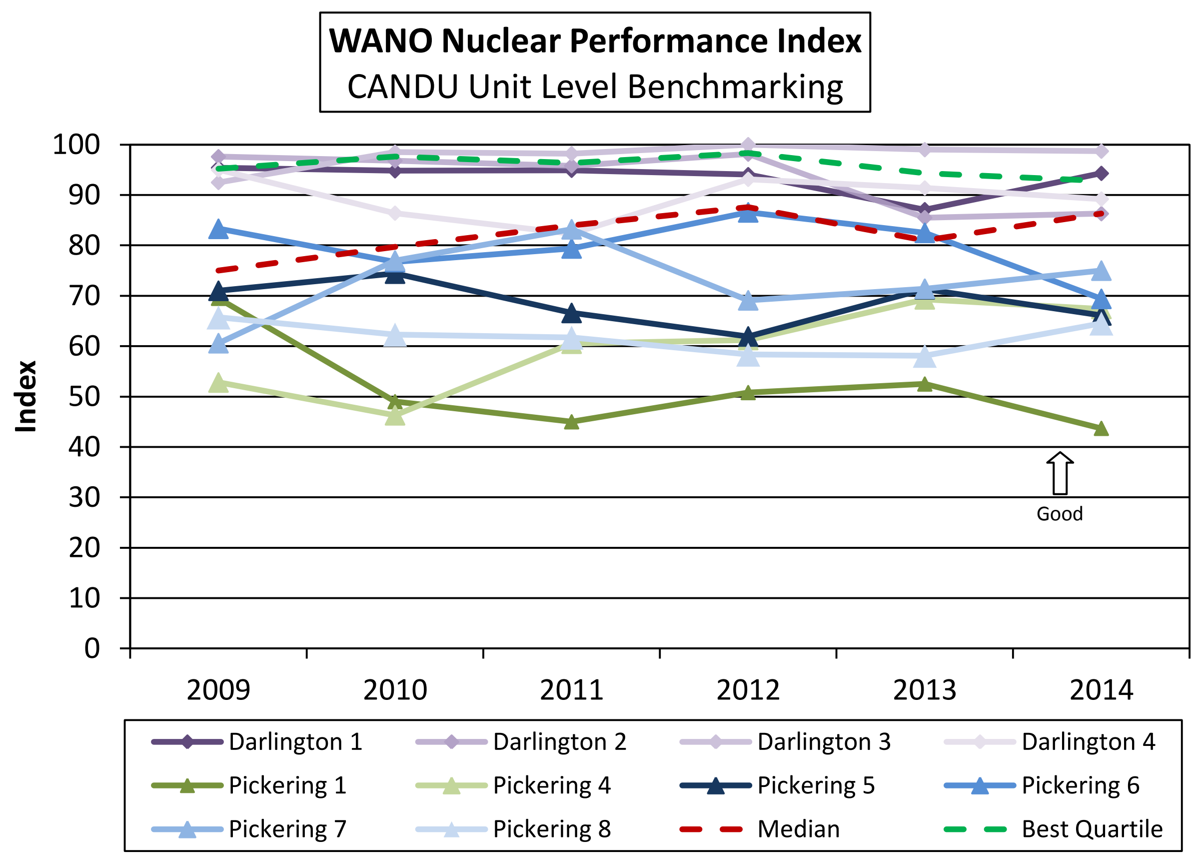
2014 WANO Nuclear Performance Index
CANDU Unit Level Benchmarking




WANO Nuclear Performance Index
CANDU Plant Level Benchmarking
Index
100
90
80
70
60
50
40
30
20
10
0
2009
2010
2011
2012
2013
2014
Good
Darlington
Median
Best Quartile
Pickering


WANO Nuclear Performance Index
CANDU Unit Level Benchmarking
Index
100
90
80
70
60
50
40
30
20
10
0
2009
2010
2011
2012
2013
2014
Good
Darlington 1
Darlington 2
Darlington 3
Darlington 4
Pickering 1
Pickering 4
Pickering 5
Pickering 6
Pickering 7
Pickering 8
Median
Best Quartile

Observations – WANO Nuclear Performance Index (NPI) (CANDU)

2014

- The 2014 best quartile of the CANDU plant comparison panel for WANO NPI is 92.9. This represents an increase of 2.2 points above the 2013 best quartile.
- The 2014 median of the CANDU plant comparison panel rose 5.7 points from last year to 85.8.
- At the plant level, Darlington scored 92.1 points, just below the best quartile NPI performance in 2014, while Pickering's 64.3 NPI points performance remained below median.
- In 2014, Darlington had two units in the top quartile, and two units in the second quartile.
- All Pickering plants were below the median quartile in 2014.

Trend

- The best quartile of the CANDU plant comparison panel, which had shown a downward trend from 2009 to 2010, reversed in 2011 and 2012, with the best quartile performance rising to its highest level in 2012. While this was not sustained in 2013 and 2014, the best quartile results for the past 2 years remain in the low 90's.
- The median value of the CANDU plant comparison panel continued to rise from 2009 to 2012, indicating that the performers in the lower quartiles are performing better. This performance was not sustained in 2013, but did recover in 2014.
- Pickering performance has remained relatively steady over the review period, scoring below the median from 2009-2014.
- As the strongest OPG performer, Darlington achieved best quartile performance over the majority of the review period, ranking just below top quartile in 2014.

Factors Contributing to Performance

- The WANO NPI is a composite index reflecting the weighted sum of the scores of 10 separate performance measures. A maximum score of 100 is possible. All of the sub-indicators in this index are reviewed separately in this benchmarking report.

Pickering

- For 2014, Pickering achieved maximum scores for 3 out of 10 NPI sub-indicators.
- For the key safety system related metrics of high pressure injection and emergency alternating current (AC) power, the station received 10 of 10 points.
- Pickering also achieved a perfect score for industrial safety accident rate (5 of 5).
- Pickering earned 8.9 of 10 points for reactor trips.
- Pickering achieved 4.1 of 5 points for chemistry performance, 7.9 of 10 points for collective radiation exposure, 8.0 of 10 points for fuel reliability and 6.7 of 10 points for auxiliary feedwater.
- Due to challenges with forced outages and forced extensions to planned outages, Pickering received 0 of 15 points for unit capability factor and 3.7 of 15 points for forced loss rate.

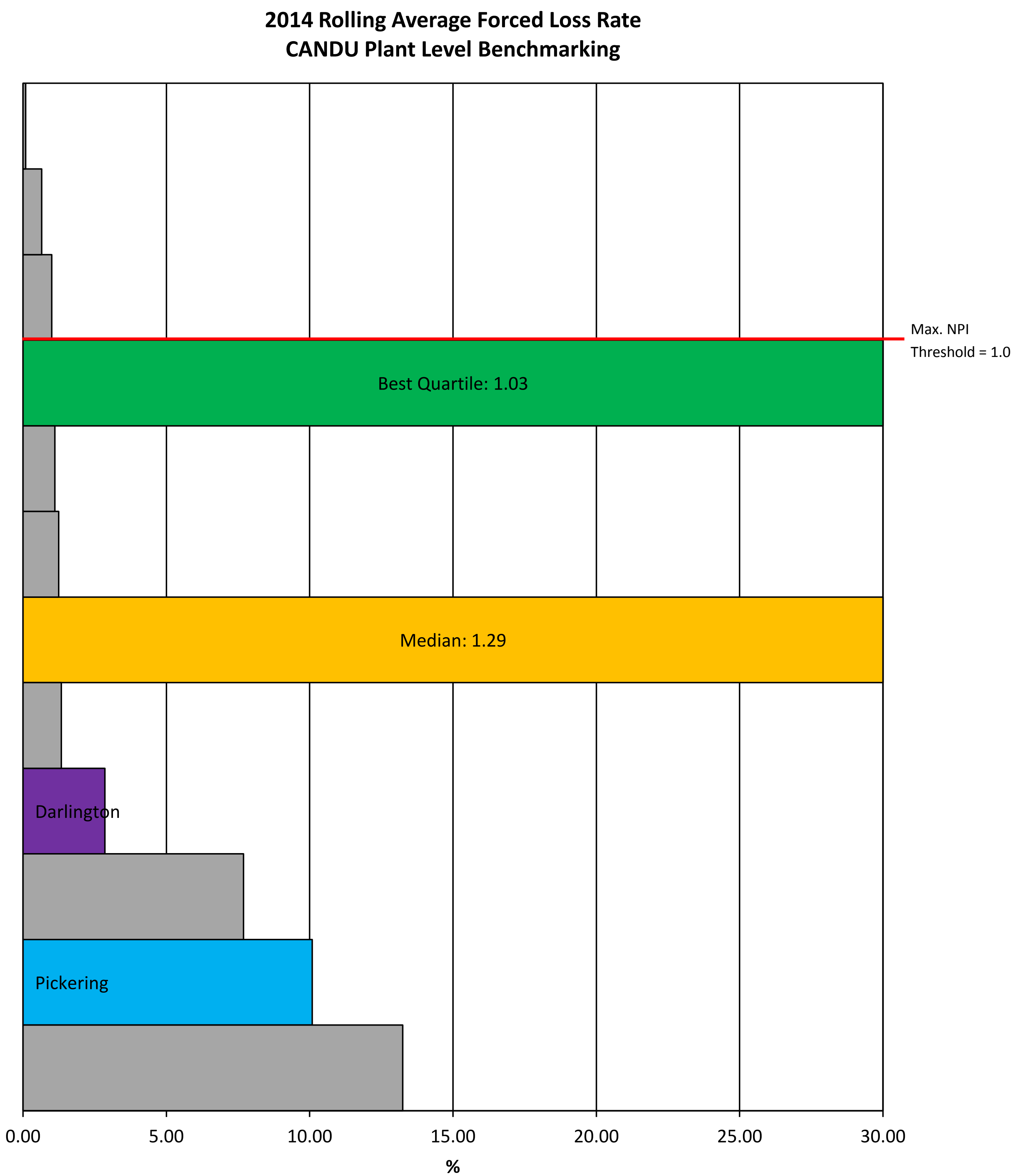
Factors Contributing to Performance (CONT'D)

Darlington

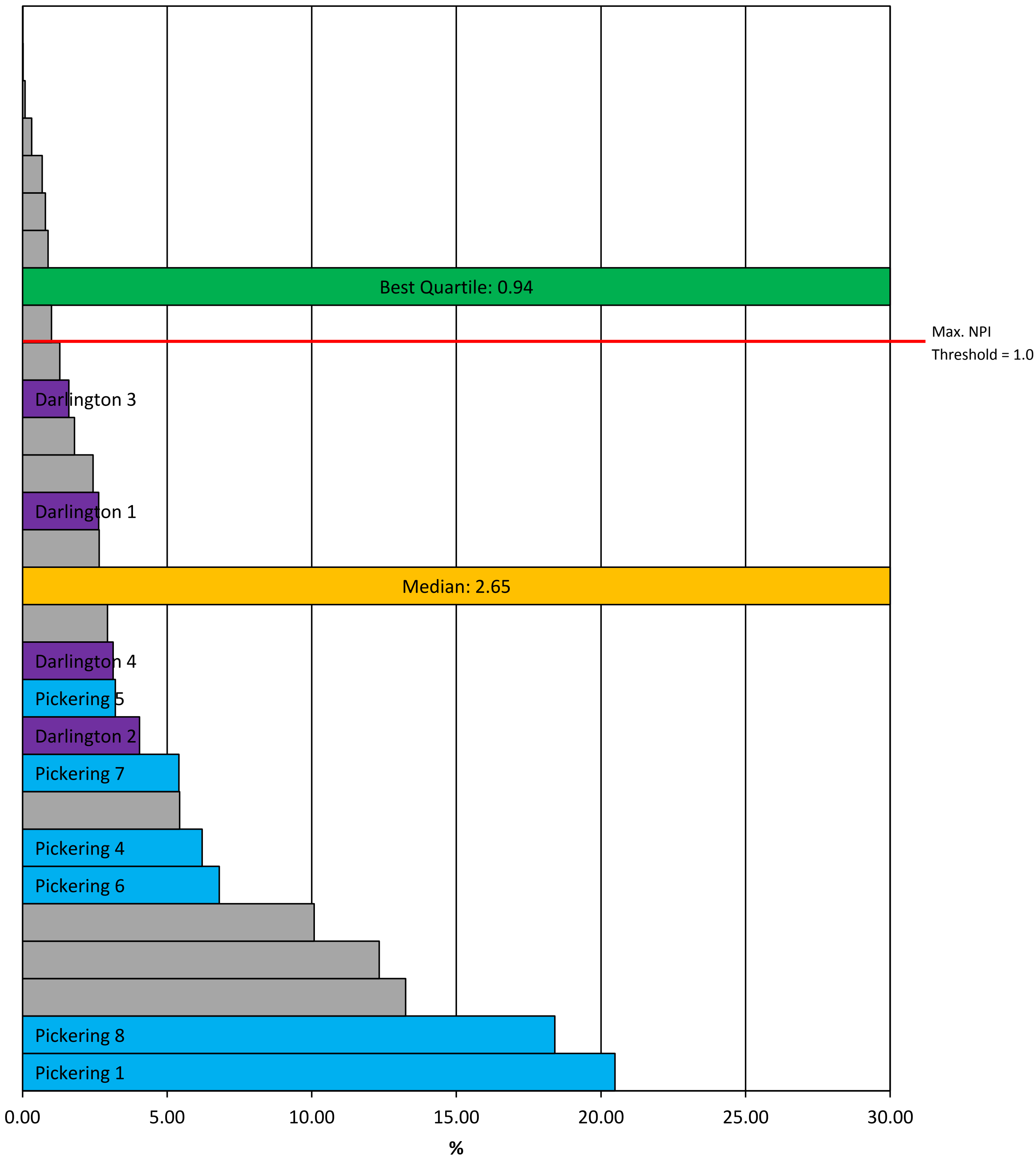
- For 2014, Darlington achieved maximum scores for 7 out of 10 NPI sub-indicators.
- For each of the key safety system related metrics, high pressure injection, auxiliary feedwater, and emergency alternating current (AC) power, Darlington received 10 of 10 points.
- Darlington also achieved perfect scores for reactor trip rate (10 of 10), fuel reliability (10 of 10), chemistry performance (5 of 5), and industrial safety accident rate (5 of 5).
- Darlington earned 9.7 out of 10 points for collective radiation exposure.
- Darlington achieved 11.4 out of 15 points for unit capability factor and 11.0 out of 15 points for forced loss rate due to the forced outages and forced extensions to planned outages.

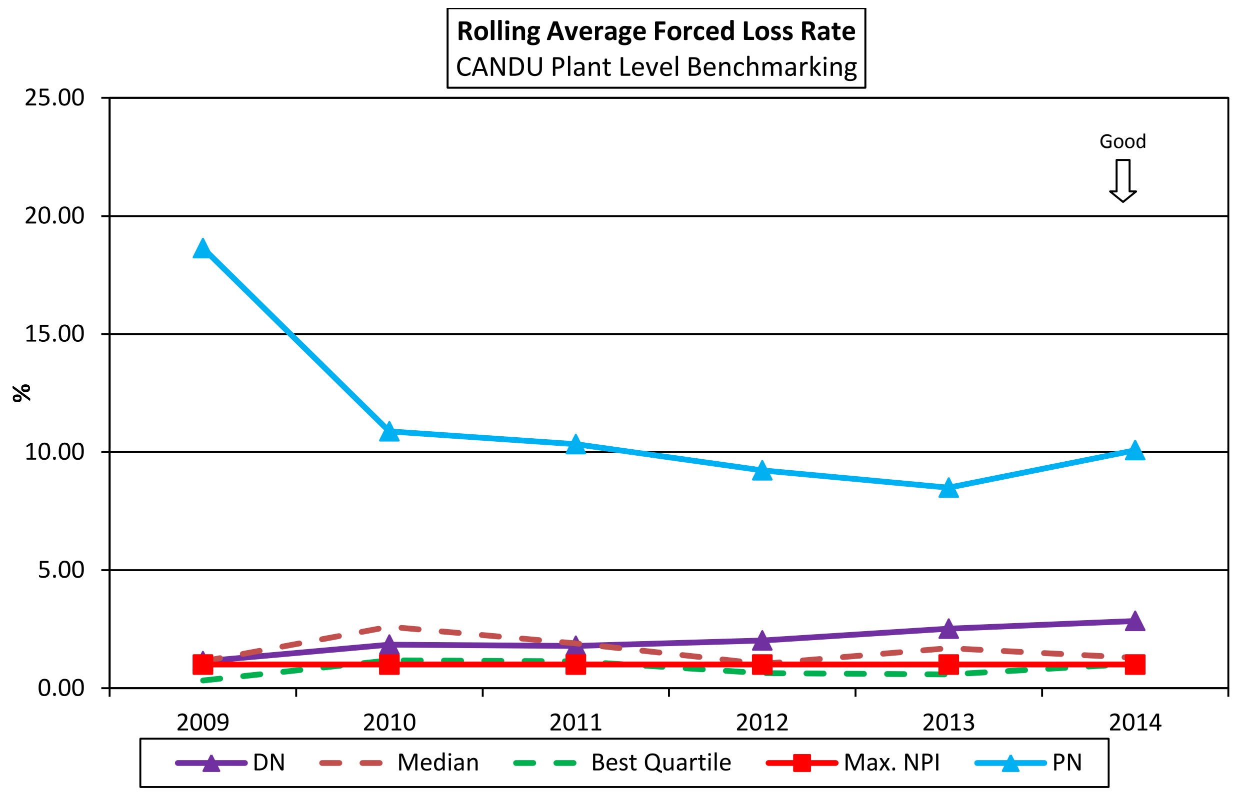
Please refer to Table 13 of the Appendix for an NPI plant level performance summary of OPG nuclear stations against the North American panel.

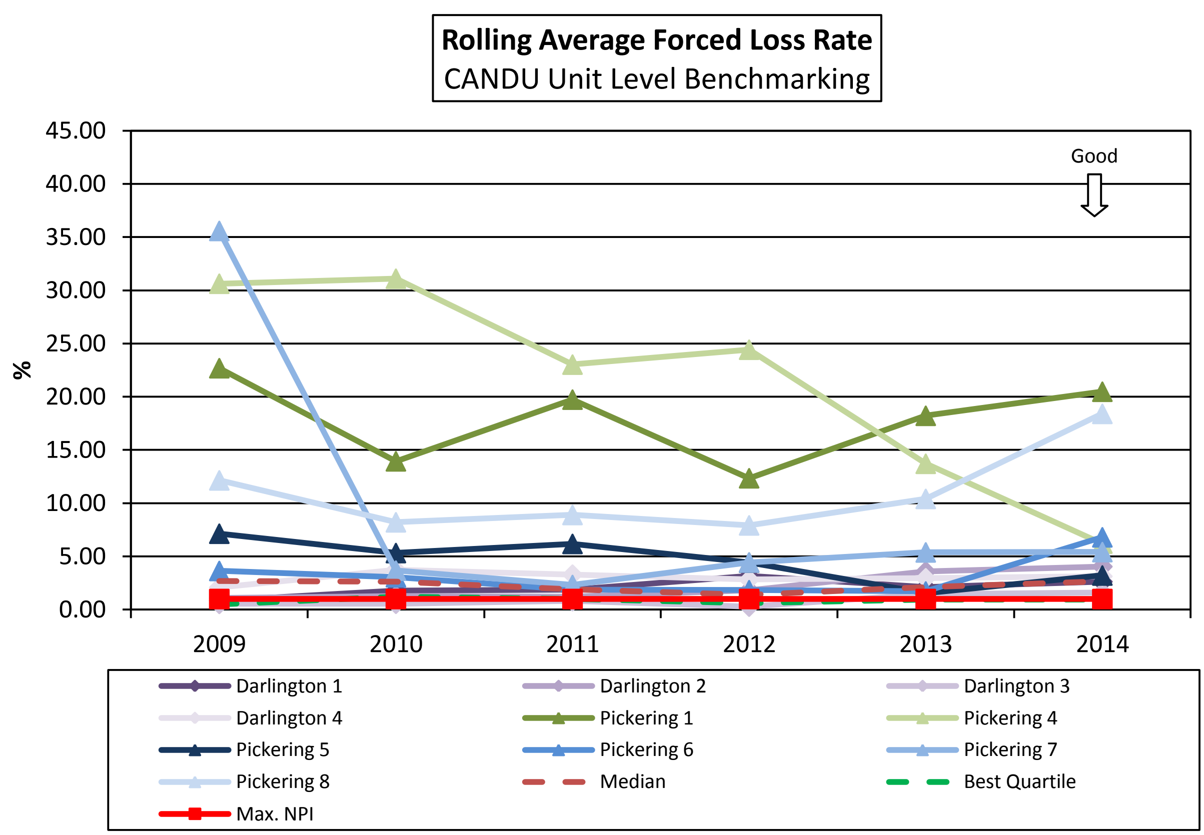
Rolling Average Forced Loss Rate



2014 Rolling Average Forced Loss Rate
CANDU Plant Level Benchmarking




Rolling Average Forced Loss Rate
CANDU Plant Level Benchmarking
25.00
20.00
15.00
10.00
5.00
0.00
%
Good
2009
2010
2011
2012
2013
2014
DN
Median
Best Quartile
Max. NPI
PN


Rolling Average Forced Loss Rate
CANDU Unit Level Benchmarking
45.00
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
%
Good
2009
2010
2011
2012
2013
2014
Darlington 1
Darlington 2
Darlington 3
Darlington 4
Pickering 1
Pickering 4
Pickering 5
Pickering 6
Pickering 7
Pickering 8
Median
Best Quartile
Max. NPI

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Observations – Rolling Average Forced Loss Rate (CANDU)

2014 (Rolling 2 Year Average Pickering %, Rolling 3 Year Average Darlington %)

- At the plant level, Pickering Forced Loss Rate (FLR) performance was 10.08 compared to the industry median of 1.29. At the unit level, all Pickering units were in the third or fourth quartile with the industry median at 2.65.
- At the plant level, Darlington FLR performance was 2.85, which was also worse than median. At the unit level, Darlington Units 1 and 3 were better than median. This is an improvement, as in 2013, only one Darlington unit was above median FLR threshold.

Trend

- Industry plant median trend continues to improve over the same period, from 2.60 in 2010 to 1.29 in 2014. Industry best quartile has also improved during the period, from 1.18 in 2010 to 0.58 in 2013 to 1.03 in 2014.
- Pickering's FLR performance over the 5 year review period, generally had been improving. The equipment reliability improvements at Pickering have been the main drivers for the favourable FLR performance. However, FLR performance declined in 2014 by an increase in station FLR (10.08) from 2013 FLR (8.50).
- Darlington's overall FLR performance decreased slightly from 2.52 in 2013 to 2.85 in 2014. Over the 5 year review period, there has been a general trend of minor decrease in FLR performance, with increasing FLR (about 1%) from 1.84 in 2010 to 2.85 in 2014.

Factors Contributing to Performance

- Equipment reliability, work order backlog and human performance are contributors to the FLR performance gap at Pickering.
- Pickering's 2014 FLR was mostly impacted by fuel handling reliability, heat transport system pumps and shutdown cooling pump seals. There were 9 forced lost events/forced outages, from 5 different units. This included multiple forced outages on Unit 1 (four) and Unit 8 (two) during 2014.
- Pickering continues to execute a list of high priority work orders to improve equipment reliability and reduce operator burden.
- Pickering has a focus on reducing corrective and deficient work order backlogs through a reduction of incoming emergent work orders by proactive equipment replacements and minor modifications to improve/correct system and equipment performance.
- Pickering is also implementing equipment reliability projects to put new equipment in the plant to prevent forced loss events.
- The largest contributors to Darlington's Forced Loss in 2014 were 3 equipment issues on the conventional side of the plant (main feedwater line repair, turbine governor control and main output transformer protection) and 1 forced outage due to high vault temperature. There were 3 forced outages in 2014, and a carryover event into January from December 2013. Equipment reliability is the major contributor to FLR performance.

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Observations – Rolling Average Forced Loss Rate (CANDU) (CONT'D)

- Darlington along with Pickering continue to drive plant reliability improvements via the system health improvement process and recovery actions. The Plant Reliability List of important work orders are implemented to improve system health. Incoming work reduction and Preventative Maintenance (PM) bundling are also being leveraged for improvements.
- Improvements in equipment reliability, high Equipment Reliability Index performance and effective mitigation of single point vulnerabilities in plant production systems are common practices of top operating plants.
- NFI-01 Fuel Handling Reliability fleet initiative has helped improve fleet performance over the past year.

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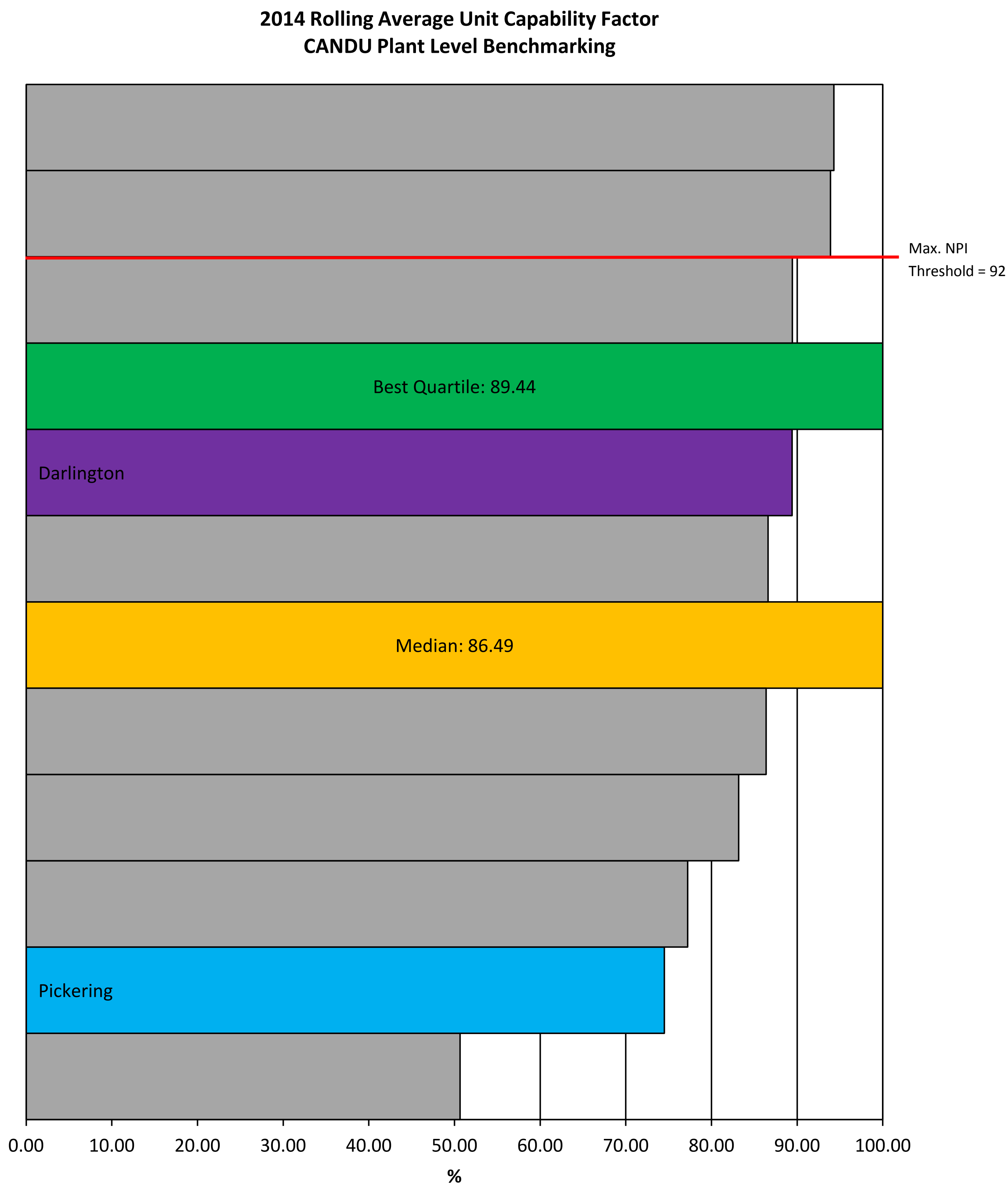
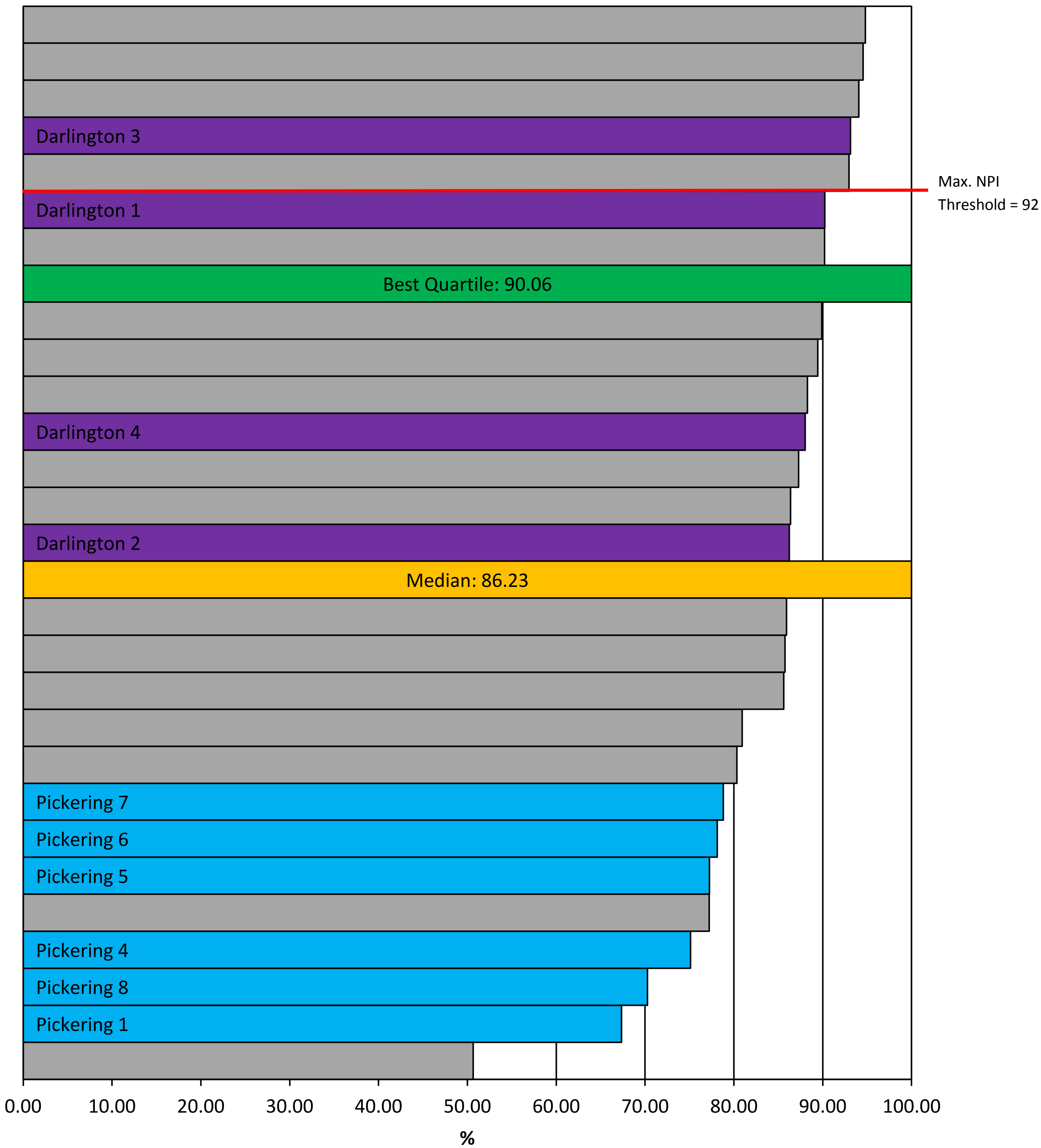
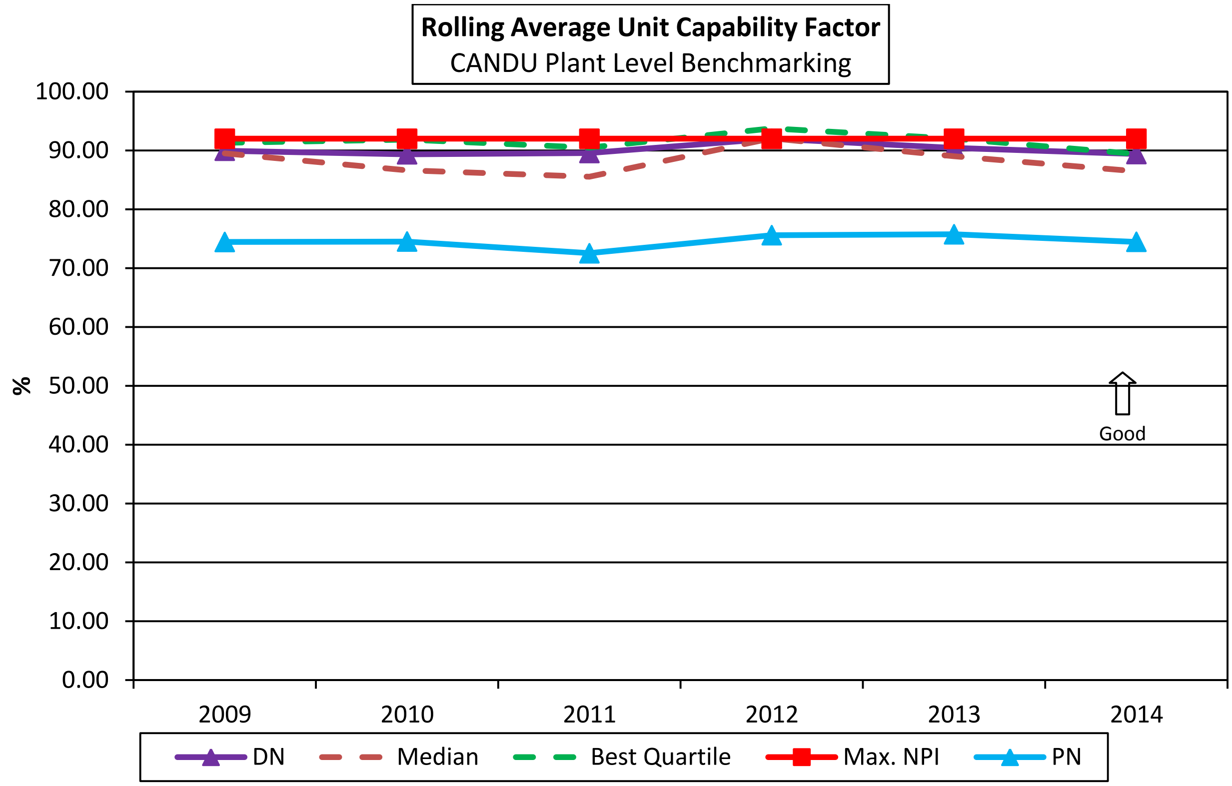
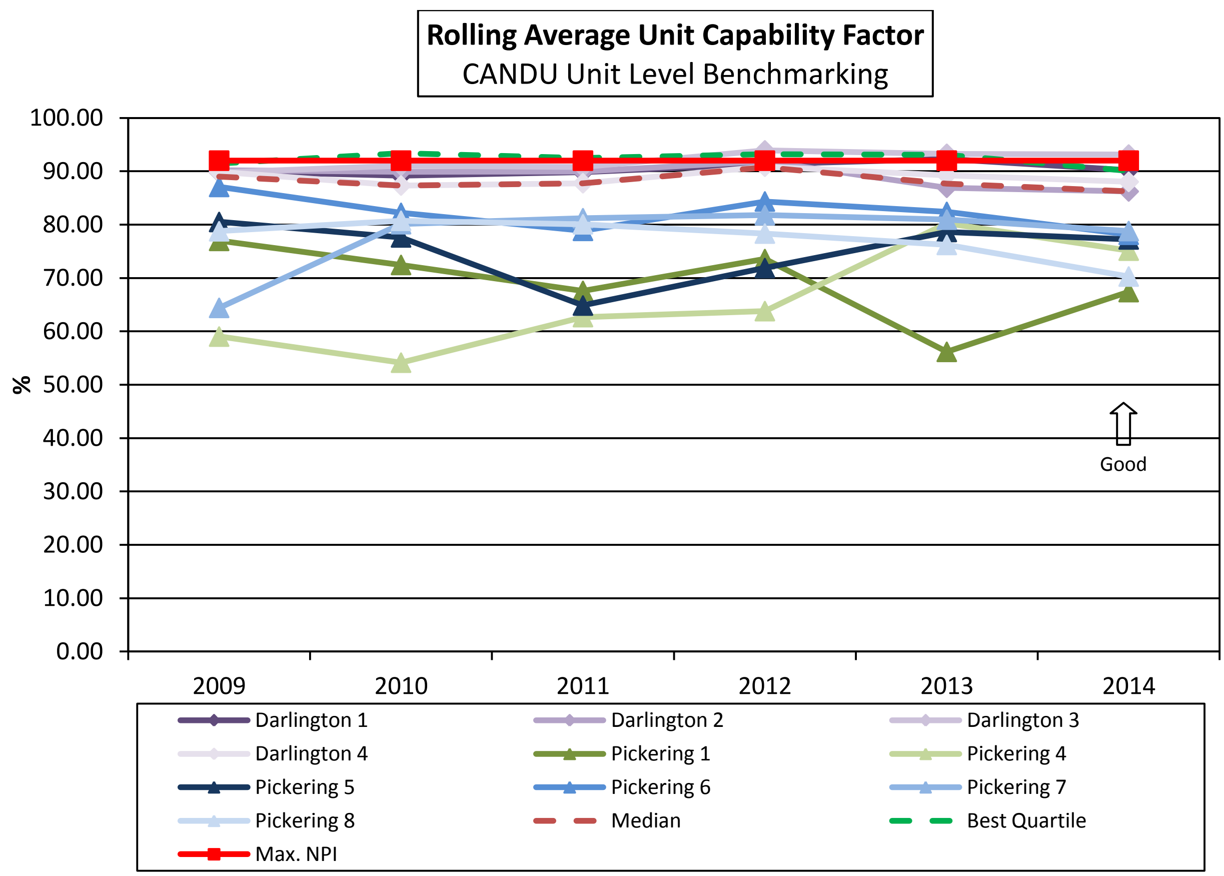
Rolling Average Unit Capability Factor



