

2025 Nuclear Benchmarking Report

Safety • Reliability • Value for Money • Human Performance



OPG Confidential – Internal Use Only
Controllership – Business Planning & Benchmarking

ONTARIOPOWER
GENERATION

*Electrifying
life*

Table of Contents

1.0 EXECUTIVE SUMMARY	2
2.0 SAFETY	10
METHODOLOGY AND SOURCES OF DATA.....	10
TOTAL RECORDABLE INJURY FREQUENCY (TRIF).....	11
ROLLING AVERAGE TOTAL INDUSTRIAL SAFETY ACCIDENT RATE (TISA).....	13
ROLLING AVERAGE COLLECTIVE RADIATION EXPOSURE (CRE).....	15
AIRBORNE TRITIUM EMISSIONS.....	17
FUEL RELIABILITY INDEX (FRI).....	19
2-YEAR UNPLANNED AUTOMATIC REACTOR TRIPS.....	21
3-YEAR AUXILIARY FEEDWATER SAFETY SYSTEM PERFORMANCE (UNAVAILABILITY).....	23
3-YEAR EMERGENCY AC POWER SAFETY SYSTEM PERFORMANCE (UNAVAILABILITY).....	25
3-YEAR HIGH PRESSURE INJECTION (ECI) SAFETY SYSTEM PERFORMANCE (UNAVAILABILITY)	27
3.0 RELIABILITY.....	29
METHODOLOGY AND SOURCES OF DATA.....	29
WANO PERFORMANCE INDICATOR INDEX (WP11)	30
ROLLING AVERAGE FORCED LOSS RATE (FLR).....	32
ROLLING AVERAGE UNIT CAPABILITY RATE (UCR)	32
ROLLING AVERAGE UNIT CAPABILITY FACTOR (UCF).....	34
ROLLING AVERAGE CHEMISTRY PERFORMANCE INDICATOR (CPI)	36
ON-LINE DEFICIENT & CORRECTIVE NON-CRITICAL BACKLOG	38
ON-LINE DEFICIENT & CORRECTIVE CRITICAL BACKLOG	38
4.0 VALUE FOR MONEY	40
METHODOLOGY AND SOURCES OF DATA.....	40
3-YEAR TOTAL GENERATING COST (TGC) PER MWH.....	41
3-YEAR NON-FUEL OPERATING COST PER MWH	43
3-YEAR FUEL COST PER MWH.....	45
3-YEAR CAPITAL COST PER MW DER (DESIGN ELECTRICAL RATING)	47
5.0 HUMAN PERFORMANCE	49
METHODOLOGY AND SOURCES OF DATA.....	49
18-MONTH HUMAN PERFORMANCE ERROR RATE.....	49
6.0 APPENDIX	51
ACRONYMS	51
SAFETY AND RELIABILITY DEFINITIONS	54
VALUE FOR MONEY DEFINITIONS	57
HUMAN PERFORMANCE DEFINITIONS	59
INDUSTRY PEER GROUPS	60
PANELS/MEMBERS.....	62

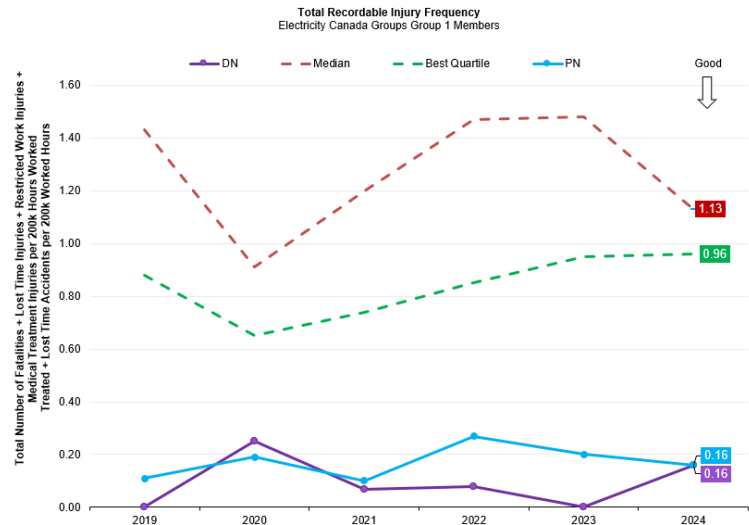
In 2024, Ontario Power Generations (OPG) results reflected strong performance relative to industry peers in multiple critical performance areas, while also identifying expected post-Refurbishment trends which will improve as the station enters steady-state.

Safety

Total Recordable Injury Frequency (TRIF)

Both Darlington Nuclear Generating Station (DNGS) and Pickering Nuclear Generating Station (PNGS) continued to deliver best quartile safety performance in 2024, maintaining excellent TRIF results compared to other Electricity Canada Group 1 members.

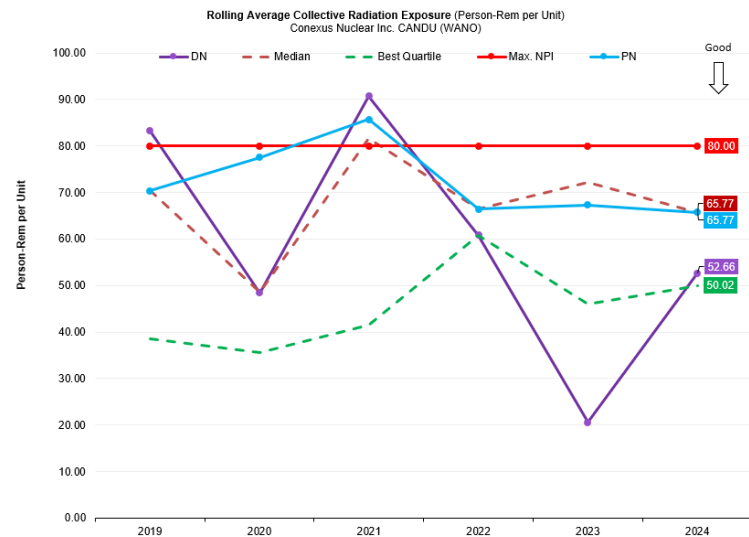
To further strengthen safety performance, OPG continues to build on its Fail Safe strategy by building capacity & strengthening safety defences, implementing the Edison Electric Institute Safety Classification & Learning (SCL) model to recognize and mitigate Serious Injuries & Fatalities (SIF) precursor conditions, as well as the integration of the Electronic Safe Work Planning & Pre-Job Briefing (eSWP) platform to enhance sharing of safe work planning knowledge including the Energy Wheel to identify energy hazards.



Collective Radiation Exposure (CRE)

DNGS and PNGS continued to achieve maximum WANO Performance Indicator Index (WPII) points in 2024, previously identified as Nuclear Performance Index (NPI). DNGS CRE performance declined as a result of one major planned outage in 2024 compared to zero in 2023. PNGS CRE performance improved due to a reduced number of maintenance, forced and planned unbudgeted outages in 2024 compared to 2023.

DNGS and PNGS have implemented source term controls to reduce worker exposure including improved shielding to reduce dose rates and having dedicated tritium emissions reduction teams. DNGS is also utilizing a new design of channel closure plugs.

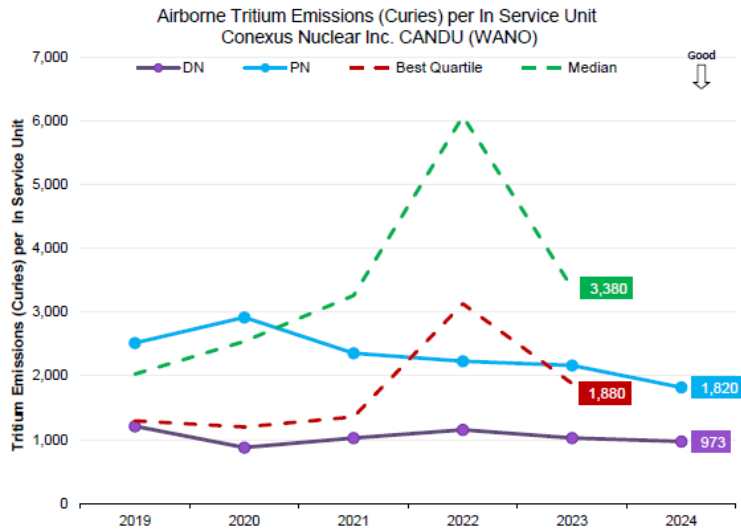


Airborne Tritium Emissions

DNGS and PNGS Airborne Tritium Emissions remain at a very small fraction of regulatory limits.

DNGS and PNGS continued to achieve best quartile performance in 2024, largely attributable to ongoing improvements to tritium identification and reduction activities at both sites.

Both sites have continued tritium reduction activities driven by dedicated teams, enhancing focus on tritium sources identification and elimination. In addition, collaboration between both sites to exchange operating experience, innovation activities on tritium mitigation, and benchmark performance.

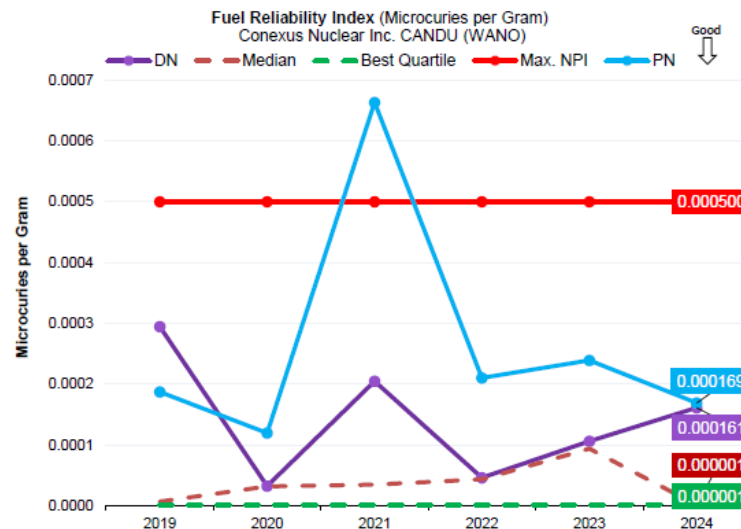


Fuel Reliability Index (FRI)

DNGS and PNGS continued to achieve maximum WPII points in 2024.

Three fuel defects were observed at DNGS in 2024 compared to one in 2023. PNGS FRI improved slightly in 2024, due to one fuel defect being observed in 2024 compared to two in 2023. All defects were discharged.

Continual efforts to enhance performance at both sites includes maintaining the fuel design manual and drawing set which strictly controls the manufacturing process as well as the fuel operating, fuel handling and fuel performance limits. DNGS continues to mitigate fuel debris failures by utilizing Foreign Material Exclusion (FME) practices. PNGS is also improving surveillance methods and eliminating foreign materials from entering the Heat Transport System (HTS) through improved Fuel Handling and Outage practices.



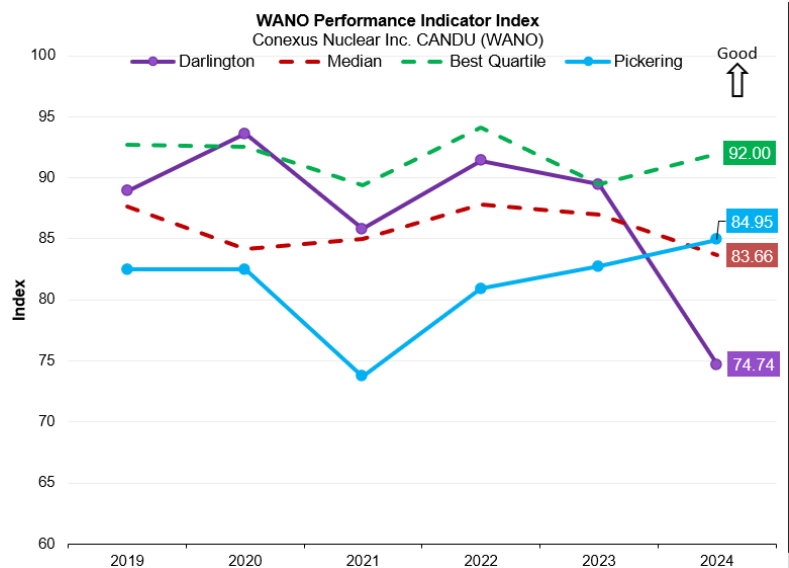
The five other safety-related metrics at DNGS and PNGS were favourable and achieved green ratings in 2024. Both DNGS and PNGS achieved maximum World Association of Nuclear Operators (WANO) performance Indicator Index (WPII) results and best quartile performance for all WPII Safety sub-metrics.

Reliability

WANO Performance Indicator Index (WPII)

In 2024, DNGS performance was third quartile compared to top quartile in 2023. The decline in performance is attributable to elevated Forced Loss Rate (FLR) and Unit Capability Rate (UCR) performance as a result of two forced outages in 2024. DNGS continued with excellent performance for all seven of the safety metrics.

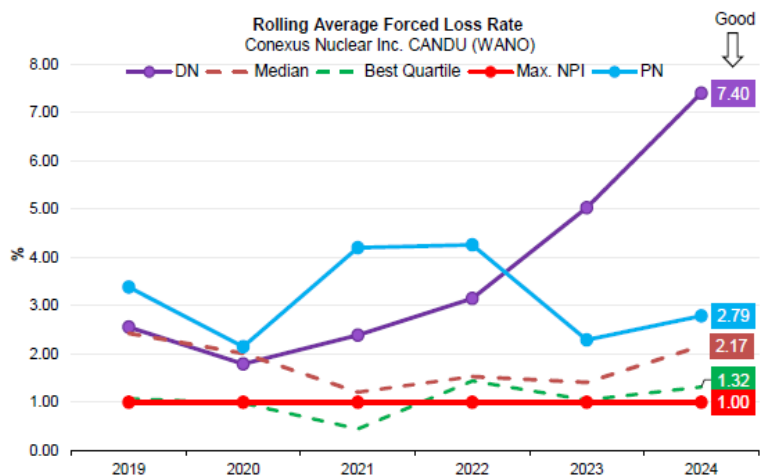
PNGS performance improved in 2024, achieving second quartile performance compared to third quartile performance in 2023. The improvement in performance is mainly attributed to the industry definition and weighting change from WPII Method 4 to WPII Method 10. PNGS sustained performance for all seven safety metrics and was partially offset by lower Chemistry Performance Index (CPI), Forced Loss Rate (FLR) and Unit Capability Rate (UCR) performance.



Forced Loss Rate (FLR)

In 2024, FLR performance declined at DNGS due to post-Refurbishment forced outages and PNGS due to forced outages.

DNGS experienced four forced outages attributable to post refurbishment outage events on Unit 2. Increased FLR is expected post refurbishment and will improve with support of ongoing initiatives to strengthen Plant reliability, Human Performance and Equipment reliability. PNGS slight decline in performance is attributable to elevated FLR in 2024 compared to 2022, which is no longer in the rolling window.

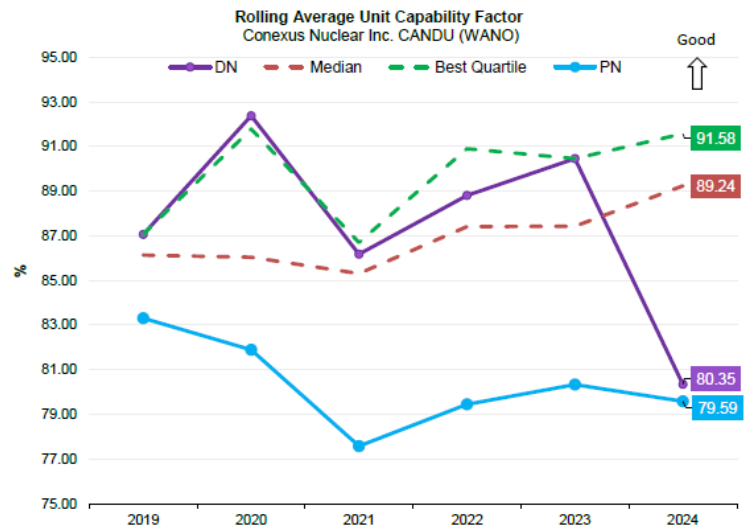


Fuel Handling contributions reduced in 2024 and remains a fleet focus area to improve sustainability. Focused initiatives including vulnerability identification and elimination, project execution, and proficiency building at both stations to increase plant reliability.

Unit Capability Factor (UCF)

In 2024, both DNGS and PNGS achieved third quartile performance. DNGS and PNGS decline in performance compared to 2023 was attributable to the declined FLR performance at both stations. DNGS performance is attributable to post refurbishment outage events on Unit 2. PNGS slight decline in performance is attributable to elevated FLR in 2024 compared to 2022, which is no longer in the rolling window.