2014 Rolling Average Unit Capability Factor
CANDU Unit Level Benchmarking




Rolling Average Unit Capability Factor
CANDU Plant Level Benchmarking
100.00
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
%
Good
2009
2010
2011
2012
2013
2014
DN
Median
Best Quartile
Max. NPI
PN


Rolling Average Unit Capability Factor
CANDU Unit Level Benchmarking
100.00
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
%
Good
2009
2010
2011
2012
2013
2014
Darlington 1
Darlington 2
Darlington 3
Darlington 4
Pickering 1
Pickering 4
Pickering 5
Pickering 6
Pickering 7
Pickering 8
Median
Best Quartile
Max. NPI

Observations – Rolling Average Unit Capability Factor (CANDU)

2014 (Rolling 2 Year Average Pickering %, Rolling 3 Year Average Darlington %)

- Pickering performed below median at both the plant and unit level UCF.
- Darlington UCF performance was 89.41, which was better than median (86.49). At the unit level, all Darlington units were better than median (86.23) and Darlington units 1 and 3 were in the top quartile.
- Pickering' gap to best quartile UCF was 14.94; and to median UCF was 11.99.
- Darlington's gap to best quartile UCF was 0.03.

Trend

- Pickering's UCF performance over the 5 year period, generally had been improving until 2014, when UCF had a minor decrease to 74.50 vs 75.77 in 2013. The equipment reliability improvements (which are tied to a reduction in FLR) at Pickering have been a driver for the favourable improvement in recent UCF performance.
- Pickering and Darlington have reduced the UCF performance gap for the third year running relative to the industry plant median and best quartiles, due to the decline in the benchmark quartiles.
- Darlington's UCF performance has been trending with the industry for the past 3 years (92.01, 90.44, 89.41) and is almost at the best quartile threshold.

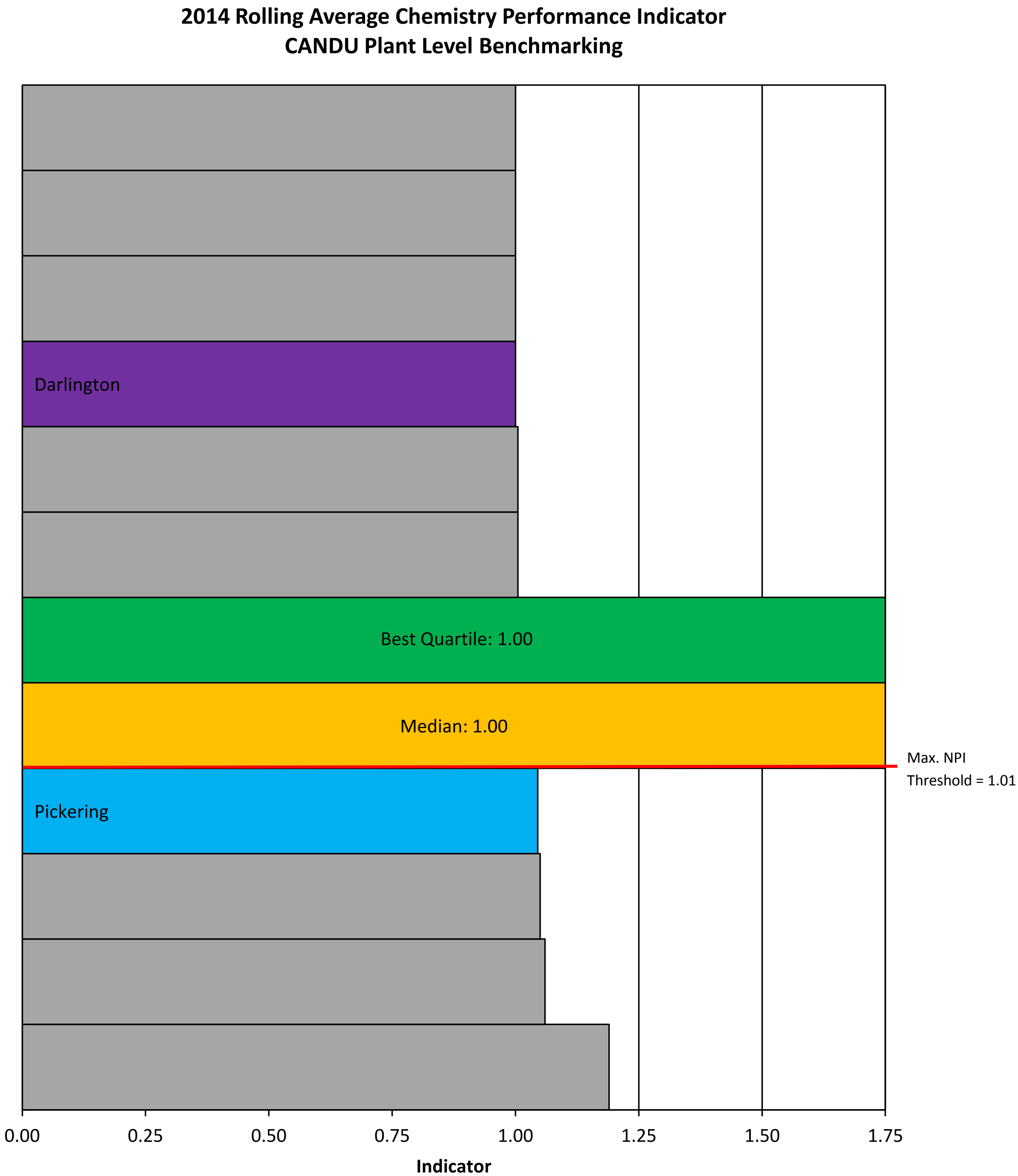
Factors Contributing to Performance

- The factors that impact UCF include planned outage, planned outage extension, forced outage and forced extension to planned outage days.
- Pickering had 284.9 days of planned outage in 2014 compared to 91.9 days for Darlington. Higher number of planned outage days contributes to lower UCF compared to CANDU peers.
- Pickering had 55.4 days of forced extension to planned outage versus 0 days for Darlington.
- The issues and causes for degrading FLR performance also negatively impact UCF. Significant improvements in equipment reliability correlate into improved FLR and UCF performance.

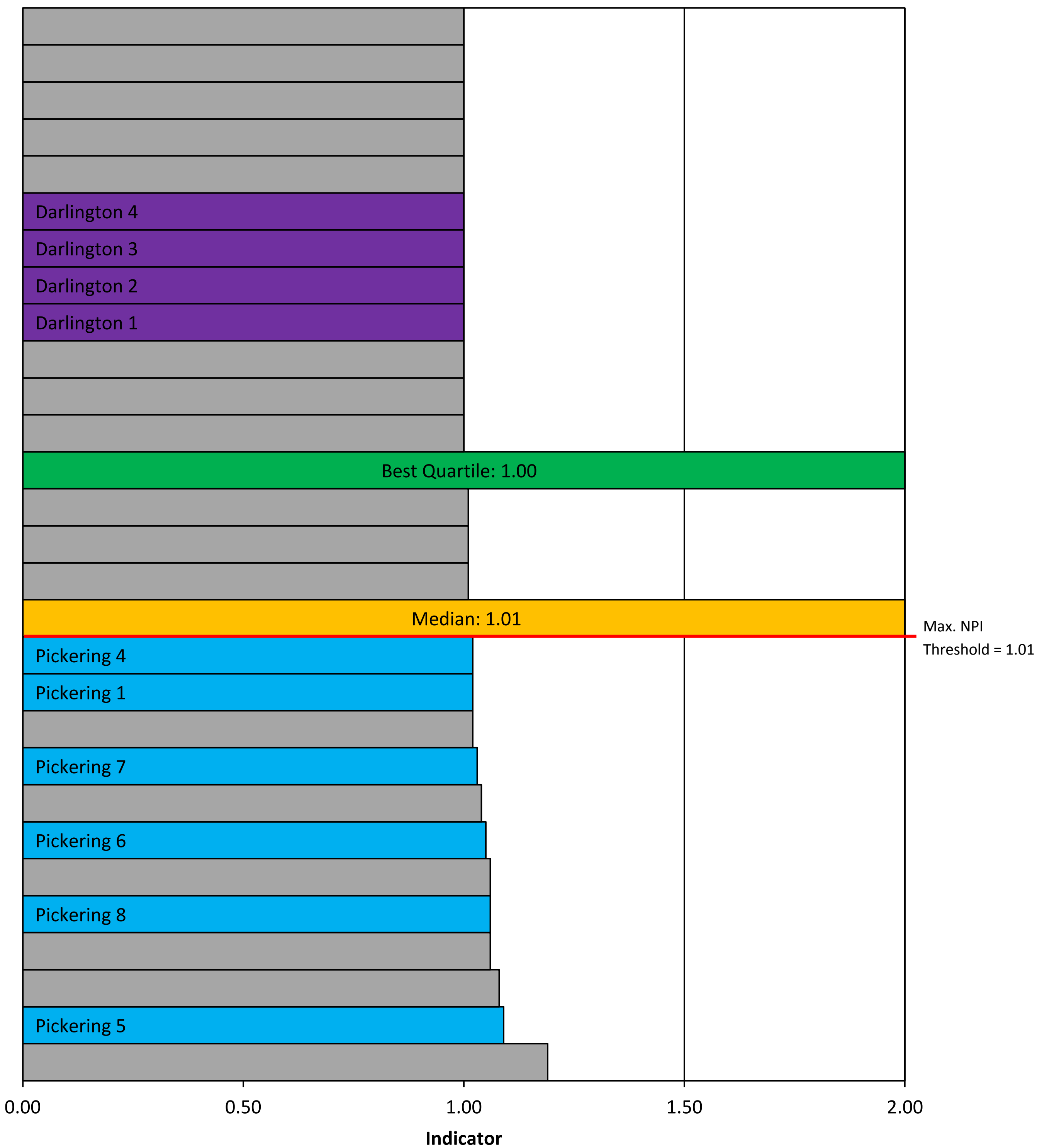
Observations – Rolling Average Unit Capability Factor (CANDU) (CONT'D)

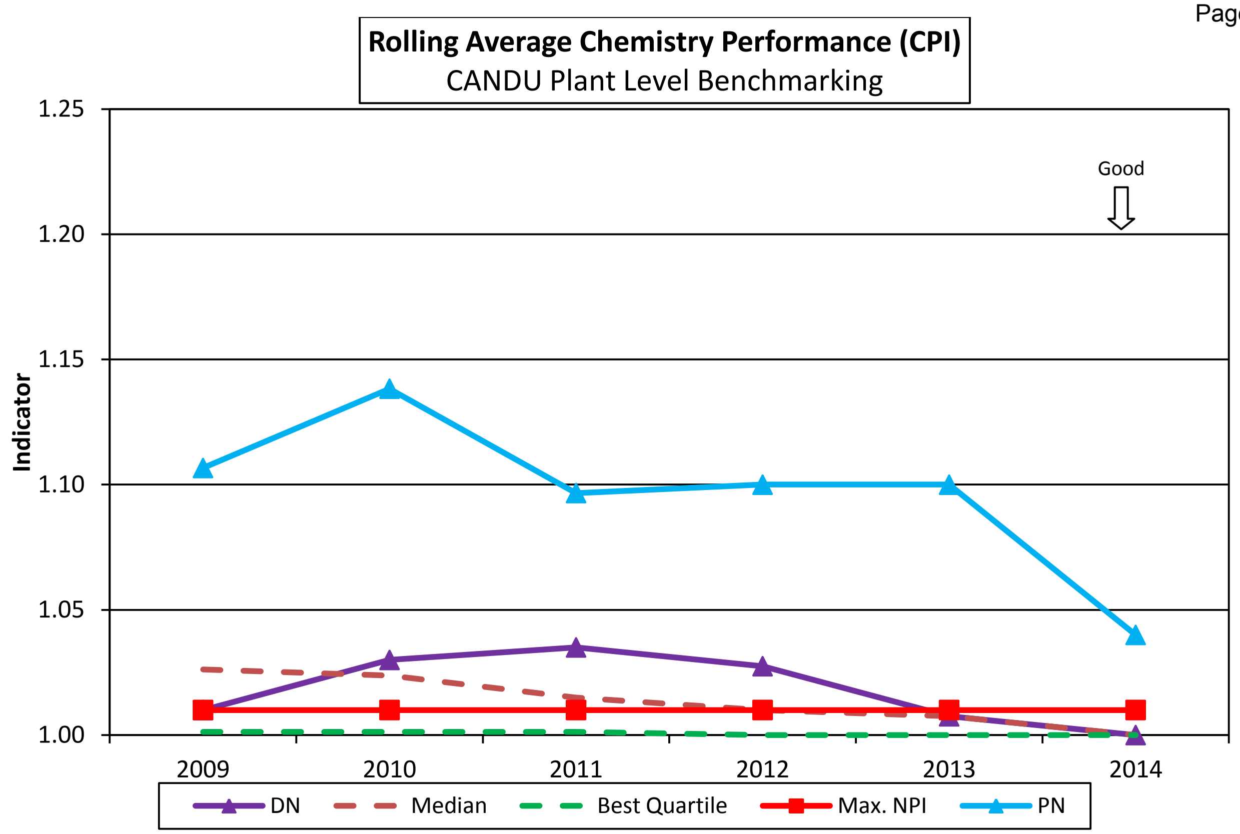
- Pickering is executing an extensive list of high-priority work orders between 2012 and 2014 to improve reliability, and reduce operator burdens.
- Pickering has teams focused on reducing corrective and deficient work backlogs, and is focusing on preventing the inflow of emergent work through proactive equipment replacement, or minor modifications to improve design.
- Darlington had extensions to the two planned outages in 2013 as well as having five forced outages.
- Darlington is completing work that will improve plant reliability through system health reporting. Included in the Plant Reliability List are work orders to improve system health and work that is identified as 'operations critical work'.
- Through system health reporting, Darlington is implementing actions to reduce the incoming rate of critical corrective and deficient work orders. This is an effort to improve plant reliability as well as allow maintenance to complete preventative maintenance.

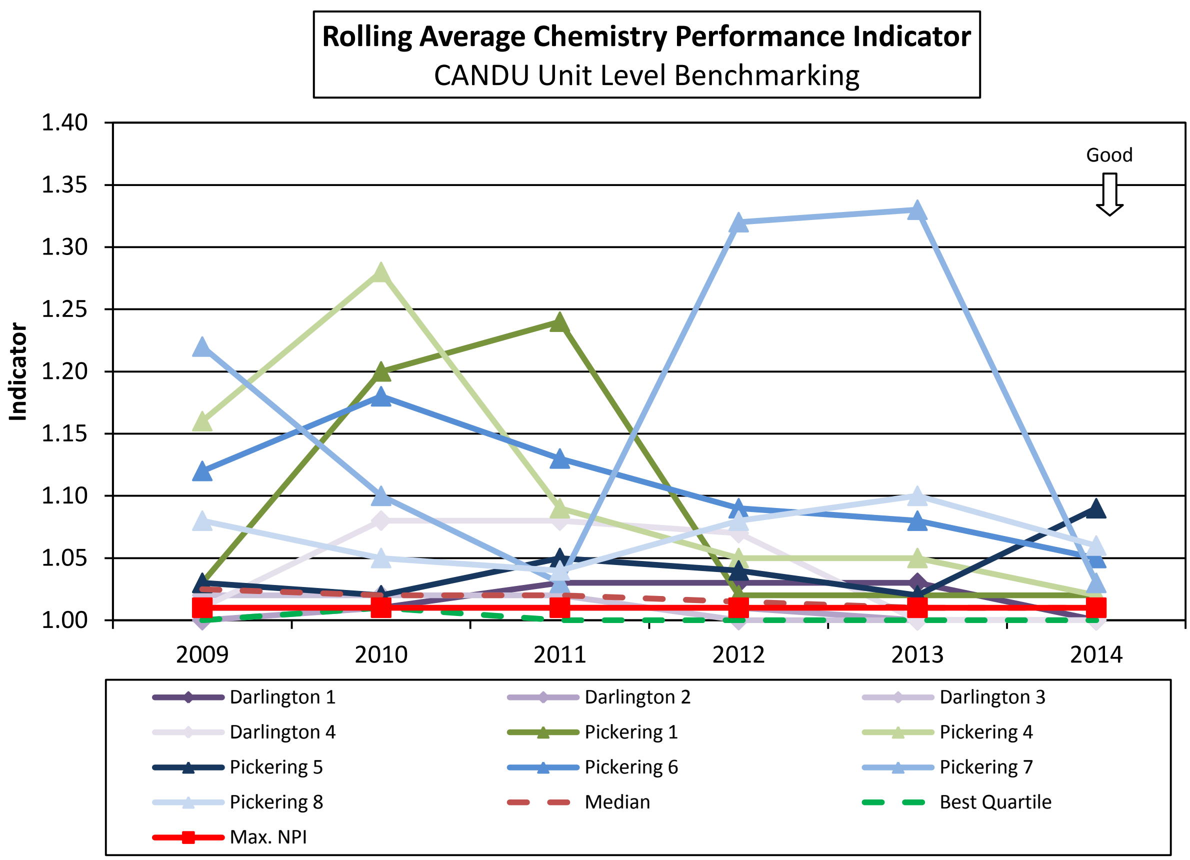
Rolling Average Chemistry Performance Indicator



2014 Rolling Average Chemistry Performance Indicator
CANDU Unit Level Benchmarking




Rolling Average Chemistry Performance (CPI)
CANDU Plant Level Benchmarking
Indicator
1.25
1.20
1.15
1.10
1.05
1.00
2009
2010
2011
2012
2013
2014
Good
DN
Median
Best Quartile
Max. NPI
PN


Rolling Average Chemistry Performance Indicator
CANDU Unit Level Benchmarking
Indicator
1.40
1.35
1.30
1.25
1.20
1.15
1.10
1.05
1.00
2009
2010
2011
2012
2013
2014
Good
Darlington 1
Darlington 2
Darlington 3
Darlington 4
Pickering 1
Pickering 4
Pickering 5
Pickering 6
Pickering 7
Pickering 8
Median
Best Quartile
Max. NPI

Observations – Rolling Average Chemistry Performance Indicator (CANDU)

2014 (Rolling 2 Year Average Pickering, Rolling 3 Year Average Darlington)

- The CANDU plant median and top quartile values are both 1.00
- The CANDU unit median and top quartile values are 1.01 and 1.00 respectively
- The Pickering plant level of performance was worse than the CANDU plant median CPI (1.04 vs 1.00).
- The Pickering unit levels of performance were all worse than the CANDU unit level median CPI (1.02 to 1.09 vs 1.01).
- Pickering plant performance in 2014 improved to 1.04 from 1.10 in 2013.
- Pickering unit performance in 2014 improved markedly on Units 4, 6, 7 and 8 whereas performance on Unit 1 remained constant and declined for Unit 5. The CPI results were impacted primarily by multiple unit start-ups from both planned and unplanned outages resulting in (primarily) elevated boiler sulphate, a Unit 5 condenser tube leak, and periodic boiler blowdown (partial) unavailability/suspension due to water treatment plant issues and Frazil ice protection.
- Darlington plant performance in 2014 was equivalent to the CANDU plant level median and best quartile performance (1.00).
- Darlington unit performance in 2014 was equivalent to the CANDU plant level best quartile performance (1.00) and better than the median level performance (1.01)

Trend

- Pickering overall plant performance has improved over the last 5 years (1.14, 1.10, 1.10, 1.10, and 1.04 for 2010-2014 respectively).
- Darlington overall plant performance has improved over the last 5 years (1.03, 1.03, 1.03, 1.01, and 1.00 for 2010-2014 respectively).

Factors Contributing to Performance

- Improvements at Pickering are hindered by numerous unit power transients which tend to result in increased boiler ion values and (potentially) an increasing rate of condenser tube leaks
- Best practices among top performing plants include use of dispersants to reduce iron transport to boilers, condenser inspections and, if necessary, cleaning to remove a source of iron and copper transport to boilers during start-ups. These inspections and cleans are now being performed at both Pickering and Darlington. Darlington has implemented morpholine addition to reduce iron transport (Pickering already employs morpholine addition). Darlington's corrosion product reduction plan also includes startup filtration, dry lay-up and sampling improvements.
- Fleetwide and station initiatives which have or are expected to improve performance include:
  - Complete:
    - Morpholine addition to reduce iron transport at Darlington completed (~40% improvement realised).
    - Improvement in the makeup water quality and quantity after completing the Pickering water treatment plant modifications (upgrades complete, testing in progress).
    - Local monitoring of feedwater dissolved oxygen to allow control to levels well below the industry median value.
  - In progress:
    - Planned blowdown piping improvements at Pickering.
    - Planned Engineering changes to reduce iron transport at Darlington.
    - Pre-startup condenser cleaning to reduce iron and copper transport at both Pickering and Darlington.
    - KT analysis on the impact on unit startup on Pickering (boiler sulphate) performance.

1-Year On-line Deficient Maintenance Backlog

Observations – On-line Deficient Maintenance Backlog

2014

- This review was performed using of INPO AP-928 guideline effective June 2010 (Revision 3).
- The industry Best Quartile and Median thresholds were 159 and 212 work orders per unit respectively for On-line Deficient Maintenance (DM) Backlog. The thresholds are released by INPO. However the individual plant data from INPO members was not available this year.
  - Darlington DM Backlogs were at 176 Work Orders per unit for 2014, placing in the second quartile relative to industry benchmarks.
  - Pickering DM Backlogs were at 276 Work Orders per unit for 2014, placing below the median quartile.

Trend

- In comparison to the 2013 data:
  - Darlington performance in 2014 continued to improve to 176 work orders/unit from 184 work orders/unit.
  - Pickering performance has dropped from a year ago (276 work orders/unit in 2014 vs 215 work orders/unit in 2013).
- Darlington has shown backlog improvement year over year since 2011.
- Pickering has shown backlog improvement from 2011-2013 while increasing in 2014.

Factors Contributing to Performance

- For Darlington and Pickering, the factors that impact the deficient maintenance backlogs include the following:
  - Forced outages and forced outage extensions which negatively impact backlog reduction efforts.
  - Gaps in the work package preparation and walkdown processes (for example: incomplete inventory parts staging, work protection not applied, inadequately assessed work packages that lead to maintenance re-work) contribute to delays in execution of backlog work orders.

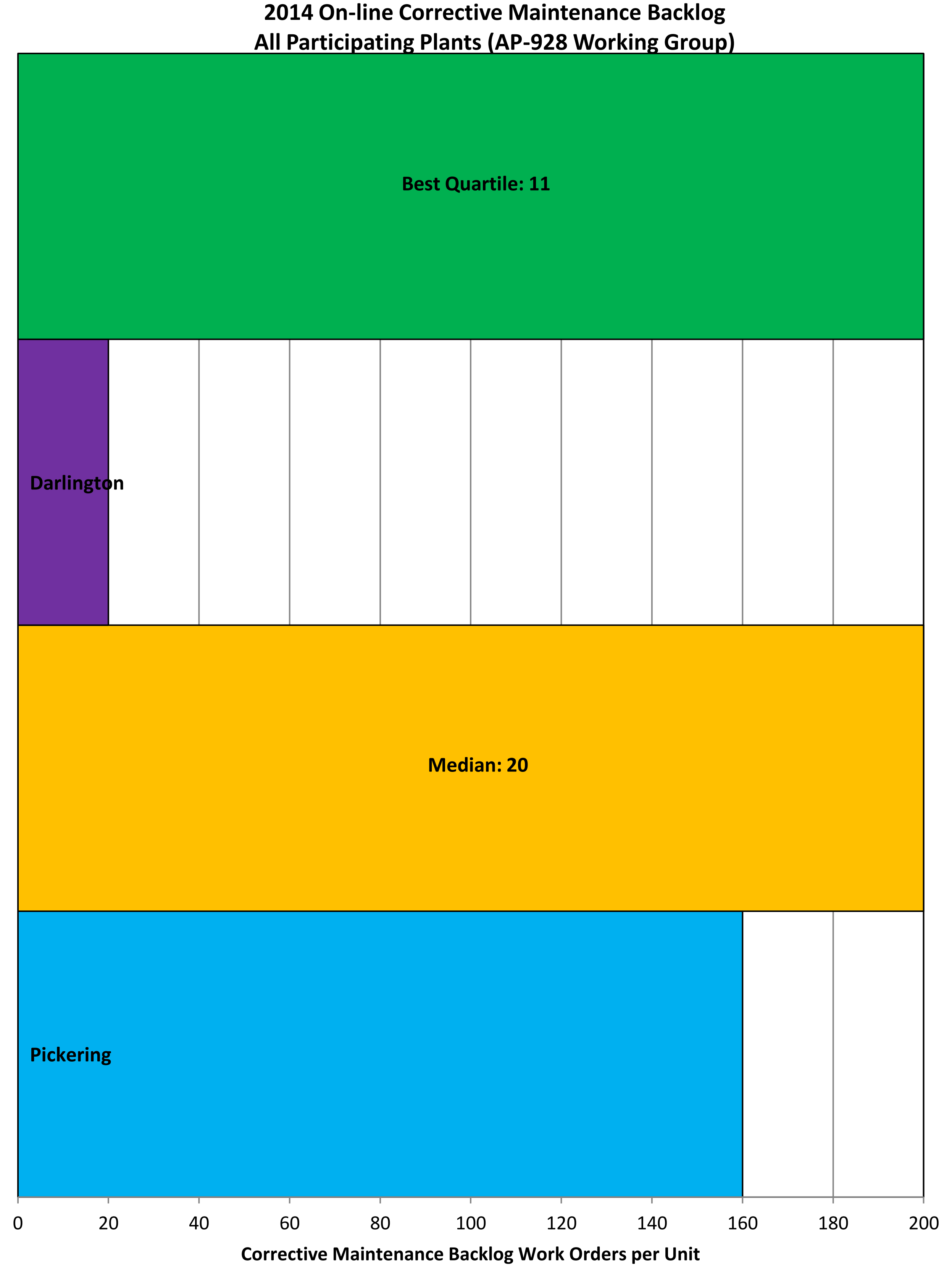
Darlington

- Darlington is currently performing better than the median threshold (176 work orders per unit). This is a 4.3% improvement from 2013 and has shown improvements for four consecutive years. On-going initiatives to continue to drive improvements include:
  - Roll out of the Parts Improvement Initiative, coding of priority work and getting parts to the plant
  - Implement a monthly review and scrub backlog to ensure fidelity

Pickering

- On-going initiatives to continue to drive improvements include:
  - Inclusion of hard to execute on-line backlogs during outage scope.
  - Lock-in resource levels 21 weeks prior to work execution.
  - Increase Fix-it-Now (FIN) resources.
  - Establish ‘Get Work Ready’ teams to ensure certain work orders are ready to execute.

1-Year On-line Corrective Maintenance Backlog



Observations – On-line Corrective Maintenance Backlog

2014

- This review was performed using of INPO AP-928 guideline effective June 2010 (Revision 3).
- The industry Best Quartile and Median thresholds were 11 and 20 work orders per unit respectively for On-line Corrective Maintenance (CM) Backlog. The thresholds are released by INPO. However the individual plant data from INPO members were not available this year.
  - Darlington CM Backlogs were at 20 work orders/unit in 2014 (at the median quartile).
  - Pickering CM Backlogs were at 160 work orders/unit placing below the median quartile.

Trend

- In comparison to the 2013 data:
  - Darlington performance in 2014 continued to improve to 20 work orders/unit from 32 work orders/unit. Darlington moved up to the second quartile as a result of this improvement.
  - Pickering performance has dropped from a year ago to 160 work orders/unit from 124 work orders/unit.
- Darlington has shown backlog improvement year over year since 2011.
- Pickering has shown backlog improvement from 2011-2012 while increasing in both 2013 and 2014.

Factors Contributing to Performance

- For Darlington and Pickering, the factors that impact the corrective maintenance backlogs include the following:
  - Forced outages and forced outage extensions which negatively impact backlog reduction efforts.
  - Gaps in the work package preparation and walkdown processes (for example: incomplete inventory parts staging, work protection not applied, inadequately assessed work packages that lead to maintenance re-work) contribute to delays in execution of backlog work orders.

Darlington

- Darlington is current at the median threshold (20 work orders per unit). This is a 37.5% improvement from the year before. On-going initiatives to continue to drive improvements include:
  - Roll out of the Parts Improvement Initiative, coding of priority work and getting parts to the plant
  - Inclusion of hardened backlogs into outage scope.

Pickering

- On-going initiatives to continue to drive for improvement with corrective maintenance backlogs include:
  - Targeting ‘Zero’ Corrective Critical backlogs upon completion of planned outage
  - The Parts Improvement Initiative has been rolled out in Pickering late 2014.
  - Increase Fix-it-Now (FIN) resources.
  - Lock-in resource levels 21 weeks prior to work execution.
  - Inclusion of hard to execute on-line backlogs into outage scope.

4.0 VALUE FOR MONEY

Methodology and Sources of Data

The Electric Utility Cost Group (EUCG) database is the source for cost benchmarking data. Data was collected for three-year rolling averages for all financial metrics covering the review period from 2009-2014. Zero values for cost indicators are excluded from all calculations. All data submitted to and subsequently extracted from EUCG by OPG is presented in Canadian dollars.

Effective January 2009 (but applied retroactively to EUCG historical data), EUCG automatically applies a purchasing power parity (PPP) factor to adjust all values across national borders. The primary function of the PPP value is to adjust for currency exchange rate fluctuations but it also adjusts for additional cross-border factors which may impact purchasing power of companies in different jurisdictions. As a result, cost variations between plants is limited, as much as possible, to real differences and not advantages of utilizing one currency over another.