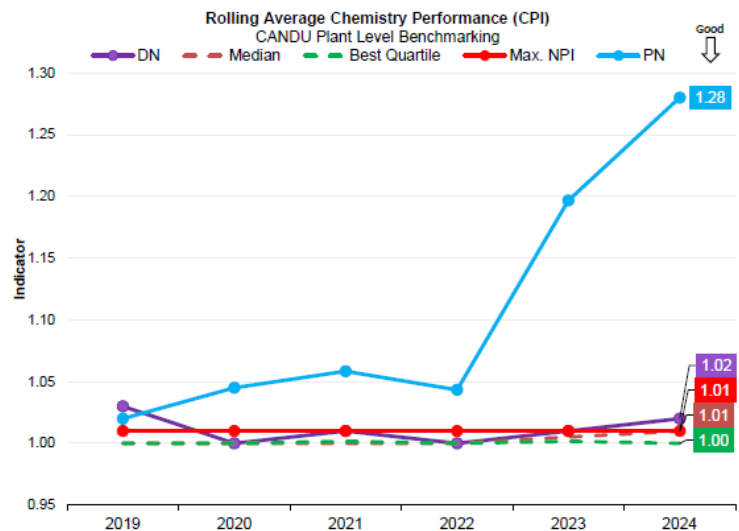
Focused initiatives including vulnerability identification and elimination, proficiency building and project execution at both stations to increase plant reliability.



Chemistry Performance Index (CPI)

DNGS performance was third quartile in 2024 compared to top quartile in 2023. The decline in performance in 2024 compared to 2023 can be attributed to Unit 2 elevated feedwater corrosion product transport post unit start-ups and condenser tube leaks.

PNGS decline in performance in 2024 compared to 2023 can be attributed to start-up boiler sulphates and condenser tube leaks that resulted in elevated boiler ions.

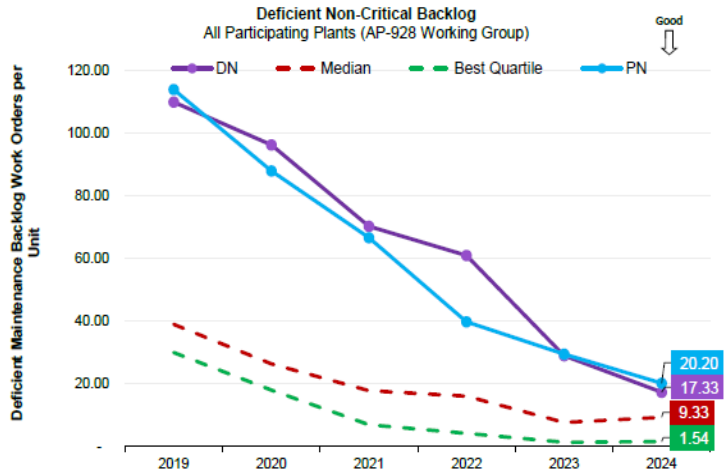


DNGS and PNGS continue to have a Chemistry Outage Single Point of Contact (SPOC) to provide improved coordination/planning such that system chemistry control is improved during start-ups/outages and explore implementing corrosion product transport formation reduction and removal processes. DNGS will improve early detection of condenser tube leaks and improve reliability of condenser equipment. PNGS also aims to improve boiler chemistry during refurbishment to improve boiler ions upon unit start-up.

On-Line Deficient Non-Critical Backlog and Deficient Critical Backlog

DNGS improved their On-line Deficient Non-Critical Backlog by 40% compared to 2023 and Deficient Critical Backlog sustained a best quartile score of zero as a result of continued station focus, overall maintenance efficiency and improved schedule quality.

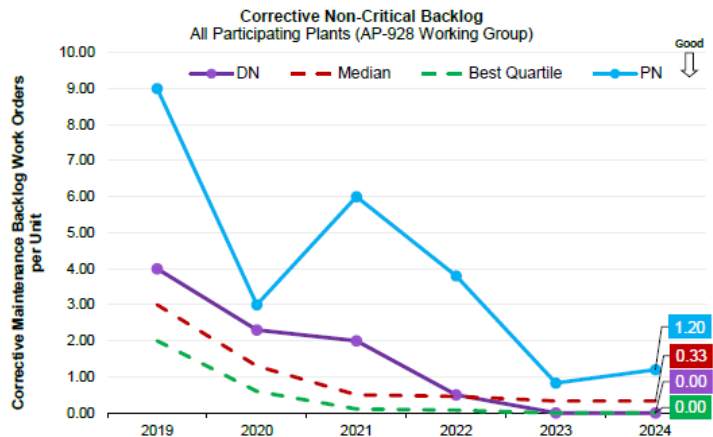
The favourable trend for Backlog performance at PNGS continued into 2024, with improvements for On-line Deficient Non-Critical Backlogs (32% improvement) from fourth in 2023 to third quartile in 2024 and slight improvement for On-line Deficient Critical Backlog compared to 2023 results.



On-Line Corrective Non-Critical Backlog and Corrective Critical Backlog

DNGS remained in best quartile score of zero for both Corrective Critical and Corrective Non-Critical Backlog metrics.

PNGS sustained best quartile performance for the Corrective Critical backlog metric with a score of zero and sustained third quartile for On-Line Corrective Non-Critical performance sustained.

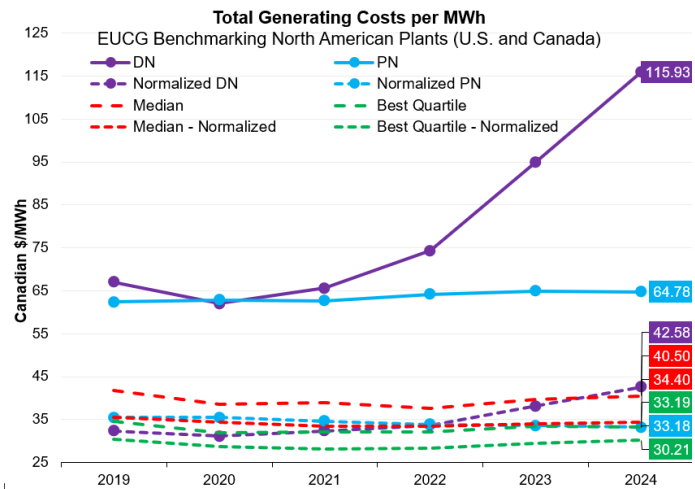


Value for Money

TGC/MWh

In 2024, normalized Total Generating Cost per Megawatt-hour (TGC/MWh) performance remained in the third quartile for DNGS and second quartile for PNGS after normalizing¹ for refurbishment, technology including outage duration and age-related impacts.

DNGS normalized performance was impacted by capital investment requirements for life post-refurbishment and reduced 3-year generation related to the refurbishment schedule while PNGS normalized performance reflects continued reduction in capital investment as the station approaches Refurbishment for Units 5-8 operations in 2026.

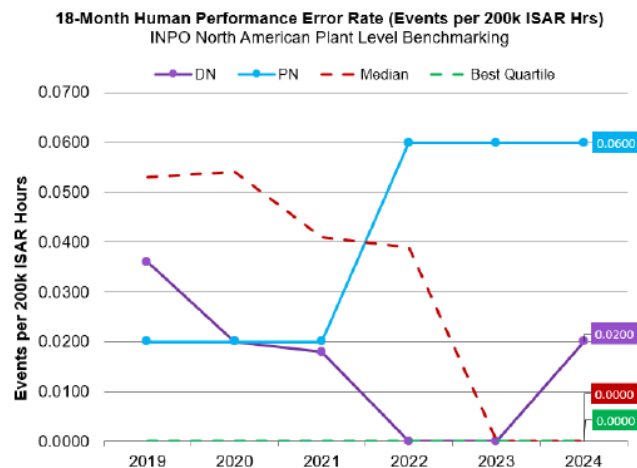


Human Performance

Human Performance Error Rate

In 2024, DNGS performance was third quartile compared to first quartile in 2023. This can be attributed to two Site Event Free Day Resets (S-EFDR) experienced in 2024 compared to zero in 2023. PNGS experienced two S-EFDR's in 2024 compared to one in 2023. Event causes were identified, and corrective actions were implemented to address the gaps.

Human Performance continues to be a focus around the fleet with actions to improve performance by continuously improving the Observation & Coaching program as well as integration of Fail-Safe strategies and trending processes to strengthen values and behaviours of Nuclear Professionals. Human performance is being further enhanced by continuing to build a positive stop culture that recognizes workers who stop work due to unknown or unexpected events.



¹ See section 4.0 for more information about the TGC/MWh normalization methodology.

Benchmarking Results – Plant Level Summary

Table 1 provides a complete summary of 2024 performance compared to benchmark results.

Metric	2024 Actuals					
	NPI Max	Best Quartile	Median	Third Quartile	Pickering	Darlington
Safety						
Total Recordable Injury Frequency (#/200k hours worked)		0.96	1.13	1.91	0.16	0.16
Rolling Average ² Total Industrial Safety Accident Rate TISA (#/200k hours worked) ¹	0.20	0.00	0.00	0.04	0.00	0.00
Rolling Average ² Collective Radiation Exposure (Person-rem per unit) ¹	80.00	50.02	65.77	87.53	65.77	52.66
Airborne Tritium Emissions (Curies) per Unit ³		1,880	3,380	4,595	1,820	973
Fuel Reliability Index (microcuries per gram) ¹	0.000500	0.000001	0.000001	0.000161	0.000169	0.000161
2-Year Reactor Trip Rate (# per 7,000 hours) ¹	0.500	0.000	0.310	0.420	0.382	0.310
3-Year Auxiliary Feedwater System Unavailability (#) ¹	0.0200	0.0000	0.0000	0.0023	0.0000	0.0000
3-Year Emergency AC Power Unavailability (#) ¹	0.0250	0.0001	0.0003	0.0035	0.0000	0.0000
3-Year High Pressure Safety Injection Unavailability (#) ¹	0.0200	0.00000	0.00000	0.00000	0.0000	0.0002
Reliability						
Rolling Average ² WPII (Index) ¹		92.00	83.66	74.74	84.95	74.74
Rolling Average ² Forced Loss Rate (%) ¹	1.00	1.32	2.17	4.21	2.79	7.40
Rolling Average ² Unit Capability Rate (%) ¹	98.00	98.50	97.83	92.60	96.82	92.60
Rolling Average ² Unit Capability Factor (%) ¹	92.00	91.58	89.24	79.59	79.59	80.35
Rolling Average ² Chemistry Performance Indicator (Index) ¹	1.01	1.00	1.01	1.03	1.28	1.02
1-Year Online Deficient Non-Critical Backlog (work orders per unit) ³		1.54	9.33	28.58	20.20	17.33
1-Year Online Corrective Non-Critical Backlog (work orders per unit) ³		0.00	0.33	1.33	1.20	0.00
1-Year Online Deficient Critical Backlog (work orders per unit) ¹		0.00	0.00	0.50	0.60	0.00
1-Year Online Corrective Critical Backlog (work orders per unit) ¹		0.00	0.00	0.00	0.00	0.00
Value for Money						
3-Year Total Generating Costs per MWh (\$ per Net MWh) ¹		33.19	40.50	50.89	64.78	115.93
Normalized 3-Year Total Generating Cost per MWh (\$ per Net MWh)		30.21	34.40	43.20	33.18	42.58
3-Year Total Generating Cost per Unit (M \$ per Unit)		285.39	315.55	365.38	231.03	745.77
Normalized 3-Year Total Generating Cost per Unit (M \$ per Unit)		251.15	283.59	331.97	134.61	278.21
3-Year Non-Fuel Operating Costs per MWh (\$ per Net MWh) ¹		19.63	24.58	32.23	58.44	74.69
3-Year Normalized Non-Fuel Operating Cost per Net MWh (\$/MWh)		19.63	24.58	32.23	--	47.88
3-Year Fuel Costs per MWh (\$ per Net MWh) ¹		5.93	6.60	7.15	3.98	4.43
3-Year Capital Costs per MW DER (k\$ per MW) ¹		38.99	67.13	107.93	16.37	269.70
Normalized 3-Year Capital Cost per MW DER (k\$ per MW)		38.99	67.13	107.93	--	115.91
Human Performance						
18-Month Human Performance Error Rate (# per 200k ISAR and contractor hours) ¹		0.0000	0.0000	0.0455	0.0600	0.0200

1. Best Quartile, Median and Third Quartile are from Q4 2024 best available information.
2. Indicates a 2-Year Rolling Average for Pickering and a 3-Year Rolling Average for Darlington.
3. Best Quartile, Median, Third Quartile are from the Q4 2023 which is the most current available benchmark for these metrics.

Legend

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

Background

This report presents a comparison of OPG Nuclear’s performance to that of nuclear industry peer groups. Benchmarking results are used during business planning to drive top-down target setting with business improvement as the objective.

Performance Indicators

Good performance indicators used for benchmarking are 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, 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 defined in Section 6.0.

Each indicator reflects a particular duration of historical performance in accordance with peer group expectations. For example, Electric Utility Cost Group (EUCG) data for Value for Money metrics are based on three-year average performance, whereas WPII safety and reliability metrics reflect multi-year rolling averages based on each station’s outage cycle. For WPII metrics, Darlington and Pickering’s results reflect a three-year and two-year outage cycle, respectively.²

Industry Peer Groups

Peer groups were selected based on performance indicators widely utilized within the nuclear industry. Overall, six different peer groups were used as illustrated in Table 2 of Section 6.0 and panel members are detailed in Tables 3 to 8 of Section 6.0.

Report Structure

Sections 2.0 to 5.0 of the report focus on safety, reliability, value for money and human performance areas.

The Major Operator Section (historically Section 6.0) was removed from this report, consistent with ScottMadden’s recommendations with respect to streamlining the report and ensuring consistency with leading practices and value for stakeholders. The Major Operator section provided a fleet operator level summary across a few key metrics, primarily across North America, utilizing a simple average of the results (mean) from each of their units/plants. While the operator level summary can be informative, it is more appropriate to look at OPG’s two nuclear facilities individually given that they are at different stages of their lifecycle, have different sized units and reflect different generations of CANDU technology. This view is aligned with ScottMadden’s most recent evaluation OPG Nuclear Benchmarking. The detailed data in sections 2.0 to 5.0 of the report provides a more complete picture of OPG’s performance.

Section 6.0 provides an appendix of supporting information, including common acronyms, definitions, peer group and panel composition details.

² The planned outage cycle for each unit at Pickering is transitioning from a 24-month to a 30-month outage cycle. Pickering continues to assume a 24-month rolling average for benchmarking to be consistent with WANO reporting expectations.

Methodology and Sources of Data

The majority of safety metrics were calculated using data from WANO. Data labelled as invalid by WANO were 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 was obtained and consolidated with previous benchmarking data.

The WANO Performance Indicator Index (WPPI), a maximum score of 100 is possible. The WPPI is an operational performance indicator comprised of 10 metrics, 7 of which are analyzed in this section:

- Total Industrial Safety Accident Rate (TISA) [Rolling Average]
- Collective Radiation Exposure (CRE) [Rolling Average]
- Fuel Reliability Index (FRI) [Annual]
- 2-Year Unplanned Automatic Reactor Trips
- 3-Year Auxiliary Feedwater Safety System Performance Unavailability
- 3-Year Emergency AC Power Safety System Performance Unavailability
- 3-Year High Pressure Safety Injection Unavailability

The remaining three WPPI metrics are included in the Reliability Section (Section 3.0).

Note: To benchmark performance, Max WPPI is used to indicate best quartile performance for metrics that perform better than the Max WPPI benchmark. If metric performance is not better than Max WPPI, quartile benchmarks are used to benchmark performance.