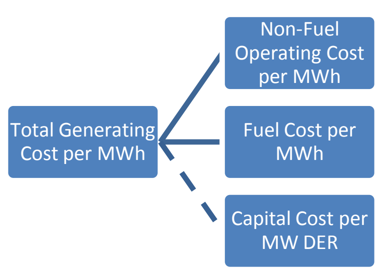
The benchmarking panel utilized for value for money metrics is made up of all North American plants reporting to EUCG. Bruce Power is the only other CANDU technology plant reporting within that panel. The remaining plants are Boiling Water Reactors or Pressurized Water Reactors. For that reason, some of the gaps in performance are associated with technology differences rather than comparable performance.

All metrics include cost information normalized by some factor (MWh or MW DER) to allow for comparison across plants.

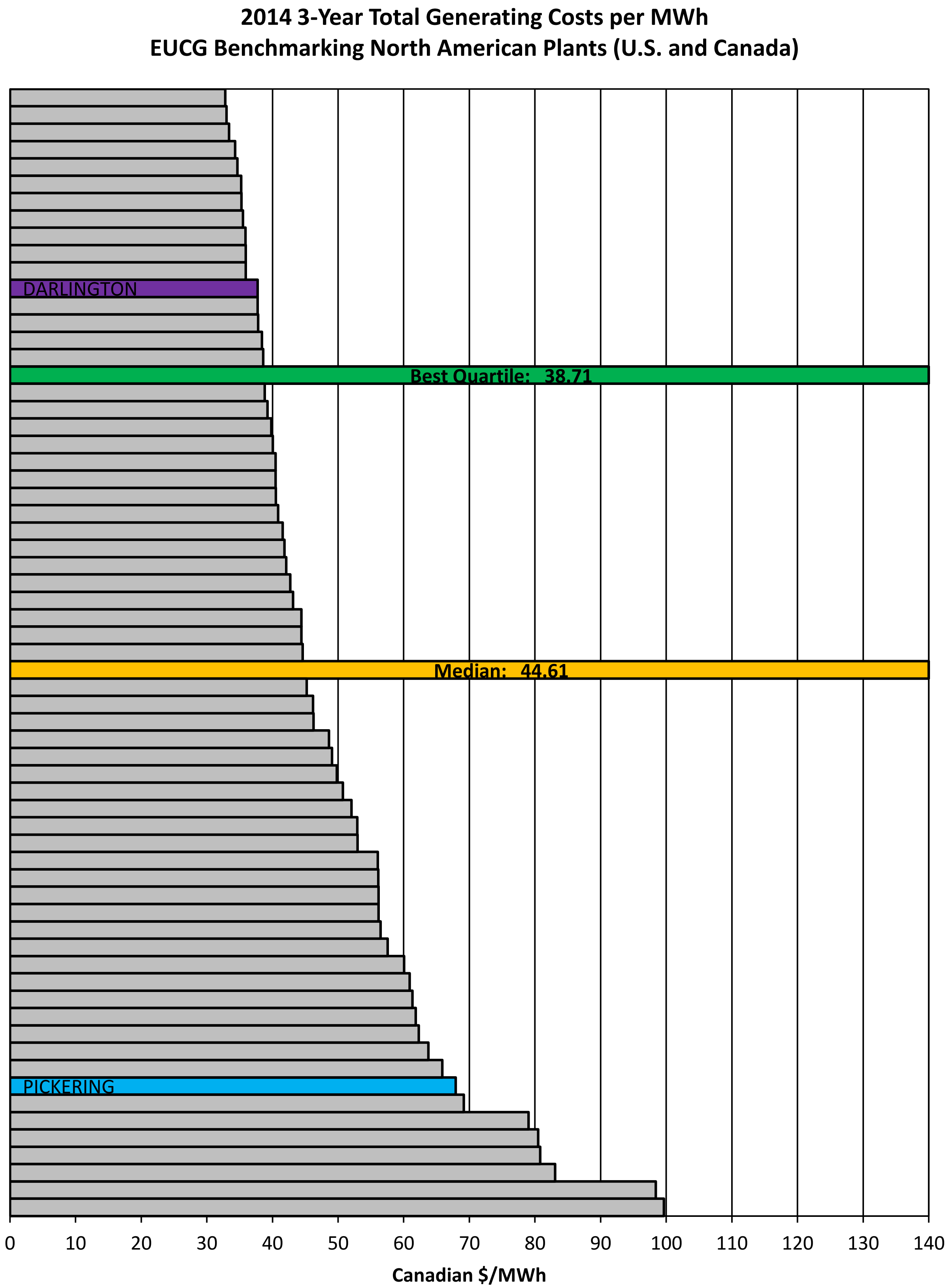
Discussion

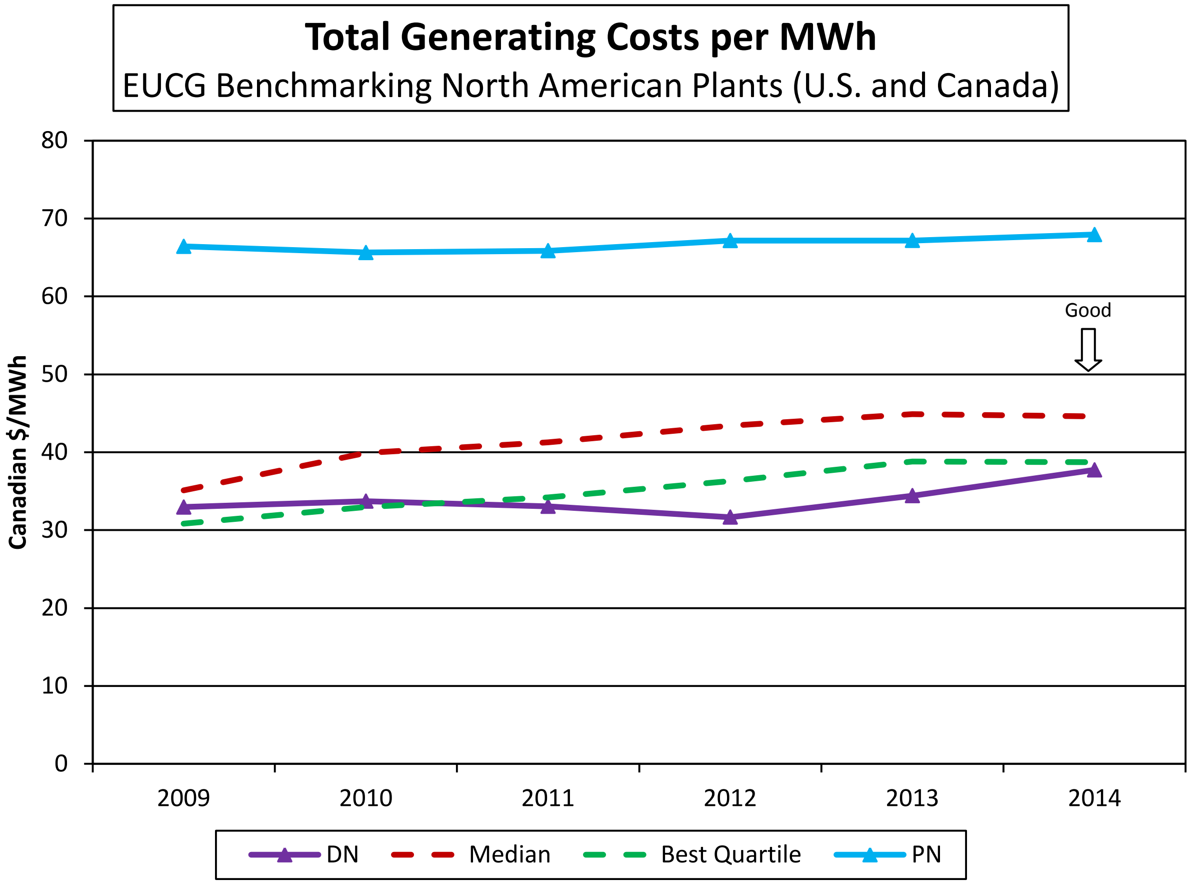
Four value for money metrics are benchmarked in this report. They are the Total Generating Cost per MWh, Non-Fuel Operating Cost per MWh, Fuel Cost per MWh, and Capital Cost per MW DER. The relationship underlying the value for money metrics is shown in the illustration below. The Total Generating Cost per MWh is the sum of Non-Fuel Operating Cost, Fuel Cost and Capital Cost measured on a per MWh basis for benchmarking purposes. Given the differences between OPG's nuclear generating stations and most North American plants with respect to both fuel costs and the different treatments of non-fuel and capital costs, the best overall financial comparison metric for OPG facilities is the Total Generating Cost per MWh.

Diagram of Summary Relationship of Value for Money Metrics



3-Year Total Generating Cost per MWh




Total Generating Costs per MWh
EUCG Benchmarking North American Plants (U.S. and Canada)
Canadian $/MWh
80
70
60
50
40
30
20
10
0
Good
2009
2010
2011
2012
2013
2014
DN
Median
Best Quartile
PN

Observations – 3-Year Total Generating Cost per MWh (All North American Plants)

2014 (3-Year Rolling Average)

- The best quartile level for Total Generating Cost per MWh (TGC/MWh) among North American EUCG participants was $38.71/MWh while the median level was $44.61/MWh.
- Darlington achieved best quartile performance with a Total Generating Cost of $37.73/MWh.
- Pickering Total Generating Cost was $67.93/MWh, worse than the median of $44.61/MWh.

Trend

- Best quartile and median TGC/MWh have escalated from 2009 to 2014. The best quartile cost rose by $7.88/MWh while the median cost rose by $9.50/MWh.
- Darlington's costs trended downward from 2010 to 2012 but have increased in both 2013 and 2014. Darlington's TGC/MWh increased by 9.6% in 2014 from 2013 levels. Even with this increase Darlington has maintained its best quartile ranking from 2011. The growth in Darlington's TGC/MWh was $4.77/MWh compared to a $7.88/MWh increase in the industry best quartile over the 2009-2014 review period.
- Over the 2009-2014 review period, Pickering maintained a relatively stable cost profile, experiencing a compound annual growth rate of only 0.5% while the industry median quartile experienced a growth rate of approximately 4.9% over the same period.

Factors Contributing to Performance

- For technological reasons, Fuel Costs per MWh is an advantage for all CANDUs and the OPG plants performed within the best quartile.
- Non-Fuel Operating Cost per MWh, for all OPG plants as a whole, yielded results that are worse than median for 2014 compared to the North American EUCG panel.
- OPG Capital Costs are below industry levels. Capital expenditures reported by the peer group include costs either not incurred by OPG due to technological differences or have been incurred by the peer group to a larger extent than OPG.

Observations – 3-Year Total Generating Cost per MWh (All North American Plants) (CON'T)

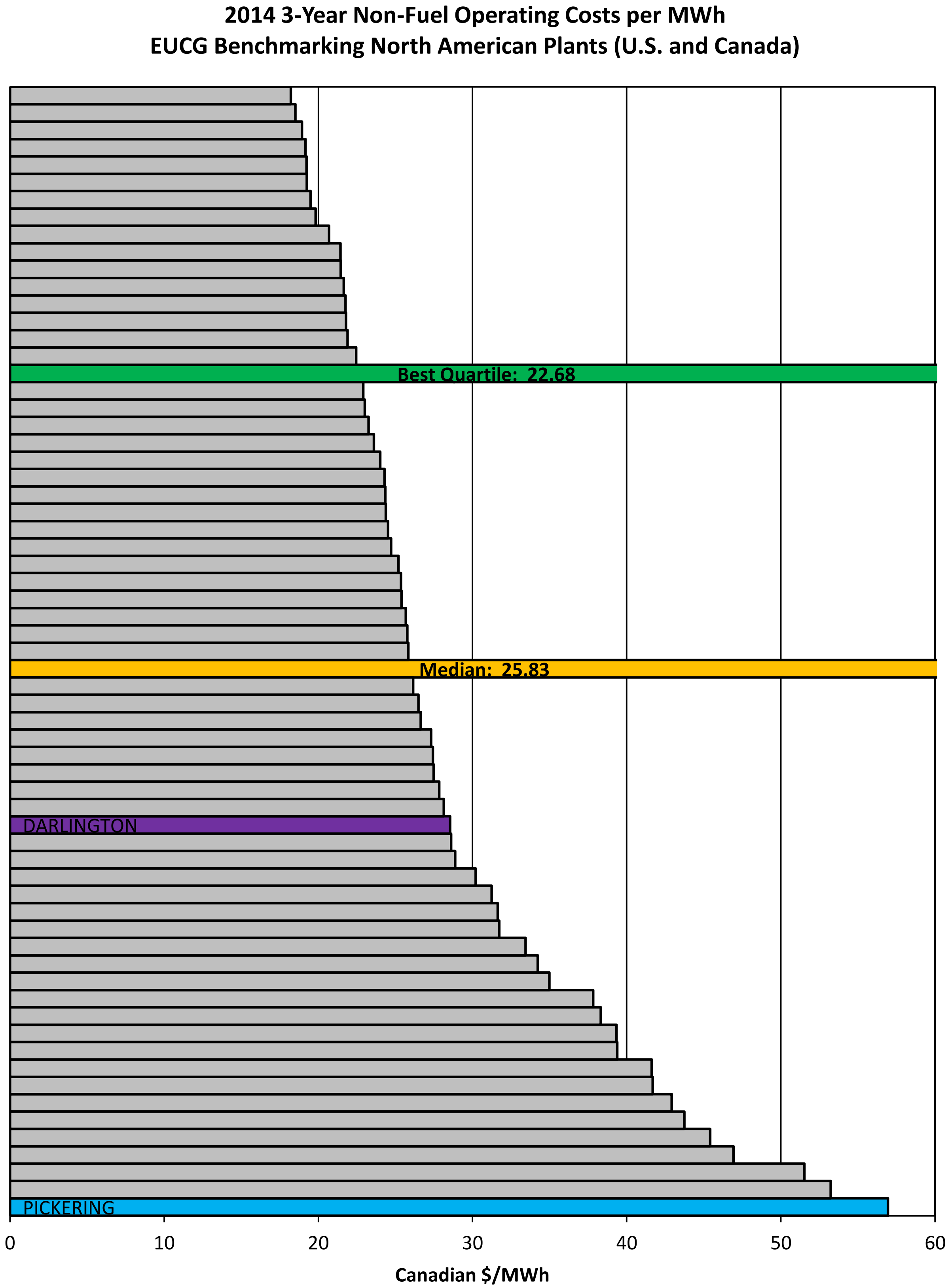
Pickering

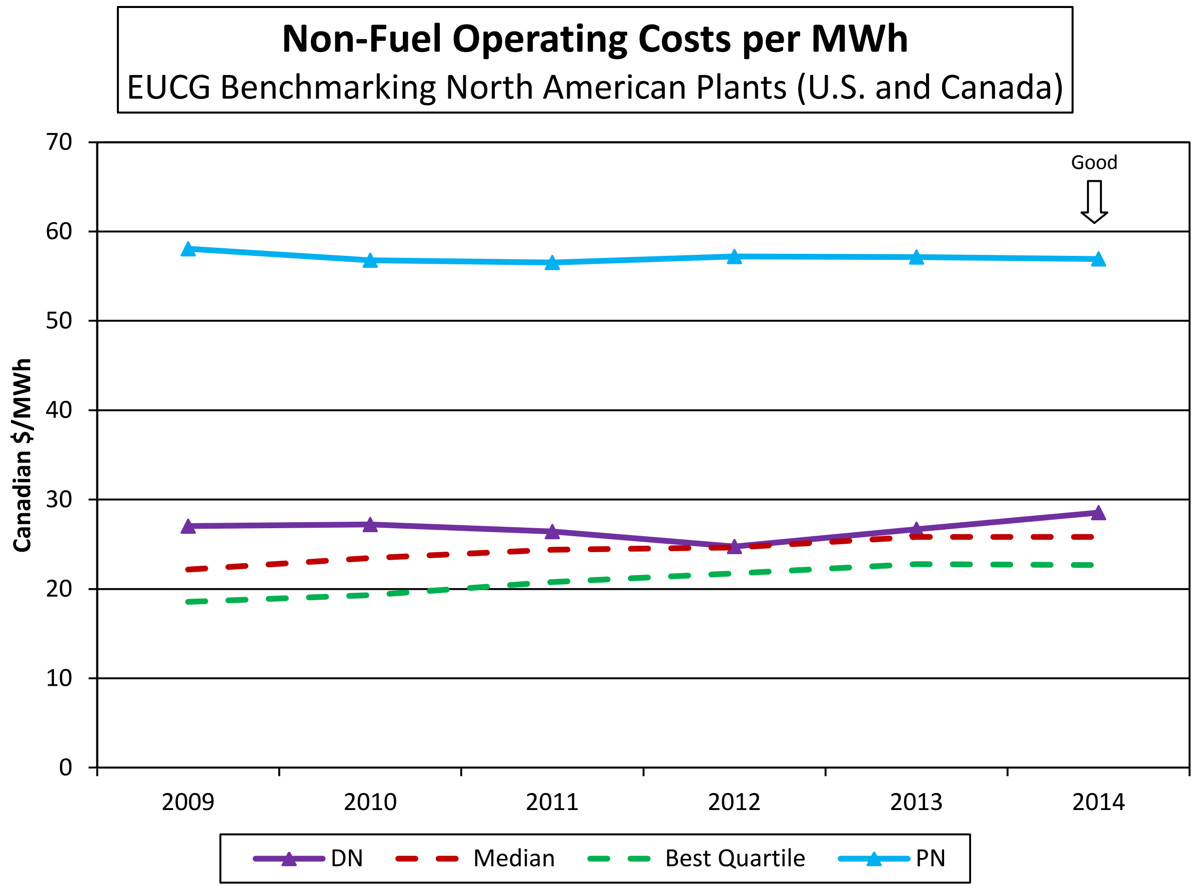
- Pickering performed within the best quartile for Fuel Cost per MWh and Capital Cost per MW DER while performing worse than the median for Non-Fuel Operating Cost per MWh.
- The primary driver for Pickering's increase in TGC/MWh in 2014 was an increase in capital costs, which was partially offset by increased generation.
- For Non-Fuel Operating Cost, the largest performance gap drivers for Pickering during the review period is CANDU technology, capability factor, smaller unit sizes, age of the plant, corporate cost allocations, and the fact that Pickering was built based on first generation CANDU technology. While OPG's ten nuclear units are all CANDU reactors, they reflect three generations of design philosophy and technology which impacts the extent and nature of operations and maintenance activity.

Darlington

- Darlington performed within the best quartile for Fuel Cost per MWh and Capital Cost per MW DER while performing slightly worse than the median for the Non-Fuel Operating Cost per MWh.
- The 2014 increase in Darlington's TGC/MWh relative to 2013 is due to higher capital costs and lower generation. The higher capital costs reflect increased investment at the station (e.g. obsolete and life expired equipment).
- For Non-Fuel Operating Cost, a large performance gap driver for Darlington during the review period is CANDU technology. The larger equipment inventory in a CANDU unit compared to the pressurized water reactor's and boiling water reactor's units represents a net increase in maintenance and operations workload which requires additional staff.
- Darlington's better than median unit capability factor as well as large unit sizes are performance gap drivers that have positively impacted the Non-Fuel Operating Cost over the review period.

3-Year Non-Fuel Operating Cost per MWh




Non-Fuel Operating Costs per MWh
EUCG Benchmarking North American Plants (U.S. and Canada)
Canadian $/MWh
Good
70
60
50
40
30
20
10
0
2009
2010
2011
2012
2013
2014
DN
Median
Best Quartile
PN

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EB-2016-0152
Exhibit F2-1-1
Attachment 1
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Observations – 3-Year Non-Fuel Operating Cost per MWh (All North American Plants)

2014 (3-Year Rolling Average)

- Best quartile plants had Non-Fuel Operating Costs per MWh (NFOC/MWh) better than $22.68/MWh.
- The median plant level threshold was $25.83/MWh.
- Compared to North American EUCG plants, the Non-Fuel Operating Costs per MWh of the OPG CANDU plants are worse than industry median performance.
- Darlington's costs, at $28.55/MWh, were $5.87/MWh higher than best quartile and $2.72/MWh higher than the median.
- Pickering's costs, at $56.94/MWh, were $34.26/MWh higher than best quartile and $31.11/MWh higher than median.

Trend

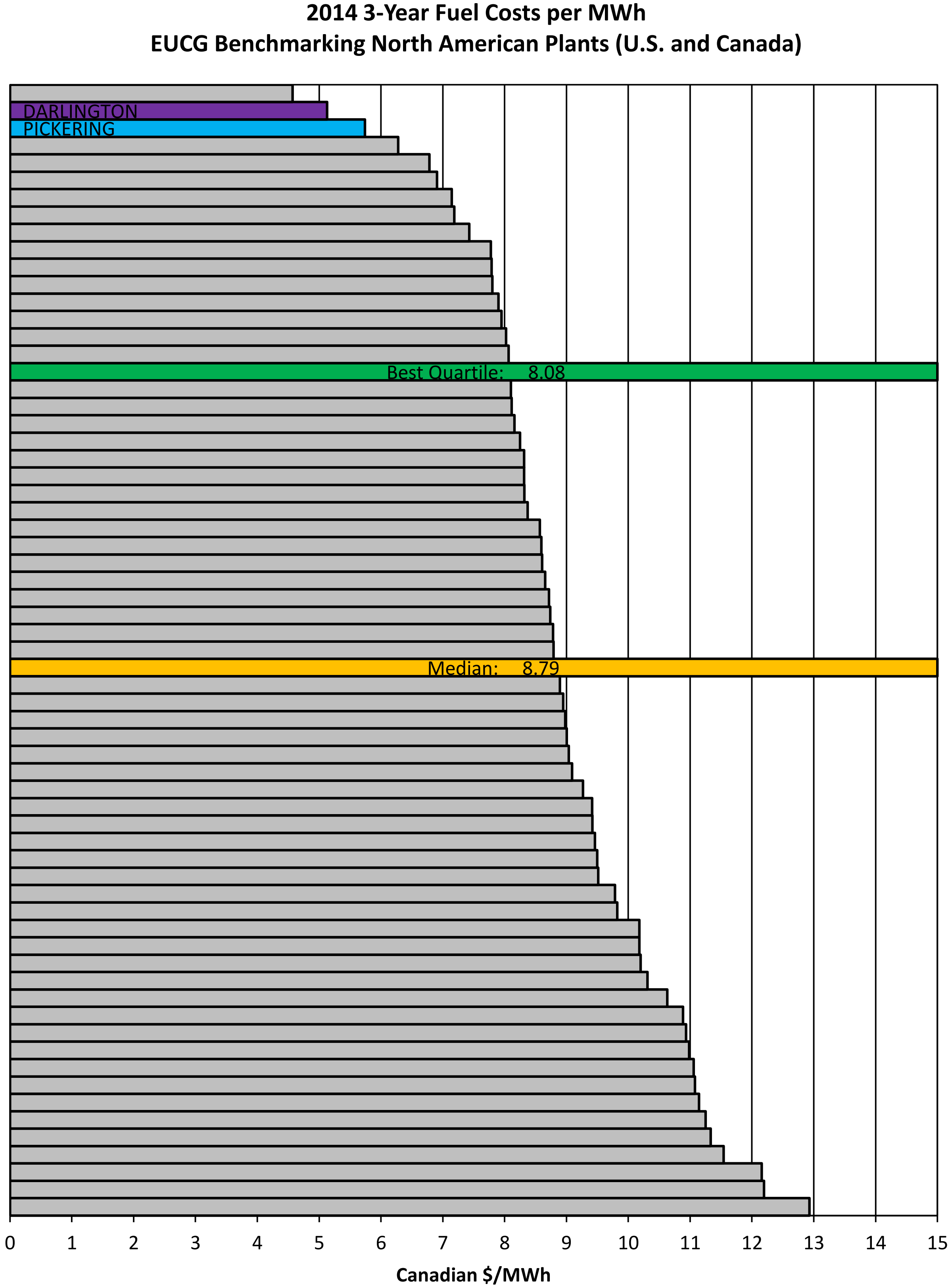
- Both best quartile and median levels increased over the 2009-2014 period with a compound annual growth rate of 4.1% for best quartile and 3.1% for median.
- Pickering NFOC/MWh has slightly decreased compared to industry since 2009 with a slight increase in 2012. The slight increase in 2012 was partly attributable to investments in the Pickering Continued Operations program. Pickering's NFOC/MWh in 2014 decreased slightly from 2013 levels, reflecting continued improved performance with respect to both generation and non capital costs. Generation and operating costs have been steady since 2009. Higher electricity production levels are largely due to the successful implementation of equipment reliability program improvement initiatives and strategic investments to resolve degraded or obsolete equipment issues which helped reduce Pickering's forced loss rate.
- Pickering's annual Non-Fuel Operating Cost, over the 2009-2014 review period, is being managed through the continuous pursuit of efficiency improvements enabled by initiatives such as the amalgamation of the Pickering A and Pickering B stations into one Pickering site. The company-wide business transformation project launched in 2011 is also helping streamline, eliminate and reduce work while sustaining safety and reliability performance.
- Darlington Non-Fuel Operating Cost per MWh increased faster than the industry best quartile and median from 2012 to 2014. NFOC/MWh decreases in 2011 and 2012 are primarily due to higher station production. This trend reversed in 2013 and 2014. Darlington's 2014 NFOC/MWh increased by 15.3% from 2012 levels while the best quartile and median levels increased by 4.2% and 4.8% respectively. The 2014 increase in Darlington's NFOC/MWh from 2013 is due primarily to lower generation and slightly higher OM&A spending.

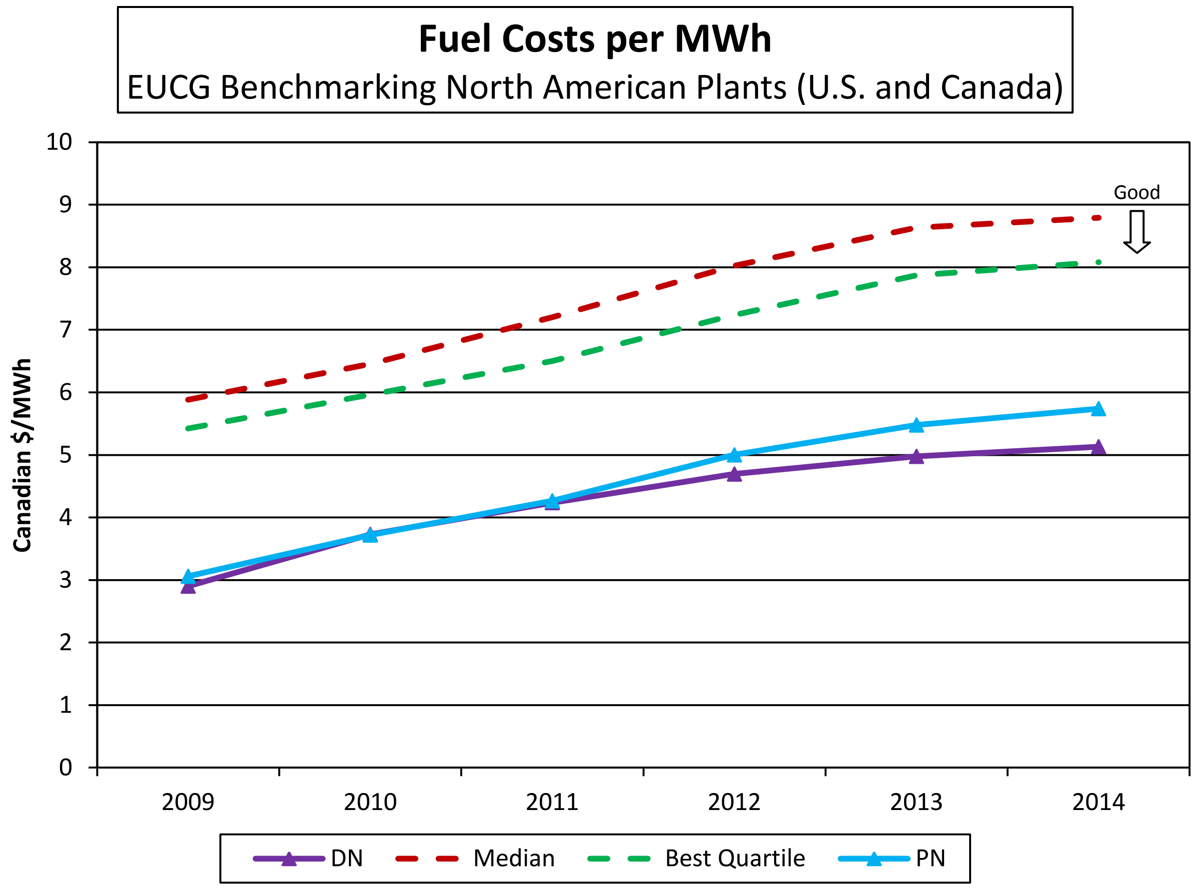
Factors Contributing to Performance – 3-Year Non-Fuel Operating Cost per MWh (CONT'D)

Factors Contributing to Performance

- Performance in Non-Fuel Operating Cost per MWh drives the majority of OPG's financial performance. Overall, the biggest drivers are: capability factor, station unit size, CANDU technology, corporate cost allocation, and staff levels. The biggest drivers are further expanded below:
  - The 'capability factor' driver is related specifically to generation performance of the station in relation to the overall potential for the station (results are discussed under the Reliability section within the Rolling Average Unit Capability Factor metric).
  - The 'station size' driver is the combined effect of number of units and size of units which can have a significant impact on plant cost performance.
  - The 'CANDU technology' driver relates specifically to the concept that CANDU technology results in some specific cost disadvantages related to the overall engineering, maintenance, and inspection costs. In addition, this factor is influenced by the fact that CANDU plants have less well-developed user groups to share and adopt competitive advantage information, than do longer-established user groups for Pressurized Water Reactors (PWR) and Boiling Water Reactors (BWR). OPG undertook a staffing study through a third-party consultant which concluded that technology, design and regulatory differences exist between CANDU and PWR reactor units and that such factors drive staffing differences. The study established that CANDU technology was a contributor to explaining higher staffing levels for CANDU versus PWR plants which also contributed to OPG's performance in Non-Fuel Operating Cost.
  - The 'corporate cost allocations' driver relates directly to the allocated corporate support costs charged to the nuclear group.

3-Year Fuel Cost per MWh




Fuel Costs per MWh
EUCG Benchmarking North American Plants (U.S. and Canada)
Canadian $/MWh
10
9
8
7
6
5
4
3
2
1
0
2009
2010
2011
2012
2013
2014
Good
DN
Median
Best Quartile
PN

Observations – 3-Year Fuel Cost per MWh (All North American Plants)

2014 (3-Year Rolling Average)

- Fuel Cost per MWh for OPG CANDU plants are better than the best quartile threshold ($8.08/MWh) for the panel of North American EUCG plants.
- The two OPG plants ranked amongst the top three lowest fuel cost plants in the North American panel with Darlington ($5.13/MWh) being the second lowest in the panel followed by Pickering ($5.74/MWh).

Trend

- The best quartile 3-year Fuel Cost per MWh has been rising since 2009 with the biggest increase in 2012.
- Since 2009, Fuel Cost per MWh for all OPG plants has been rising, a trend similarly experienced by the nuclear industry. The increase can be attributed in part to rising raw uranium prices. OPG’s raw uranium acquisition costs peaked in 2010 and have since declined; OPG’s use of weighted average cost accounting smoothes the impact on overall fuel costs. Another driver to OPG’s rising fuel costs per MWh is the significant cost increase in the used fuel storage and disposal provision in both 2010 and 2012. The rate of increase in the Fuel Cost per MWh has moderated since 2012, due primarily to lower input uranium costs and moderating used fuel storage and disposal provision costs. However, annual Uranium Conversion and Fuel Bundle Manufacturing base prices, which are indexed to inflation, continue to increase overall fuel costs.
- Fuel Cost per MWh, at the two OPG Nuclear plants converged in 2010 but is currently higher for Pickering, due primarily to its higher costs associated with the used fuel storage and disposal provisions.

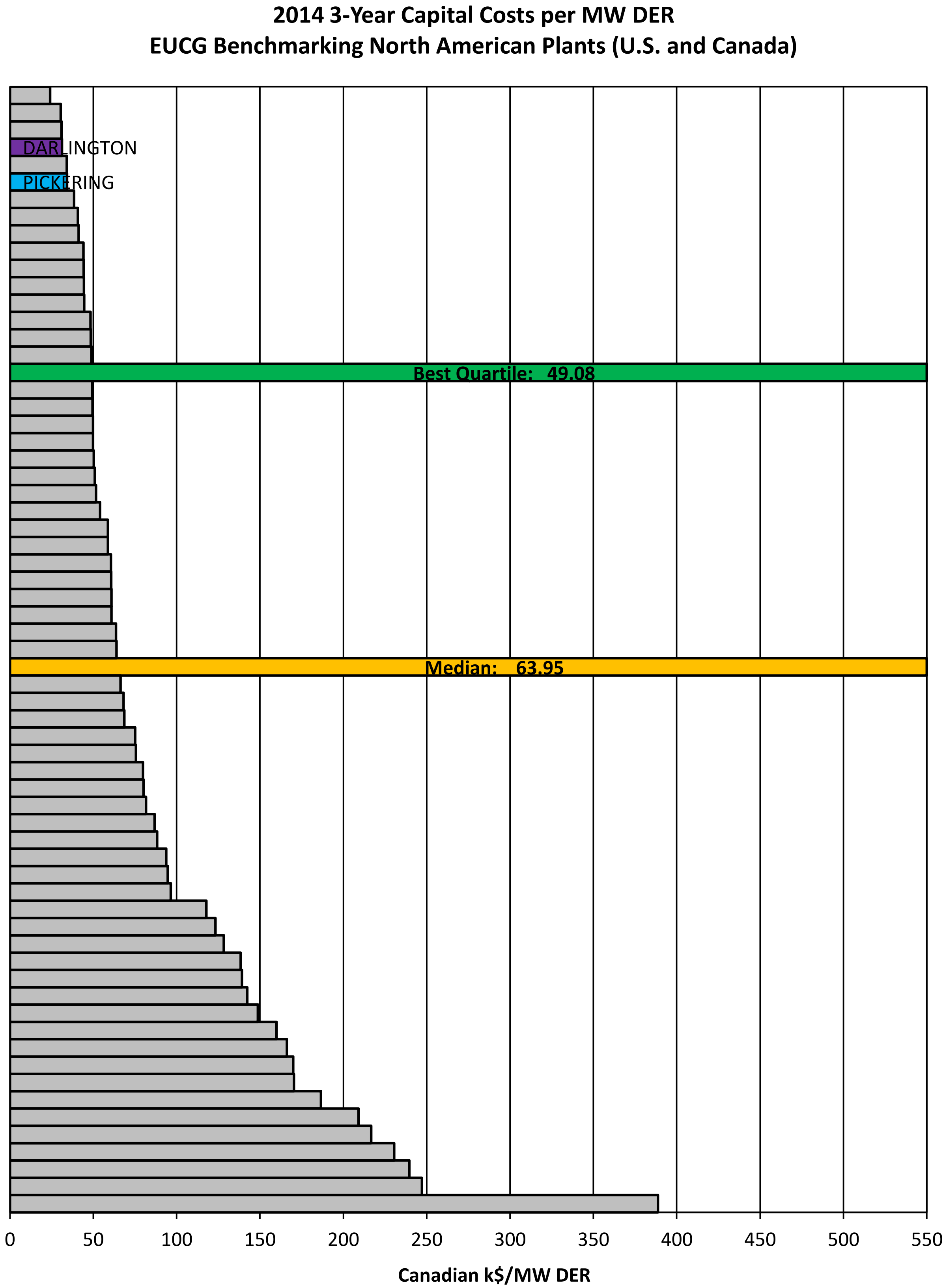
Factors Contributing to Performance

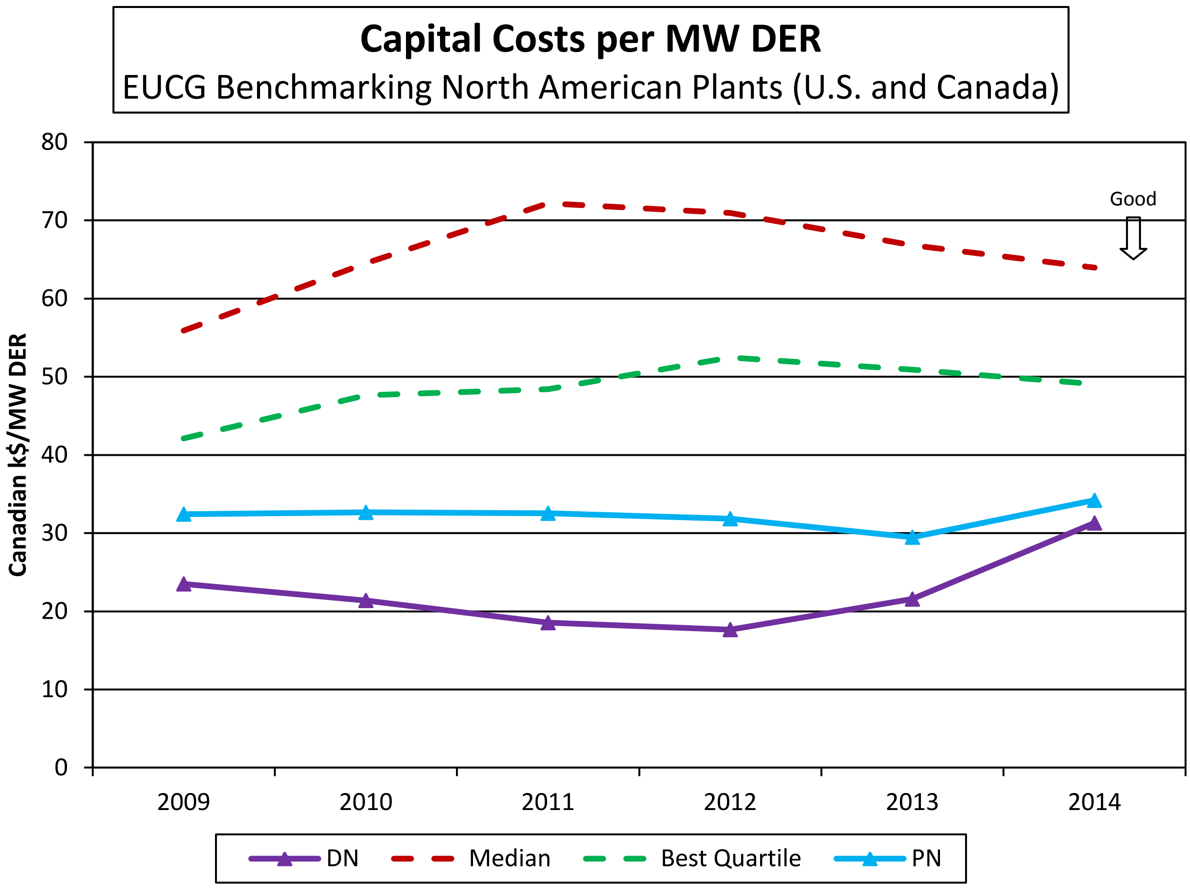
- Fuel costs, primarily driven by the technological differences in CANDU technology, are lower for OPG than all North American Pressurized Water Reactors or Boiling Water Reactors (PWR/BWR) reactors as CANDUs do not require enriched uranium like BWRs and PWRs. This provides a significant advantage for OPG in this cost category.

Best quartile fuel cost performance noted above is due to the following factors:

- Uranium fuel costs: Raw uranium is processed directly into uranium dioxide to make fuel pellets, without the cost and process complexity of enriching the fuel as required in light water reactors. The advantage due to fuel costs also includes transportation, handling and shipping costs.
- Reactor core efficiency: CANDU is the most efficient of all reactors in using uranium, requiring about 15% less uranium than PWRs for each megawatt hour of electricity.

3-Year Capital Cost per MW DER




Capital Costs per MW DER
EUCG Benchmarking North American Plants (U.S. and Canada)
Canadian k$/MW DER
80
70
60
50
40
30
20
10
0
Good
2009
2010
2011
2012
2013
2014
DN
Median
Best Quartile
PN

Observations – 3-Year Capital Cost per MW DER (All North American Plants)

2014 (3-Year Rolling Average)

- First quartile threshold for Capital Cost per MW DER across the North American EUCG peer panel plants was k$49.08/MW DER.
- Median cost for the panel was k$63.95/MW DER.
- Both Pickering and Darlington had lower capital cost/MW DER than the first quartile.

Trend

- First quartile Capital Cost per MW DER declined in 2014 to approximately the same level as 2011. This is being driven by reduced investment in enhancements in the US fleet – particularly life extension, uprates and steam generator replacements – partially offset by increased spending in regulatory assets for Fukushima response activities.
- Median levels for capital cost are approximately the same as 2010. Spending on uprates, reliability improvements and security declined, partially offset by spending on Fukushima response.
- Darlington's Capital Cost per MW DER increased in 2014 due to increased spending on sustaining and infrastructure investments.
- Pickering's Capital Cost per MW DER increased in 2014 due to investments to improve reliability and safety for its remaining commercial operations.

Factors Contributing to Performance

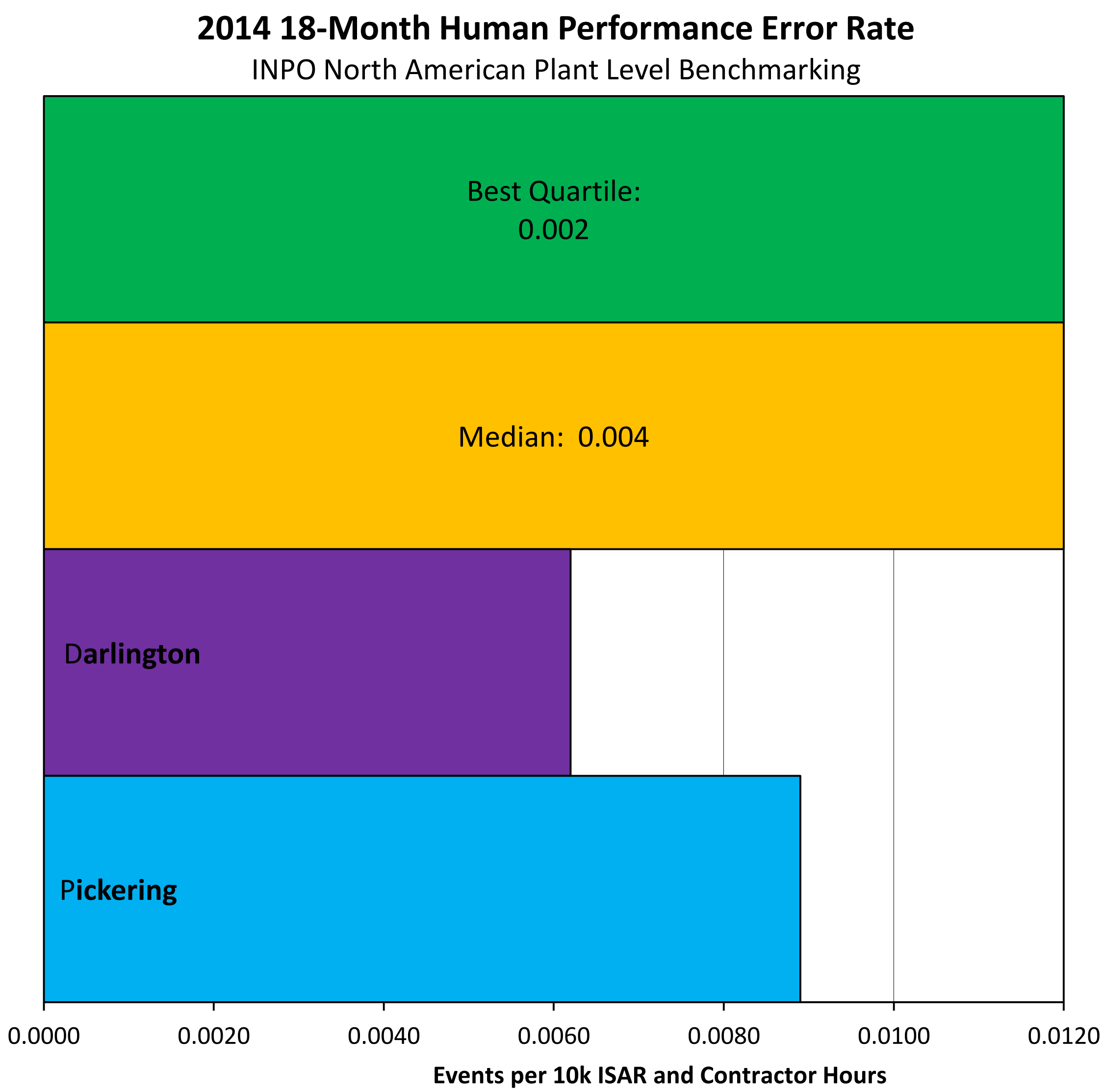
- Both Darlington and Pickering are performing within the first quartile for the panel.
- A review of the capitalization policies submitted to the EUCG shows that the majority of the North American peer group base their capitalization decision on the type and size of component. Basing capitalization decisions on the size and type of component can result in more capitalization of life-expired and obsolete equipment replacement. OPG's assets are grouped by systems and groups of systems rather than by type of component. Application of the policy for classifying projects is biased towards expensing work as Operations, Maintenance & Administration (OM&A).
- Another factor is that the capital expenditures reported by the peer group include costs either not incurred by OPG due to technological differences or have been incurred by the peer group to a larger extent than OPG.
- An analysis of capital spending versus DER over the 2012-2014 period indicates that approximately 25% of capital spending correlates with the design output of the plant. This is consistent with the typical cost breakdown for a capital project. Material and equipment cost is typically 15 to 20% of total project cost. Installation labour costs will be higher for larger equipment. Other project costs, such as design and project management, are not highly correlated with the size of the unit.

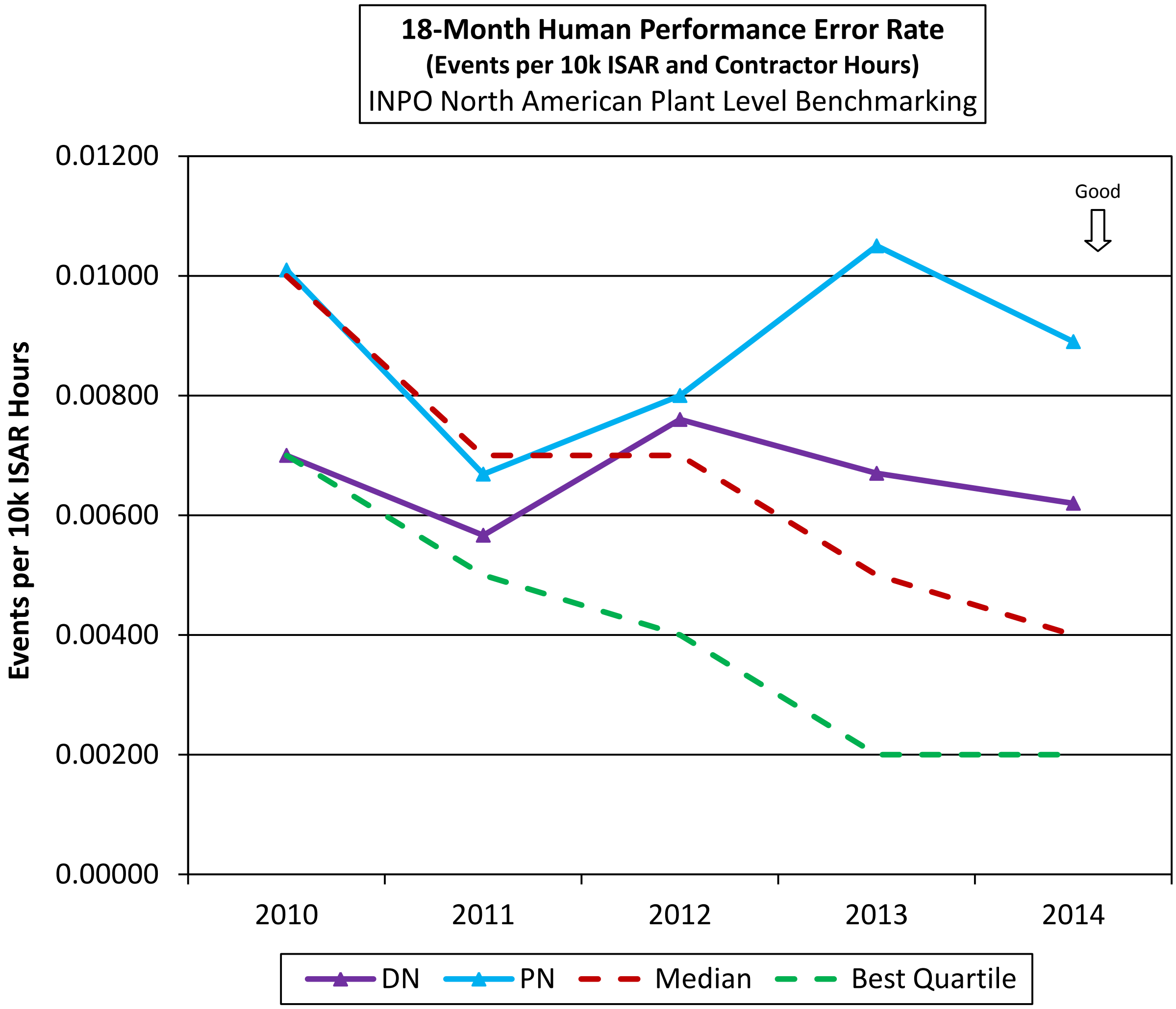
5.0 HUMAN PERFORMANCE

Methodology and Sources of Data

The Human Performance Error Rate metric has been selected to benchmark the performance of OPG's Nuclear fleet against other INPO utilities in the area of Human Performance. This will ensure a continued focus on improving Human Performance by comparing OPG Nuclear stations to industry quartiles through the use of consistent and comparable data.

18-Month Human Performance Error Rate




18-Month Human Performance Error Rate
(Events per 10k ISAR and Contractor Hours)
INPO North American Plant Level Benchmarking
Events per 10k ISAR Hours
0.01200
0.01000
0.00800
0.00600
0.00400
0.00200
0.00000
2010
2011
2012
2013
2014
Good
DN
PN
Median
Best Quartile

Observations – 18 Month Human Performance Error Rate (INPO North American Plants)

2014 (18 Month Rolling Average)

- The 2014 18-month Human Performance Error Rate (HPER) INPO best quartile was 0.0020, unchanged from 2013, while the median quartile improved to 0.0040 from 0.0050 in 2013.
- Compared to the INPO Peer group at the end of 2014, the Darlington station (HPER 0.0062) remained in the third quartile and the Pickering station (HPER 0.0089) remained in the fourth quartile.

Trend

- Darlington and Pickering HPER have both improved in 2014, however performance on average is relatively flat-lined over the past 5 years.
- Industry performance has been improving year-over-year with respect to both top quartile and median quartile results with the exception of 2014, where the top quartile benchmark remained the same as 2013 (HPER 0.002).
- Inconsistent oversight of work execution is the primary contributor to performance gaps versus targets in 2014. This was in clear evidence during a fleet self-assessment conducted at Darlington and Pickering.

Factors Contributing to Performance

- Areas that impact human performance:
  - Adherence to established standards and expectations.
  - Supervisor/managers consistently monitoring and reinforcing established standards and expectations.
  - Departmental error rate targets which sufficiently challenge the organization to improve performance.
- Strong coaching culture and consistent management reinforcement of standards and expectations is characteristic of organizations which achieve top quartile performance in this benchmark area.
- In 2014, human performance at OPG Nuclear received significant focus. The fleet established a Corporate Functional Area Manager to align the stations around common initiatives to drive improved performance. A fleet strategic plan was issued and a nuclear fleet initiative was drafted and approved. The focus of this fleet initiative is to improve coaching culture and establish consistent reinforcement of standards.
- As stated above, the stations have demonstrated some improvement in 2014 however the initiatives had little run time in 2014. Ongoing monitoring of performance will provide evidence that performance is improving and serve as a feedback mechanism to allow for adjustment of initiatives as appropriate.

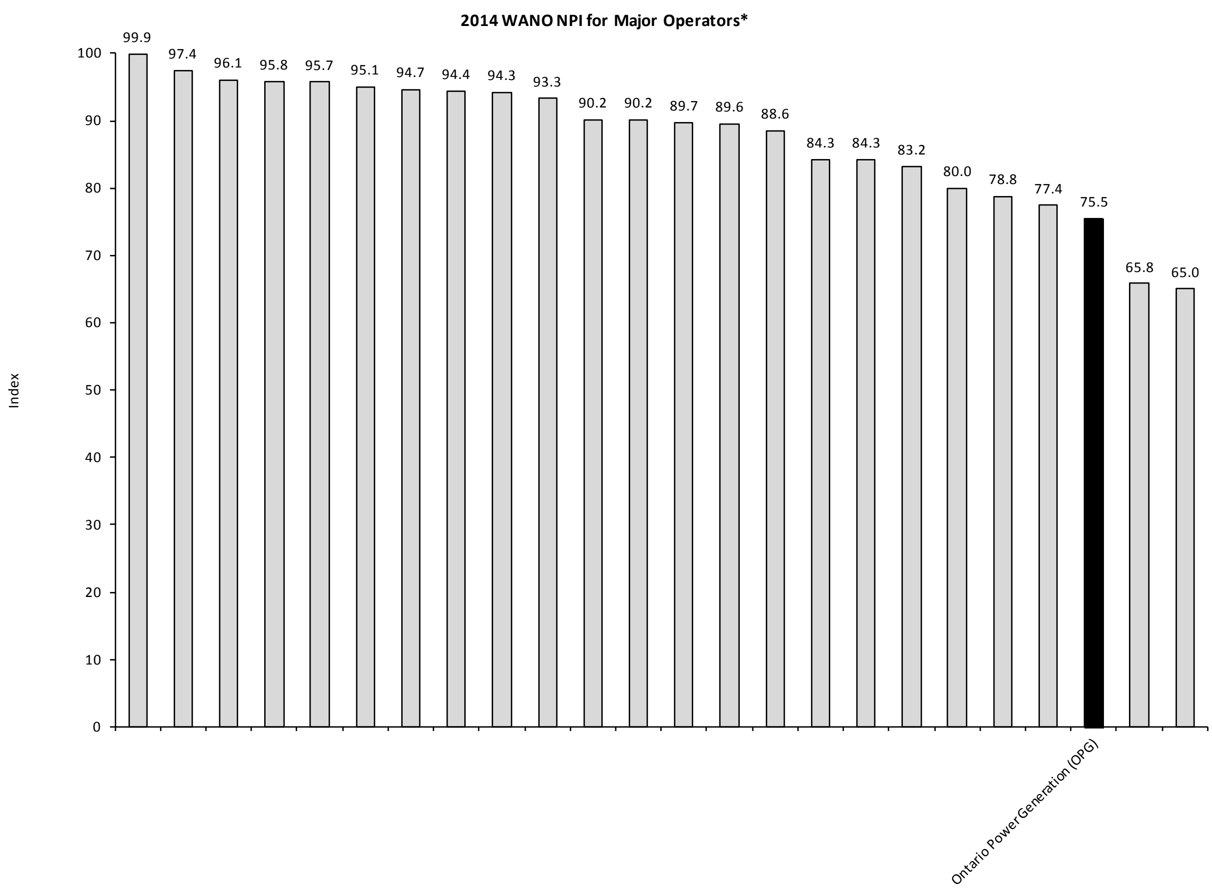
6.0 MAJOR OPERATOR SUMMARY

Purpose

This section supplements the Executive Summary, providing more detailed comparison of the major operators of nuclear plants for three key metrics: WANO Nuclear Performance Index (NPI), Unit Capability Factor (UCF), and Total Generating Cost (TGC) per MWh. Although the benchmarking study has been primarily focused on operational performance comparison to COG CANDUs, this section of the report contemplates the larger industry by capturing OPG Nuclear's performance against North American PWR and PHWR operators in addition to the international CANDU panel. Operator level summary results are the average (mean) of the results across all plants managed by the given operator. These comparisons provide additional context, but the detailed data in the previous sections provide a more complete picture of plant by plant performance. The WANO NPI and UCF are calculated as the mean of all unit performance for a specific operator. The TGC per MWh is the mean of plant level data because costs are not allocated to specific units within the EUCG industry panel.

WANO Nuclear Performance Index Analysis

The WANO Nuclear Performance Index (NPI) results for the operators in 2014 are illustrated in the graph below. OPG Nuclear performance ranking was maintained from 2013 as shown in Table 3.



*See Table 7 in the Appendix for listing of operators and plants.

**OPG Nuclear unit values averaging to a WANO NPI of 75.5 in 2014 are shown below:

Unit	2014 WANO NPI
Pickering 1	43.7
Pickering 4	67.4
Pickering 5	66.1
Pickering 6	69.4
Pickering 7	75.0
Pickering 8	64.5
Darlington 1	94.3
Darlington 2	86.3
Darlington 3	98.7
Darlington 4	89.2

In 2014, OPG ranked 22nd, with an NPI of 75.5. Although maintaining the same ranking from 2013, OPG dropped slightly in NPI performance from the previous reporting year. Darlington performed better overall than Pickering, achieving slightly less than top quartile results against the CANDU panel in 2014. Refer to Section 3.0 for further information.

The NPI rankings of the major operators from 2009 to 2014 are listed in Table 3. The list and ranking of operators has been updated to reflect industry developments.

Table 3: Average WANO NPI Rankings

Operator	2009	2010	2011	2012	2013	2014
	11	4	13	19	14	1
	3	13	19	10	13	2
	13	20	21	23	24	3
	6	3	8	6	5	4
	10	9	20	22	10	5
	24	22	9	8	7	6
	5	7	7	7	4	7
	1	1	4	17	16	8
	14	6	6	18	8	9
	12	2	1	5	6	10
	18	15	11	15	19	11
	15	18	14	12	9	12
	9	14	10	3	1	13
	17	16	3	4	2	14
	16	17	16	13	17	15
	21	10	5	2	12	16
	2	11	18	21	3	17
	22	19	15	11	15	18
	8	24	27	24	23	19
	20	12	2	1	18	20
	25	21	23	20	21	21
Ontario Power Generation (OPG)	23	23	24	25	22	22
	7	8	17	9	20	23
	28	28	NA*	27	25	24
	19	25	22	16	11	NA
	4	5	12	14	NA	NA
	26	27	25	26	NA	NA
	27	26	26	26	NA	NA

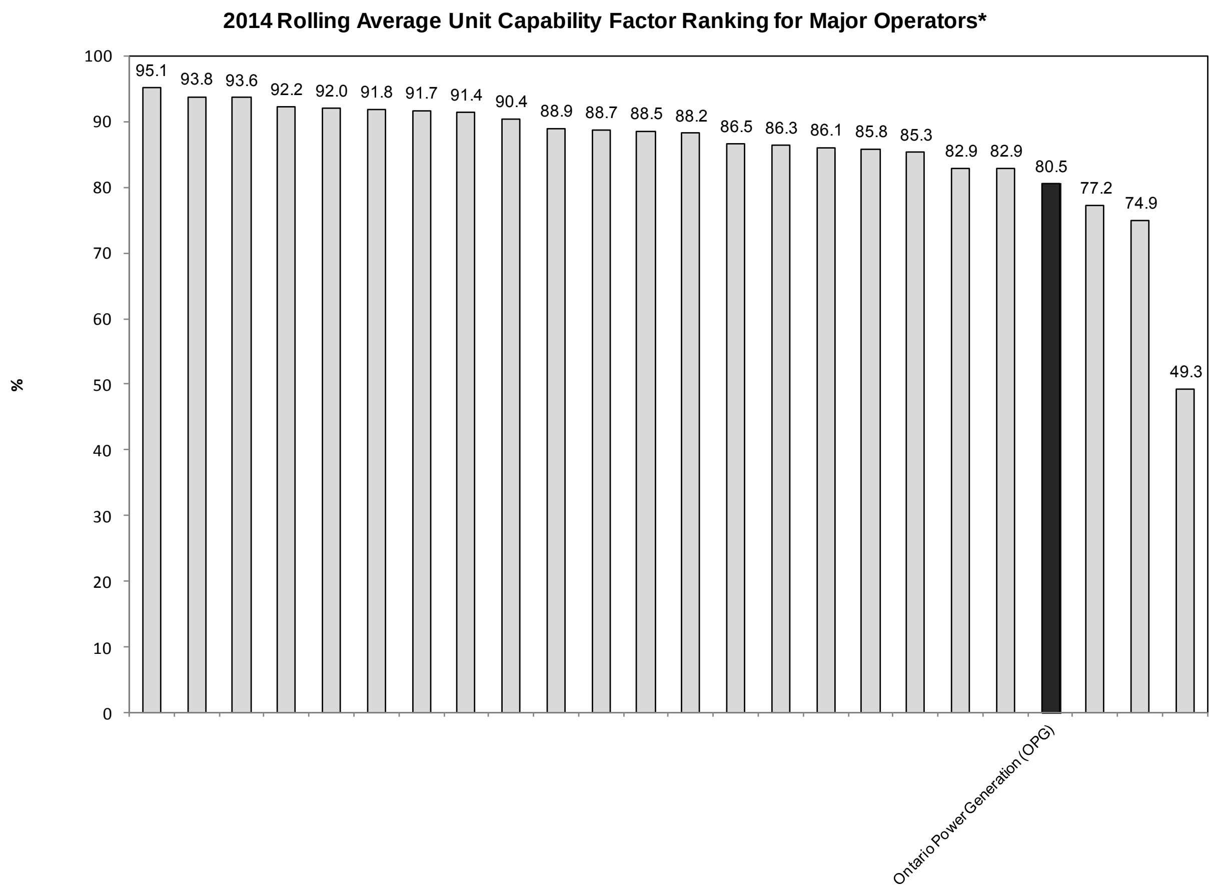
*NA: Not applicable due to multi-year refurbishment of the generating Station.

Note: Four operators are no longer shown in the ranking as of 2014 (reason for 28 operators shown in 2009 to 2010 vs. 24 in 2014). These operators were removed as a result of plant acquisitions or closures. All 2009-2013 rankings and numbers are carried over from previous benchmarking reports.

Unit Capability Factor Analysis

Unit Capability Factor (UCF) is the ratio of available energy generation over a given time period to the reference energy generation of the same time period, expressed as a percentage. Reference energy generation is the energy that could be produced if the unit were operating continuously at full power under normal conditions. Since nuclear generation plants are large fixed assets, the extent to which these assets generate reliable power is the key to both their operating and financial performance.

A comparison of UCF values for major nuclear operators is presented in the graph below. UCF is expressed as a two-year average for all operators except for OPG Nuclear, which includes a three-year average for the Darlington station and a two-year average for Pickering to reflect each plant's respective outage cycle. OPG Nuclear achieved a rolling average UCF of 80.5% and ranked 21 out of 24 operators in the WANO data set. The list and ranking of operators has been updated to reflect industry developments.



* See Table 7 in the Appendix for listing of operators and plants.

**OPG unit values averaging to a rolling average UCF of 80.5% in 2014 are shown below:

Unit	2014 Rolling Average UCF
Pickering 1	67.4
Pickering 4	75.1
Pickering 5	77.2
Pickering 6	78.1
Pickering 7	78.8
Pickering 8	70.3

Unit	2014 Rolling Average UCF
Darlington 1	90.2
Darlington 2	86.2
Darlington 3	93.1
Darlington 4	88.0

Rankings for the major operators for UCF over the past six years are provided in Table 4 below.

Table 4: Rolling Average Unit Capability Factor Rankings

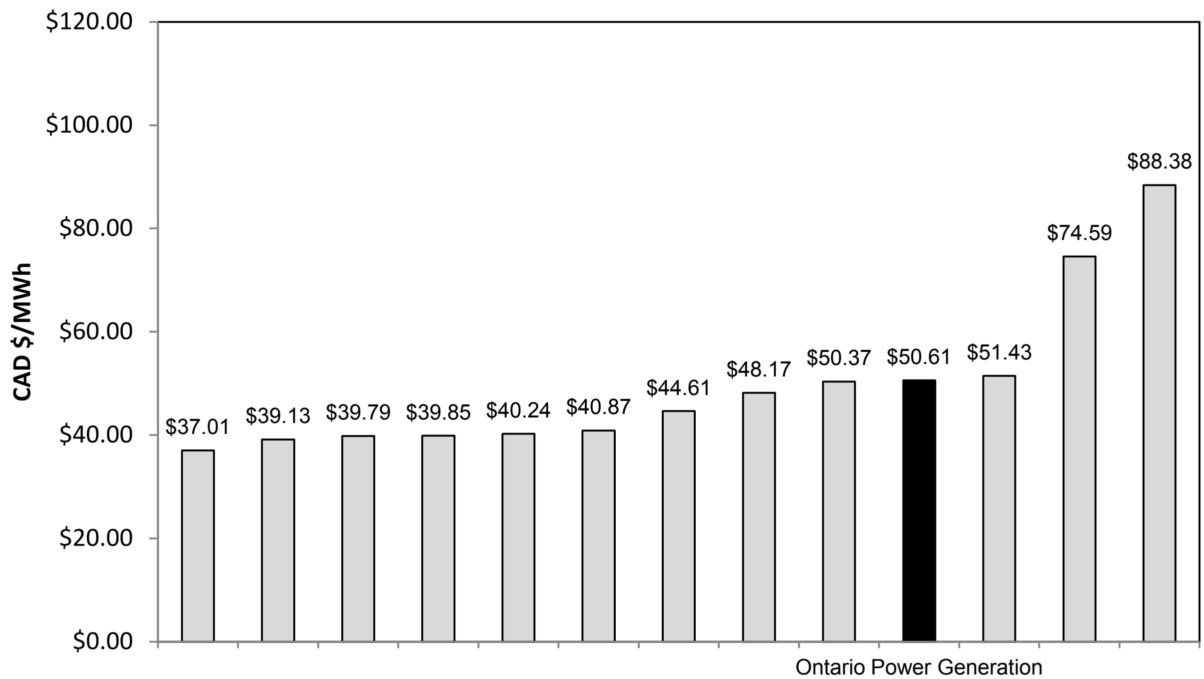
Operator	2009	2010	2011	2012	2013	2014
	3	4	2	4	4	1
	17	10	21	22	6	2
	13	12	11	16	15	3
	8	13	13	10	7	4
	2	1	4	5	1	5
	5	6	7	1	2	6
	19	17	14	12	10	7
	11	5	9	15	8	8
	27	27	16	3	3	9
	10	18	18	13	9	10
	6	8	8	14	16	11
	23	15	6	18	11	12
	20	20	1	6	12	13
	9	3	12	8	5	14
	18	19	17	17	17	15
	12	21	20	24	23	16
	15	22	22	9	14	17
	16	9	5	19	20	18
	7	14	19	2	13	19
	4	11	15	20	21	20
Ontario Power Generation (OPG)	25	23	25	21	19	21
	28	28	28	27	24	22
	21	16	24	23	22	23
	22	7	10	26	25	24
	14	25	27	7	18	NA
	1	2	3	11	NA	NA
	24	24	23	25	NA	NA
	26	26	26	NA	NA	NA

Note: Four operators are no longer shown in the ranking as of 2014 (reason for 28 operators shown in 2009 to 2010 vs. 24 in 2014). These operators were removed as a result of plant acquisitions or closures. All 2009-2013 rankings and numbers are carried over from previous benchmarking reports.

Total Generating Cost/MWh Analysis

The 3-year Total Generating Cost results for the major operators in 2014 are displayed in the chart below. Total Generating Costs are defined as total operating costs plus capital costs and fuel costs of all plants that the operator operates in 2012-2014. This value is divided by the total net generation of all plants that the operator operates for the same period and is provided as a three-year average. OPG Nuclear ranked 10th, with a 3-year Total Generation Cost of $50.61 per MWh.