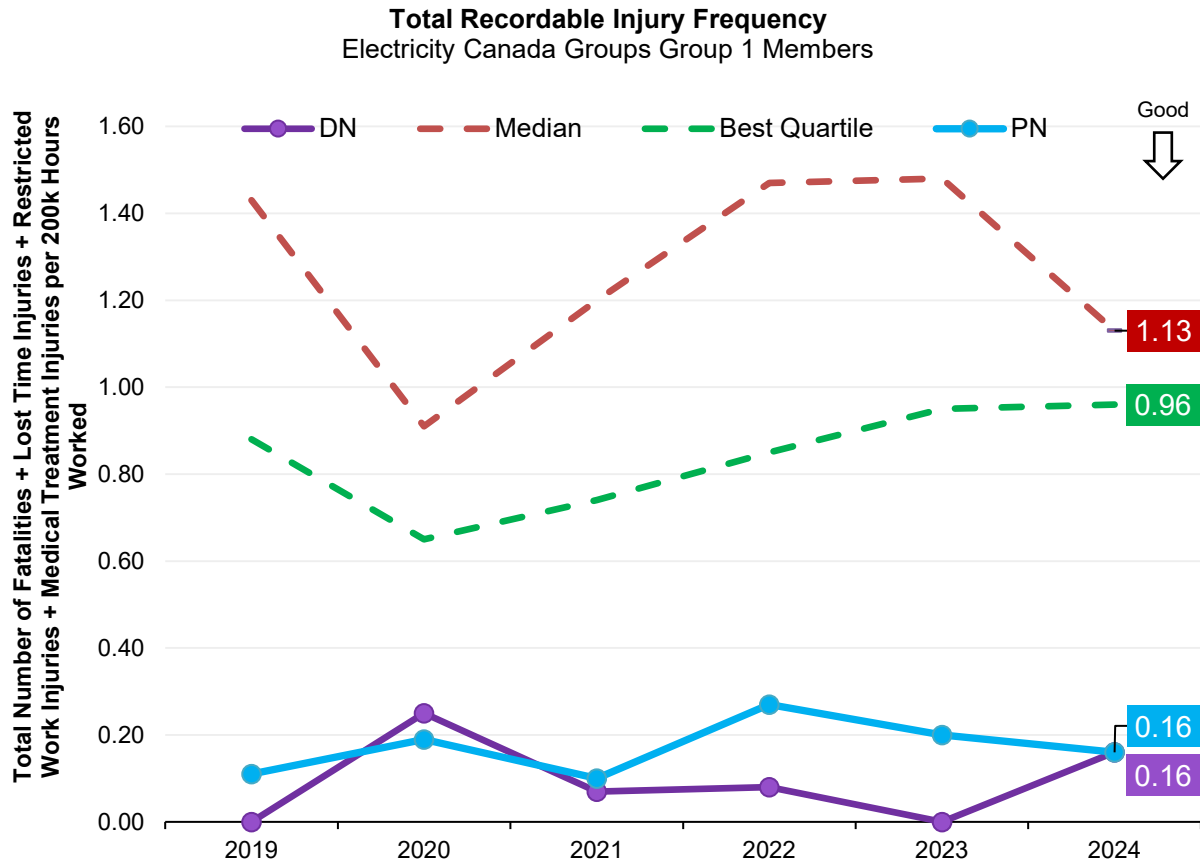
In addition to the WPPI safety sub-indicators listed above, Total Recordable Injury Frequency and Airborne Tritium Emissions per In Service Unit are included in this section of the report.

Total Recordable Injury Frequency (TRIF) was calculated using data from Electricity Canada (EC). The peer group are members of Electricity Canada (EC) (Section 6.0, Table 6).

- OPG benchmarks against EC Group 1 peers (a subset of all EC members), which incorporates organizations with more than 1,500 employees, including most provincial utilities, leveraging EC's Occupational Health & Safety Statistics 2024 Report.

Airborne Tritium Emissions per In Service Unit data was collected from the Conexus Nuclear Inc. The peer group for this metric is all CANDUs who are members of Conexus Nuclear Inc. There is a one-year lag for the industry values associated with this metric.

Total Recordable Injury Frequency (TRIF)



Note: Annual Value

2024 Value	
DN	0.16
PN	0.16
Best Quartile	0.96
Median	1.13

Factors Contributing to Performance

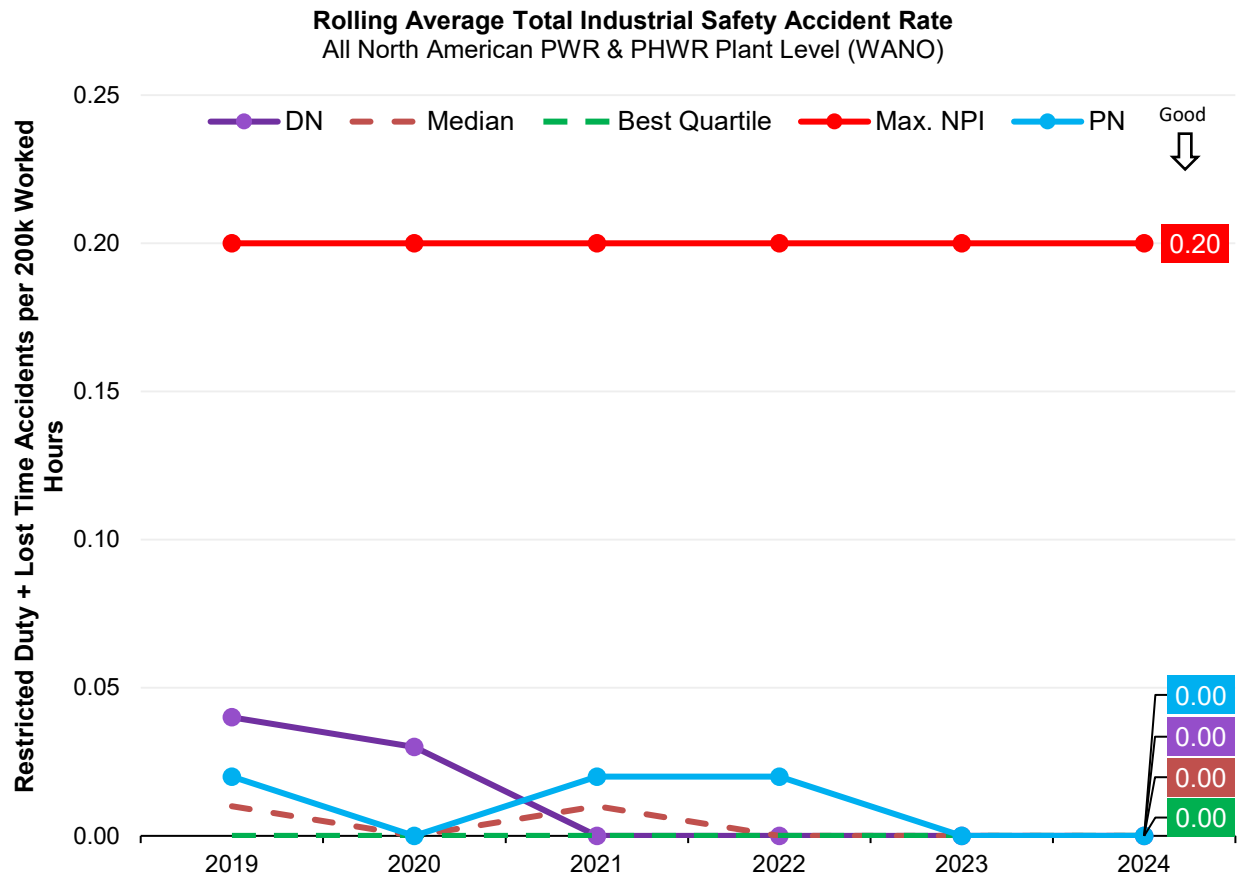
- In 2024, DNGS and PNGS continued to achieve best quartile safety performance, maintaining excellent TRIF results compared to other Electricity Canada Group 1 members (1500+ employees).
- All injuries at DNGS and PNGS in 2024 were low-severity injuries (e.g., cuts, pinches).
- OPG remains focused on advancing safety improvements through its fleetwide fail-safe culture. OPG’s fail-safe culture includes ensuring appropriate safety controls are in place to protect employees should an event occur, and sharing knowledge and lessons learned from safety events with particular attention on high-energy incidents that can cause serious injuries or fatalities. DNGS and PNGS have also implemented a Positive Stop culture that recognizes workers who stop work due to unknown or unexpected events.

- OPG supports the prevention of injuries through initiatives such as job aids to help employees recognize workplace energy hazards, ongoing enhancements to OPG’s Electronic Safe Work Planning & Pre-Job Briefing (eSWP) platform, interactive activities and coaching to engage employees and encourage meaningful discussions about safety. The eSWP platform also features the “Energy Wheel” tool designed to help identify energy hazards that are often overlooked, and to support workers in implementing additional safety precautions for high-energy tasks that pose significant risks in the event of human error or equipment failure.

Initiatives to improve and sustain favorable performance include:

- In April 2024, OPG began using the Edison Electric Institute’s Safety Classification and Learning (SCL) model. The SCL model helps enable early recognition and mitigation of Serious Injuries & Fatalities (SIF) precursor conditions as well as allows OPG to objectively classify safety events and better learn from events to prevent their recurrence. It also helps OPG identify a wider range of safety trends and will facilitate benchmarking with electrical industry peers. OPG added SCL performance data to its intranet safety reporting dashboards to raise awareness of SCL concepts, measure if barriers/controls were in place when safety events occurred and improve the characterization of exposures to high-energy hazards.
- OPG is committed to continually improving its health and safety managed system in accordance with ISO 45001 requirements, including taking corrective action to address findings from self-assessments, internal and external audits, and industry peer reviews.
- OPG is conducting a detailed self-assessment, including identification of gaps and actions plans, of the World Association of Nuclear Operators’ (WANO) significant operating experience report for “Leadership in Preventing Fatalities and Severe Injuries” (SOER 2024-1).

Rolling Average Total Industrial Safety Accident Rate (TISA) * +



Sub-indicator for WPII

+ 3-year avg DNGS - Unit 2 (U4 in Refurbishment. Unit 3 RTS Q3 2023 & Unit 1 RTS Q4 2024, not online for 3 years), 2-year avg PNGS - Unit 4 & 5-8 (U1 end of commercial life Q3 2024)

* Previously ISAR (2019-2023), 2024 onwards is TISA

2024 Value	
DN	0.00
PN	0.00
Best Quartile	0.00
Median	0.00

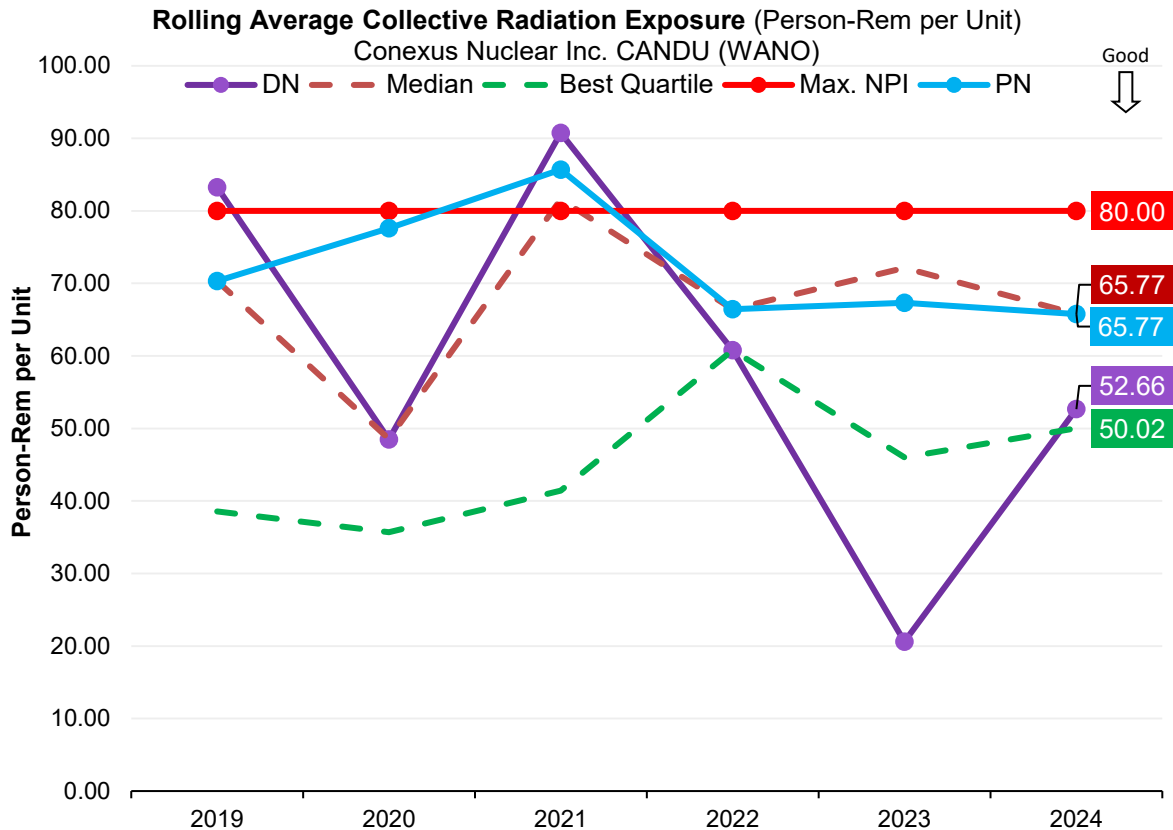
Factors Contributing to Performance:

- DNGS and PNGS continued to achieve maximum WANO Performance Indicator Index (WPII) points.
- DNGS achieved best quartile performance in 2024, with zero TISA events during the last three-year rolling average reporting period.
- PNGS achieved best quartile performance in 2024, with zero TISA events recorded during the last two-year rolling average reporting period.

Initiatives to Improve and Sustain Favorable Performance:

- Continued implementation of the “Fail Safe” health and safety program, focusing on high-energy work, sequential control measures, event learning, and a variety of targeted strategies:
 - Use of Electronic Safe Work Planning (eSWP), which assesses and applies direct controls to address high-energy hazards during work execution.
 - Ongoing use of the Edison Electric Institute Safety Classification and Learning (SCL) model to identify additional learning opportunities through safety classifications and enable more effective industry benchmarking.
 - Use of Quality of Safety Practices (QSP) as a leading indicator to monitor high and low energy conventional safety risks to identify vulnerabilities and opportunities for improvement.
 - Continuous oversight to monitor performance for prevention and early intervention, with increased focus on addressing behaviors and program gaps through Observation and Coaching (O&C’s), performance metrics, audits and assessments, benchmarking, and event learning.
 - Advancement of safety innovation through technology, including Peer-to-Peer Coaching Kiosks, Confined Space Application, Hazardous Material Application, Housekeeping Application, Lighting Application, Signage Kiosks, and Remote Temperature Monitoring Systems.
- These efforts collectively support the ongoing achievement of high standards in safety, reliability, and overall operational performance in the nuclear industry.

Rolling Average Collective Radiation Exposure (CRE) * +



Sub-indicator for WPII

+ 3-year avg DNGS - Unit 2 (U4 in Refurbishment. Unit 3 RTS Q3 2023 & Unit 1 RTS Q4 2024, not online for 3 years), 2-year avg PNGS - Unit 4 & 5-8 (U1 end of commercial life Q3 2024)

2024 Value	
DN	52.66
PN	65.77
Best Quartile	50.02
Median	65.77

Factors Contributing to Performance:

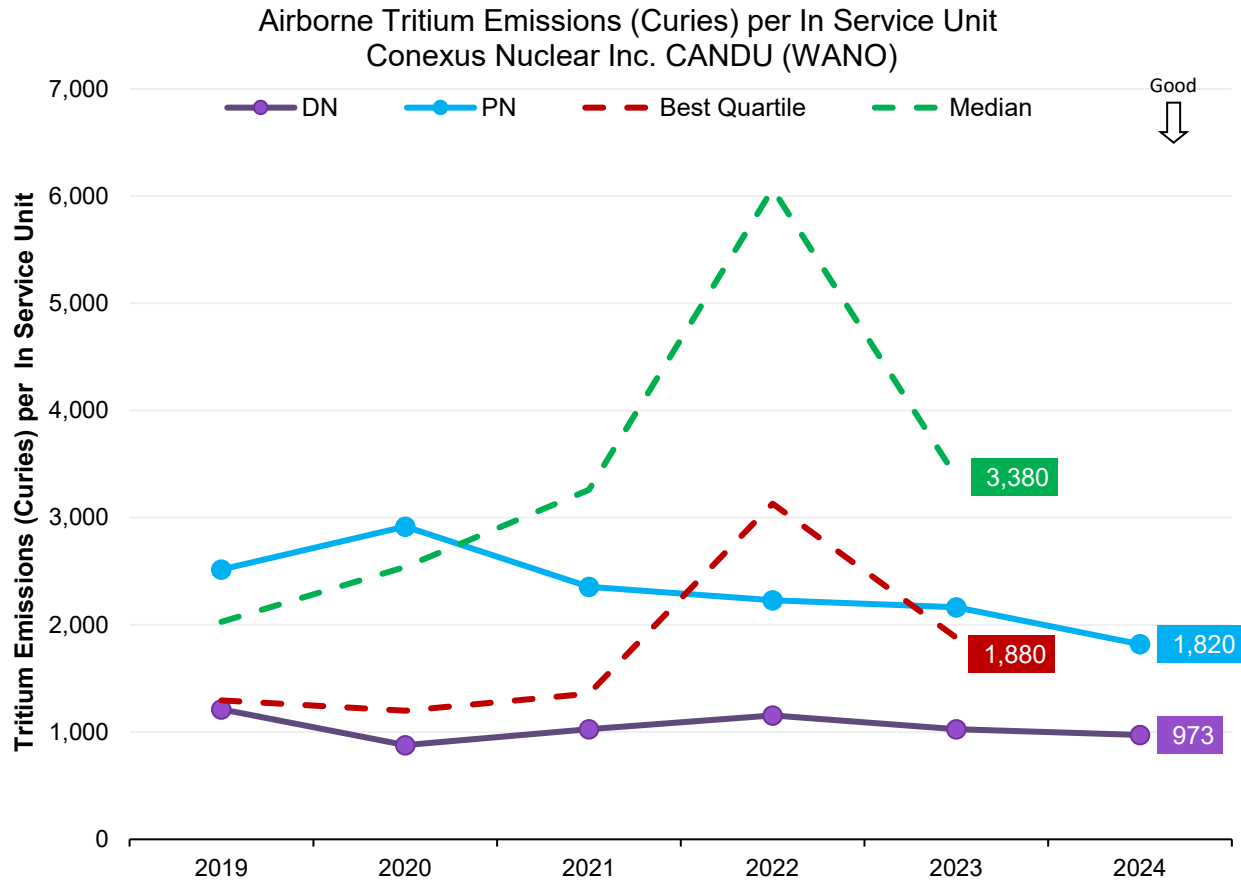
- DNGS and PNGS continued to achieve maximum WANO Performance Indicator Index (WPII) points.
- DNGS performance declined in 2024 compared to 2023 was a result of a major planned outage for Unit 2 in 2024 and zero planned outages in 2023.
 - A major planned maintenance outage on Unit 2 following unit refurbishment was executed which contributed to dose. Work included feeder inspections, reactor area bridge and carriage maintenance, calandria rupture disc replacements, various period inspection programs, and pressurizer heater replacements. CRE from this planned outage was 23% below target.
- PNGS performance improved in 2024, as a result of:

- Two planned maintenance outages, one forced outage and one planned unbudgeted outage in 2024, compared to three planned maintenance outages, two planned unbudgeted outages and six forced outages in 2023.
- Work programs for the planned maintenance outages which contributed to dose included fuel channel components periodic inspection, boiler inspections and a Single Fuel Channel Replacement (SFCR).
- Scope of work for the planned unbudgeted outage was to repair vault Air Conditioning Unit (ACU) leaks and recovery of stuck irradiated fuel bundles, and the forced outage was to address emergent conditions.
- Unit 1 was shut down for safe storage in September and Unit 4 at the end of December.