2014 - 3 Year Total Generating Costs per MWh



*OPG plant values of 3-year rolling average TGC per MWh are shown below:

Unit	2014 3-Year TGC
Darlington	$37.73/MWh
Pickering	$67.93/MWh

Table 5: Three-Year Total Generating Cost per MWh Rankings

	2009	2010	2011	2012	2013	2014
	11	9	7	4	1	1
	5	3	1	1	2	2
	2	2	3	3	3	3
	3	4	4	5	4	4
	1	1	2	2	6	5
	10	10	8	7	7	6
	NA	NA	NA	NA	11	7
	4	5	5	6	5	8
	8	11	11	11	9	9
Ontario Power Generation	12	12	12	10	8	10
	7	7	9	9	10	11
	14	14	13	14	14	12
	13	13	14	13	13	13
	9	8	10	12	12	NA
	6	6	6	8	NA	NA

Note: Two operators have been removed due to acquisitions by other operators in the panel (reason for 14 ranked operators in 2009 to 2013 vs.13 in 2014):

Total Generating Cost is comprised of: (a) Non-Fuel Operating Costs, plus (b) Fuel Costs, plus (c) Capital Costs. Table 6 below shows the relative contribution of these cost components to Total Generating Cost and compares OPG's costs to those of all EUCG operators.

Table 6: EUCG Indicator Results Summary (Operator Level)

EUCG Indicator Results Summary	OPG Average	EUCG Major Operators*		Units
		Median	Best Quartile	
Value for Money Performance				
3-Yr. Non-Fuel Operating Costs per MWh	$ 40.65	$ 25.60	$ 23.40	CAD $/MWh
3-Yr. Fuel Costs per MWh	$ 5.39	$ 9.03	$ 7.93	CAD $/MWh
3-Yr. Capital Costs per MWh	$ 4.56	$ 7.89	$ 5.78	CAD $/MWh
3-Yr. Total Generating Costs per MWh	$ 50.61	$ 42.53	$ 37.12	CAD $/MWh

*See Table 8 in the appendix for list of operators included.

Notes: This summary contains the average of all plant results per operator. Numbers may not add due to rounding.

7.0 APPENDIX

Acronyms

Acronym	Meaning
ALARA	As Low As Reasonably Achievable
BWR	Boiling Water Reactor
CANDU	CANada Deuterium Uranium (type of PHWR)
CEA	Canadian Electricity Association
COG	CANDU Owners Group
DER	Design Electrical Rating
EUCG	Electric Utility Cost Group
INPO	Institute of Nuclear Power Operators
OPG	Ontario Power Generation
PHWR	Pressurized Heavy Water Reactor
PWR	Pressurized Water Reactor
WANO	World Association of Nuclear Operators

Safety and Reliability Definitions

The following definitions are summaries extracted from industry peer group databases.

All Injury Rate is the average number of fatalities, total temporary disabilities, permanent total disabilities, permanent partial disabilities and medical attention injuries per 200,000 hours worked.

Industrial Safety Accident Rate is defined as the number of accidents for all utility personnel (permanently or temporarily) assigned to the station, that result in one or more days away from work (excluding the day of the accident) or one or more days of restricted work (excluding the day of the accident), or fatalities, per 200,000 man-hours worked. The selection of 200,000 man-hours worked or 1,000,000 man-hours worked for the indicator will be made by the country collecting the data, and international data will be displayed using both scales. Contractor personnel are not included for this indicator.

Collective Radiation Exposure, for purposes of this indicator, is the total external and internal whole body exposure determined by primary dosimeter (thermoluminescent dosimeter (TLD) or film badge), and internal exposure calculations. All measured exposure should be reported for station personnel, contractors, and those personnel visiting the site or station on official utility business.

Visitors, for purposes of this indicator, include only those monitored visitors who are visiting the site or station on official utility business.

Airborne Tritium Emissions per Unit: Tritium emissions to air are one of the sites' leading components of dose to the public. By specific tracking of tritium emissions, the sites can maintain or reduce dose. Reducing OPG Nuclear's dose to the public demonstrates continuous improvement in operations.

Fuel Reliability Index is inferred from fission product activities present in the reactor coolant. Due to design differences, this indicator is calculated differently for different reactor types. For PHWR's, the indicator is defined as the steady-state primary coolant iodine-131 activity (Becquerels/gram or Microcuries/gram), corrected for the tramp uranium contribution and power level, and normalized to a common purification rate.

Unplanned automatic reactor trips (SCRAMS) is defined as the number of unplanned automatic reactor trips (reactor protection system logic actuations) that occur per 7,000 hours of critical operation. The indicator is further defined as follows:

- Unplanned means that the trip was not an anticipated part of a planned test.
- Trip means the automatic shutdown of the reactor by a rapid insertion of negative reactivity (e.g., by control rods, liquid injection shutdown system, etc.) that is caused by actuation of the reactor protection system. The trip signal may have resulted from exceeding a setpoint or may have been spurious.
- Automatic means that the initial signal that caused actuation of the reactor protection system logic was provided from one of the sensors' monitoring plant parameters and conditions, rather than the manual trip switches or, in certain cases described in the clarifying notes, manual turbine trip switches (or pushbuttons) provided in the main control room.
- Critical means that, during the steady-state condition of the reactor prior to the trip, the effective multiplication factor (k_{eff}) was essentially equal to one.
- The value of 7,000 hours is representative of the critical hours of operation during a year for most plants, and provides an indicator value that typically approximates the actual number of scrams occurring during the year.

The **safety system performance indicator** is defined for the many different types of nuclear reactors within the WANO membership. To facilitate better understanding of the indicator and applicable system scope for these different type reactors a separate section has been developed for each reactor type.

Also, because some members have chosen to report all data on a system train basis versus the "standard" overall system approach, special sections have also been developed for those reactor types where train reporting has been chosen. (The resulting indicator values resulting from these methods are essentially the same.)

Each section is written specifically for that reactor type and reporting method. If a member desires to understand how a different member is reporting or wishes to better understand that member's indicator, it should consult the applicable section.

The safety systems monitored by this indicator are the following:

PHWRs

Although the PHWR safety philosophy considers other special safety systems to be paramount to public safety, the following PHWR safety and safety-related systems were chosen to be monitored in order to maintain a consistent international application of the safety system performance indicators:

- Auxiliary boiler feedwater system
- Emergency AC power
- High pressure emergency coolant injection system

These systems were selected for the safety system performance indicator based on their importance in preventing reactor core damage or extended plant outage. Not every risk important system is monitored. Rather, those that are generally important across the broad nuclear industry are included within the scope of this indicator. They include the principal systems needed for maintaining reactor coolant inventory following a loss of coolant, for decay heat removal following a reactor trip or loss of main feedwater, and for providing emergency AC power following a loss of plant off-site power. (Gas cooled reactors have an additional decay heat removal system instead of the coolant inventory maintenance system)

Except as specifically stated in the definition and reporting guidance, no attempt is made to monitor or give credit in the indicator results for the presence of other systems at a given plant that add diversity to the mitigation or prevention of accidents. For example, no credit is given for additional power sources that add to the reliability of the electrical grid supplying a plant because the purpose of the indicator is to monitor the effectiveness of the plant's response once the grid is lost.

The **Nuclear Performance Index** Method 4 is an INPO sponsored performance measure, and is a weighted composite of ten WANO Performance Indicators related to safety and production performance reliability.

The NPI is used for trending nuclear station and unit performance, and comparing the results to the median or quartile values of a group of units, to give an indication of relative performance. The quarterly NPI has also been used to trend the performance and monitor the effectiveness of various improvement programs in achieving top quartile performance and allows nuclear facilities to benchmark their achievements against other nuclear plants worldwide.

The **Forced Loss Rate (FLR)** is defined as the ratio of all unplanned forced energy losses during a given period of time to the reference energy generation minus energy generation losses corresponding to planned outages and any unplanned outage extensions of planned outages, during the same period, expressed as a percentage.

Unplanned energy losses are either unplanned forced energy losses (unplanned energy generation losses not resulting from an outage extension) or unplanned outage extension of planned outage energy losses.

Unplanned forced energy loss is energy that was not produced because of unplanned shutdowns or unplanned load reductions due to causes under plant management control when the unit is considered to be at the disposal of the grid dispatcher. Causes of forced energy losses are considered to be unplanned if they are not scheduled at least four weeks in advance. Causes considered to be under plant management control are further defined in the clarifying notes.

Unplanned outage extension energy loss is energy that was not produced because of an extension of a planned outage beyond the original planned end date due to originally scheduled work not being completed, or because newly scheduled work was added (planned and scheduled) to the outage less than four weeks before the scheduled end of the planned outage.

Planned energy losses are those corresponding to outages or power reductions which were planned and scheduled at least four weeks in advance (see clarifying notes for exceptions).

Reference energy generation is the energy that could be produced if the unit were operated continuously at full power under reference ambient conditions throughout the given period. Reference ambient conditions are environmental conditions representative of the annual mean (or typical) ambient conditions for the unit.

Unit Capability Factor is defined as the ratio of the available energy generation over a given time period to the reference energy generation over the same time period, expressed as a percentage. Both of these energy generation terms are determined relative to reference ambient conditions.

Available energy generation is the energy that could have been produced under reference ambient conditions considering only limitations within control of plant management, i.e., plant equipment and personnel performance, and work control.

Reference energy generation is the energy that could be produced if the unit were operated continuously at full power under reference ambient conditions.

Reference ambient conditions are environmental conditions representative of the annual mean (or typical) ambient conditions for the unit.

The **Chemistry Performance Indicator** compares the concentration of selected impurities and corrosion products to corresponding limiting values. Each parameter is divided by its limiting value, and the sum of these ratios is normalized to 1.0. For BWRs and most PWRs, these limiting values are the medians for each parameter, based on data collected in 1993, thereby reflecting recent actual performance levels. For other plants, they reflect challenging targets. If an impurity concentration is equal to or better than the limiting value, the limiting value is used as the concentration. This prevents increased concentrations of one parameter from being masked by better performance in another. As a result, if a plant is at or below the limiting value for all parameters, its indicator value would be 1.0, the lowest chemistry indicator value attainable under the indicator definition. The following is used to determine each unit's chemistry indicator value:

- PWRs with recirculating steam generators and VVERs
  - Steam generator blowdown chloride
  - Steam generator blowdown cation conductivity
  - Steam generator blowdown sulphate
  - Steam generator blowdown sodium

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- Final feedwater iron
- Final feedwater copper (not applicable to PWRs with I-800 steam generator tubes)
- Condensate dissolved oxygen (only applicable to PWRs with I-800 steam generator tubes)
- Steam generator molar ratio target range (by reporting the upper and lower range limits (as "from" and "to" values when using molar ratio control)
- Steam generator actual molar ratio (if reporting molar ratio control data)
- Feedwater oxygen
- Feedwater pH value at 270deg. C

- PWRs with once through steam generators
  - Final feedwater chloride
  - Final feedwater sulfate
  - Final feedwater sodium
  - Final feedwater iron
  - Final feedwater copper
  -
- Pressurized heavy water reactors (PHWRs)
  - *Inconel-600 or Monel tubes
    - Steam generator blowdown chloride
    - Steam generator blowdown sulfate
    - Steam generator blowdown sodium
    - Final feedwater iron
    - Final feedwater copper
    - Final feedwater dissolved oxygen
  - Incoloy-800 tubes
    - Steam generator blowdown chloride
    - Steam generator blowdown sulfate
    - Steam generator blowdown sodium
    - Final feedwater iron
    - Final feedwater dissolved oxygen

- PHWRs on molar ratio control
  - Steam generator blowdown chloride
  - Steam generator blowdown sulfate
  - Final feedwater iron
  - Final feedwater copper
  - Feedwater dissolved oxygen
  - Steam generator molar ratio target range (by reporting the upper and lower range limits (as "from" and "to" values)
  - Steam generator actual molar ratio

Online Deficient Maintenance Backlog is the average number of active on-line maintenance work orders per operating unit classified as Deficient Critical (DC) or Deficient Non-Critical

(DN) that can be worked on without requiring the unit shutdown. This metric identifies deficiencies or degradation of plant equipment components that need to be remedied, but which do not represent a loss of functionality of the component or system.

Online Corrective Maintenance Backlog is the average number of active on-line maintenance work orders per operating unit classified as Corrective Critical (CC) or Corrective Non-Critical (CN) that can be worked on without requiring the unit shutdown. This metric identifies deficiencies or degradation of components that need to be remedied, and represents a loss of functionality of a major component or system.

On-line maintenance is maintenance that will be performed with the main generator connected to the grid.

Value for Money Definitions

The following definition summaries are taken from the *January 2013 EUCG Nuclear Committee Nuclear Database Instructions*.

Capital Costs ($)
All costs associated with improvements and modifications made during the reporting year. These costs should include design and installation costs in addition to equipment costs. Other miscellaneous capital additions such as facilities, computer equipment, moveable equipment, and vehicles should also be included. These costs should be fully burdened with indirect costs, but exclude AFUDC (interest and depreciation).

Fuel ($)
The total cost associated with a load of fuel in the reactor which is burned up in a given year.

Net Generation (Gigawatt Hours)
The gross electrical output of the unit measured at the output terminals of the turbine-generator minus the normal station service loads during the hours of the reporting period, expressed in Gigawatt hours (GWh). Negative quantities should not be used.

Design Electrical Rating (DER)
The nominal net electrical output of a unit, specified by the utility and used for plant design (DER net expressed in MWe). Design Electrical Rating should be the value that the unit was certified/designed to produce when constructed. The value would change if a power uprate was completed. After a power uprate, the value should be the certified or design value resulting from the uprate.

Operating Costs ($)
The operating cost is to identify all relevant costs to operate and maintain the nuclear operations in that company. It includes the cost of labour, materials, purchased services and other costs, including administration and general.

Total Generating Costs ($)
The sum of total operating costs and capital costs as above.

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Total Operating Costs ($)
The sum of operating costs and fuel costs as above.

Note: Capital costs, fuel costs, operating costs and Total Generating Costs are divided by net generation as above to obtain per MWh results. Capital costs are also divided by MW DER to obtain MW results.

Human Performance Definitions

The following definition summary is taken from the Institute of Nuclear Power Operations (INPO) database.

Human Performance Error Rate (# per ISAR and Contractor Hours)
. The Human Performance Error Rate metric represents the number of site level human performance events in an 18-month period per 10,000 ISAR hours worked (including on site supplemental personnel). The formula used is:

{(# of S-EFDRs) / (Total ISAR Hours + Total Contractor Hours)} x 10,000 Hours (Calculated as an 18-month rolling average)

INPO guidelines define non utility personnel to include contractor, supplemental personnel assigned to perform work activities on site or at other buildings that directly support station operation. This includes personnel who deliver and receive equipment, deliver fuel oil, remove trash and radioactive waste, and provide building and grounds maintenance within the owner-controlled areas or facilities that support the station.

INPO defines an event to occur as a result of the following:

An initiating action (error) by an individual or group of individuals (event resulting from an active error) or an initiating action (not an error) by an individual or group of individuals during an activity conducted as planned (event resulting from a flawed defense or latent organizational weakness). They may be related to Nuclear Safety, Radiological Safety, Industrial Safety, Facility Operations or considered to be a Regulatory Event reportable to a regulator or governing agency. OPG Nuclear's criteria for defining station event free day resets have been developed based on INPO guidelines. However, the definition may differ slightly due to adaptation resulting from technological differences.

Panels

Table 7: WANO Panel

Operator	Plant
Ameren Missouri	Callaway
American Electric Power Co.	Cook
Arizona Public Service Co.	Palo Verde
Bruce Power	Bruce A Bruce B
Dominion Generation	Millstone North Anna Surry
Duke Energy	Catawba Harris Mcguire Oconee Robinson
Entergy Nuclear	Arkansas Nuclear One Indian Point Palisades Waterford
Exelon Generation Co.	Braidwood Byron Three Mile Island Calvert Cliffs Ginna
FirstEnergy Nuclear Operating Co.	Beaver Valley Davis-Besse
Florida Power & Light Co. (FPL)	St. Lucie Turkey Point

Operator	Plant
International CANDU	Cernavoda Embalse Qinshan 3 Wolsong A Wolsong B
Luminant Generation	Comanche Peak
New Brunswick Power	Point Lepreau
NextEra Energy Resources	Point Beach Seabrook
Northern States Power Company	Prairie Island
Omaha Public Power District	Fort Calhoun
Ontario Power Generation (OPG)	Darlington Pickering
Pacific Gas & Electric Co.	Diablo Canyon
Public Service Enterprise Group (PSEG) Nuclear	Salem
South Carolina Electric & Gas Co.	V.C. Summer
Southern Nuclear Operating Co.	Farley Vogtle
STP Nuclear Operating Co.	South Texas
Tennessee Valley Authority (TVA)	Sequoyah Watts Bar
Wolf Creek Nuclear Operating Corp.	Wolf Creek

Table 8: EUCG Panel

Major Operator	Plant
Bruce Power	Bruce A Bruce B
Dominion Generation	Millstone North Anna Surry
Duke Energy	Brunswick Catawba Harris Mcguire Oconee Robinson
Entergy Nuclear	Arkansas Nuclear One Fitzpatrick Grand Gulf Indian Point Palisades Pilgrim River Bend Waterford
Exelon Generation Co.	Braidwood Byron Calvert Cliffs Clinton Dresden Lasalle Limerick Nine Mile Oyster Creek Peach Bottom Quad Cities Ginna Three Mile Island
FirstEnergy Nuclear Operating Co.	Beaver Valley David-Besse Perry
Florida Power & Light Co. (FPL)	St Lucie Turkey Point
NextEra Energy Resources	Duane Arnold Point Beach Seabrook
Northern States Power Company (Formerly Exce	Monticello Prairie Island
Ontario Power Generation (OPG)	Darlington Pickering
Public Service Enterprise Group (PSEG) Nuclear	Hope Creek Salem
Southern Nuclear Operating Co.	Farley Hatch Vogtle
Tennessee Valley Authority (TVA)	Browns Ferry Sequoyah Watts Bar

Remaining EUCG Members

Operator	Plant	Operator	Plant
AmerenUE	Callaway	Nebraska Public Power District	Cooper
American Electric Power Co. Inc.	Cook	Pacific Gas & Co.	Diablo Canyon
Arizona Public Service Co.	Palo Verde	Talen Energy	Susquehanna
DTE Energy	Fermi	South Carolina Electric & Gas Company (SCE&G)	V.C. Summer
Energy Northwest	Columbia	STP Nuclear Operating Co.	South Texas
Luminant Generation	Comanche Peak	Wolf Creek Nuclear Operations Corp.	Wolf Creek

Table 9: COG CANDUs

Operator	Plant
Bruce Power	Bruce A Bruce B
China (CNNP)	Qinshan 3
NASA	Embalse
Korea (KHNP)	Wolsong A Wolsong B
New Brunswick Power	Point Lepreau
OPG	Darlington Pickering
Romania	Cernavoda

Table 10: CEA Members

Companies
AltaLink
ATCO Electric
ATCO Power
BC Hydro and Power Authority
Brookfield Renewable Energy Group
Capital Power Corporation
City of Medicine Hat, Electric Utility
Columbia Power Corporation
Emera Inc.
ENMAX
EnWin
EPCOR
FortisAlberta Inc.
FortisBC Inc.
Horizon Utilities Corp
Hydro One

Companies
Hydro Ottawa
Manitoba Hydro
Maritime Electric Company
Nalcor Energy
New Brunswick Power
Newfoundland Power
Northwest Territories Power Corp.
Nova Scotia Power
Oakville Hydro Corp.
Ontario Power Generation
PowerStream
Saint John Energy
Saskatoon Light & Power
SaskPower
Toronto Hydro Corp.
TransCanada
Yukon Energy Corp.

Table 11: INPO Members for Human Performance Error Rate

Plant	
Arkansas Nuclear One (ANO)	Millstone
Beaver Valley	Monticello
Braidwood	Nine Mile Point
Browns Ferry	North Anna
Brunswick	Oconee
Byron	Oyster Creek
Callaway	Palisades
Calvert Cliffs	Palo Verde
Catawba	Peach Bottom
Clinton	Perry
Columbia Gen	Pilgrim
Comanche Peak	Point Beach
Cook	Prairie Island
Cooper	Quad Cities
Davis-Besse	River Bend
Diablo Canyon	Robinson
Dresden	Salem
Duane Arnold	Seabrook
Farley	Sequoyah
Fermi 2	South Texas
Fitzpatrick	St. Lucie
Fort Calhoun	Summer
Ginna	Surry
Grand Gulf	Susquehanna
Harris	Three Mile Island
Hatch	Turkey Point
Hope Creek	Vermont Yankee
Indian Point	Vogtle
LaSalle	Waterford
Limerick	Watts Bar
McGuire	Wolf Creek

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Table 12: INPO Members for On-Line Maintenance Backlogs

Plant	
Arkansas Nuclear One (ANO)	Monticello
Beaver Valley	Nine Mile Point
Braidwood	North Anna
Browns Ferry	Oconee
Brunswick	Oyster Creek
Byron	Palisades
Callaway	Palo Verde
Calvert Cliffs	Peach Bottom
Catawba	Perry
Clinton	Pilgrim
Columbia Gen	Point Beach
Comanche Peak	Prairie Island
Cook	Quad Cities
Cooper	River Bend
Davis-Besse	Robinson
Diablo Canyon	Salem
Dresden	Seabrook
Duane Arnold	Sequoyah
Farley	South Texas
Fermi 2	St. Lucie
Fitzpatrick	Summer
Ginna	Surry
Grand Gulf	Susquehanna
Harris	Three Mile Island
Hatch	Turkey Point
Hope Creek	Vermont Yankee
Indian Point	Vogtle
LaSalle	Waterford
Limerick	Watts Bar
McGuire	Wolf Creek
Millstone	

Table 13: NPI Plant Level Performance Summary (North American Panel)

	2014 Actuals				
Indicator	NPI Max	Best Quartile	Median	Pickering	Darlington
Rolling Average Industrial Safety Accident Rate (#/200k hours worked)	0.20	0.00	0.02	0.03	0.06
Rolling Average Collective Radiation Exposure (person-rem per unit)	80.00	31.30	43.30	82.24	69.06
Fuel Reliability Index (microcuries per gram)	0.000500	0.000001	0.000004	0.001580	0.000158
2-Year Reactor Trip Rate (# per 7,000 hours)	0.500	0.000	0.235	0.363	0.000
3-Year Auxiliary Feedwater System Unavailability (#)	0.0200	0.0029	0.0043	0.0181	0.0000
3-Year Emergency AC Power Unavailability (#)	0.0250	0.0098	0.0132	0.0000	0.0000
3-Year High Pressure Safety Injection Unavailability (#)	0.0200	0.0020	0.0033	0.0000	0.0000
Rolling Average Forced Loss Rate (%)	1.00	0.76	1.55	10.08	2.85
Rolling Average Unit Capability Factor (%)	92.0	93.2	90.4	74.5	89.4
Rolling Average Chemistry Performance Indicator (Index)	1.01	1.00	1.00	1.04	1.00
WANO NPI (Index)	Not Applicable	98.1	93.5	64.3	92.1

2014 Nuclear Staffing Benchmarking Analysis

A Report For:

ONTARIO POWER GENERATION

December 22nd 2014

GOODNIGHT CONSULTING

Introduction & Methodology

- Executive Summary

Analysis

Appendices

GOODNIGHT CONSULTING

Executive Summary: OPG Has Reduced The Variance From The Staffing Benchmarks Since 2011

- OPG asked Goodnight Consulting to compare OPG Nuclear staffing to other North American nuclear operators through an approach consistent with the one we used in 2011 and 2013.

- We benchmarked 5,421 OPG Nuclear staff and long-term contractors; 2,036 OPG Nuclear personnel could not be benchmarked.

- Our current analysis shows that OPG, as of March 2014, is 213 FTEs (4.1%) above the total benchmark of 5,208 FTEs.

- OPG is above benchmark staffing in 17 job functions, and at or below benchmark staffing in 23 functions.

- OPG's variance above the benchmark has narrowed from 17% in 2011 due to attrition, increases in the benchmarks, OPG actions including the centre-led initiative and the Pickering Station amalgamation.

GOODNIGHT CONSULTING

Introduction & Methodology

- OPG Data Collection & Aggregation

Analysis

Appendices

GOODNIGHT CONSULTING

Our Objective Was To Compare OPG Nuclear Staffing To Other North American Nuclear Operators

To benchmark OPG staffing we assigned all applicable staff & contractors to standardized nuclear functions

Identify ***OPG personnel*** supporting steady-state operations

Exclude personnel whom we are ***unable to benchmark***

Identify ***contractors*** who provide baseline support

Assign OPG and contractor personnel/FTEs* to standardized nuclear ***work functions***

*Full-Time Equivalents

GOODNIGHT CONSULTING

Goodnight Consulting's Staffing Functions Allow For "Apples-To-Apples" Comparisons

- Job descriptions, titles, and organizational structures vary from company to company
- Goodnight Consulting maintains our own job functions and definitions to establish commonality between companies
- Functions allow benchmark comparisons between different companies by aligning common activities, independent of job position titles or organizational/group labels
- Descriptions for specific functions capture the majority of activities performed by individuals performing work in that activity

GOODNIGHT CONSULTING

40 Different Job Functions Were Used To Benchmark OPG Nuclear Staffing

Operate the Plant

Chemistry
Environmental
Operations
Operations Support

Equipment Reliability

Engineering - Computer
Engineering - Plant
Engineering - Technical
QC/NDE

Materials & Services

Contracts/Purchasing[1]
Materials Mgt
Warehouse

Support Svcs & Training

Admin/Clerical
Budget/Finance
Communications
Document Control
Facilities
Human Resources
Information Mgmt (Excluded)[3]
Management
Management Assist
Training

Work Management

ALARA
HP Applied
HP Support
Maint/Construction
Maint/Constr Support
Outage Management
Project Management
Radwaste/Decon
Scheduling

Configuration Management

Design/Drafting
Engineering - Mods
Engineering - Procurement
Engineering - Reactor
Nuclear Fuels

Loss Prevention

Emergency Prep
Fire Protection
Licensing
Nuclear Safety Review
QA
Safety/Health
Security (Excluded)[2]

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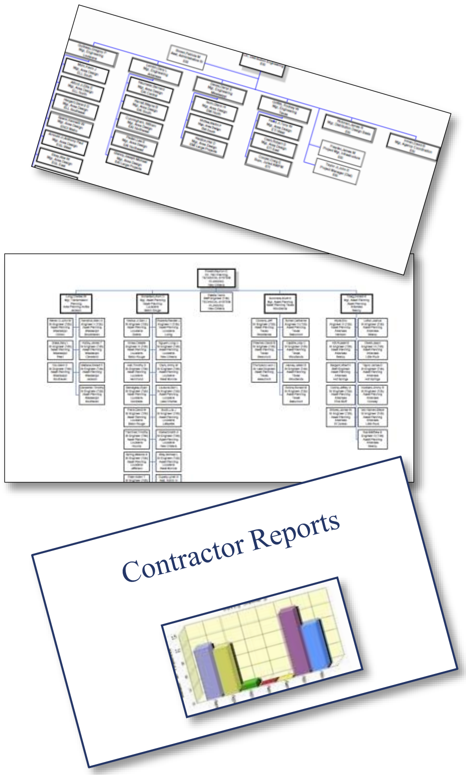
[1] Contracts and Purchasing functions were combined due to overlap within the benchmark plant set.
[2] The Security function was excluded to be consistent with OPG policy.
[3] Information Mgmt. was Benchmarked via a different method external to this study

To Ensure Proper Functionalization We Utilized OPG Data And Interviews With OPG Staff

OPG Staffing & Contractor Data



Goodnight Staffing Functions

- Nuclear Safety Review
- Operations
- Maintenance/Constr.
- Emergency Planning
- RP Applied
- Others . . .

GOODNIGHT CONSULTING

5,421 OPG Employees & Contractors Were Functionalized For Benchmarking

	Employees	Contractor FTEs	Grand Total
Assurance	36	0	36
Business & Admin Services	570	71	641
Commercial Operations & Environment	33	0	33
Corporate Relations & Communications	16	0	16
Finance	66	1	67
Nuclear	3606	305	3911
Nuclear Projects	199	114	313
People and Culture	364	41	405
Grand Total	**4890**	**531**	**5421**

This data is organized by OPG Business Group; employees supporting various job functions are found within each Business Group, for example the "People & Culture" Business Group includes Training, HR, and Support staff

	Regular	Contractor	Grand Total
Configuration Control	310	35	345
Equipment Reliability	406	36	442
Loss Prevention	268	35	303
Materials & Services	187	21	208
Operate The Plant	1055	17	1072
Support Services & Training	1013	136	1149
Work Management	1651	251	1902
Grand Total	**4890**	**531**	**5421**

This data is organized by Goodnight Consulting Process Area.

A line-by-line accounting of where each employee was functionalized is provided in the Appendix

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OPG Contractor Support Data Was Reviewed To Identify Headcounts For Baseline Contractors

Staff augmentation contractor data	• *Professional staff providing specialized skills, including authorized training contractors and/or variable work support*
Other purchased service data	• *Specialized contractors, such as nuclear safety analysis, and maintenance/construction trades*
Exclusions	• *Consistent with our standard nuclear benchmarking methodology, outage execution contractors and outage overtime were both excluded*

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OPG Contractor Data Was Converted From Hours Or Costs, Into Full Time Equivalents (FTEs)

Data Provided

OPG provided contractor data via contractor billed annual costs, or cumulative contractor annual hours

Spend Converted to FTEs

Cumulative contractor billed annual dollar values were first divided by an average hourly cost that include wages plus benefits, and then by estimated annual hours* to prorate the data into annual FTEs

Hours Converted to FTEs

Cumulative contractor annual hours were also divided by the same value to prorate the data into annual FTEs

*1890 hours/year = 1 FTE, consistent with previous studies

Applicable OPG Baseline Contractors Equates To 531 FTEs In 32 Job Functions

32 job functions where OPG contractor FTEs were identified

	Contractor FTEs
Admin/Clerical	14
Budget/Finance	1
Chemistry	12
Contracts/Purchasing	3
Emergency Planning	11
Eng.--Computer	2
Eng.--Modification	11
Eng.--Plant	17
Eng.--Procurement	1
Eng.--Reactor	17
Eng.--Technical	12
Environmental	2
Facilities	77
HP Applied	4
HP Support	2
Human Resources	1
Licensing	1
Maintenance/Construction	133
Maintenance/Construction Support	53
Management	3
Management Assist	1
Nuclear Fuels	6
Nuclear Safety Review	17
Operations Support	3
Project Management	32
QA	2
QC/NDE	5
Radwaste/Decon	26
Safety/Health	4
Scheduling	1
Training	39
Warehouse	18
Grand Total	**531**

Number of OPG contractor FTEs identified in each function (531 total)

A line-by-line accounting of where each Contractor was functionalized is provided in the Appendix

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We Were Unable To Obtain Benchmark Data For CANDU-Specific Activities

- We contacted CANDU facilities around the world requesting CANDU-specific data for benchmarking:
  - Argentina
  - Canada
  - China
  - Romania
  - South Korea
- CANDU owners from these countries either did not reply or were not willing to contribute data to this study
- This resulted in a number of CANDU-specific functions that could not be benchmarked (see the next page)

2,036 OPG Nuclear Personnel Could Not Be Benchmarked

CANDU-Specific Exclusions*

- *Fuel Handling:* Comparable function in PWRs only occurs during outages
- *Heavy Water Handling*
- *Tritium Removal Facility*
- *Feeder and Fuel Channel Support*
- *Other CANDU-Specific support to excluded functions e.g. Refueling Ops*

*Unique to CANDU design with no comparable PWR activity

OPG-Specific Exclusions

- *Pickering Units 2 & 3 Safe Store Support:* However, cross-tied operations for Units 2 & 3 ***were counted***
- *Major Projects/ One time initiatives:* e.g., Darlington Refurbishment, New Build, etc.

Generic Exclusions**

- *Nuclear waste and used fuel*: Functions not performed by plants in the benchmark
- *Outage execution activities:* Less than 10% were applied as "on-line“ support to various functions
- *Water treatment:* Functions not performed by plants in the benchmark

**Both CANDU & PWR activities but excluded as non-baseline/non-steady state

Other Exclusions

- *Security:* Excluded consistent with OPG Security policy
- *Information Management:* Benchmarked via a different method external to this study
- *Long Term Leave Personnel*: Excluded consistent with Goodnight Consulting benchmarking methodology
- *Corporate Support Not Directly Supporting The Nuclear Program:* Excluded consistent with Goodnight Consulting benchmarking methodology

GOODNIGHT CONSULTING

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- Benchmark Development & Methodology

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To Identify Staffing Benchmarks, We Used A Methodology Similar To Prior OPG Engagements

Identify Plants

Identify applicable nuclear plants/nuclear organizations as the benchmarking sources

Identify Benchmarks

Identify staffing benchmarks reflecting steady-state operations from functional staffing data using selected nuclear plants

Adjust For Technology

Adjust for technical/design differences (i.e., PWR vs. CANDU)

Adjust For Work Rules

Adjust for regulatory and/or work rule differences (i.e., 35 vs. 40 hour work week)

Finalize Benchmarks

Apply adjustments and identify final functional staffing benchmarks

We Apply Several Key Assumptions In Our Staffing Benchmarking Methodology

Benchmarks Are From Steady State, On-Power Activities

Plants are considered to be in steady state operation:

- Short-term & outage contractors *excluded*
- Baseline contractors are *included*
- Major initiatives (i.e., Darlington Refurbishment, PWR Steam Generator Replacement, PWR Vessel Head replacements, etc.) are *excluded*

Average Productivity Is Assumed

No productivity adjustments are applied to the benchmarks or OPG staffing; *however, the benchmarks were adjusted for 35 vs. 40 hour work weeks where applicable*

Current Vacancies Excluded

Benchmark staffing levels do not include permanent vacancies, i.e., vacancies not planned to be filled in the next 30 days are not counted. Regular staff absences (e.g., maternity leave or long term disability leave) are not counted as "regular staff", but may be captured as non-regular staff i.e., temporary backfills

Our Approach Begins With Current Staffing Data From Large PWRs (Most Complex US Designs)

1. Apply Goodnight Consulting Staffing Database

- 126 Operating Units

2. Select The Most Similar Plants

- Apply functional staffing data from large US (>800 MWe) Pressurized Water Reactors (see the following page)

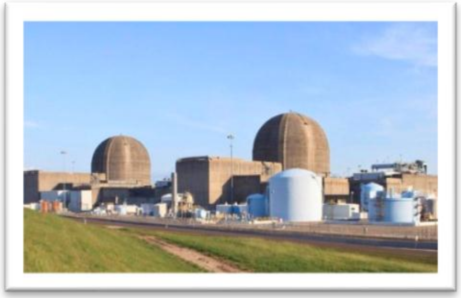
3. Identify Benchmark Functional Staffing

- Apply adjustments for PWR to CANDU design differences
- Apply adjustments for OPG conditions

4. Develop Functional Staffing Comparison

GOODNIGHT CONSULTING

Large 2-Unit PWRs Provide The Closest Comparison to CANDUs For Benchmarking



Approach

- Goodnight Consulting applies current information from plants that are the most similar in design to the client’s operating plants

Design Similarities

- CANDU plants are similar to PWRs in that there are steam generators with similar primary and secondary loops

Later-Model PWRs

- Larger capacity, later-model PWRs are more complex than earlier models; this increased complexity is closer to the CANDU design than smaller PWRs of an earlier vintage

“Most Similar” to CANDU

- Thus, the “most similar” plants in our database are large (over 800 MWe) 2-unit PWRs

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To Determine Adjustments For CANDU Design Differences, We Reviewed Many Technical Areas

Design & Operational Consideration Areas – PWR to CANDU Benchmark Conversion

- Vacuum Building
- Gadolinium Nitrate Injection
- Liquid Zone Control System
- Health Physics / ALARA / Environmental
- Annulus Gas Systems
- Inspection and Testing
- In Service Inspection / Non-Destructive Examination
- Surveillance Testing
- Materials
- Carbon Steel Primary Heat Transport System
- Fuel Channels (Zr Alloy)
- Systems and Major Components
- 12 steam generators & 16 Main HTS Pumps/unit at Pickering
- Engineering and Maintenance Programs
- PM Program Tasks / Activities
- Mechanical Components
- Electrical Components
- Instrumentation and Controls /Computers
- Reactivity Management in Calandria design, Fuels
- Corrective / Elective / Preventive Maintenance Backlogs
- Radioactive Source Term
- Building and Support Systems Maintenance
- Canadian Nuclear Safety Commission (CNSC)
- OPG as initial point of contact for CANDU Generic Issues
- Nominal 5-year License Interval
- Supply Chain
- Demineralized Water Consumption
- Design Philosophy Differences
- Separation of Control and Safety Channels
- PWR Systems, Programs, and Issues
- Turbine Driven Auxiliary Feedwater
- Condensate Polishing
- Boric Acid Corrosion
- Etc.

Our technical team reviewed the differences between PWR and CANDU and accounted for those differences in a staffing model discussed later in this section of the report

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2-Unit CANDU Staffing Benchmark Is 1,024* (Includes Corporate & Contractor FTEs)

Staffing Function	2014 2-Unit U.S. PWR Bmk	Raw Adjustments 2014	Total Bmk (2014)
Admin/Clerical	36	3	39
ALARA	5	2	7
Budget/Finance	13	1	14
Chemistry	27	0	27
Communications	3	0	3
Contracts/Purchasing	8	0	8
Design/Drafting	16	1	17
Document Control	15	2	17
Emergency Planning	6	0	6
Engineering - Computer	4	0	4
Engineering - Mods	31	3	34
Engineering - Plant	47	8	55
Engineering - Procurement	8	2	10
Engineering - Reactor	6	5	11
Engineering - Technical	29	5	34
Environmental	5	2	7
Facilities	28	0	28
Fire Protection	31	0	31
HP Applied	29	3	32
HP Support	11	1	12
Human Resources	6	1	7
Licensing	9	1	10
Maintenance/Construction	177	22	199
Maintenance/Construction Support	39	4	43
Management Assist	4	0	4
Materials Management	9	0	9
Nuclear Fuels	8	-1	7
Nuclear Safety Review	11	0	11
Operations	126	0	126
Operations Support	40	0	40
Outage Management	11	3	14
Project Management	19	1	20
QA	12	0	12
QC/NDE	11	1	12
Radwaste/Decon	9	3	12
Safety/Health	5	0	5
Scheduling	22	2	24
Training	50	3	53
Warehouse	18	2	20
Total	**944**	**80**	**1024**

The ***Raw Adjustments*** account for technical differences between PWR and CANDU plants and are detailed on the next page

*Does not include Management. A Separate Management Benchmark was developed and is discussed later in this section

Technical Adjustments Were Utilized To Derive The 2-Unit CANDU Staffing Benchmark From PWRs*

Staffing Function	Raw Adjustments 2014	Total Bmk (2014)	Rationale
Admin/Clerical	3	39	Approximately 1 additional admin/clerical person is needed for each additional 25 staff
ALARA	2	7	"Hotter shop" tritium, alpha radiation pervasive, more opportunities for ALARA-more equipment, bigger source of radiation and more space.
Budget/Finance	1	14	1 FTE additional functional staff needed to support the added personnel due to CANDU technology differences
Chemistry	0	27	No basis for adjustment
Communications	0	3	No basis for adjustment
Contracts/Purchasing	0	8	No basis for adjustment
Design/Drafting	1	17	Higher number of systems
Document Control	2	17	Higher number of systems, more control documents to manage
Emergency Planning	0	6	No basis for adjustment
Engineering - Computer	0	4	No basis for adjustment
Engineering - Mods	3	34	Higher number of systems
Engineering - Plant	8	55	Higher number of systems
Engineering - Procurement	2	10	Higher number of commercial parts dedications due to a smaller vendor market, lower availability of conforming parts
Engineering - Reactor	5	11	Adjusted to 2-unit equivalent of OPG CANDU stated requirements
Engineering - Technical	5	34	Higher number of systems, diversity instead of redundancy design philosophy
Environmental	2	7	Tritium monitoring, Canadian regulatory requirements
Facilities	0	28	No basis for adjustment
Fire Protection	0	31	No basis for adjustment
HP Applied	3	32	Additional radiation sources, differences in staffing are due to choices in program structures
HP Support	1	12	Additional radiation sources, differences in staffing are due to choices in program structures
Human Resources	1	7	1 FTE additional functional staff needed to support the added personnel due to CANDU technology differences
Licensing	1	10	Different regulatory scheme, greater number of safety systems, design philosophy of diversity over redundancy
Maintenance/Construction	22	199	Higher number of systems, diversity instead of redundancy design philosophy-track IMS impacts on numbers
Maintenance/Construction Support	4	43	Higher number of systems, diversity instead of redundancy design philosophy
Management Assist	0	4	No basis for adjustment
Materials Management	0	9	No basis for adjustment
Nuclear Fuels	-1	7	Adjusted to 2-unit equivalent of OPG CANDU stated requirements
Nuclear Safety Review	0	11	No basis for adjustment
Operations	0	126	Additional systems to monitor= increases, common systems = decreases
Operations Support	0	40	Additional systems to monitor= increases, common systems = decreases
Outage Management	3	14	Non fueling outages=decreases, more systems to deal with during an outage=increase
Project Management	1	20	Higher number of systems, diversity instead of redundancy design philosophy
QA	0	12	No basis for adjustment
QC/NDE	1	12	Due to additional maintenance work, additional QC/NDE work is required, "Innate" IMS counted here,
Radwaste/Decon	3	12	Larger volumes of I&LLW generated and packaged.
Safety/Health	0	5	No basis for adjustment
Scheduling	2	24	Greater number of systems resulting in more scheduling work
Training	3	53	Additional trainers required to handle additional maintenance training requirements
Warehouse	2	20	Additional parts and components needed for more systems and to overcome more materials kept on hand due to a smaller vendor base
Total	**80**	**1024**	

*Does not include Management. A Separate Management Benchmark was developed and is discussed later in this section

GOODNIGHT CONSULTING

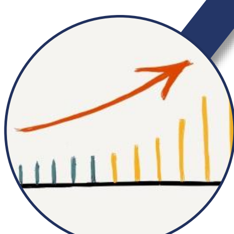
We Developed Functional Scaling Factors* Based On Our Experience & Best Estimates

This is similar to the approach that was applied in 2011 and 2013

For example, Operations requires fully staffed shift crews for each reactor or 2-unit set of reactors from our international observations

Several exceptions from the 1.8x scaling factor were applied, and are shown on the next page

This approach was based on staffing levels we have observed at several international 4-unit sites relative to our 2-unit benchmark



For most functions, we applied a scaling factor of 1.8 times the 2-unit level for a 4-unit plant

*Scaling factor not used for Management benchmark. A separate Management benchmark was developed and is discussed later in this section

GOODNIGHT CONSULTING

2-Unit *OPG* CANDU Benchmark Is 1,024*
Adjusted 4-Unit *OPG* CANDU Benchmark Is 1,976*

- Where applicable, adjustments were made for OPG's 35 Hour Work work week vs. 40 hours at U.S. plants
- The net increase in the 2-Unit benchmarks from the work week adjustment is 55 FTEs
- CANDU 2-Unit then scaled up to a 4-Unit model

2-unit to 4-unit Scaling Factors, by Functional Area

Staffing Function	2-Unit CANDU Benchmark	35 hour week?	Adjustment for 35 hour week	Scaling Factor From 2 to 4-Units	Initial 4-Unit CANDU Benchmark
Admin/Clerical	39	1	45	1.8	81
ALARA	7		7	1.8	13
Budget/Finance	14	1	16	1.8	29
Chemistry	27		27	1.8	49
Communications	3		3	1.8	5
Contracts/Purchasing	8	1	9	1.8	16
Design/Drafting	17	1	19	1.8	34
Document Control	17	1	19	1.9	36
Emergency Planning	6	1	7	1.5	11
Engineering - Computer	4	1	5	2	10
Engineering - Mods	34	1	39	1.8	70
Engineering - Plant	55	1	63	1.8	113
Engineering - Procurement	10	1	11	1.8	20
Engineering - Reactor	11	1	13	2	26
Engineering - Technical	34	1	39	1.8	70
Environmental	7	1	8	1.8	14
Facilities	28		28	1.8	50
Fire Protection	31		31	1.8	56
HP Applied	32		32	1.8	58
HP Support	12	1	14	1.8	25
Human Resources	7	1	8	1.8	14
Licensing	10	1	11	1.8	20
Maintenance/Construction	199		199	1.8	358
Maintenance/Construction Support	43		43	1.8	77
Management Assist	4	1	5	1.8	9
Materials Management	9	1	10	1.8	18
Nuclear Fuels	7	1	8	1.8	14
Nuclear Safety Review	11	1	13	1.8	23
Operations	126		126	2	252
Operations Support	40		40	2	80
Outage Management	14		14	1.8	25
Project Management	20	1	23	1.8	41
QA	12	1	14	1.8	25
QC/NDE	12		12	1.8	22
Radwaste/Decon	12		12	1.8	22
Safety/Health	5	1	6	1.8	11
Scheduling	24		24	1.8	43
Training	53		53	1.8	95
Warehouse	20	1	23	1.8	41
Total	**1024**		**1079**		**1976**

*Scaling factor not used for Management benchmark. A Separate Management Benchmark was developed and is discussed later in this section

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Adjustments For Pickering Units 1-4 Increase The OPG 2-Unit CANDU Benchmark To 1,095*

- Some cross-tied systems remain active at Pickering Units 2 & 3: We adjusted the benchmark to include personnel required to support those systems (16)

- FTEs assigned to SAFESTORE activities at Pickering Units 2 & 3 were **not** included in the benchmark

Adjustments to 2-Unit OPG CANDU for Pickering Units 1-4						
Staffing Function	2-Unit CANDU Benchmark	35 hour week	Adjustment for 35 hour week	Adjustments for Units 2 & 3	Pickering 1-4 Benchmark	Rationale
Admin/Clerical	39	1	45		45	
ALARA	7		7		7	
Budget/Finance	14	1	16		16	
Chemistry	27		27		27	
Communications	3		3		3	
Contracts/Purchasing	8	1	9		9	
Design/Drafting	17	1	19		19	
Document Control	17	1	19		19	
Emergency Planning	6	1	7		7	
Engineering - Computer	4	1	5		5	
Engineering - Mods	34	1	39		39	
Engineering - Plant	55	1	63	4	67	One additional System Engineer per discipine (M, E, I&C, Civil)
Engineering - Procurement	10	1	11		11	
Engineering - Reactor	11	1	13		13	
Engineering - Technical	34	1	39		39	
Environmental	7	1	8		8	
Facilities	28		28		28	
Fire Protection	31		31		31	
HP Applied	32		32	1	33	One additional Rad Pro technican to conduct surveillances
HP Support	12	1	14		14	
Human Resources	7	1	8		8	
Licensing	10	1	11		11	
Maintenance/Construction	199		199	5	204	Estimated Additional staff (FIN-like)
Maintenance/Construction Support	43		43	1	44	Ratio of support to additional Maintenance/Construction
Management Assist	4	1	5		5	
Materials Management	9	1	10		10	
Nuclear Fuels	7	1	8		8	
Nuclear Safety Review	11	1	13		13	
Operations	126		126	5	131	1 Additional Ops person per shift crew for rounds
Operations Support	40		40		40	
Outage Management	14		14		14	
Project Management	20	1	23		23	
QA	12	1	14		14	
QC/NDE	12		12		12	
Radwaste/Decon	12		12		12	
Safety/Health	5	1	6		6	
Scheduling	24		24		24	
Training	53		53		53	
Warehouse	20	1	23		23	
Total	1024		1079		1095	

*Scaling factor not used for Management benchmark. A Separate Management Benchmark was developed and is discussed later in this section

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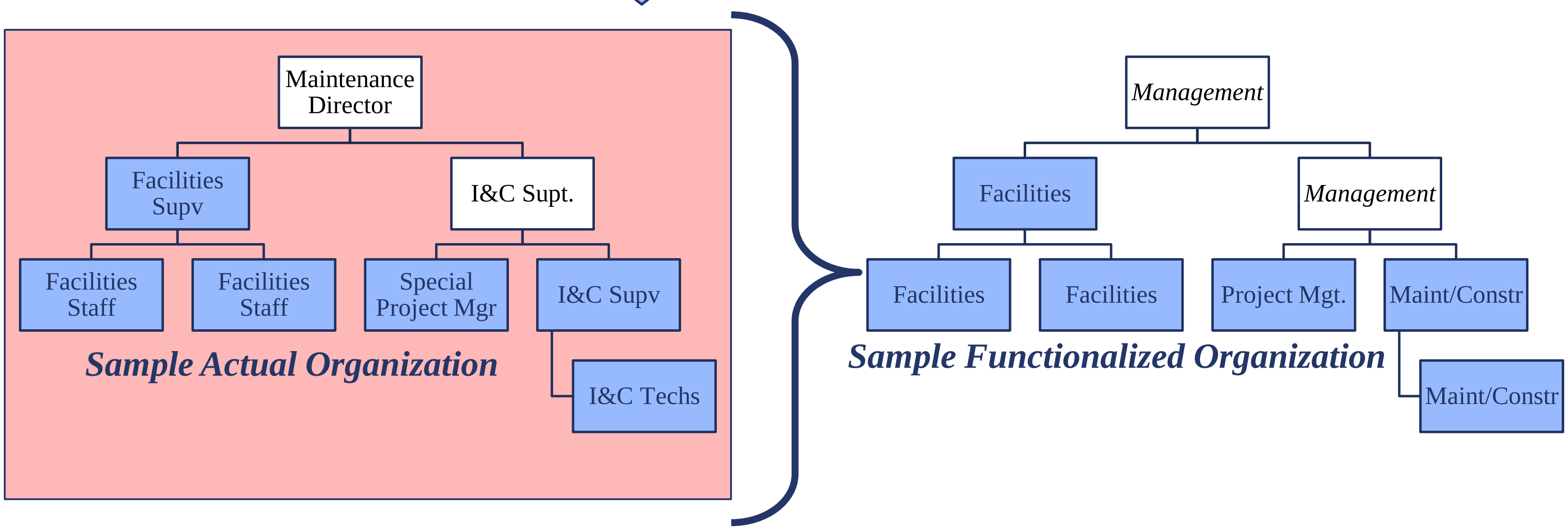
Management Is A Function, Not A Title, In Our Model; It Includes All Personnel Above 1st Line Supervisors

Management Function

- All those above first line supervisor
- Job title not a factor
- At least one of their direct reports must also have a direct report

All Other Functions

- First Line Supervisors
- Individual Contributors



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A Separate Methodology Was Used For Developing The Staffing Benchmark For The *Management* Function

OPG *Management* Function Benchmark = 161

- 97 for Pickering
- 64 for Darlington
- These include distributed Management Function staff from OPG Corporate Nuclear
- These 161 FTEs are 3.1% of total benchmarked staffing which is close to the expected ratio of Management/Total for smaller fleets like OPG

Applying the aforementioned scaling to the Management function produced an output not reflective of a reasonable organizational structure

The benchmark for this function is based on a reasonable organizational structure for OPG

We accounted for OPG's fleet environment, which provides opportunities for efficiency

Final Benchmark Nuclear Organizational Chart has 161 Managers (excluding managers for not-benchmarked activities such as Info Management, Security, Refueling Ops, Etc.

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Benchmarking *Summary:*
Total 2014 OPG Nuclear Benchmark Is 5,208

	Pickering 1-4	Pickering 5-8	Darlington	Total
Large 2-Unit PWR Benchmark	944	944	944	2832
CANDU Technology Adjustment	80	80	80	240
35 Hour Work Week Adjustment	55	55	55	165
Scale From 2 to 4 Units	0	897	897	1794
Adjust For Pickering Units 2 & 3	16	0	0	16
Add Management Benchmarks	37	60	64	161
Total	**1132**	**2036**	**2040**	**5208**

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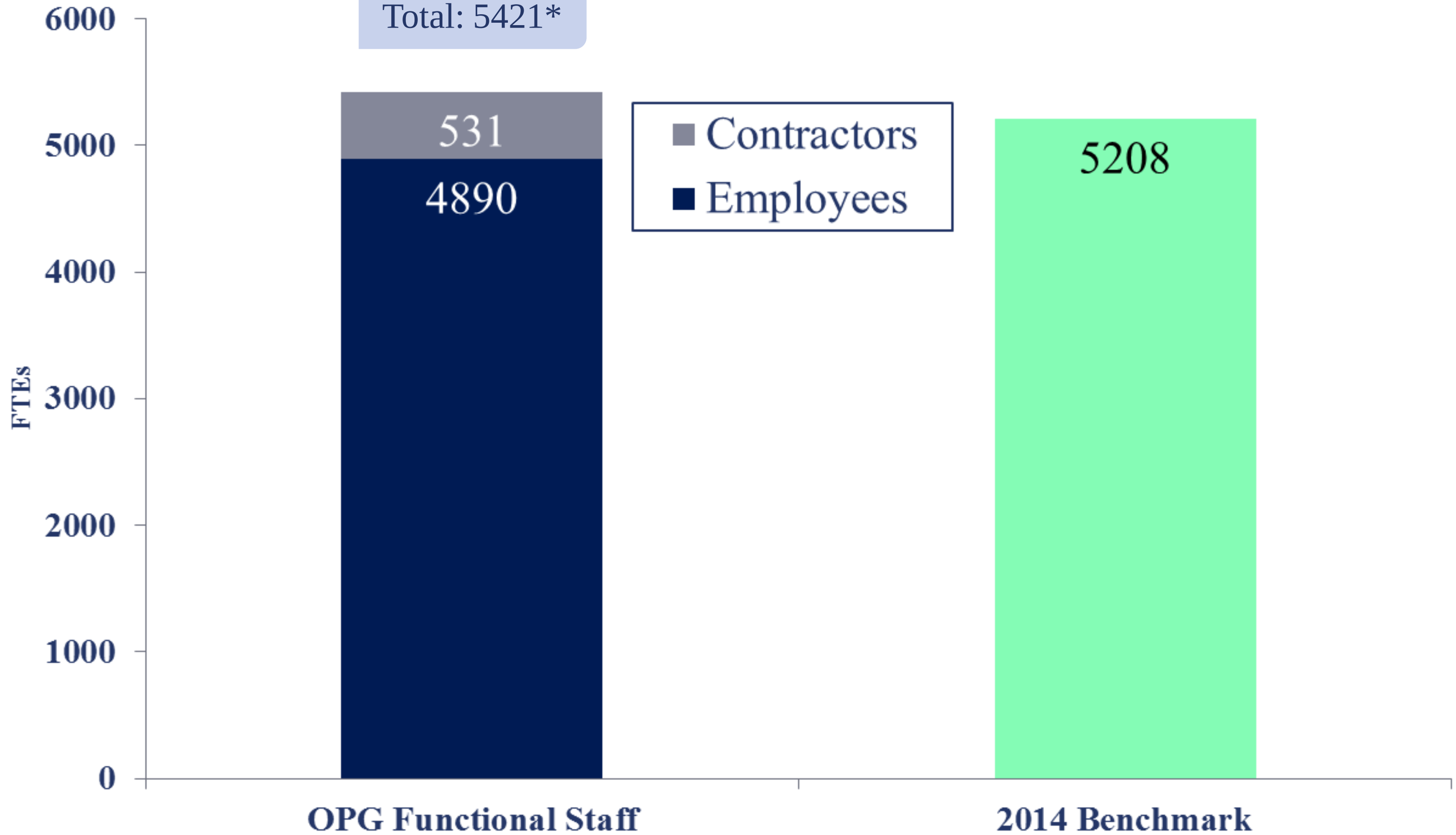
OPG Is 213 FTEs (4.1%) Above The Current Benchmark

Total: 5421*



*Data from March 2014

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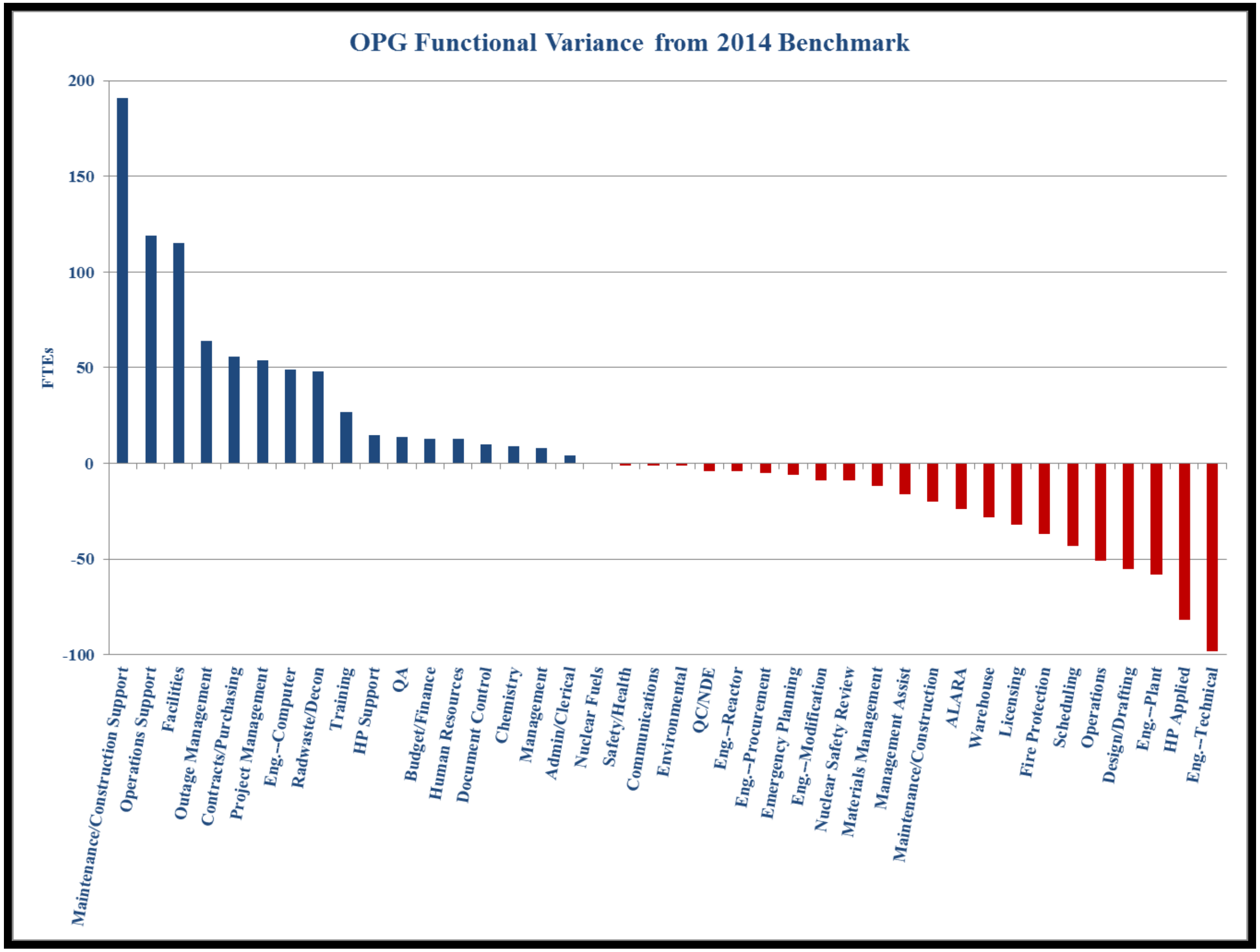
17 Functions Are Above The 2014 Benchmark; 23 Functions Are At Or Below The 2014 Benchmark



Maintenance/Construction Support	191
Operations Support	119
Facilities	115
Outage Management	64
Contracts/Purchasing	56
Project Management	54
Eng.--Computer	49
Radwaste/Decon	48
Training	27
HP Support	15
QA	14
Budget/Finance	13
Human Resources	13
Document Control	10
Chemistry	9
Management	8
Admin/Clerical	4
Nuclear Fuels	0
Safety/Health	-1
Communications	-1
Environmental	-1
QC/NDE	-4
Eng.--Reactor	-4
Eng.--Procurement	-5
Emergency Planning	-6
Eng.--Modification	-9
Nuclear Safety Review	-9
Materials Management	-12
Management Assist	-16
Maintenance/Construction	-20
ALARA	-24
Warehouse	-28
Licensing	-32
Fire Protection	-37
Scheduling	-43
Operations	-51
Design/Drafting	-55
Eng.--Plant	-58
HP Applied	-82
Eng.--Technical	-98

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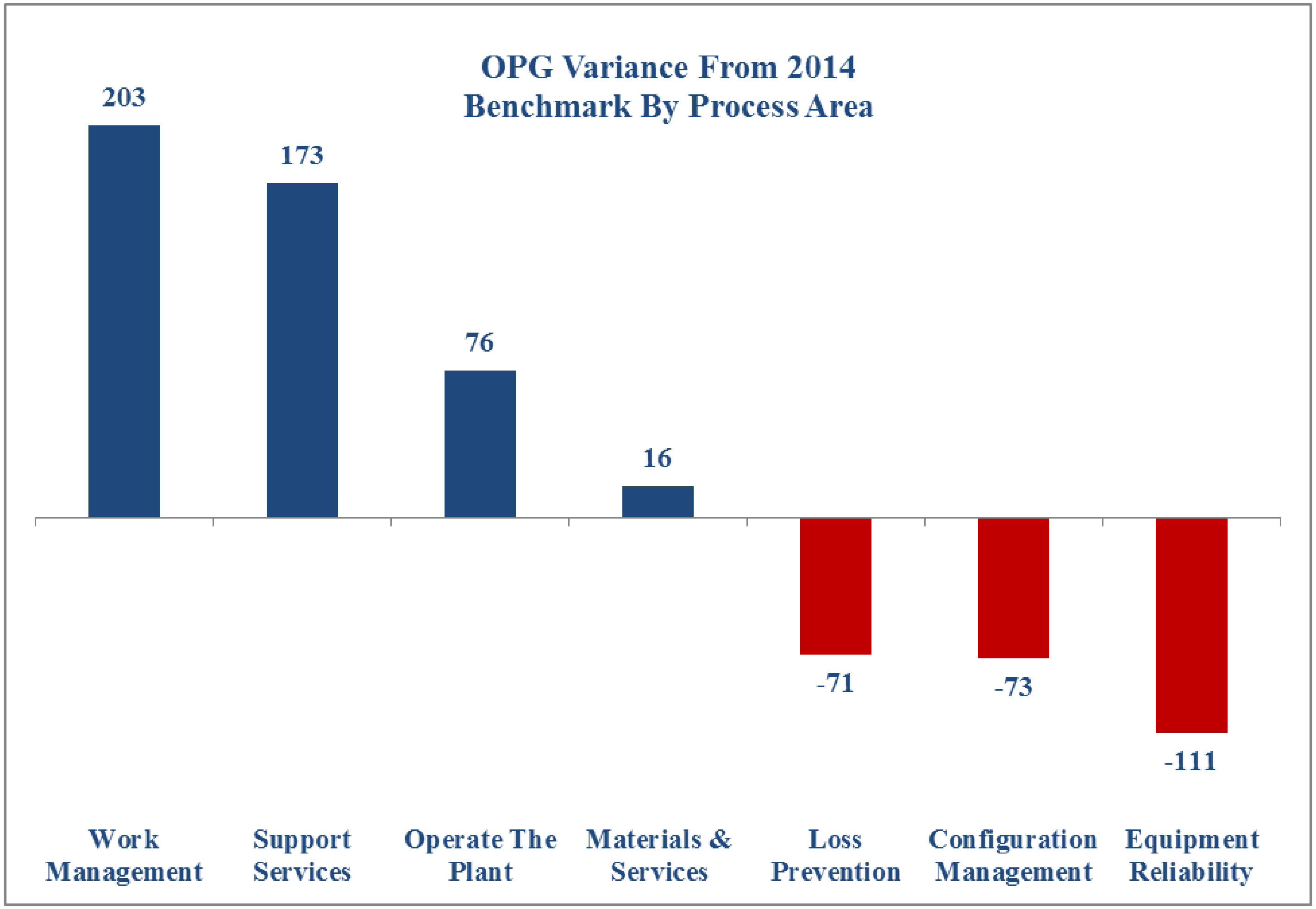
Work Management & *Equipment Reliability*
Are The Process Areas With The Largest Variances



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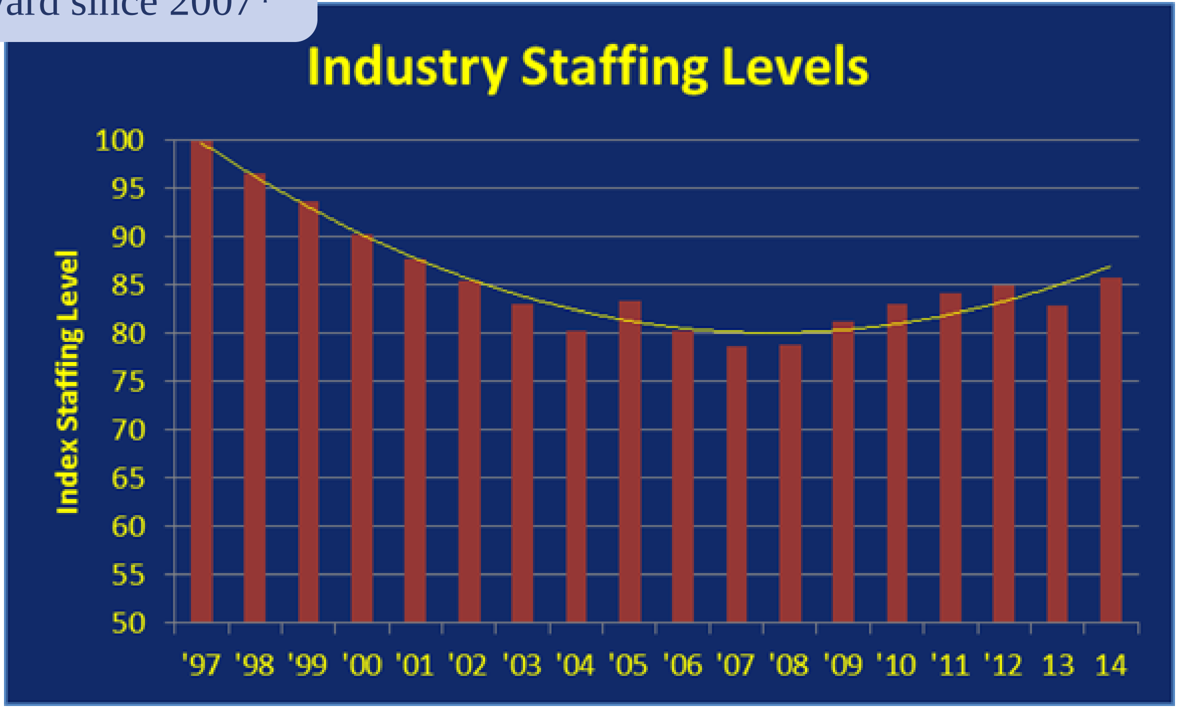
Factors Common To The Entire US Nuclear Industry Have Increased The Benchmarks Since 2013

US nuclear industry staffing has been trending upward since 2007*



This upward trend is driven by a number of factors including new programs resulting from capital investments, regulatory changes, an aging demographic profile across the nuclear power industry, and Fukushima-related initiatives.