Initiatives to Improve and Sustain Favourable Performance Include:

- DNGS is undertaking various opportunities to reduce worker exposures and keeping collective doses As Low As Reasonably Achievable (ALARA). This includes, but is not limited to, the following initiatives and programs:
 - Utilizing a new design of channel closure plugs that effectively manage D₂O channel leakage. As a result, tritium levels in the vault decrease significantly. Thus, this also reduces worker tritium exposure.
 - Upcoming deployment of enhancing fuel channel inspection techniques by utilizing a Rapid Delivery Machine (RDM) to perform Advanced Non-Destructive Examination (ANDE), ANDE replication and Machine Delivered Scrape (MDS). Utilizing these systems reduces worker exposure by eliminating ice plug work inside feeder cabinets and workers performing channel inspection in front of the reactor face, which will also aid in tritium recovery in containment by maximizing performance on the Vault Vapour Recovery System (VVRS).
 - Modifying Emergency Coolant Injection (ECI) steel band to facilitate shielding on all units, outstanding installation on Unit 3 to be completed by 2026 during the planned maintenance outage. The expected benefit from this initiative will reduce worker exposure while working or traversing near the ECI lines.
 - A tritium oversight committee provides weekly updates on site tritium recovery systems to ensure tritium emission to environment is maintained ALARA.
- PNGS CRE for 2024 received maximum WANO Performance Indicator Index (WPPI) points due to the initiatives and activities conducted in the last calendar year to improve the control of worker exposure and radiological hazards. Some of these initiatives and activities include:
 - Use of shielded canopy platform and customized shielded transport flasks during the Unit 7 Single Fuel Channel Replacement (SFCR) project contributed to reduction in dose rates to workers.
 - Dedicated Tritium emissions reduction team contributed to the lower than target performance for tritium emissions and lower internal collective radiation exposure for the year by ensuring proper dryer maintenance and revised procedures to optimize equipment performance.
 - ALARA initiatives, such as improved shielding, source term reduction initiatives and work methods improvements and efficiencies, contribute to improvements in dose performance.
 - Application of specialized source term reduction agents (i.e., Lanxess resin, fueling machine filter pore size reduction)
 - Continued focus on foreign material management and chemistry heat transport purification management.

Airborne Tritium Emissions



Annual Value

Median and Best Quartiles are plotted until 2023 as the 2024 results were unavailable at the time of benchmarking (one-year lag).

** Darlington values exclude Tritium Removal Facility (TRF) and associated West Annex emissions (consistent with Conexus Nuclear benchmark results).*

Unit 1 and Unit 4 refurbishment periods, and the Retube Waste Processing Building (RWPB)

	2024 Value
DN	973
PN	1,820
Best Quartile	1,880
Median	3,380

Factors Contributing to Performance:

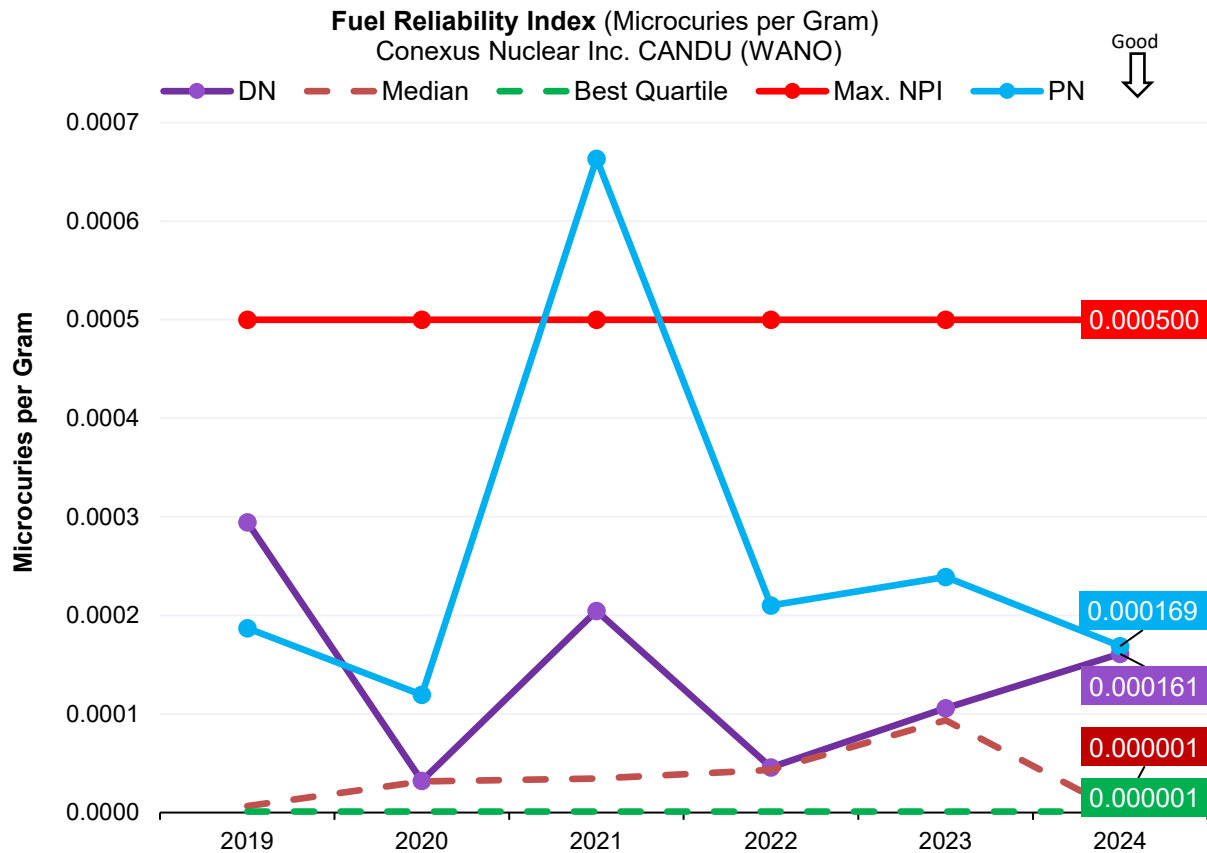
- DNGS and PNGS Airbourne Tritium Emissions remain at a very small fraction of regulatory limits.
- Both sites have continued tritium reduction activities driven by dedicated teams that focus on day-to-day tritium reduction activities such as heavy water leaks and repairs, drier performance, continued management oversight and communication of priorities, utilized enhanced monitoring system station wide to provide real-time tritium monitoring capability.

- DNGS continues to achieve best quartile performance in 2024. This was mainly attributed to efforts by the station to focus on tritium identification and reduction activities such as prioritizing repairs of leaking equipment and driers, utilizing enhanced monitoring system station-wide to provide real-time tritium monitoring capability, and ensuring Operations responded promptly to field deficiencies to minimize airborne tritium emission impacts.
- PNGS continued to achieve industry best quartile performance in 2024. This can be attributed to the efforts made by dedicated teams in place to drive station tritium reduction activities such as a focused effort on reducing drier downtime, and prioritizing repairs and equipment leaks clean up, thus minimizing airborne impact.

Initiatives to Improve and Sustain Favourable Performance Include:

- Dedicated teams at both sites focus on identifying and eliminating tritium sources, including improving drier performance and repairing heavy water leaks.
- Continued management oversight and communication of priorities to focus tritium reduction activities daily at Integrated Station Brief (ISB) meetings at both sites.
- Collaboration between both sites to share operating experience and benchmark tritium mitigation efforts to improve performance.
- Source term reduction on heat transport and moderator water.
- Tritium Oversight Committee at DNGS develops long-term plans, provide oversight, and proactively schedules preventive maintenance activities.
- Incorporated tritium reduction discussions during the re-occurring Operations United meeting at DNGS, enabling risk identification and constructive challenges to further improve performance.
- Ongoing participation in Conexus Nuclear Inc. environmental benchmarking of participating CANDU stations to determine best environmental practices.

Fuel Reliability Index (FRI) *



Sub-indicator for WPII

Note: 2024 Most Recent Operating Quarter

+ DNGS – Unit 2 (U4 in Refurbishment, Unit 3 RTS Q3 2023 & Unit 1 RTS Q4 2024, not online 3 years), PNGS - Unit 4 & 5-8 (U1 end of commercial life Q3 2024)

	2024 Value
DN	0.000161
PN	0.000169
Best Quartile	0.000001
Median	0.000001

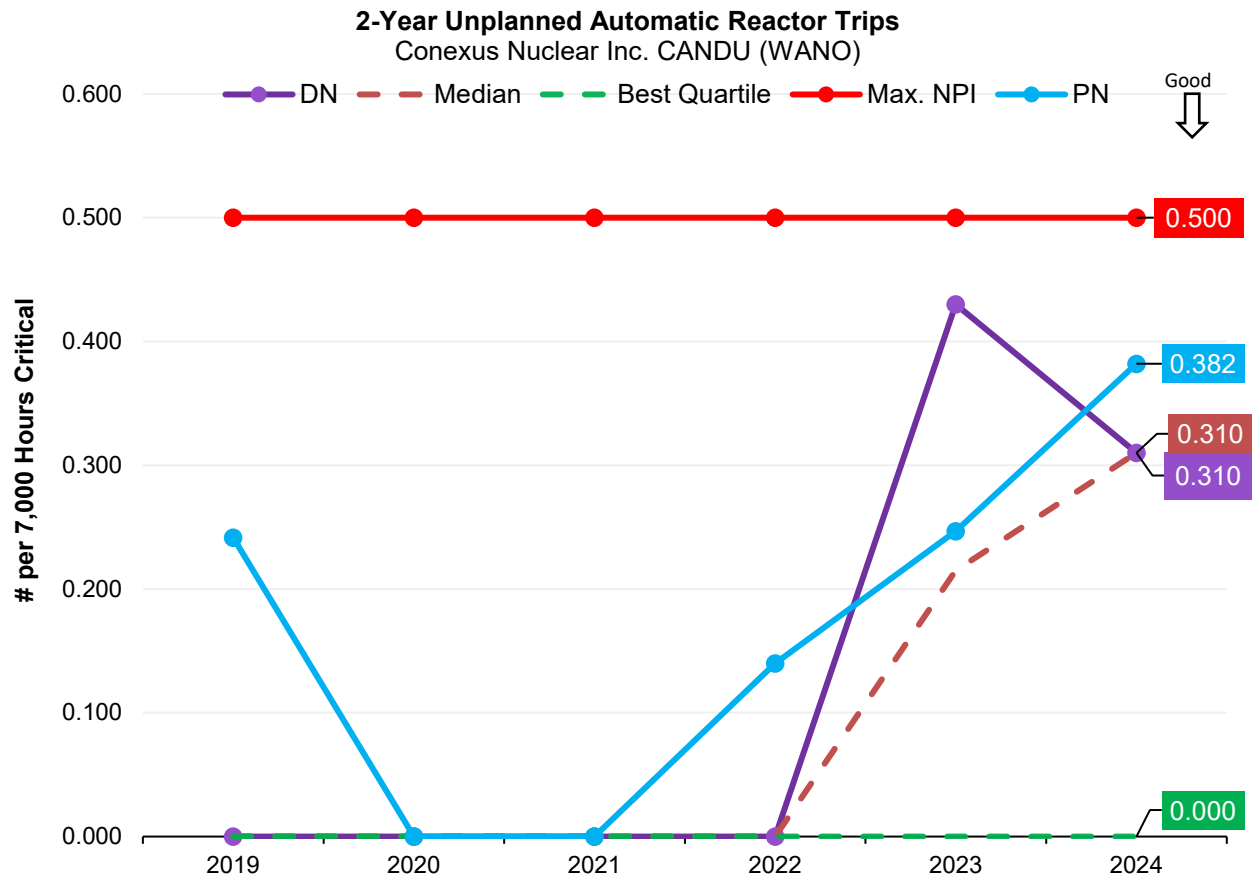
Factors Contributing to Performance

- DNGS and PNGS continued to achieve maximum WANO Performance Indicator Index (WPII) points.
- Three fuel defects were observed and discharged at DNGS in 2024, compared to one in 2023.
- One fuel defect was observed at PNGS in 2024 and discharged in 2025, compared to two fuel defects observed in 2023 that were discharged in 2024.

Initiatives to Improve and Sustain Favourable Performance Include:

- Both sites maintained their respective fuel design manuals and fuel drawing sets. These documents strictly control the manufacturing process, fuel operating limits, fuel handling limits and the fuel performance limits. OPG continues to source fuel with tighter manufacturing tolerances at both sites, thereby eliminating certain modes of fuel defecting following fuelling runs.
- DNGS improvement initiatives include:
 - Foreign Material Exclusion (FME) practices continue to mitigate debris fretting fuel failures as shown by the low number of defects following DNGS reactor refurbishment activities. Proactive measures are in place in an effort to avoid FME shutdowns with a planned post-Refurbishment outage on D2512.
 - Improving and sustaining awareness that the impact foreign material, specifically micro-debris potentially introduced through Fuel Handling and Outage activities, has on fuel performance.
- PNGS improvement initiatives include:
 - Enhancing surveillance by increasing the scope of Primary Heat Transport System (PHTS) grab sampling and analysis when defects are in-core continues to assist in earlier detection and removal minimizing the risk of foreign materials.
 - Improving and sustaining awareness of the impact foreign material in the PHTS, specifically micro-debris potentially introduced through Fuel Handling and Outage activities, has on fuel performance.
 - Improved capability among Units 5 to 8 of detecting defected fuel bundles following discharge from the fuelling machines continues to assist in re-directing failed fuel to the inspection area in support of root cause analysis and driving corrective actions.
 - Initiated planning for a confirmatory out-of-reactor test series to address risks associated with prolonged crossflow exposure during fueling incidents.

2-Year Unplanned Automatic Reactor Trips *



Sub-indicator for WPII

+ DNGS – Unit 2 (U4 in Refurbishment. Unit 3 RTS Q3 2023 & Unit 1 RTS Q4 2024, not online 3 years), PNGS - Unit 4 & 5-8 (U1 end of commercial life Q3 2024)

Note 3: Reactor Trip Rate was replaced by Reactor Automatic & Manual Trip Rate following the WPII Method 10 transition in 2024. The indicator change includes the change from Unplanned Automatic Scrams (UA7) to Unplanned Total Scrams (US7). Method 4 utilized UA7 metric which only included the automatic scram data. The new indicator, US7, includes both automatic and manual scrams.

	2024 Value
DN	0.310
PN	0.382
Best Quartile	0.000
Median	0.310

Factors Contributing to Performance:

- DNGS and PNGS continued to achieve maximum WANO Performance Indicator Index (WPII) points.
- DNGS had no unplanned automatic or manual reactor trips in 2024 compared to one trip occurring in 2023. Improved performance is due to the excellence in Human Performance and Operator and Maintenance fundamentals.

- PNGS decline in performance in 2024 was impacted by the following unplanned automatic or manual reactor trips:
 - Unit 8: A manual Shutdown System (SDS)1 trip occurred due to the loss of Liquid Zone Control zones. The cause of this event was a passing liquid zone traps that resulted in compressors short cycling and high cover gas hydrogen levels.
 - Unit 4: A reactor trip on Heat Transport Low Flow (HTLF) trip parameter associated with the Reactor Protective System (SDS) and Shutdown System Enhancement (SDSE), which was caused by a failure of protection circuit in Hydro 1 switchyard, Unit 4 was load rejected, leading to a total loss of Class IV power.
 - Unit 5: During the warm-up of Heat Transport System (HTS), reactor trip occurred on Boiler Low Level (BLL) trip parameter (SDS2). This event is due to the heat sink challenge, which was not recognized nor resolved during turnover following ending of HTS warm up.