*Source: 2014 Goodnight Consulting US Nuclear Plant Staffing Newsletter

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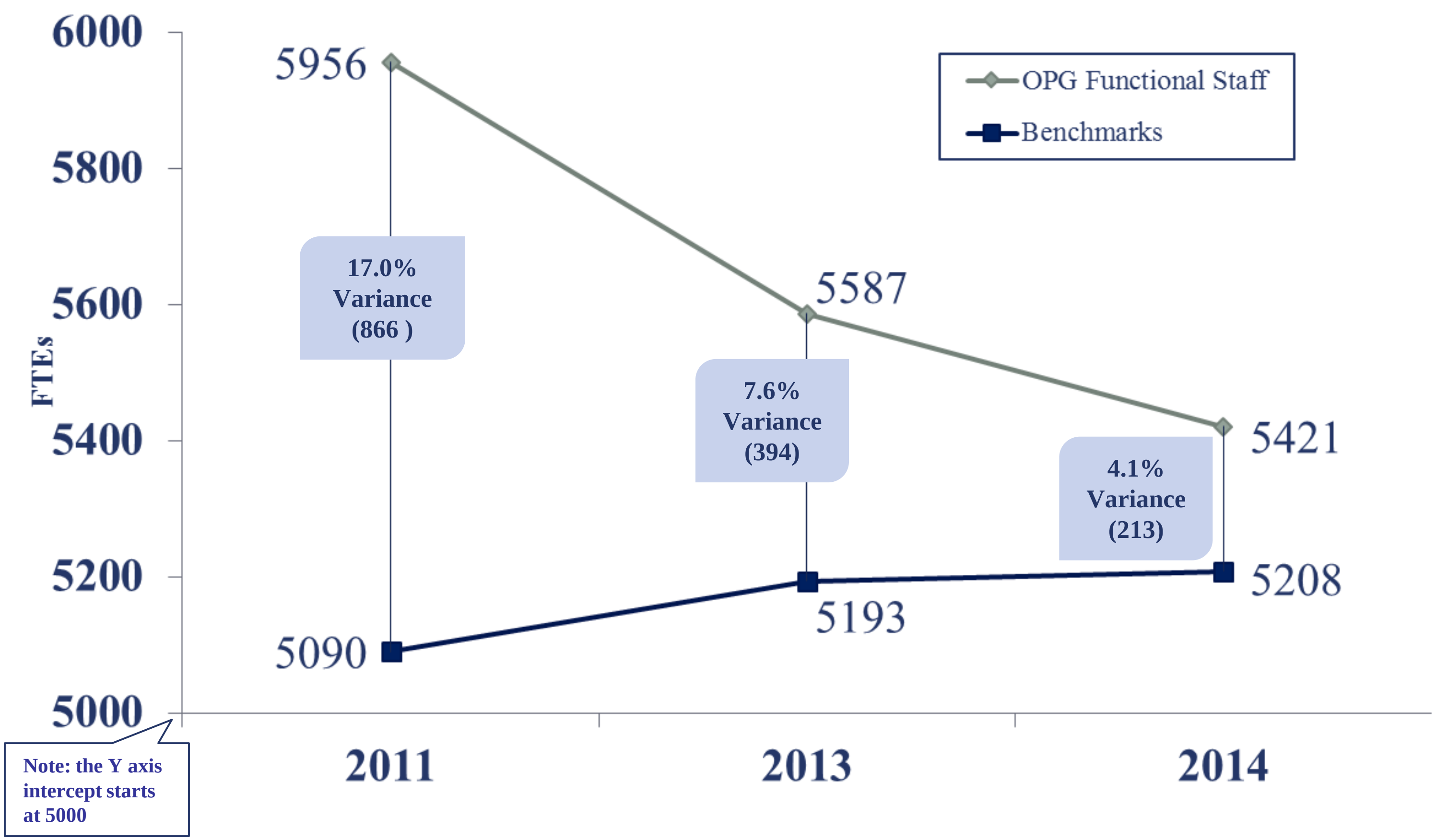
Attrition, OPG Actions, & Increases In The Benchmark Have Reduced OPG's Variance From The Benchmark



The Center-Led Initiative involved a major reorganization effort, decreasing staffing in a number of functions since 2011, most notably Management.

The Pickering Station amalgamation helped OPG achieve efficiencies and improve variances from the benchmark in a number of functions since 2011.

As Pickering approaches shutdown, the attrition rate has increased as more personnel retire early and some vacant positions go unfilled.

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Qualitative Analysis Of Key Functions Can Help OPG Identify Functions Warranting Change

- Benchmarking provides a quantitative snapshot of *"what"* staffing looks like.
- A qualitative evaluation of the "why" behind the numbers can highlight differences from the benchmarks to help OPG determine whether changes are warranted.
- However, for certain functions, a qualitative analysis is inefficient, costly, and provides OPG with no useful information in identifying the functions warranting change:
  - For example, functions with smaller variances seldom provide clear opportunities for effective change as they are rarely driven by major inefficiencies or significant differences from benchmark plants.

We Conducted A Heuristic Analysis To Identify Functions Best Suited For Qualitative Analysis

- To identify functions meriting qualitative analysis, we conducted a heuristic analysis based on our expertise, which included these factors within each function (as applicable):
  - Functional Importance / Mission Criticality
  - Feasibility/cost of potential change
  - Pareto optimality/ROI of potential change
  - Magnitude of variance from benchmark
  - Staffing benchmark variance on a per reactor basis
  - Degree of specialization
  - OPG's application of industry best practices
  - Unique variables per function
  - Etc.
- By applying this approach we identified 13 functions for qualitative analysis.

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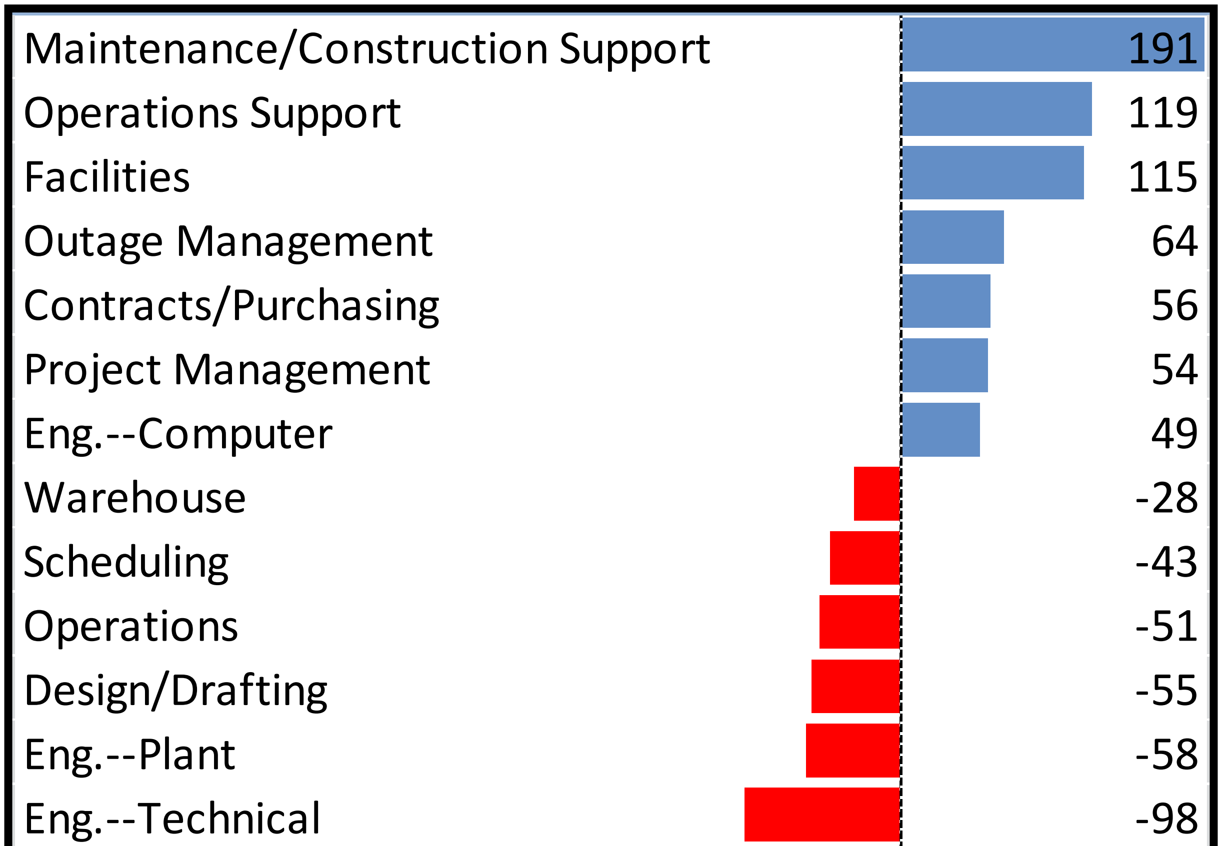
The 13 Functions We Identified Represent The Majority Of OPG’s Total Variance From The Benchmark

We identified these 13 functions for qualitative analysis by applying the methodology discussed on pages 35-36



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The Appendix Was Provided To OPG Electronically Under Separate Cover

Appendix A[1]

- OPG Data by Staffing Function

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1. Appendix A is a spreadsheet that lists OPG employees by name, provides details regarding their job and identifies their associated Goodnight job category. It has not been filed as it includes personal information.

ScottMadden Evaluation of OPG Nuclear Benchmarking

Final

Smart. Focused. Done Right.®

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MANAGEMENT CONSULTANTS

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1. Executive Summary

In 2009 Ontario Power Generation (OPG) retained ScottMadden to assist in formally benchmarking its nuclear financial and non-financial performance with industry peers. This initiative was undertaken consistent with shareholder mandate and pursuant to the direction from the Ontario Energy Board (OEB). Since this time, annual benchmarking has been a standard part of OPG Nuclear's annual business planning process. OPG has continued to publish annual benchmarking results, comparing OPG to the nuclear industry in terms of financial and non-financial performance metrics. Results are then used to inform target setting for the business planning process.

Since 2009 OPG has made a number of minor changes to the original benchmarking report to reflect changes in available industry metrics, the selection of appropriate peer companies, and in comparison techniques. In an effort to ensure OPG's benchmarking and target setting processes are still responsive to the expectations of the OEB, OPG has retained ScottMadden, as an independent evaluator, to examine the current methods used by Ontario Power Generation to benchmark the Company's operating performance against its peer companies in the industry. The benchmarking methods evaluated were those recently performed by OPG in support of its 2015-17 business planning cycle.

The approach adopted by the evaluation team was to compare the 2014 OPG Nuclear Benchmarking report to that previously designed by ScottMadden and approved by OPG management in 2009. The two documents were compared in terms of: (1) consistency in format and presentation, (2) use of appropriate peer companies for comparison, (3) use of industry standard metrics, (4) correctness of calculations, formulas and associated analyses, and (5) application of the benchmark results to inform and guide management during the Company's business planning process.

Changes in Report Format and Presentation

In our opinion all of the changes noted in this report are appropriate and/or immaterial to the overall conclusion of the benchmarking analysis.

Changes in Comparative Peer Panels

In this report, references to both "PHWRs" and "CANDUs" are made. In all instances, these two terms are used interchangeably.

The primary difference noted in the 2014 OPG Nuclear Benchmarking report was the exclusion of multiple operational (i.e., safety and reliability) metrics comparisons of OPG performance to the panel for "North America PWR and PHWR" nuclear units. It is ScottMadden's practice to use the most rigorous and broad-based panels for comparison and benchmarking whenever possible, but we believe that omitting this panel for these safety and reliability metrics is justified given the technological differences between PWR and CANDU plants, the consistent differences between performance of these two plant designs, and the fact that the overall NPI performance for the "North America PWR and PHWR" operator panel is still included within the benchmarking report. Further, OPG continues to benchmark these safety and reliability metrics against other CANDU plants through the "WANO/COG CANDUs" peer panel.

Changes in Comparative Benchmark Metrics

While there have been several minor modifications to the metrics used by OPG in 2014 versus those used in 2009 or those used by other nuclear operators, these modifications are minor and/or are justified given the explanation above. We recommend that all "rolling average" benchmarks using different rolling average durations for Pickering versus Darlington clearly indicate this unique situation in the footnotes or observations regarding those metrics. Overall, the metrics selected for comparison present a fair and balanced view of the Company's performance compared to its industry peers.

Validation of Data Calculations and Reporting

In our review of the spreadsheet calculations performed by OPG and their subsequent use in tables and charts, we found no instances of material errors. All results were accurate and reproducible.

Use of Benchmarks in the Business Planning Process

Our review indicates that OPG's performance targets were established using the results of the benchmarking exercise. Historical performance against benchmarks was documented and projections of future performance against the same benchmarks were also included to provide a clear picture of the planned direction of OPG's performance versus the industry. Additionally, gaps in performance were discussed in the Board presentation consistent with the 2014 Nuclear Benchmarking Report. There was clear evidence that the benchmarks were employed to inform the business planning and target setting processes. It is our opinion that the approach taken by OPG is consistent with the Company's established governance and with industry leading practice.

Overall Evaluation

Based on a review of the benchmarking reports and methods OPG has employed in support of its business planning cycle since 2009, it is ScottMadden's opinion that OPG has continued to formally benchmark its nuclear financial and non-financial performance with industry peers in a manner that is consistent with industry leading practices. Further, we found clear evidence that these performance benchmarks continue to be employed to inform the business planning and target setting processes, as reflected in established OPG governance.

2. Background

In 2009 Ontario Power Generation (OPG) retained ScottMadden to assist in formally benchmarking its nuclear financial and non-financial performance with industry peers. The objective of the exercise was to identify, clarify and confirm performance gaps and to identify potential cost and performance improvement areas for inclusion in that year's nuclear business plan. This initiative was undertaken consistent with shareholder mandate and pursuant to the expectations of the Ontario Energy Board (OEB). Since this time, annual benchmarking has been a standard part of OPG Nuclear's annual business planning process. OPG has continued to publish annual benchmarking results, comparing OPG to the nuclear industry in terms of financial and non-financial performance metrics. Results are then used to inform target setting for the business planning process.

Since 2009 OPG has made a number of changes to the original benchmarking report to reflect changes in available industry metrics, the selection of appropriate peer companies, and in comparison techniques. In an effort to ensure OPG's benchmarking and target setting processes are still responsive to the expectations of the OEB, OPG has requested an independent third-party evaluation of its current benchmarking methods and presentation.

3. Objectives, Scope and Approach

In 2015 ScottMadden was asked to evaluate the current methods used by Ontario Power Generation to benchmark the Company's operating performance against its peer companies in the industry. The benchmarking methods evaluated were those recently performed by OPG in support of its 2015-17 business planning cycle.

The scope of our review included the following:

- Identification of key performance metrics used for comparison
- Selection of companies to be included in the peer panels
- Preparation of supporting analyses and displays of data
- Use of the benchmarks in the business planning cycle

The purpose of the current evaluation is to confirm that the Company's current benchmarking methods and approach are still responsive to the original direction from the OEB.

The approach adopted by the evaluation team was to compare the 2014 OPG Nuclear Benchmarking report to that previously designed by ScottMadden and approved by OPG management in 2009. The two documents were compared in terms of: (1) consistency in format and presentation, (2) use of appropriate peer companies for comparison, (3) use of industry standard metrics, (4) correctness of calculations, formulas and associated analyses, and (5) application of the benchmark results to inform and guide management during the Company's business planning process.

In each case the key differences are identified together with OPG's justification for making the change. At the end of each section, we have noted ScottMadden's opinion regarding the changes noted.

4. Changes In Report Format and Presentation

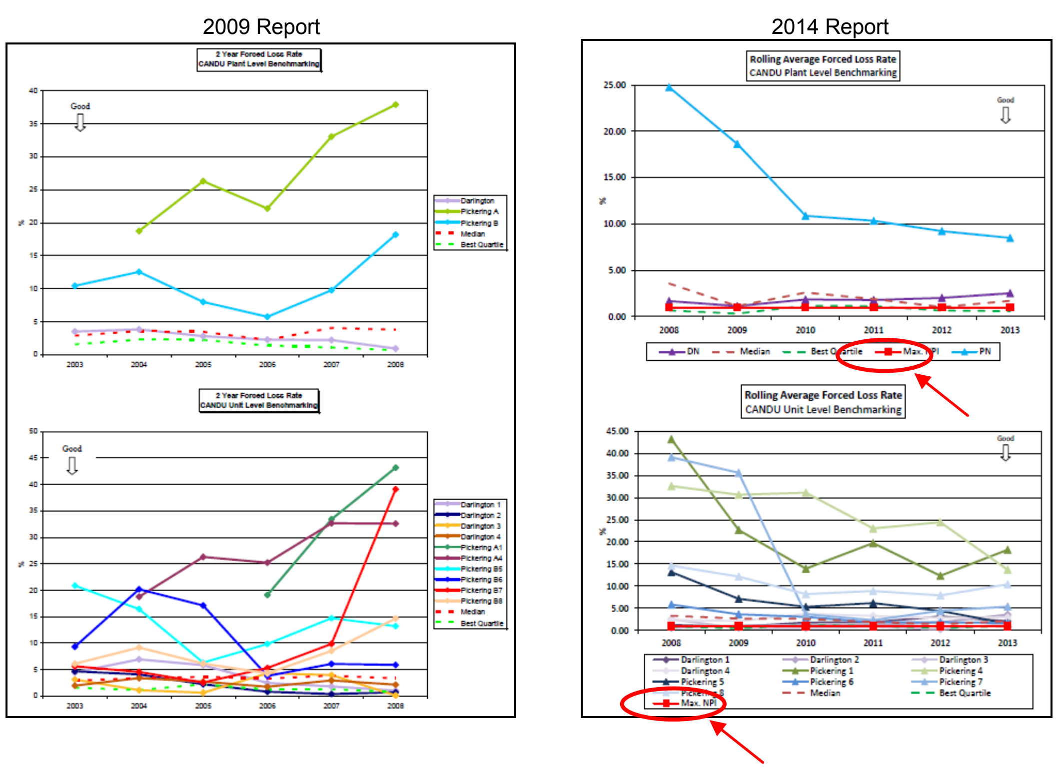
In comparing the 2009 and 2014 reports it is important to note that the underlying data reflects changes in the availability of comparative data for the nuclear industry as well as changes in company performance. For example, in 2014 a new "human performance" metric was available with sufficient peer panel companies for comparison. Sufficient comparators for this metric were not available in 2009.

Key Changes and Their Justification

1. Throughout the 2009 report, the Pickering Nuclear Station was reported as two separate operating entities ("Pickering A" and "Pickering B"), whereas in the 2014 report, Pickering was reported as a single operating plant to reflect the amalgamation of the two operating licenses.

2. Another change, as shown in Figure 1, was the addition of the "Max NPI" line in many of the graphs found in the 2014 report. For any metric included in the "Nuclear Performance Index (NPI)" calculation, this line shows the value required to achieve the maximum NPI score. The justification for this addition is that the "Max NPI" value may vary from what is technically "best quartile" and so represents an alternative definition of what "excellent" performance is as defined by WANO/INPO.

Figure 1: Inclusion of the Max NPI Line



3. The 2009 report contained a comparison of performance data at the major operator level in the section titled "Benchmarking Results – Operator Summary" within the

Executive Summary. This comparison was also presented in the 2014 report but comparative information was not included in the Executive Summary as in 2009.

4. The 2009 report was structured around three "Cornerstone Areas" whereas the 2014 report is structured around four "Cornerstone Areas." The new addition is the "Human Performance" cornerstone. Human performance was a company cornerstone in 2009, but there was no cross-industry performance metric that could be reliably compared at that time. At that time INPO had recently introduced an industry-wide metric but the specifics were still being worked out in the design and reporting of the metric and results were not available for a sufficiently large comparative peer panel. The justification for this addition is that the new metric was widely available in 2014 and could be used reliably for industry benchmarking.

5. In Table 13 OPG results are compared to North American plants using the aggregate Nuclear Performance Index (NPI). The 2014 report displays both Darlington and Pickering scores whereas the 2009 report only presented OPG consolidated scores.

6. The 2009 report referred to rolling average metrics by noting the number of years averaged (e.g., 1, 2, or 3-Year). The same number of years was used for both Pickering and Darlington. The 2014 report labels the same metrics as a "Rolling Average" without specifying the duration. In Figure 2, for example, the 2009 report presented the metric "2-Year Forced Loss Rate" whereas the 2014 report presented the same metric as "Rolling Average Forced Loss Rate." The primary reason for this change is that a different number of years are being used for Pickering vs. Darlington based on the outage cycle. The justification for the difference is discussed further in the "Changes in Comparative Benchmark Metrics" section.

Figure 2: Metric Title Modifications

2009 Report

Safety
All Injury Rate
2-Year Industrial Safety Accident Rate*
Fuel Reliability*
2-Year Reactor Trip Rate*
3-Year Auxiliary Feedwater System Unavailability*
3-Year Emergency AC Power Unavailability*
3-Year High Pressure Safety Injection Unavailability*
2-Year Collective Radiation Exposure*
Airborne Tritium Emissions per Unit
Reliability
WANO NPI
2-Year Forced Loss Rate*
2-Year Unit Capability Factor*
2-Year Chemistry Performance Indicator*
1-Year On-line Elective Maintenance Backlog (OEMB)
1-Year On-line Corrective Maintenance Backlog (OCMB)
Value for Money
3-Year Total Generating Costs / MWh
3-Year Non-Fuel Operating Costs (OM&A) / MWh
3-Year Fuel Costs (OM&A) / MWh
3-Year Capital Costs / MW DER

* Subindicator of WANO NPI

2014 Report

Safety
All Injury Rate
Rolling Average Industrial Safety Accident Rate*
Rolling Average Collective Radiation Exposure*
Airborne Tritium Emissions per Unit
Fuel Reliability Index*
2-Year Reactor Trip Rate*
3-Year Auxiliary Feedwater System Unavailability*
3-Year Emergency AC Power Unavailability*
3-Year High Pressure Safety Injection Unavailability*
Reliability
WANO NPI
Rolling Average Forced Loss Rate*
Rolling Average Unit Capability Factor*
Rolling Average Chemistry Performance Indicator*
1-Year On-line Deficient Maintenance Backlog
1-Year On-line Corrective Maintenance Backlog
Value for Money
3-Year Total Generating Cost / MWh
3-Year Non-Fuel Operating Cost (OM&A) / MWh
3-Year Fuel Cost (OM&A) / MWh
3-Year Capital Cost / MW DER
Human Performance
Human Performance Error Rate

* Sub-indicator of WANO NPI

ScottMadden's Evaluation

In our opinion all of the changes noted above are appropriate and/or immaterial to the overall conclusion of the benchmarking analysis

5. Changes in Comparative Peer Panels

The benchmarking panels used by OPG in 2014 are displayed in Figure 3. One additional panel is shown in this table that was not used in 2009. This is the "INPO" panel used to compare the "Human Performance Error Rate." Use of this metric will be described further in Section 6.

Figure 3: OPG's 2014 Peer Panels

	WANO / COG CANDUs	All North American PWR and PHWRs (WANO)	INPO AP-928 Workgroup	INPO	CEA	EUCG North American Plants (U.S. and Canada)
Safety						
All Injury Rate					X	
Rolling Average Industrial Safety Accident Rate*		X				
Rolling Average Collective Radiation Exposure*	X					
Airborne Tritium Emissions per Unit	X					
Fuel Reliability Index*	X					
2-Year Reactor Trip Rate*	X					
3-Year Auxiliary Feedwater System Unavailability*	X					
3-Year Emergency AC Power Unavailability*	X					
3-Year High Pressure Safety Injection Unavailability*	X					
Reliability						
WANO NPI	X					
Rolling Average Forced Loss Rate*	X					
Rolling Average Unit Capability Factor*	X					
Rolling Average Chemistry Performance Indicator*	X					
1-Year On-line Deficient Maintenance Backlog			X			
1-Year On-line Corrective Maintenance Backlog			X			
Value for Money						
3-Year Total Generating Cost / MWh						X
3-Year Non-Fuel Operating Cost (OM&A) / MWh						X
3-Year Fuel Cost (OM&A) / MWh						X
3-Year Capital Cost / MW DER						X
Human Performance						
Human Performance Error Rate				X		

* Sub-indicator of WANO NPI

Key Changes and Their Justification

While the peer panels used to compare OPG's performance have not changed noticeably, the metrics compared to these panels differed significantly in one instance. In 2009 OPG compared their performance to the "All North American PWR and PHWRs" peer panel across a total of seven "Safety" metrics and four "Reliability" metrics. In 2014, this comparison was reduced to only one "Safety" metric ("Rolling Average Industrial Safety Accident Rate"). Comparisons of the remaining metrics are still present but the peer panel is restricted to "WANO / COG CANDUs."

The justification provided for this change by OPG is that as more reliable data became available for other CANDU plants in both North America and worldwide, it made more sense to restrict comparison to these plants since they differ in design, configuration and performance to the PWR-reactors used in the rest of North America.

ScottMadden's Evaluation

The primary difference noted in the 2014 OPG Nuclear Benchmarking report was the exclusion of multiple operational (i.e., safety and reliability) metrics comparisons of OPG performance to the panel for "North America PWR and PHWR" nuclear units. It is ScottMadden's practice to use the most rigorous and broad-based panels for comparison and benchmarking whenever possible, but we believe that omitting this panel for these safety and reliability metrics is justified given the technological differences between PWR and CANDU plants, the consistent differences between performance of these two plant designs, and the fact that the overall NPI performance for the "North America PWR and PHWR" operator panel is still included within the benchmarking report. Further, OPG continues to benchmark these safety and reliability metrics against other CANDU plants through the "WANO/COG CANDUs" peer panel.

6. Changes in Comparative Benchmark Metrics

We compared the metrics currently used by OPG to those currently used by other nuclear operators to benchmark their operational and financial performance. While there were some minor differences, there are no notable gaps from industry standard and the metrics used provide a complete picture of performance. All of the metrics used in the 2009 report are also found in the 2014 report. These are also the metrics still most widely used within the industry to compare performance. An additional metric, "Human Performance Error Rate," is included in the 2014 report. Figure 4 displays the performance metrics used in OPG 2014 benchmarking report.

Figure 4: OPG's 2014 Metrics

Metric
Safety
All Injury Rate (#/200k hours worked)
Rolling Average Industrial Safety Accident Rate (#/200k hours worked)
Rolling Average Collective Radiation Exposure (Person-rem per unit)
Airborne Tritium Emissions (Curies) per Unit[2]
Fuel Reliability Index (microcuries per gram)
2-Year Reactor Trip Rate (# per 7,000 hours)
3-Year Auxiliary Feedwater System Unavailability (#)
3-Year Emergency AC Power Unavailability (#)
3-Year High Pressure Safety Injection Unavailability (#)

Reliability
WANO NPI (Index)
Rolling Average Forced Loss Rate (%)
Rolling Average Unit Capability Factor (%)
Rolling Average Chemistry Performance Indicator (Index)
1-Year On-line Deficient Maintenance Backlog (work orders per unit)
1-Year On-line Corrective Maintenance Backlog (work orders per unit)
Value for Money
3-Year Total Generating Cost per MWh ($ per Net MWh)
3-Year Non-Fuel Operating Cost per MWh ($ per Net MWh)
3-Year Fuel Cost per MWh ($ per Net MWh)
3-Year Capital Cost per MW DER (k$ per MW)
Human Performance
18-Month Human Performance Error Rate (# per 10k ISAR hours)

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Key Changes and Their Justification

Safety Cornerstone Metrics: The 2014 benchmark report contains nine comparative performance metrics – all of which were included in the 2009 report. The metrics and the comparative peer panels are the same.

While the metrics are the same, they are calculated differently in the most recent report: (1) “Rolling Average Industrial Safety Accident Rate” and (2) “Rolling Average Collective Radiation Exposure” were calculated on a 2-year rolling average in the original 2009 report and on a mixed 2-year and 3-year rolling average in the 2014 report. In the 2014 report, these metrics were reported on a 2-year rolling average basis for Pickering and non-OPG plants/units and on a 3-year rolling average for Darlington. This change was made to recognize the differences in outage cycles between these two stations. Use of a 3-year rolling average for Darlington is better as it avoids large swings in the performance results driven by the presence, or absence, of outages within the reporting period. This approach presents a more easily comparable performance trend over time.

Reliability Cornerstone Metrics: The 2014 benchmark report contains six comparative performance metrics – four of which were included in the 2009 report. The comparative peer panels are the same. The two differences in metrics are as follows:

1. As in the case of the Safety Cornerstone metrics, three of the Reliability Cornerstone metrics: (1) “Rolling Average Forced Loss Rate %,” (2) Rolling Average Unit Capability Factor,” and (3) “Rolling Average Chemistry Performance Indicator” were calculated on a 2-year rolling average in the original 2009 report and on a mixed 2-year and 3-year rolling average in the 2014 report. In the 2014 report, these metrics were reported on a 2-year rolling average basis for Pickering and non-OPG plants/units and on a 3-year rolling average for Darlington. This change was made to recognize the differences in outage cycles between these two stations. Use of a 3-year rolling average for Darlington is better as it avoids large swings in the performance results driven by the presence, or absence, of outages within the reporting period This approach presents a more easily comparable performance trend over time.

2. The metric title and scale on the graphs under the Airborne Tritium Emissions metric are different. The metric title in the 2009 report read “Airborne Tritium Emissions per Unit” whereas the 2014 report metric title read “Airborne Tritium Emissions per In Service Unit”. The scale in the 2009 report was “Tritium Exposure (TBq) per GWh” whereas the scale in the 2014 report was “Tritium Emissions (curies) per In Service Unit.” This change was a result of CANDU COG changing the metric in 2012. Tritium emissions from each facility are compared per in service reactor unit to allow for consideration of decreased emissions resulting from generating units undergoing major refurbishment work campaigns. OPG changed their metric and the metric unit to follow the industry accepted norm for measuring Airborne Tritium Emissions.

3. The “1-Year On-Line Elective Maintenance Backlog” metric in the 2009 report was replaced by the “1-Year On-Line Deficient Maintenance Backlog” metric in the 2014 report. This change occurred in 2012. The rationale behind this replacement stems from the INPO AP-928 group, which gathers data for this metric. Industry backlog

benchmark standards changed with Revision 3 of AP-928 Work Management Practices at INPO in June 2010. The new standard created an alignment between engineering criticality coding and backlog classification that allows improved focus on the more critical outstanding work. The new standard also sets a more consistent foundation for classification of backlogs such that comparisons between utilities will be more meaningful. All OPG sites converted to the new standard in January 2011 and therefore the 2012 report and subsequent reports, including 2014, reflect the new standard.

Other nuclear operators sometimes benchmark reliability metrics such as: (1) Refueling Outage/Fuel Reliability, (2) Scope Stability, and (3) Schedule Adherence. These metrics are not reported by OPG in the 2014 benchmarking report (nor were they recommended by ScottMadden in the 2009 report). Refueling outage metrics are not applicable to OPG because of CANDU technology, which allows for online refueling vs. offline. The work management metrics (Scope Stability and Schedule Adherence) are relatively new for the industry. OPG benchmarks their performance against these metrics at a lower level in the organization vs. in their top tier benchmarking report because the metrics are new, data is not yet consistently reported and there are limited historical trends.

OPG annually evaluates the need to potentially adjust or add new metrics. OPG looks for reliable, consistently reported metrics which allow for reasonable, longer term comparison and they also try to balance the number of top tier indicators they use for their benchmarking report (and thus for business planning) to avoid diluting their focus. Focusing on key top tier metrics is a standard industry practice. Scope Stability and Schedule Adherence may be added in the future as more reliable historic information is available.

<u>Value for Money Metrics:</u> The 2014 benchmark report contains four comparative performance metrics – all of which were included in the 2009 report. The comparative peer panel is the same.

Inventory values are sometimes used by other nuclear operators but are not currently utilized by OPG, though a benchmarking effort is presently underway. These metrics are not consistently reported by any of the nuclear oversight organizations (INPO, WANO, COG, CEA or EUCG) and so are not readily available, requiring a custom effort to produce. Thus, these are not metrics we would recommend annually refreshing today. They are often used for “second tier” analysis using smaller subsets of nuclear operators and have only recently become a focus.

<u>Human Performance Metrics</u>: The 2014 report contains one Human Performance Metric – the “18-Month Human Performance Error Rate.” This is a relatively new metric designed and reported by INPO for 62 nuclear stations. Consistent data for this metric was not available in 2009 and was not included at that time.

Other metrics often used by nuclear operators in this area are: (1) Event Free Day Resets, (2) Training, and (3) Overtime. Unfortunately, there are no industry-wide accepted benchmarking data for these metrics. OPG uses these metrics for internal performance tracking but not for benchmarking due to limited data.

ScottMadden's Evaluation

While there have been several modifications to the metrics used by OPG in 2014 versus those used in 2009 or those used by other nuclear operators, we believe these modifications are justified given the explanations above. We recommend that all "rolling average" benchmarks using different rolling average durations for Pickering versus Darlington clearly indicate this unique situation in the footnotes or observations regarding those metrics. Overall, the metrics selected for comparison present a fair and balanced view of the Company's performance compared to its industry peers.

7. Validation of Data Calculations and Reporting

Data Validation Exercise

A data validation exercise was conducted to ensure that the benchmarking data contained in the 2014 report was accessed, calculated, and reported accurately. Data consolidation for the OPG benchmarking reports occurs in three principal steps:

1. Receipt of data from the reporting agencies (e.g., WANO, INPO, COG, etc.) and posting of this data to an OPG consolidated spreadsheet,
2. Calculation of the data as needed (e.g., development of 2 or 3 year rolling averages if not directly reported as such),
3. Development of tables and charts comparing OPG performance to that of associated peer panels

ScottMadden independently validated both steps 2 and 3. We were unable to directly validate Step 1-insofar as ScottMadden is not a member utility and does not have direct access to the underlying reports provided by these organizations. Membership rules restrict distribution to third parties. In validating Step 2, OPG data and associated calculations were examined cell-by-cell. Data and calculations for other comparators were examined and validated in aggregate.

ScottMadden's Evaluation

In our review of the spreadsheet calculations and their subsequent use in tables and charts, we found no instances of discrepancies or material errors. We did identify a few instances where labeling was unclear for columns in OPG's supporting Excel worksheets, though the data was used and presented correctly in the report. OPG followed our recommendation and addressed this labeling issue to reduce the risk of future misinterpretation.

8. Use of Benchmarks in the Business Planning Process

The use of performance benchmarks to inform business planning is clearly spelled out in OPG governance (Document N-PROC-AS-0080). This document outlines OPG's adoption of a top-down, bottom-up business planning process that utilizes benchmarking to inform target setting and also implements the principles of "gap-based" business planning. All three elements of this governance: (1) top-down, bottom up budgeting, (2) the use of benchmarks to inform business planning, and (3) the use of "gap-based" business planning are recognized industry best practices.