Initiatives to Improve and Sustain Favourable Performance Include:

The following measures are being implemented at DNGS and PNGS:

- On-going performance monitoring and improvement activities by Station Operations, Engineering, and Maintenance organizations.
- OPEX and lessons learned from the continuous exchange of information among Canadian utilities are incorporated into the OPG governance and governance support documents.
- Internal and external audits as well as inspections and self-assessments are performed to verify compliance and recommend future improvement opportunities.
- Training and qualification requirements are established and reviewed to be up to date to execute the job tasks at all levels of Operations, Maintenance and Engineering.

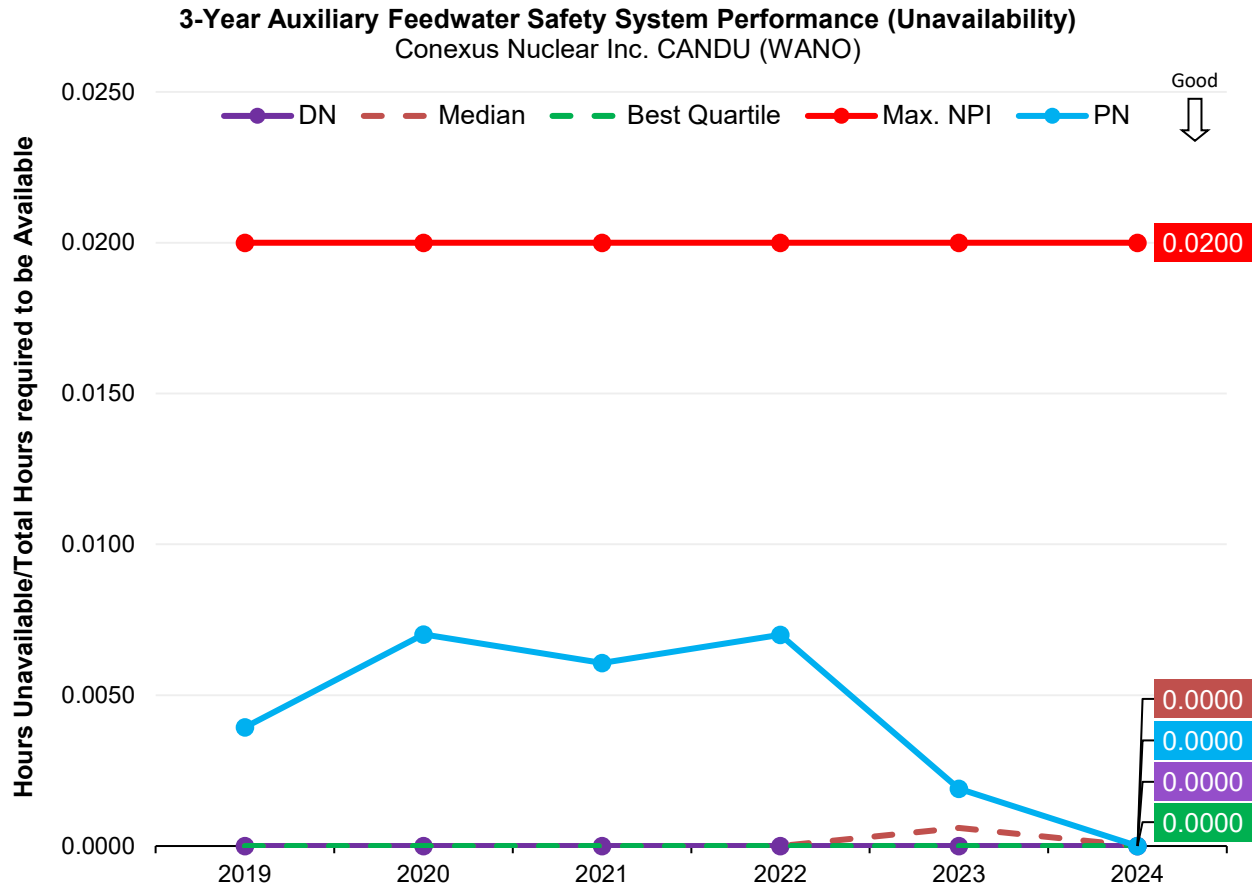
DNGS planned actions are as follows:

- Continuous actions, such as, Engineering Technical Surveillance Program, are being implemented in Darlington to ensure the best performance through Safety Related System Tests.

PNGS planned actions are as follows:

- Establish clear criteria for maintaining effective supervisory oversight during critical unit activities over turnover.
- Revise the Overall Unit Manual for HT pressurization and warm-up.
- Perform a focused roll-out of Conduct of Control Room Turnover.
- Provide control room operations staff with key information in preparation for unit warm-up tasks.
- Reduce the number of equipment-related challenges in the control room during critical evolutions.
- Address knowledge gaps in Authorized Training for HT pressurization
- Isolation of all traps on all units.
- Continuous monitoring of Liquid Zone chemistry and compressor cycle.
- Organizational Effectiveness Group leads paired learning sessions to drive risk elimination behaviors with chosen station work groups (Engineering, Maintenance, Operations, Chemistry and Fuel Handling).

3-Year Auxiliary Feedwater Safety System Performance (Unavailability)*



Sub-indicator for WP11

+ DNGS – Unit 2 (U4 in Refurbishment. Unit 3 RTS Q3 2023 & Unit 1 RTS Q4 2024, not online 3 years), PNGS - Unit 4 & 5-8 (U1 end of commercial life Q3 2024)

	2024 Value
DN	0.0000
PN	0.0000
Best Quartile	0.0000
Median	0.0000

Factors Contributing to Performance:

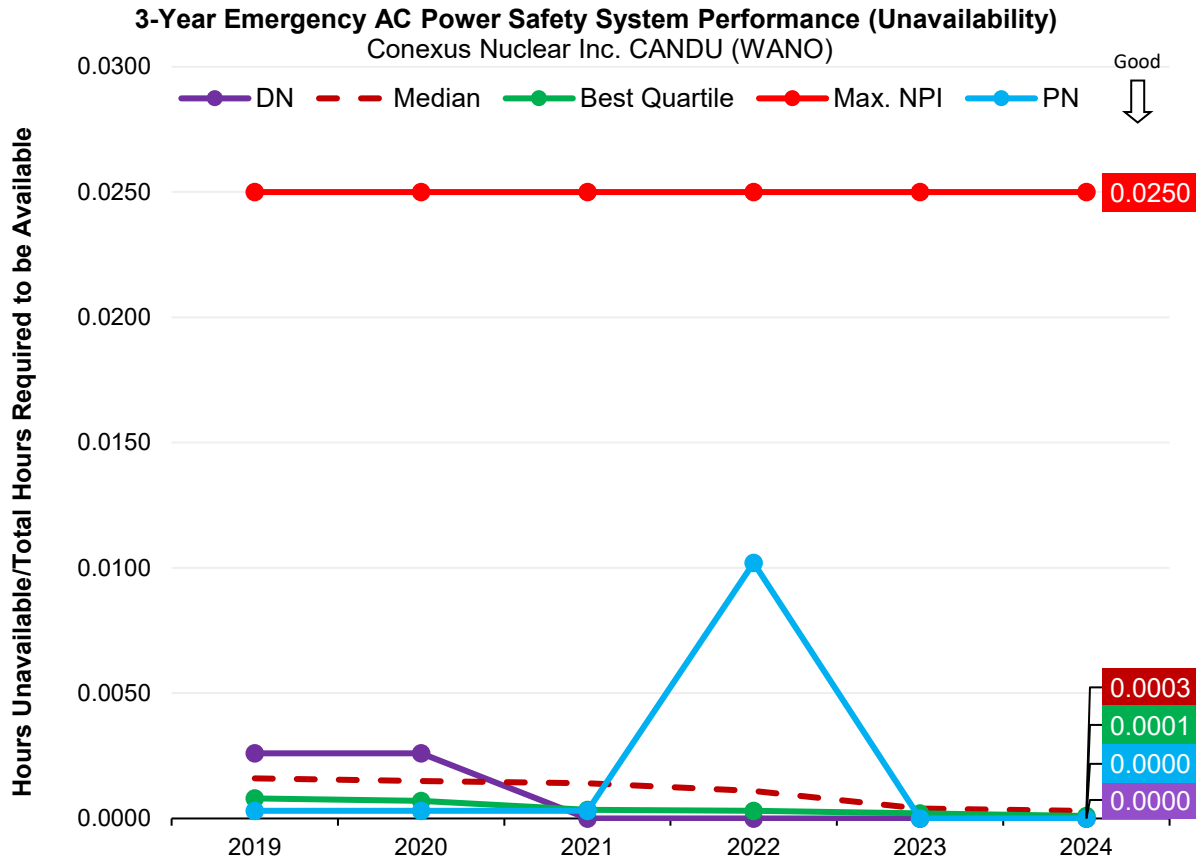
- DNGS and PNGS continued to achieve maximum WANO Performance Indicator Index (WP11) points.
- DNGS achieved best quartile performance of zero unavailability. Factors contributing to performance include:
 - Identifying critical work on the plant reliability list.
 - Scheduling work using Integrated Planning Group and Cycle Plan processes.
 - Adhering to the cycle planning.
 - Following the System Performance Monitoring Plan.
 - Adhering to the Health Report 10-Year Improvement Plan.

- PNGS achieved the best quartile performance of zero unavailability due to ongoing improvement actions.

Initiatives to Improve and Sustain Favourable Performance Include:

- DNGS design changes to the Auxiliary Boiler Feed (ABF) system include:
 - Installing gland injection cooling on pump seals to resolve mechanical seal O-ring failure.
 - Replacement of reverse rotation device for main and ABF pumps.
- The following was implemented on PNGS to improve the ABF system performance:
 - Perform evaluation of repeat failures of Units 1 and 4 ABFP discharge pressure control valves.

3-Year Emergency AC Power Safety System Performance (Unavailability) *



Sub-indicator for WPII

+ DNGS – Unit 2 (U4 in Refurbishment. Unit 3 RTS Q3 2023 & Unit 1 RTS Q4 2024, not online 3 years), PNGS - Unit 4 & 5-8 (U1 end of commercial life Q3 2024)

2024 Value	
DN	0.0000
PN	0.0000
Best Quartile	0.0001
Median	0.0003

Factors Contributing to Performance:

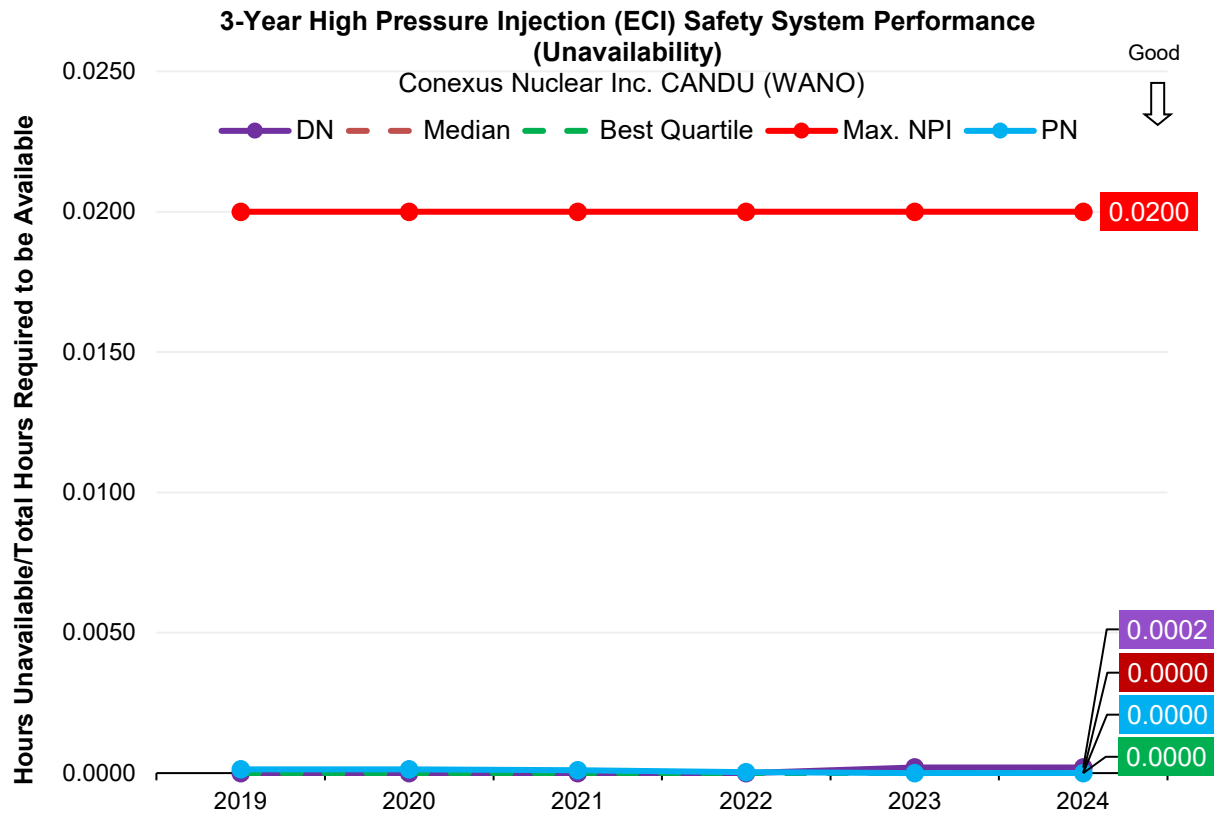
- DNGS and PNGS continued to achieve maximum WANO Performance Indicator Index (WPII) points.
- DNGS Emergency AC Power system achieved the best quartile performance of zero unavailability. Factors contributing to performance include:
 - Identifying critical work on the plant reliability list.
 - Scheduling work using Integrated Planning Group and Cycle Plan processes.
 - Adhering to the 10-year Outage Maintenance Strategy for the Standby Generators (SGs) and Health Report Improvement Plan.
 - Following the System Performance Monitoring Plan.
 - Adhering to the Health Report 10-Year Improvement Plan.

- PNGS Emergency AC Power system achieved the best quartile performance of zero unavailability. Factors contributing to performance include:
 - Inspection of 058 Standby Generators (SGs) for power turbine cracking failures, repairing SGs as required.

Initiatives to Improve and Sustain Favourable Performance Include:

- DNGS planned actions include
 - A 10-year project is in progress on the SG protective relays to replace all the old electro-mechanical relays with modern digital versions directly preceding the end of each SG outage. Installation and commissioning for SG3 is complete. SG1, SG2, and SG4 will proceed in 2024 and 2025
- PNGS planned actions include:
 - Actions to ensure timely review/implementation of the corrective and routine maintenance.
 - Cracked power turbine casings will be repaired or replaced.

3-Year High Pressure Injection (ECI) Safety System Performance (Unavailability) *



Sub-indicator for WPII
 + DNGS – Unit 2 (U4 in Refurbishment. Unit 3 RTS Q3 2023 & Unit 1 RTS Q4 2024, not online 3 years), PNGS - Unit 4 & 5-8 (U1 end of commercial life Q3 2024)

	2024 Value
DN	0.0002
PN	0.0000
Best Quartile	0.0000
Median	0.0000

Factors Contributing to Performance

- DNGS and PNGS continued to achieve maximum WANO Performance Indicator Index (WPII) points.
- DNGS High Pressure Safety Injection (HPSI) unavailability was 0.0002. The factors contributing to performance includes:
 - Reducing fault occurrences by improving equipment reliability through Preventative Maintenance Optimization, Performance Monitoring and Life Cycle Management programs.
 - Planned maintenance on ECIs is being managed to ensure the target is met, providing unplanned faults/maintenance remain at historical levels.

- Improving scheduling of discretionary maintenance so that equipment unavailability is reduced during quarters with lower reactor critical hours.
- PNGS continued with the best High Pressure Safety (HPSI) quartile performance of zero unavailability. Continuous improvement through mitigation of aggregate risk to maintain system redundancy contributed to PNGS performance.

Initiatives to Improve and Sustain Favourable Performance Include:

- Darlington HPSI related activities include the following:
 - Units 1-4 injection valve internals were overhauled.
 - On-going equipment reliability improvement work.
 - Performing preventive maintenance on schedule to reduce component failures and unplanned unavailability hours and scheduling maintenance work to maximize availability.
 - Overhaul or replacement of critical components during outages to increase equipment reliability (i.e., ECI Hydraulic Power Unit (HPU)/ECI Accumulator Control Module (AMCA)).
 - Completion of equipment reliability improvement work is driven via the 52-week cycle plan and Plant Reliability List (PRL) initiatives.
- Pickering HPSI related activities include the following:
 - Placing an additional Calandria face cooling fan to rectify erroneous moderator level indications.
 - Fixing the leaking H₂O injection valve.
 - Mitigating the leakage to the miscellaneous collection tank from a motorized valve.
 - Due to drift issues, 40V DC power supplies to ECI channel S logic instrumentation are being replaced on all units.
 - Engineering Change Request (ECR) has been approved to address the incorrect logic associated with ECI storage tank low level annunciation.

Methodology and Sources of Data

The majority of reliability metrics were calculated using 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.

For the WANO Performance Indicator Index (WPPI), a maximum score of 100 is possible. The WPPI is an operational performance indicator comprised of 10 metrics, three of which are analyzed in this section:

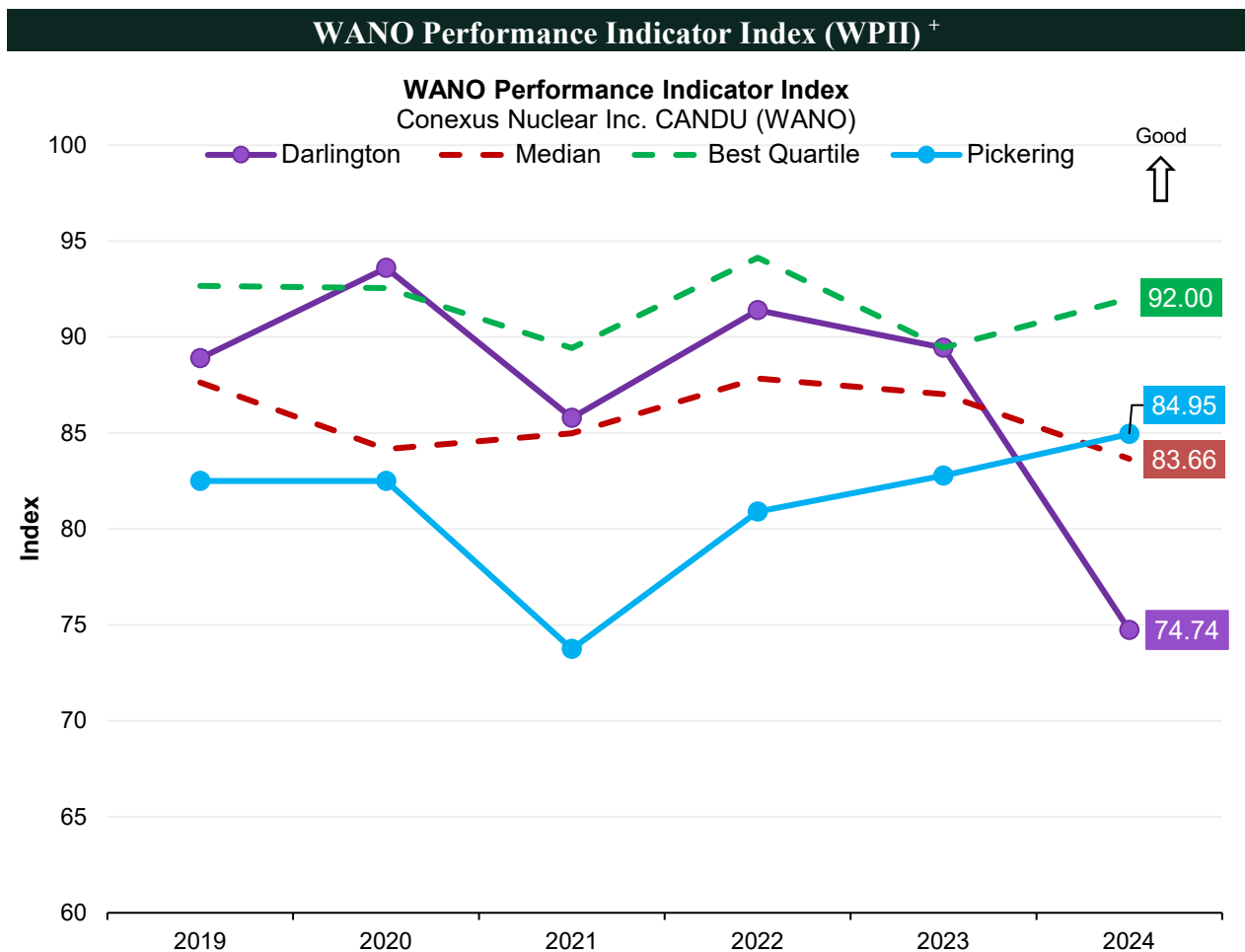
- Forced Loss Rate (FLR) [Rolling Average]
- Rolling Average Unit Capability Rate (UCR) [Rolling Average]
- Chemistry Performance Indicator (CPI) [Rolling Average]

The other seven WPPI components are shown in the Safety Section (Section 2.0).

Note: To benchmark performance, Max WPPI is used to indicate best quartile performance for metrics that perform better than the Max WPPI benchmark. If metric performance is not better than Max WPPI, benchmark quartiles are utilized to indicate quartile performance.

In addition to the WPPI indicators listed above, Unit Capability Factor (UCF) is also included in this section, and the calculations utilize data from WANO. Data points benchmarked for UCF are a rolling average.

Backlog metrics for On-line Deficient and Corrective Maintenance are also included within this section and the data comes from an industry sponsored Institute of Nuclear Power Operators (INPO) AP-928 subcommittee. Data points benchmarked on backlogs are annual, not a rolling average. All data is self-reported.



+ 3-year avg DNGS - Unit 2 (U4 in Refurbishment. Unit 3 RTS Q3 2023 & Unit 1 RTS Q4 2024, not online for 3 years), 2-year avg PNGS - Unit 4 & 5-8 (U1 end of commercial life Q3 2024)

* WPII methodology changed from Method 4 to Method 10 starting in 2024. This adjustment affects both the metric's definition and index weighting. Data from 2019 through 2023 was calculated using Method 4, 2024 onward will reflect Method 10.

	2024 Value
DN	74.74
PN	84.95
Best Quartile	92.00
Median	83.66

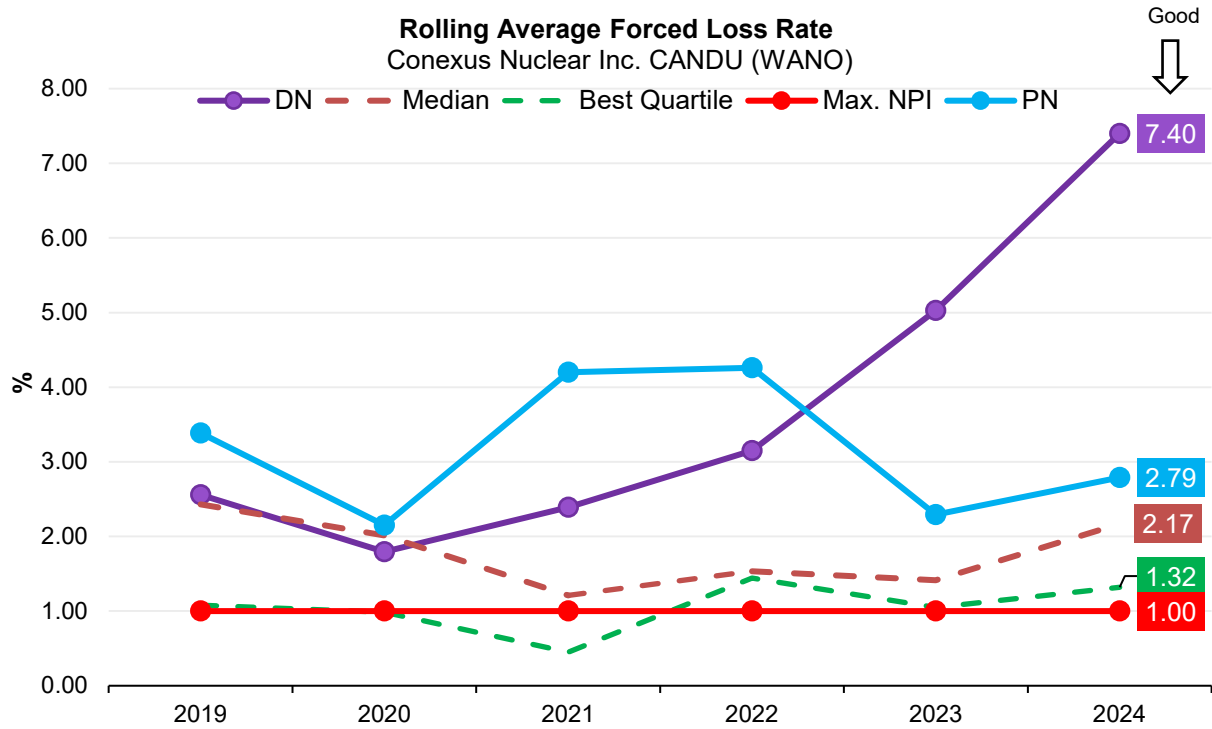
Factors Contributing to Performance:

- DNGS WPII performance declined in 2024 compared to 2023. The decline in performance is attributed to elevated Forced Loss Rate (FLR) and Unit Capability Rate (UCR) performance as result of two forced outages in 2024. Since FLR and UCR have the most significant weighting (15 and 10 points respectively) in the WPII method 10 calculation, the resulting score of WPII was reduced. DNGS continued with excellent performance for all seven safety metrics.
- PNGS performance improved by 2.17 points primarily due the industry definition and weighting change from WPII method 4 to WPII method 10.
 - UCR and FLR have the most significant weighting in the WPII calculation.

- Sustained performance for all seven safety was partially offset by lower Chemistry Performance Index (CPI), Forced Loss Rate (FLR) and Unit Capability Rate (UCR) performance.

Further details on factors contributing to performance and initiatives to improve and sustain favourable performance are discussed within each respective WPII sub-metric in this report.

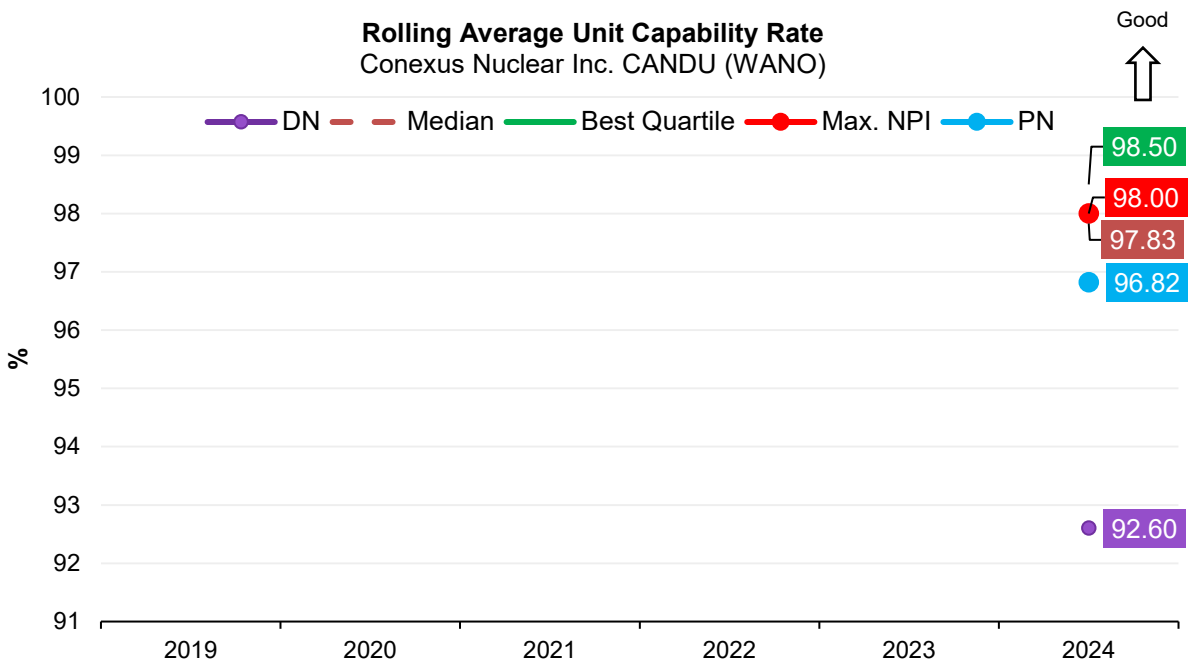
Rolling Average Forced Loss Rate (FLR) * +



Sub-indicator for WPII

+ 3-year avg DNGS - Unit 2 (U4 in Refurbishment. Unit 3 RTS Q3 2023 & Unit 1 RTS Q4 2024, not online for 3 years), 2-year avg PNGS - Unit 4 & 5-8 (U1 end of commercial life Q3 2024)

Rolling Average Unit Capability Rate (UCR) * +



Note: New metric for WPII Method 10, replacing Unit Capability Factor (UCF) for WPII Method 4

	2024 FLR	2024 UCR
DN	7.40	92.60
PN	2.79	96.82
Best Quartile	1.32	98.50
Median	2.17	97.83

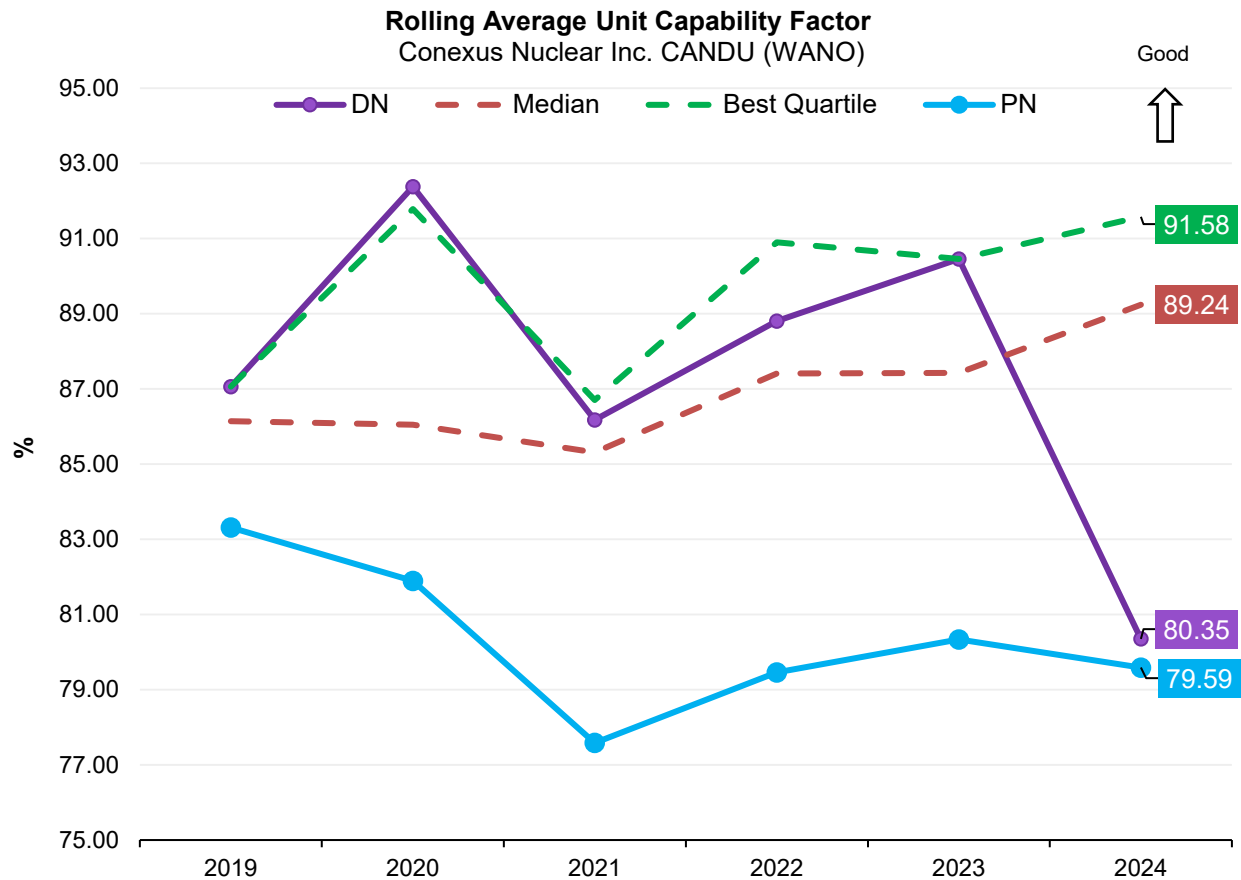
Factors Contributing to Performance:

- DNGS decline in performance is attributable to post-Refurbishment forced outages. As the metric is a rolling average, in 2023 & 2024 only Unit 2 results are included (Units 1, 3, 4 were in refurbishment during all or part of the window), compared to only Unit 4 being included prior to entering Refurbishment in 2022. Increased FLR is expected post refurbishment and will improve with support of ongoing initiatives to strengthen Plant reliability, Human Performance and Equipment reliability. DNGS experienced four forced outage events related to Unit 2 post-Refurbishment on Generator (2024), Primary Heat Transport (2023), and Turbines & Main Power Output (2022).
- PNGS slight decline in performance is attributable to elevated FLR in 2024 compared to 2022, which is no longer included in the rolling window. In 2024, there were three forced outages related to Primary Heat Transport, Liquid Zone Control and Generator systems, and six forced outages related to Turbine, Boiler Feedwater, Main Output, and Human Performance in 2023. Unit 6 obtained Industry Best Quartile FLR in 2024.