Process Validation

To ensure that the process described in N-PROC-AS-0080 was used during the most recent 2015-2017 business planning cycle, ScottMadden reviewed the 2015-2017 Business Plan as submitted by Glenn Jager (Chief Nuclear Officer) and Dietmar Reiner (Senior Vice President – Nuclear Projects) to the OPG Board of Directors on November 14, 2014.

ScottMadden's Evaluation

Our review indicates that OPG's performance targets were established using the results of the benchmarking exercise. Historical performance against benchmarks was documented and projections of future performance against the same benchmarks were also included to provide a clear picture of the planned direction of OPG's performance versus the industry. Additionally, gaps in performance were discussed in the Board presentation consistent with the 2014 Nuclear Benchmarking Report. There was clear evidence of benchmarking informing the business planning process and target setting. It is our opinion that the process followed by OPG is consistent with the Company's established governance and with industry leading practice.

PRIOR GAP CLOSURE INITIATIVES

1.0 FUEL HANDLING RELIABILITY INITIATIVE

1.1 Objective

The Fuel Handling Reliability initiative was designed to improve fuel handling equipment reliability at both Darlington and Pickering, with an expectation of improved forced loss rate and lower total generating cost per unit. The initiative was completed in 2015 with new actions on-going into 2016.

A benefit of CANDU technology is online refueling which provides the ability to continue to generate during refueling, improving unit capability and reducing the unit cost per MWh. However, in the period 2012-2014 OPG experienced a number of issues with fuel handling equipment reliability, which negatively impacted fueling operations. When a fuel handling machine is unavailable the units cannot be refueled, which can result in either a reduction in reactor power (a “forced derate”) or a forced outage while the machinery is being repaired.

The unavailability of fuel handling machines at Darlington could also pose a risk to the Darlington Refurbishment Program (“DRP”). The DRP outage schedule assumes an event-free defueling program of Unit 2 reactor starting in October 2016.

1.2 Description

OPG established a Fuel Handling Centre of Excellence to drive collaboration and convergence of best practices across the Darlington and Pickering sites.

Through the Fuel Handling Centre of Excellence, OPG developed a fuel handling equipment reliability index (“FHERI”) based on best practices and leading indicators. The subcomponents which make up the FHERI encompass various areas such as Overall System Availability, Equipment Deficiencies, Preventive Maintenance program, Work Management program and Implementation of Key Reliability Improvements. The FHERI was developed in collaboration with members of the CANDU Owners Group and has been adopted by other CANDU utilities.

Following the development of the FHERI, Darlington and Pickering developed short-term and long-term fuel handling reliability plans to meet FHERI targets. OPG also developed a common fuel handling reliability program across both sites to provide the proper oversight and support to meet those targets and improve fuel handling performance.

OPG executed the initiative through six key processes:

1. **Gap Identification**: Assessing OPG's fuel handling reliability program against equipment reliability programs in place across North America, identifying gaps and incorporating actions into the fuel handling reliability plan to close them.
2. **Collaboration**: Working collaboratively with vendors to develop a fuel handling machine parts strategy to support the short and long term maintenance program.
3. **Prospective Maintenance**: Establishing a forward-looking fuel handling maintenance program.
4. **Specialized "Fix-It-Now" Team**: Creating a fuel handling "Fix It Now" ("FIN") team. The FIN team is a cross-functional working team assembled as a self-sufficient workgroup capable of independently performing work with minimal support from other organizations. The team manages and executes work outside the normal 13-week work schedule on a real-time and immediate basis. The FIN team's primary responsibility is to address emergent, high priority, and minor work activities, such that the scheduled and planned work activities are protected, and shop resources are not distracted from their assigned tasks.
5. **Improved Monitoring**: Improving system health monitoring, reporting and action plans.
6. **Measuring Performance**: Developing a standard set of metrics, guidance and oversight to align the organization to meet its fuel handling maintenance targets.

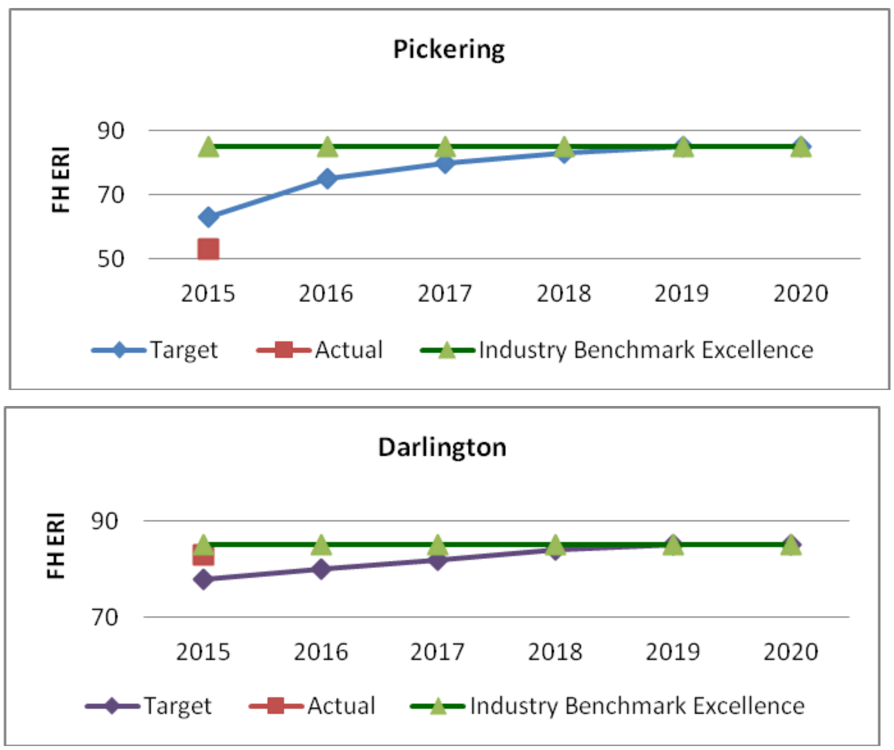
In addition, OPG is pursuing a number of capital projects (including Project #46634 Pickering A Fuel Handling Single Point of Vulnerability Equipment Reliability Improvement and Project #40976 Pickering B Fuel Handling Reliability Modifications) to replace life-expired mechanical and control components and install modifications to improve the reliability of the Pickering fuel handling systems.

1.3 Benefits Realized

The FHERI Index Benchmark is 85. As the FHERI was created in 2015, there is no historical data available prior to 2015. In 2015, Pickering achieved a FHERI of 53 against a target of 63, while Darlington achieved a FHERI of 83 relative to a target of 78. Chart 1 below sets out the results for 2015 and targets going forward for Pickering and Darlington.

Chart 1

Fuel Handling Equipment Reliability Index

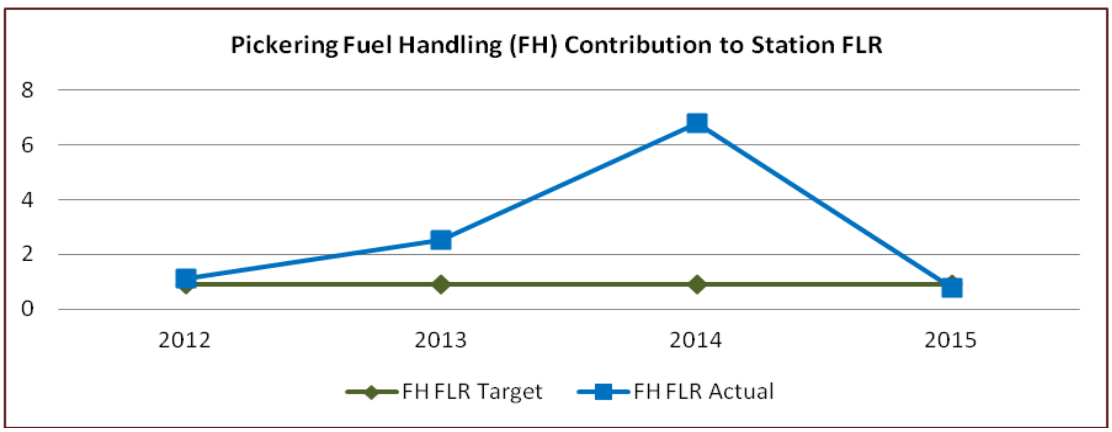


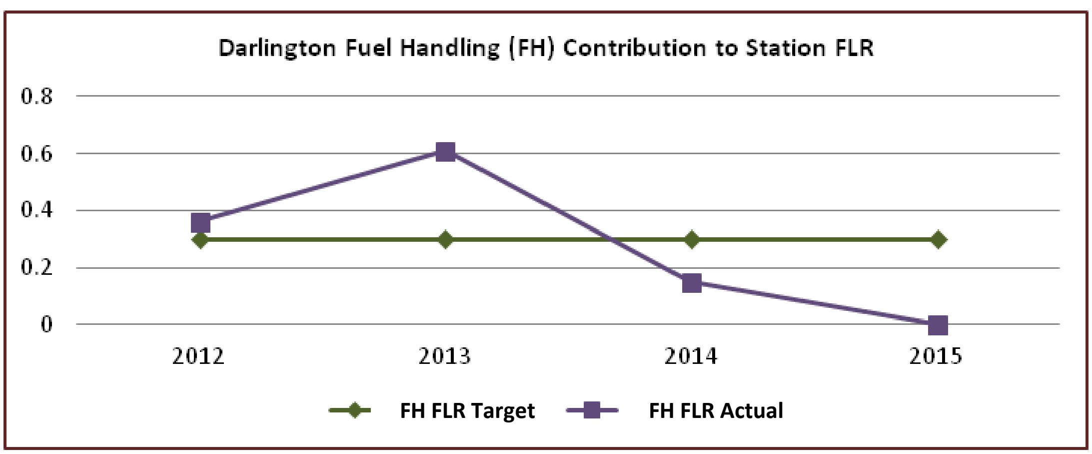
Another measure of fuel handling reliability is Fuel Handling Contribution to Station Forced Loss Rate ("FLR"). Historical information is available for this metric and, as shown below in Chart 2, improved fuel handling reliability achieved through this initiative was a contributor to reducing FLR at the stations. In 2014, Pickering's FLR was 10.7 per cent and fuel handling was estimated to have contributed over 6 per cent to that outcome (i.e. 56 per cent of total FLR). In 2015, Pickering's FLR was 2.9 per cent and the fuel handling contribution had declined to 0.79**%.**

Darlington also experienced a similar declining trend. In 2014 Darlington's FLR was 1.5 per cent and fuel handling was estimated to have contributed less than 0.2 per cent to that outcome. In 2015 the fuel handling contribution to Darllington's FLR was 0 per cent.

Chart 2

Fuel Handling Contribution to Station FLR





2.0 3K3 EQUIPMENT RELIABILITY INITIATIVE

2.1 Objective

Pickering has historically experienced unplanned generation loss primarily due to Pickering's actual Force Loss Rate exceeding business plan targets.

In 2013 Pickering initiated a Forced Loss Rate Improvement initiative that consisted of various sub-initiatives to address unplanned generation loss. The 3K3 Reliability initiative was one of the key sub-initiatives to address Equipment Reliability. The objective was to target the completion of 3,000 key reliability work orders (3k) over the three year period 2013-2015 (3K3). High backlogs of key work orders (e.g., work orders related to on-line deficient maintenance backlogs and on-line corrective maintenance backlogs) can impact equipment reliability because deferral can increase the potential for forced outages due to equipment failure.[1]

2.2 Description

The complexity, resource commitment, cost and benefit of work orders can vary significantly based on the nature of the work order. While all work orders must be completed, the 3K3 initiative introduced a more strategic approach to work order completion by seeking to better identify, prioritize and complete key work orders that will achieve maximum benefit.

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[1] Two key reliability metrics benchmarked by OPG are On-line Deficient Maintenance Backlogs and On-Line Corrective Maintenance Backlogs. On Line Deficient Backlogs is the average number of active maintenance work orders per operating unit classified as Deficient Critical (DC) or Deficient Non-Critical that can be worked on without requiring unit shutdown. This metric identifies deficiencies or degradation of plant equipment components that need to be remedied, but which do not represent a loss of functionality of the component or system. On-line Corrective Maintenance Backlog is the average number of active maintenance work orders per operating unit classified as Corrective Critical (CC) or Corrective Non-Critical (CN) that can be worked on without unit shutdown. This metric identifies deficiencies or degradation of components that need to be remedied, and represents a loss of functionality of a major component or system. In 2014 and 2015 OPG focused on both reducing its on-line deficient and corrective maintenance backlogs relative to industy best quartile and median backlog thresholds (see Ex. F2-1-1 Attachment 1) and also through this initiative prioritizing completion of such backlogs to achieve maximum benefit.

Pickering typically schedules and completes in excess of 70,000 work orders per year. New work orders are continuously being identified, and a key challenge for work management is scheduling work to address incoming work orders plus the existing inventory of outstanding work orders, in addition to executing the preventive maintenance program. The ability to complete work orders including deficient and corrective backlogs, as well as executing preventive maintenance, is limited by the available resources.

The 3K3 initiative was implemented in two areas:

1. Detailed Analysis of the Problem and Strategic Scope Selection:

As a first step, the 3K3 initiative completed a detailed analysis of program areas, systems (e.g., turbines) and components (e.g., shut down system components) that were seen as having the biggest impact on equipment reliability. From this analysis, 3,000 work orders were selected on the basis that they were the most challenging and would have the most impact on improving equipment reliability. The initiative was successful in prioritizing resources towards completing work orders having the most significant impact on improving reliability. The three year time frame was essential in order to align and focus the entire organization for an extended period of time to meet the very aggressive target of completion of the 3,000 prioritized work orders with existing resources.

2. Optimize incoming corrective and deficient work orders to minimize future backlog increase:

In addition to executing the 3,000 prioritized work orders, the initiative also focused on ensuring that incoming work orders are strategically reviewed to eliminate duplication of reported work and to identify opportunities to bundle work orders to improve efficiency and reduce the overall work order backlog . This was done through two activities:

(i.) A process to screen and analyze incoming work on a monthly basis was established. This process looked for system/component trends and opportunities to reduce the maintenance burden.

(ii.) Establishing Critical Failure Review meetings to track equipment failures to ensure adequate corrective actions were put in place to prevent recurrence of failures. This process was designed to resolve issues in a timely manner and reduce the number of functional failures in critical equipment, with the expectation of reducing incoming new work orders on critical equipment.

2.3 Benefits Realized

Pickering successfully identified, prioritized and executed in excess of 3,000 key reliability work orders over the period 2012-2014, per Chart 3 below:

Chart 3

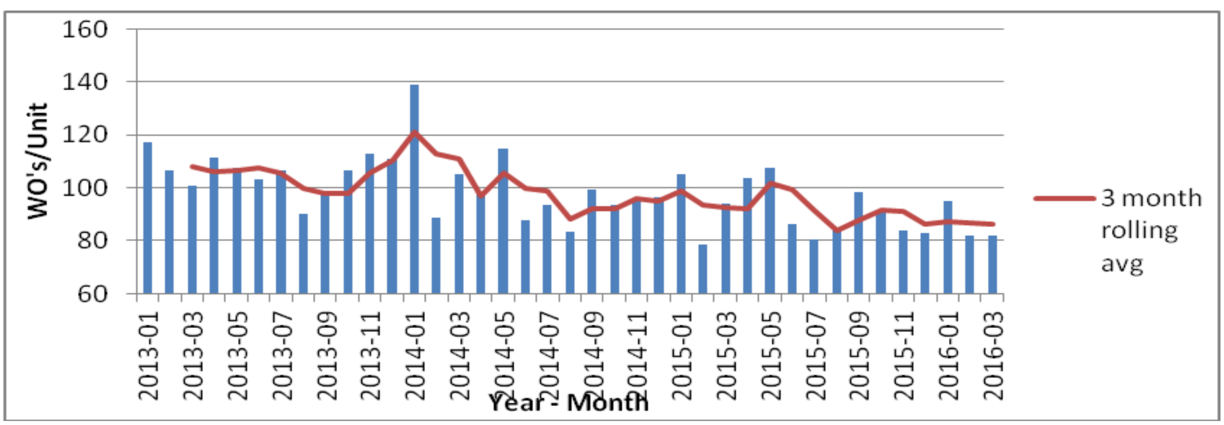
Completed 3K3 Work Orders 2012-2014

	2012	2013	2014
Completed Work Orders	940	996	1,074

In addition, monthly incoming corrective and deficient backlog work orders decreased significantly since 2013, as shown below in Chart 4 below:

Chart 4

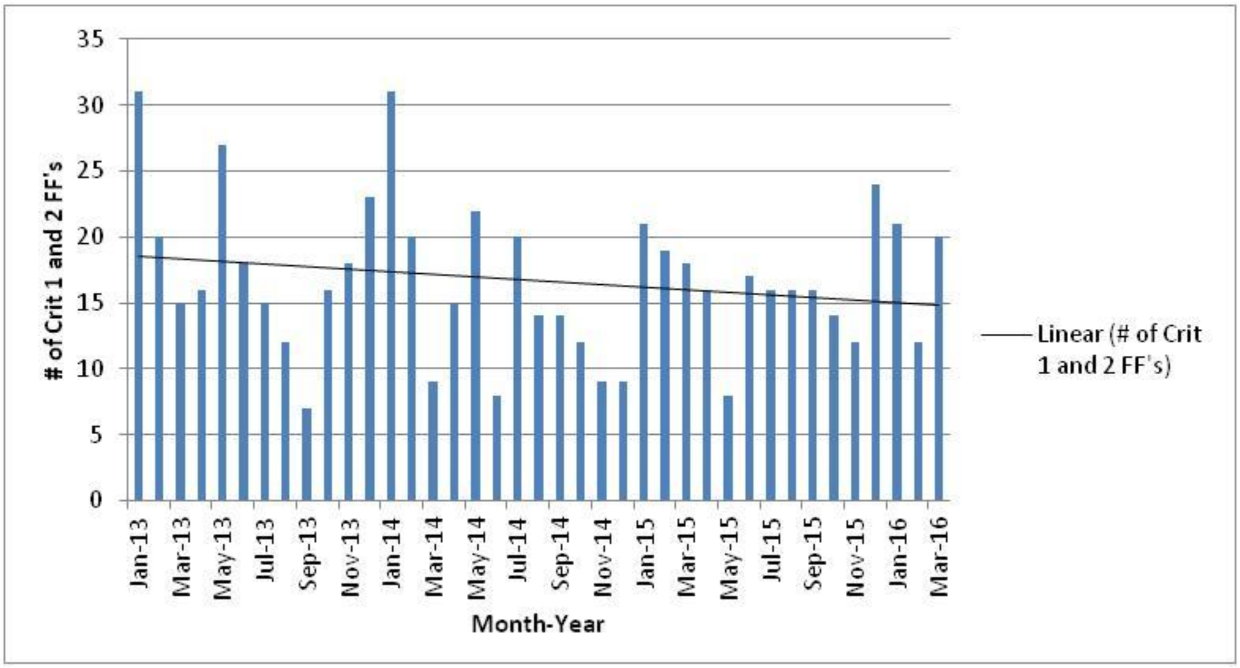
Incoming Corrective and Deficient Backlog Work Orders 2013-2016



Pickering was also able to achieve a reduction in functional failures of critical equipment in the period of 2013-2016, as demonstrated by the negative linear trendline on Chart 5 below:

Chart 5

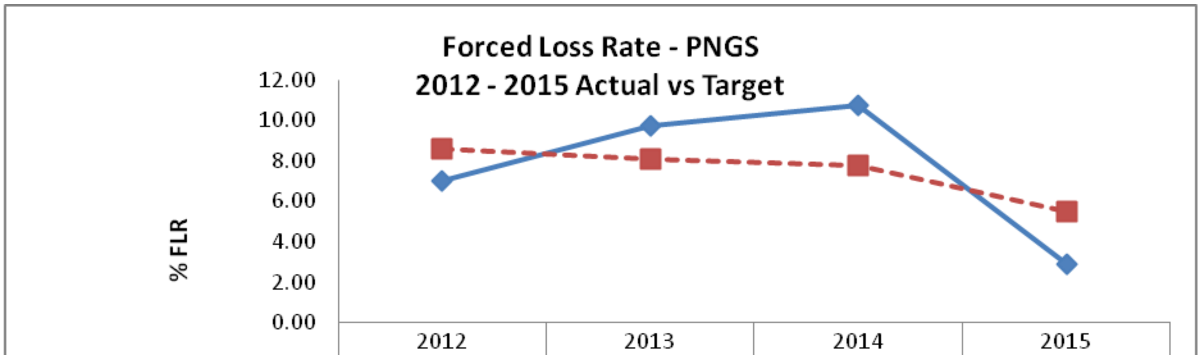
Critical Functional Failures (Jan 2013- Mar 2016)



The successful outcome of the 3K3 reliability initiative was a major contributor to Pickerng achieving its best ever station FLR performance in 2015, per Chart 6 below. The strategic approach implemented by the 3K3 initiative to identify, prioritize and complete key work orders that will achieve maximum benefit has been embedded into Pickering's work management processes going forward.

Chart 6

Pickering Forced Loss Rate

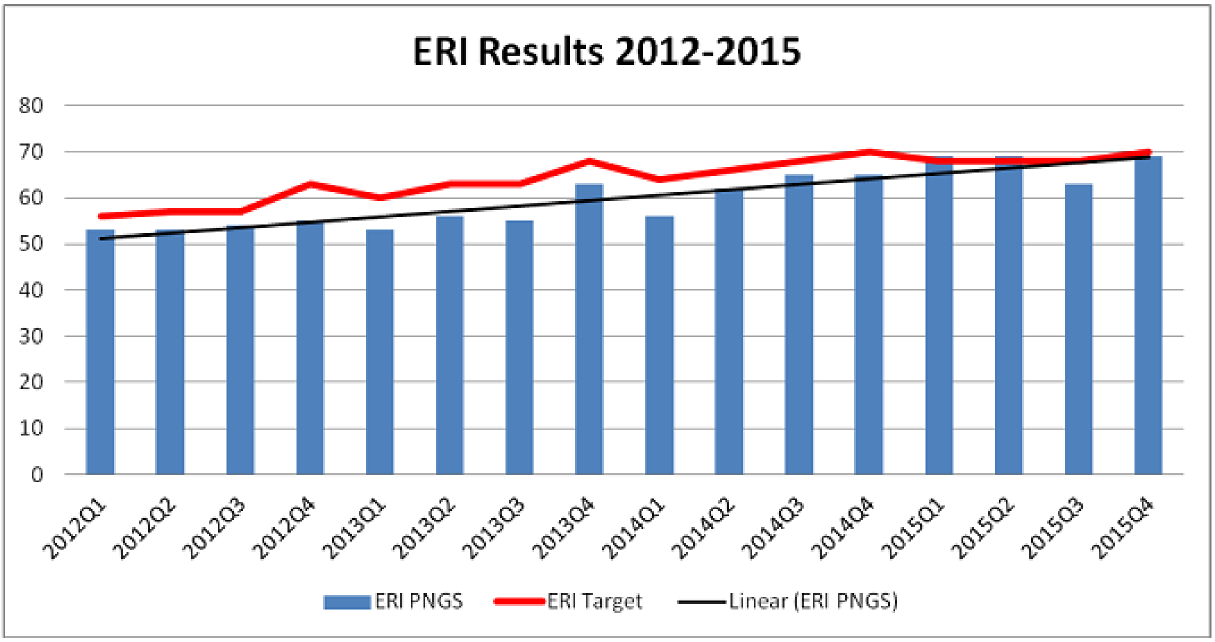


	2012	2013	2014	2015
Actual	7.02	9.73	10.72	2.89
Business Plan Targets	8.59	8.09	7.76	5.50

This initiative has also contributed to an improving Equipment Reliability Index ("ERI") over the period 2012 to 2015 as demonstrated by the positive linear trendline in Chart 7 below. The ERI measures the health of Pickering's reliability program and performance, and a positive trend is supportive in Pickering's ability to achieve its FLR business plan targets going forward.

Chart 7

Equipment Reliability Index for Pickering (2012-2015)



3.0 DAYS BASED MAINTENANCE INITIATIVE

3.1 Objective

Prior to 2010, OPG's maintenance functions were scheduled around-the-clock on a shift basis. Shift-based maintenance was required in order to meet regulatory requirements for on-site and off-site radiation surveys, and emergency response duties.

In its 2010-2014 Business Plan OPG Nuclear identified an opportunity to provide greater value for money and align with leading industry practices by moving away from a shift-based maintenance schedule to a days-only maintenance schedule (the "Days Based Maintenance" initiative).

The primary expected benefit of implementing Days Based Maintenance was to lower costs through improved labour productivity and efficiency. The initiative was projected to realize labour cost reductions by eliminating shift premiums, and eliminating compensation costs for voluntary emergency response duties.

In addition, studies of shift-based versus days-based maintenance indicated other potential secondary productivity benefits such as reduced employee fatigue, lower human performance error rate, less rework, improved accountability and “ownership” of work task by maintenance crews, higher task completion rates (i.e., the number of work tasks completed and the percentage of tasks completed relative to schedule) and lower backlogs. The implementation of days-based maintenance was also expected to improve efficiency by eliminating hand-over of work between shifts; i.e. a days-based schedule allowed OPG to implement more specialized teams who continue working on the same task the next day, rather than handing it off to the following shift.

OPG required CNSC approval for the initiative, since it involved changing the minimum compliment staffing number.

3.2 Description

Five core tasks were necessary to implement the Days Based Maintenance initiative:

1. **Regulatory Submission**: To enable the move from shift-based to days-based maintenance, OPG had to demonstrate to the CNSC that a minimum complement staffing number can adequately cover any design basis accident. The CNSC ultimately approved OPG’s request.[2]
2. **Source Term and Off-Site Monitoring**: The single biggest contributor to high maintenance shift numbers was the requirement for staff to perform on-site and off-site radiation surveys. To eliminate this requirement, automated monitoring systems were installed.
3. **Emergency Response Organization (“ERO”) Staffing**: Following CNSC approval, the newly-installed automated gamma radiation monitoring systems removed the need for maintenance staff to have ERO certification, eliminating related training requirements.

[2] CNSC Submission G323.

4. **Voluntary Emergency Response Team ("VERT") Staffing**: OPG requires a number of shift staff to have emergency response training. Prior to the initiative, VERT positions were used to augment OPG's Emergency Response Team ("ERT"). Implementing days-based maintenance included enhanced training for OPG's ERT, upgrades to the plant fire systems and coordination between the ERT and the fire department. These improvements allowed OPG to eliminate the VERT requirement. This reduced compensation costs ($1,350/year per qualified employee for each of the 257 employees who were previously VERT-certified).
5. **Maintenance reorganization**: By moving to a days-based maintenance schedule, each site was able to significantly reduce shift employee headcount. The remaining shift employees were moved to days, which enabled the reorganization of maintenance crews. The shift allowed for more effective utilization of staff (e.g., less hand-offs between shift maintenance crews, and efficiency gains by having tasks assigned to a single maintenance crew).

3.3 Benefits Realized

The Days Based Maintenance initiative was successfully implemented at both Pickering and Darlington stations. Direct savings are approximately $4.5 million per year as a result of savings on shift premiums and compensation for VERT qualification. One time capital expenditures of $5.7M were incurred to install automated monitoring systems.

Secondary benefits from implementing this initiative are expected to include reduced employee fatigue, lower human performance error rate, less rework, and higher work task completion rates.

Numbers may not add due to rounding.

Table 1
Operating Costs Summary - Nuclear ($M)

Line No.	Cost Item	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)
	OM&A:									
	Nuclear Operations OM&A									
1	**Base OM&A**	1,127.7	1,127.1	1,159.6	1,201.8	1,210.6	1,226.0	1,248.4	1,264.7	1,276.3
2	**Project OM&A**	105.7	101.9	115.2	98.2	113.7	109.1	100.1	100.2	86.8
3	**Outage OM&A**	277.5	221.3	313.7	321.2	394.6	393.8	415.3	394.4	308.5
4	**Subtotal Nuclear Operations OM&A**	1,510.8	1,450.3	1,588.5	1,621.3	1,718.9	1,728.9	1,763.8	1,759.4	1,671.6
5	**Darlington Refurbishment OM&A**	6.3	6.3	1.6	1.3	41.5	13.8	3.5	48.4	19.7
6	**Darlington New Nuclear OM&A**[1]	25.6	1.5	1.3	1.2	1.2	1.2	1.2	1.3	1.3
7	**Allocation of Corporate Costs**	428.4	416.2	418.8	442.3	448.9	437.2	442.7	445.0	454.1
8	**Allocation of Centrally Held and Other Costs**[2]	413.5	416.9	461.0	331.9	80.2	118.2	108.3	91.1	81.3
9	**Asset Service Fee**	22.7	23.3	32.9	28.4	27.9	27.9	28.3	22.9	20.7
10	**Subtotal Other OM&A**	896.5	864.1	915.5	805.0	599.7	598.3	584.1	608.6	577.1
11	**Total OM&A**	2,407.3	2,314.5	2,504.0	2,426.3	2,318.6	2,327.1	2,347.9	2,368.0	2,248.7
12	**Nuclear Fuel Costs**	244.7	254.8	244.3	264.8	219.9	222.0	233.1	228.2	212.7
	Other Operating Cost Items:									
13	**Depreciation and Amortization**	270.1	285.3	298.0	293.6	346.9	378.7	384.0	524.9	338.1
14	**Income Tax**	(76.4)	(61.5)	(31.8)	(18.7)	(18.4)	(18.4)	(18.4)	51.2	51.7
15	**Property Tax**	13.6	13.2	13.2	13.5	14.6	14.9	15.3	15.7	17.0
16	**Total Operating Costs**	2,859.3	2,806.2	3,027.8	2,979.4	2,881.6	2,924.4	2,961.9	3,187.9	2,868.2

Notes:

1 Nuclear Operations expenditures to maintain the Nuclear New Build option. In addition there are allocated corporate costs (included in line 7) for Nuclear New Build of $0.8M in 2016, $1.1M in 2017, $0.2M in 2018, $0.5M in 2019, $0.5M in 2020 and $0.5M in 2021.

2 Comprises centrally-held costs from Ex. F4-4-1 Table 3 and amounts of approximately $1M-$6M per year for machine dynamics and performance testing services provided by Hydro Thermal Operations in support of Nuclear Operations.

Numbers may not add due to rounding.

Table 2

Comparison of Nuclear Operations OM&A Cost ($M)

Line No.	Business Unit	2013 Budget	(c)-(a) Change	2013 Actual	(g)-(c) Change	2014 OEB Approved	(g)-(e) Change	2014 Actual	(k)-(g) Change	2015 OEB Approved	(k)-(i) Change	2015 Actual
		(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)
1	**Nuclear Operations OM&A Cost Before OEB Adjustments**[1]	1,555.5	(44.7)	1,510.8	(60.5)	1,527.6	(77.3)	1,450.3	138.1	1,591.1	(2.6)	1,588.5
2	**OEB Adjustments to Nuclear OM&A**[2]					(87.7)	87.7			(87.8)	87.8	
3	**Nuclear Operations OM&A Cost**	1,555.5	(44.7)	1,510.8	(60.5)	1,440.0	10.4	1,450.3	138.1	1,503.3	85.2	1,588.5

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)
4	**Nuclear Operations OM&A Cost Before OEB Adjustments**[1]	1,588.5	32.8	1,621.3	97.6	1,718.9	10.0	1,728.9	34.9	1,763.8	(4.4)	1,759.4
5	**Nuclear Operations OM&A Cost**	1,588.5	32.8	1,621.3	97.6	1,718.9	10.0	1,728.9	34.9	1,763.8	(4.4)	1,759.4

Line No.	Business Unit	2020 Plan	(c)-(a) Change	2021 Plan
		(a)	(b)	(c)
6	**Nuclear Operations OM&A Cost Before OEB Adjustments**[1]	1,759.4	(87.7)	1,671.6
7	**Nuclear Operations OM&A Cost**	1,759.4	(87.7)	1,671.6

Notes:

1 Nuclear Operations OM&A Cost includes Base OM&A, Project OM&A and Outage OM&A, as in Ex. F2-1-1 Table 1.

2 OEB Adjustments of $87.7M for 2014 OEB Approved and $87.8M for 2015 OEB Approved are the allocated portions of the $100M total disallowance applied to both nuclear and hydroelectric in each of 2014 and 2015 (EB-2013-0321 Decision with Reasons, p. 68). The $100M total disallowance was allocated to nuclear and hydroelectric based on total compensation cost as described in EB-2013-0321 Payment Amounts Order, App. A, Table 3a, Note 4.

Numbers may not add due to rounding.

Table 3

Nuclear Staff Summary - Regular and Non-Regular (FTEs)[1]

Line No.	Group	2013 Actual[2]	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)
	NUCLEAR OPERATIONS:									
1	**Regular Staff**	5,870.7	5,626.7	5,430.4	5,788.6	5,710.8	5,666.2	5,602.1	5,504.1	5,394.7
2	**Non-Regular Staff**	496.9	578.1	670.0	666.7	614.4	646.6	632.2	526.8	420.4
3	**Subtotal Nuclear Operations**	6,367.6	6,204.8	6,100.4	6,455.3	6,325.2	6,312.8	6,234.3	6,030.9	5,815.1
	DARLINGTON REFURBISHMENT:									
4	**Regular Staff**	282.0	307.2	329.7	427.6	587.2	599.9	620.5	589.5	597.8
5	**Non-Regular Staff**	24.6	35.3	60.7	73.5	153.2	152.2	137.4	157.7	230.1
6	**Subtotal Nuclear Generation Development**	306.6	342.5	390.4	501.1	740.4	752.1	757.9	747.2	827.9
7	**Total Nuclear**	6,674.2	6,547.3	6,490.8	6,956.4	7,065.6	7,064.9	6,992.2	6,778.1	6,643.0

1 Nuclear Operations and Darlington Refurbishment FTEs are aligned to where costs related to the FTEs are incurred.

2 The 2013 Actual FTEs shown are adjusted from those provided in EB-2013-0321, Ex. J7.3, Attachment 1. The adjustment increases the number of FTEs by excluding the impact of banked overtime (overtime taken as time off rather than pay) and shows the 2013 Actual FTEs on a consistent basis with the remaining years in the table.