Initiatives to Improve and Sustain Favourable Performance Include:

- Focused actions, including vulnerability identification and elimination, project execution, and building proficiency at both the fleet and site level to increase plant reliability, have been implemented for identified systems that are contributing to historical and industry forced loss events.
- Major projects installed during Darlington Refurbishment have improved reliability, and major projects are scoped for Pickering Refurbishment to improve reliability of contributing systems.
- Fuel Handling fleet and industry peer teams have continued to reduce or eliminate FLR contribution year over year and remains a fleet focus area to build sustainability. DNGS has achieved industry best performance with no contributing Fuel Handling FLR.
- Internal peer teams, industry benchmarking, fleet assessments against industry best practice, enhanced participation in industry working groups are in place to help manage risks going forward. Continued actions building proficiency at both the fleet and site level have been implemented for top fleet contributors, supported by industry peers.

Rolling Average Unit Capability Factor (UCF) * †



+ 3-year avg DNGS - Unit 2 (U4 in Refurbishment. Unit 3 RTS Q3 2023 & Unit 1 RTS Q4 2024, not online for 3 years), 2-year avg PNGS - Unit 4 & 5-8 (U1 end of commercial life Q3 2024)

2024 Value	
DN	80.35
PN	79.59
Best Quartile	91.58
Median	89.24

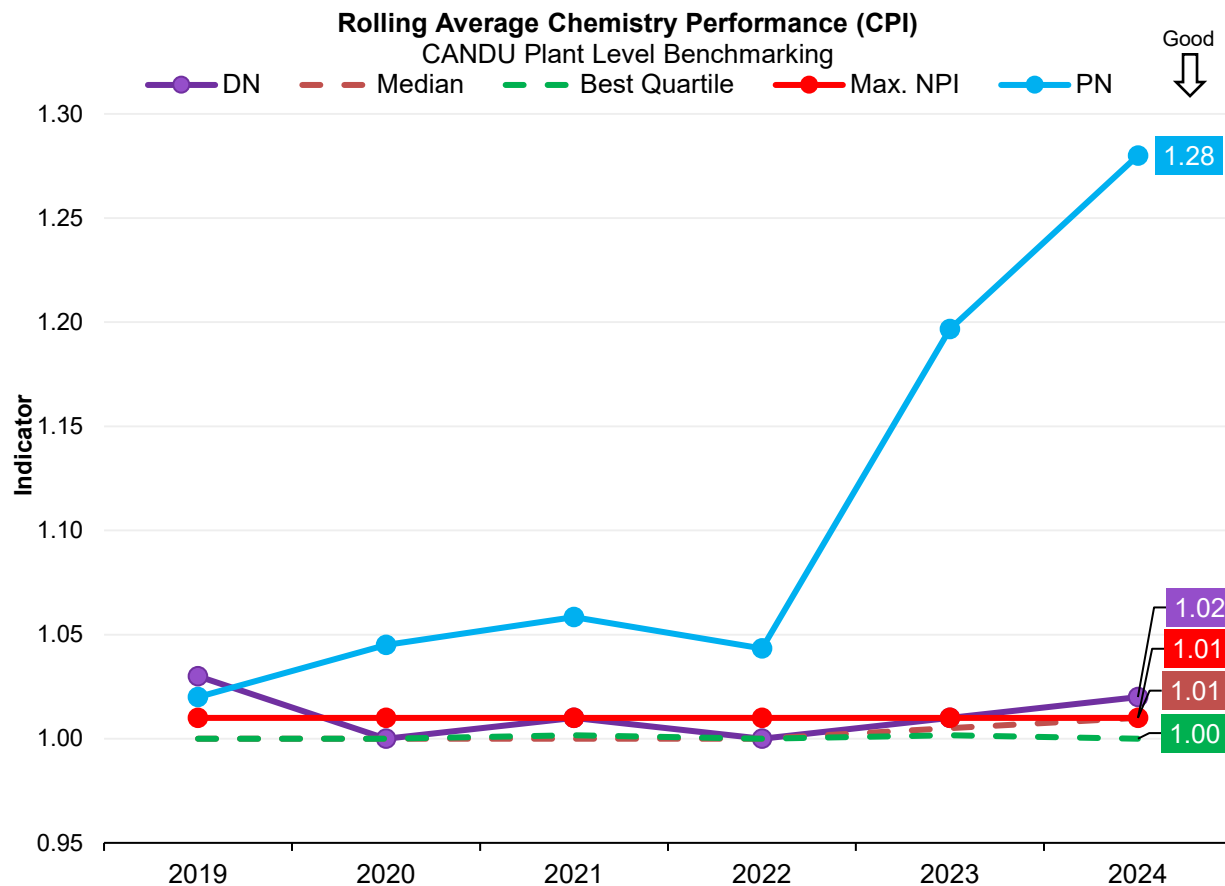
Factors Contributing to Performance:

- DNGS decline in performance is attributable to a decline in FLR performance in 2024, which is expected post-Refurbishment. As the metric is a rolling average, only Unit 2 results are included in 2023 & 2024 (Units 1, 3 and 4 were in refurbishment during all or part of the window). 2022 results were measured against Unit 4 performance prior to entering refurbishment (Unit 1 & 3 were in refurbishment and Unit 2 was only online for two years).
- PNGS decline in performance is attributable to decline in FLR performance in 2024 compared to 2022, which is no longer in the rolling window. Unit 7 achieved Industry Best Quartile in 2023.

Initiatives to Improve and Sustain Favourable Performance Include:

- Focused actions, including vulnerability identification and elimination, project execution, and building proficiency at both the fleet and site level have been implemented for identified systems contributing to historical and industry forced loss events.
- Major projects installed during Darlington Refurbishment have improved reliability, and major projects are scoped for Pickering Refurbishment to improve reliability of contributing systems.
- Fuel Handling fleet and industry peer teams have continued to reduce or eliminate FLR contribution year over year and remains a fleet focus area to build sustainability. DNGS has achieved industry best quartile with no contributing Fuel Handling FLR.
- Internal peer teams, industry benchmarking, fleet assessments against industry best practice, enhanced participation in industry working groups are in place to help manage risks going forward. Continued actions focused on building proficiency at both the fleet and site level have been implemented for top fleet contributors, supported by industry peers.

Rolling Average Chemistry Performance Indicator (CPI) *+



+ 3-year avg DNGS - Unit 2 (U4 in Refurbishment. Unit 3 RTS Q3 2023 & Unit 1 RTS Q4 2024, not online for 3 years), 2-year avg PNGS - Unit 4 & 5-8 (U1 end of commercial life Q3 2024)

2024 Value	
DN	1.02
PN	1.28
Best Quartile	1.00
Median	1.01

Factors Contributing to Performance:

The decline in performance at DNGS in 2024 compared to 2023 can be attributed to the following:

- Unit 2 Feedwater corrosion product transport post unit start-ups and elevated boiler ions upon unit start-ups (2024).
- Condenser tube leak on Unit 2 (2023).

The decline in performance at PNGS in 2024 compared to 2023 can be attributed to the following:

- Post Unit 7 start-up boiler sulphates for ~ 9 months (2024)
- Post Unit 5 start-up boiler sulphates for ~ 5 months (2024)

- Post Unit 8 Condenser Tube Leak that resulted in boiler ions in Action Level 3 high (2023)
- Multiple condenser tube leaks on Unit 8 (2023)
- Post Unit 6 start-up boiler sulphates for ~ 6 months (2023)

Initiatives to Improve and Sustain Favourable Performance Include:

Both sites have an ongoing Chemistry Outage SPOC to provide improved coordination/planning such that system chemistry control has improved during outages/start-ups.

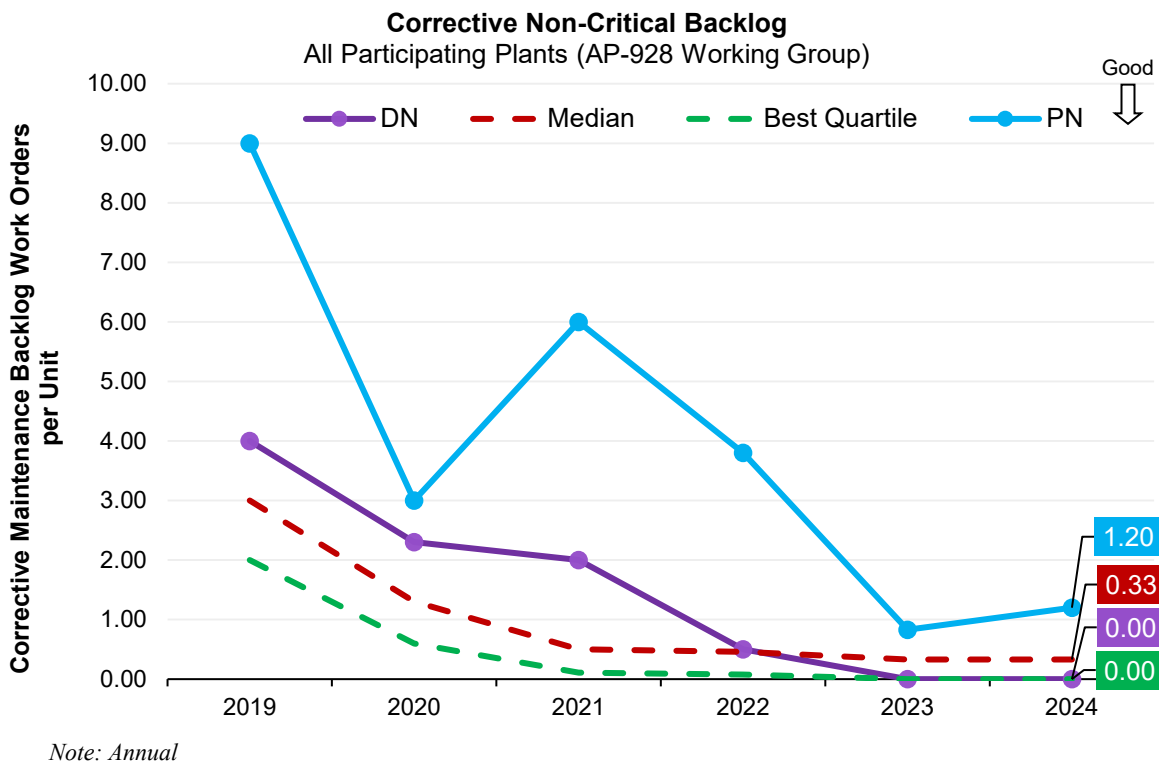
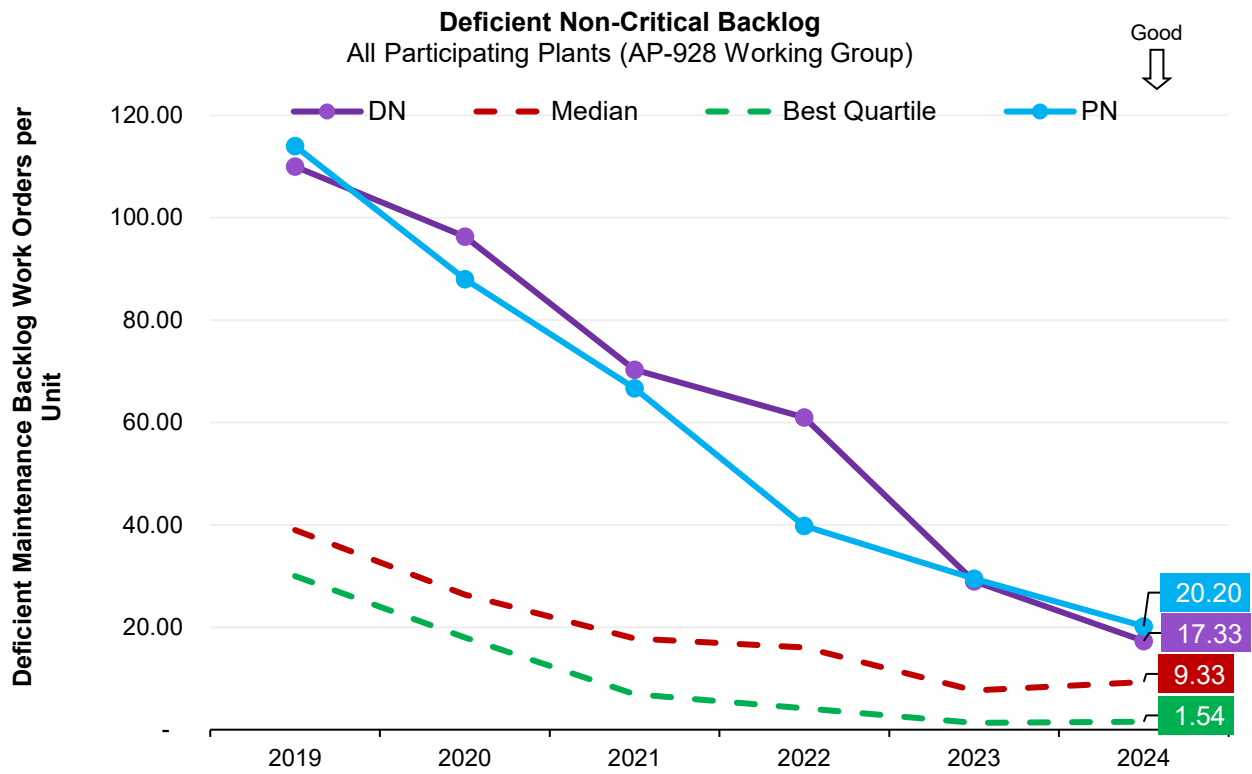
DNGS:

- Explore implementing film forming amine injection for corrosion product transport formation reduction.
- Explore further enhanced corrosion product transport removal processes via larger side stream filtration and/or condensate polisher.
- Improve integration into Outage meetings to optimize boiler chemistry (i.e. minimize duration where boilers are drained, improvements in Boiler Water Lancing activities etc.).
- Implemented a revised chemistry control strategy using continuous boiler blowdowns to manage secondary side chemistry control leading until Unit start-up to remove boiler ions.
- Revise the condenser tube leak response procedure and guidance to include previous operating experience and pre-decision-making logic during leak searching activities.
- Install permanent sodium hotwell analyzers for early detection of condenser tube leaks, to assist in isolating the correct Waterbox and minimize time out of specification.
- Improve reliability of condenser equipment including Condenser Tube Cleaning System (CTCS) through piping and valve replacements and increase inspections to assess condenser tube health to prevent and mitigation condenser tube leaks.

PNGS:

- Explore implementing film forming amine injection for corrosion product transport formation reduction.
- To improve boiler chemistry, a modification is planned during refurbishment to increase the continuous boiler blowdown capacity. This will help improve boiler ions upon unit start-up.
- Improve planning and execution of chemistry start-up activities through integration of Chemistry, Outage, and Operations.

On-Line Deficient & Corrective Non-Critical Backlog
On-Line Deficient & Corrective Critical Backlog



	Deficient Non-Critical Backlog	Deficient Critical Backlog	Deficient Maintenance Backlog	Corrective Non-Critical Backlog	Corrective Critical Backlog	Corrective Maintenance Backlog
DN	17.33	0.00	17.33	0.00	0.00	0.00
PN	20.20	0.60	20.80	1.20	0.00	1.20
Best Quartile	1.54	0.00	1.54	0.00	0.00	0.00
Median	9.33	0.00	9.33	0.33	0.00	0.33

Factors Contributing to Performance:

- DNGS and PNGS continue to achieve industry best quartile for Corrective Critical Backlog.
- DNGS continues to achieve industry best quartile for Deficient Critical Backlog.
- PNGS performance improved for Deficient Critical Backlog.
- Both sites experienced performance improvement for Deficient Non-Critical Backlog, PNGS 32%, and DNGS 40% compared to 2023.
- Factors contributing to performance:
 - Continued focus on reducing backlog using Fix It Now (FIN) and Work Management (WM) processes.
 - Actions completed to make FIN process sustainable for Live Zero backlog, including enhancements for long-lead parts and grace periods.
 - Weekly cross-functional meetings to review all current backlog work orders and ensure proper coding quality.
 - Initiated cross-functional Backlog Recovery Teams.
 - Oversight of Refurbishment and Safe Storage activities requires strengthening to reduce online backlog impacts
 - Not all station backlog targets were set to Industry Top Quartile for 2024.

Initiatives to Improve and Sustain Favorable Performance Include:

- Continued review of opportunities to execute online work during unit shutdowns and specific unit configurations.
- Improved oversight and support for Safe Storage activities that impact online Backlogs and Refurbishment Backlogs to ensure targets are met.
 - DNGS and PNGS FIN Managers coordinate with the Refurbishment Maintenance and Work Management teams to ensure targets are met during the transfer of Backlog work orders into/out of Refurbishment and Online.
- Improved oversight at New Work Screening to ensure proper coding of work orders.
- Monitor and track actions as well as metrics via weekly Integrated Station Briefing meetings (DNGS), monthly Senior Work Management meetings, and monthly Station Management meetings.

Note: Factors Contributing to Performance and Initiatives to Improve and Sustain Favorable Performance are relevant to all backlogs.

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. All data submitted to and subsequently extracted from EUCG by OPG is presented in Canadian dollars.

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

The benchmarking panel utilized for value for money metrics is made up of all North American (U.S. & Canada) 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 making it challenging to compare performance across plants with technology differences. As a result, beginning with 2017 results, both PNGS and DNGS TGC/MWh and TGC/Unit performance has been normalized for CANDU technology (including outage duration) and age-related impacts.

Darlington's TGC/MWh, TGC/Unit, Non-Fuel Operating Costs (NFOC)/MWh and Capital Cost/MW DER performance have also been normalized for refurbishment. The refurbishment normalization methodology allows OPG to adjust the distribution of actual operating and capital costs to reflect Darlington's number of operating units rather than a four-unit site. OPG is performing a mid-life refurbishment at Darlington, which involves bringing units offline for the replacement of certain life-limiting components. It is necessary to normalize these metrics during refurbishment to allow for comparisons to prior site performance and industry peers, given reduced generation and no corresponding decline in fixed costs.

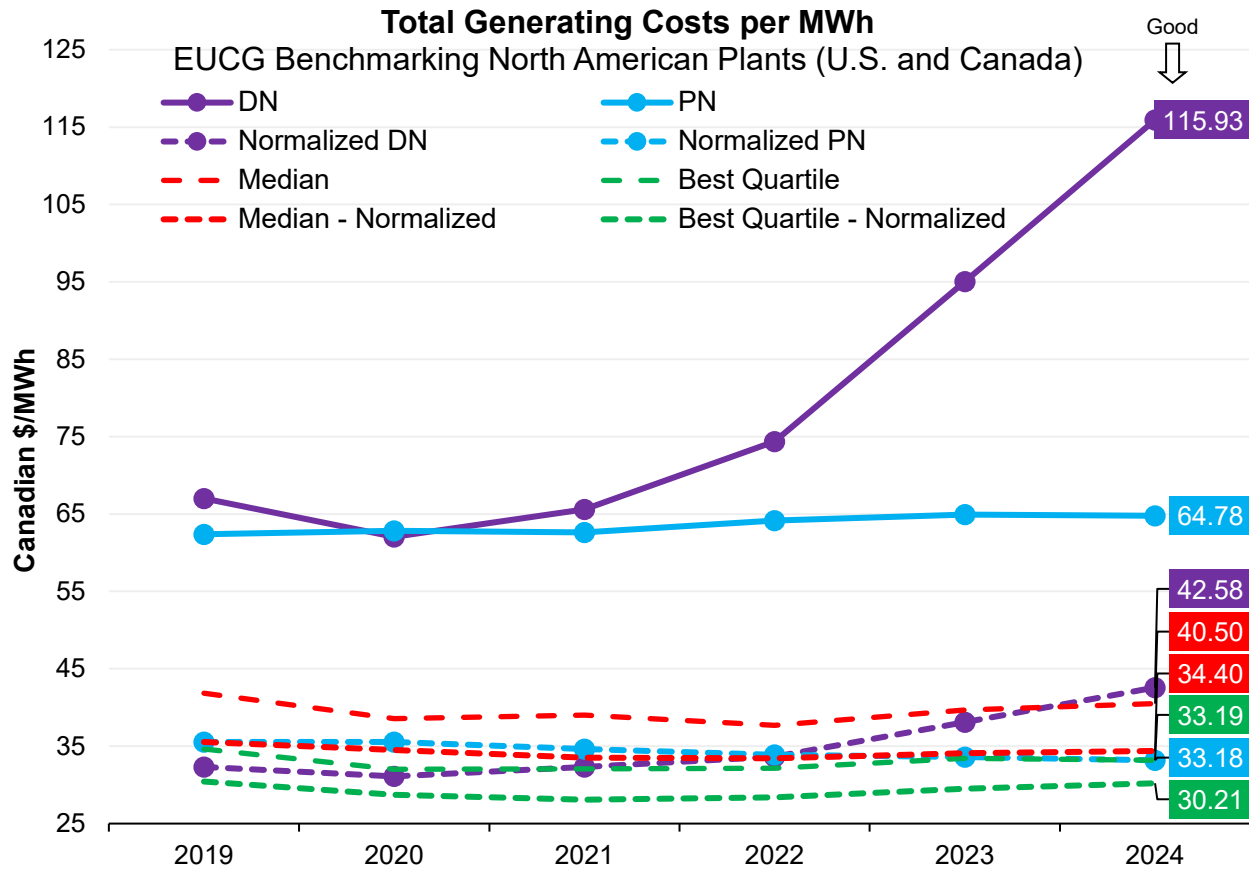
OPG engaged ScottMadden Management Consultants (ScottMadden) to develop the normalization methodologies³. The combined normalization allows for a more comparable assessment of performance between peers.

Total Generating Cost per MWh is the sum of Non-Fuel Operating Cost (NFOC), 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 non-fuel operating costs, fuel and capital costs, it is difficult to compare plants using non-fuel operating cost, fuel cost or capital cost metrics separately.

³ Two ScottMadden normalization reports provide details on the normalization methodologies: 1) *OPG Nuclear Cost Performance Benchmarking A Study of Factors Impacting TGC/MWh Performance with Normalizing Adjustments to Facilitate Closer Comparison* and 2) *OPG Nuclear Cost Performance Benchmarking Methodology to Adjust for Refurbishment and Validation of Implementation*

3-Year Total Generating Cost (TGC) per MWh



+ DNGS – Unit 2 RTS Q2 2020, Unit 3 RTS Q3 2023, Unit 1 RTS Q4 2024. (U4 in Refurbishment)
 * Utilizing the updated technology, age-related and outage duration normalization methodology from ScottMadden

	2024 Non-Normalized Value	2024 Normalized Value
DN	115.93	42.58
PN	64.78	33.18
Best Quartile	33.19	30.21
Median	40.50	34.40

Factors Contributing to Performance

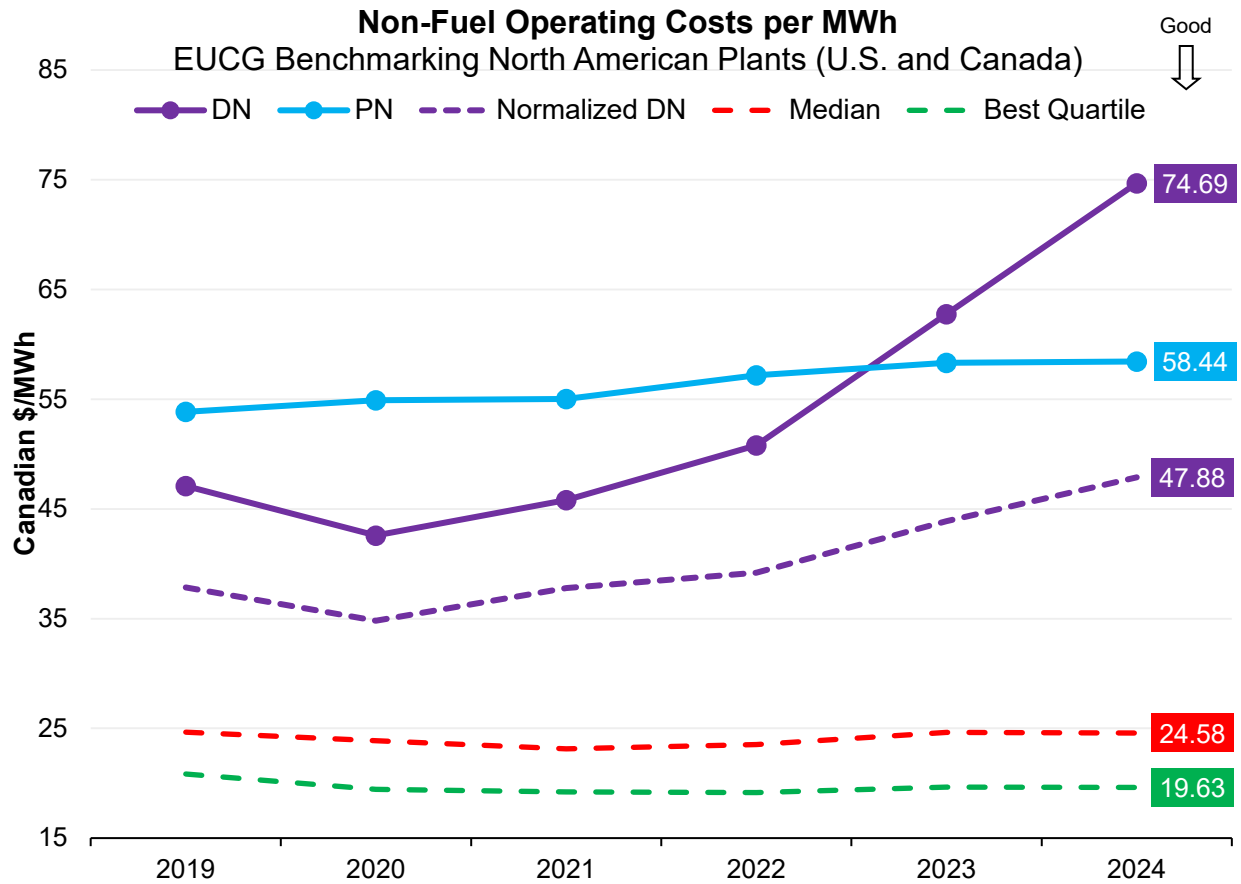
- DNGS normalized performance declined in 2024 compared to 2023 due to reduced 3-year generation related to the Refurbishment outage schedule with the equivalent of two units being in refurbishment outages the full year in 2024 (Unit 4 full year, Unit 1 offline until Q4 2024) compared to one unit in 2021 (Unit 3 offline full year), increasing spending on sustaining investments to ensure long term reliability, and higher OM&A costs in 2024 from increased unionized compensation as a result of the Ontario Superior court decision finding unconstitutional provincial legislation that set limits on compensation increases for employees in the Ontario public sector in which the maximum annual increase in both wages and total compensation to one percent for a three-year period (Bill 124 Court Decision), partially offset by lower fuel & OM&A costs due to refurbishment schedule.

- DNGS non-normalized performance declined in 2024 compared to 2023 due to reduced 3-year generation related to the Refurbishment outage schedule (as per above), higher OM&A costs in 2024 from increased unionized compensation as a result of the Bill 124 court ruling (as per above), and increased capital investment requirements for life post-refurbishment, partially offset by lower fuel costs due to refurbishment schedule.
- PNGS normalized and non-normalized 2024 performance is similar to 2023, reflecting reduced capital spending while maintaining reliable operations in the period leading up to the Refurbishment of Units 5-8 in 2026, partially offset by higher OM&A costs from increased unionized compensation as a result of the Bill 124 court ruling (as per above).
- PNGS units are the smallest in the peer group at 540 MW/unit compared to the peer average of 1,026 MW, a factor for which results have not been normalized.

Initiatives to Improve and Sustain Favourable Performance Include:

- Maximizing generation: See initiatives to improve and sustain favourable performance for Reliability Metrics UCF and FLR.
- Continue to utilize opportunities to reduce operating costs through strategic initiatives, excellence plans, technology deployment and resource planning.
- Employing a portfolio and asset management approach to assess, prioritize and deliver all nuclear operations projects which are developed to meet regulatory commitments (e.g., from the Canadian Nuclear Safety Commission), increase system or unit reliability, address system obsolescence, or optimize station generation.

3-Year Non-Fuel Operating Cost per MWh



+ DNGS – Unit 2 RTS Q2 2020, Unit 3 RTS Q3 2023, Unit 1 RTS Q4 2024. (U4 in Refurbishment)

	2024 Non-Normalized Value	2024 Normalized Value
DN	74.69	47.88
PN	58.44	-
Best Quartile	19.63	19.63
Median	24.58	24.58

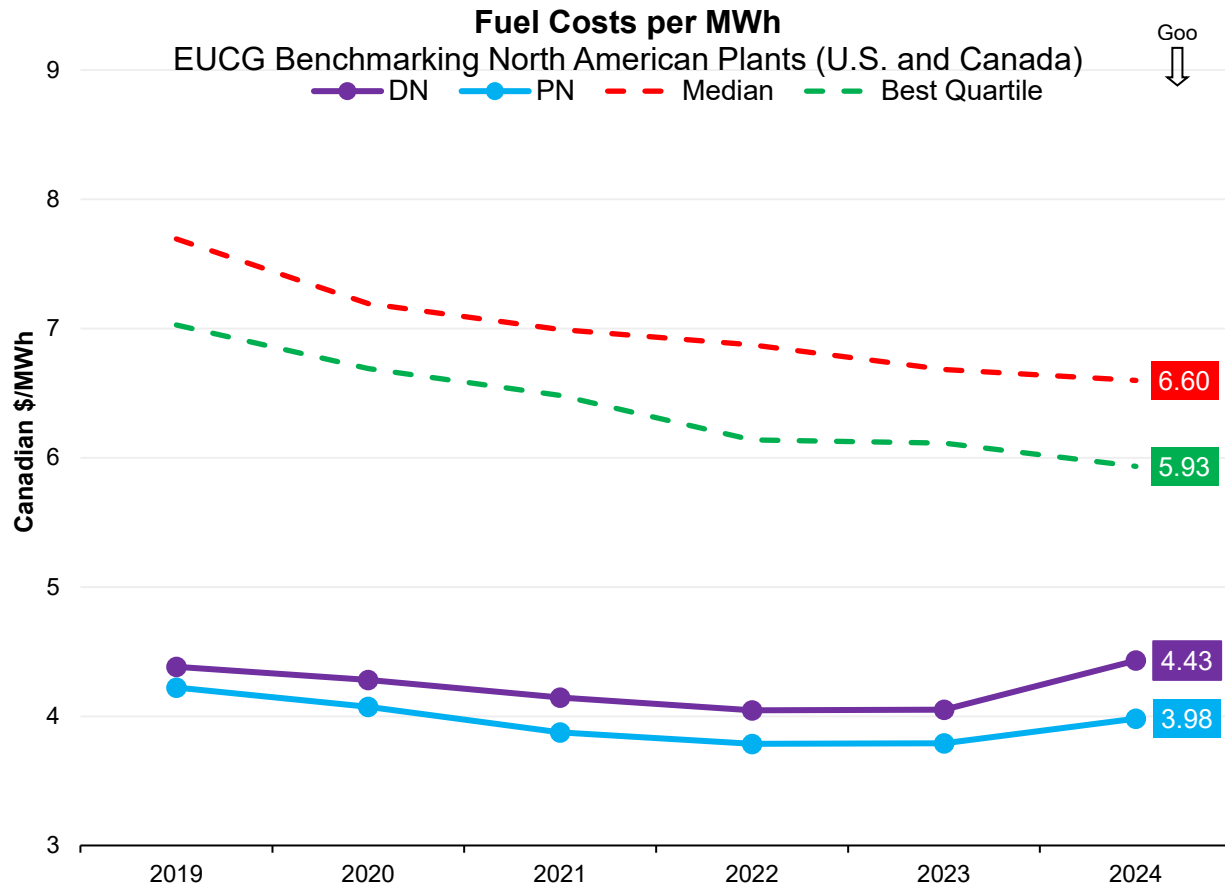
Factors Contributing to Performance

- DNGS normalized performance declined in 2024 compared to 2023 due to reduced 3-year generation related to the Refurbishment outage schedule with the equivalent of two units being in refurbishment outages the full year in 2024 (Unit 4 full year, Unit 1 offline until Q4 2024) compared to one unit in 2021 (Unit 3 offline full year), higher OM&A costs in 2024 from increased unionized compensation as a result of the Ontario Superior court decision finding unconstitutional provincial legislation that set limits on compensation increases for employees in the Ontario public sector in which the maximum annual increase in both wages and total compensation to one percent for a three-year period (Bill 124 Court Decision).

- PNGS non-normalized performance reflects higher OM&A costs in 2024 from increased unionized compensation as a result of the Bill 124 court ruling (as per above).
- PNGS units are the smallest in the peer group at 540 MW/unit compared to the peer average of 1,026 MW, a factor for which results have not been normalized.

Initiatives to Improve and Sustain Favourable Performance – refer to TGC/MWh.

3-Year Fuel Cost per MWh



+ DNGS – Unit 2 RTS Q2 2020, Unit 3 RTS Q3 2023, Unit 1 RTS Q4 2024. (U4 in Refurbishment)

2024 Value	
DN	4.43
PN	3.98
Best Quartile	5.93
Median	6.60

Factors Contributing to Performance

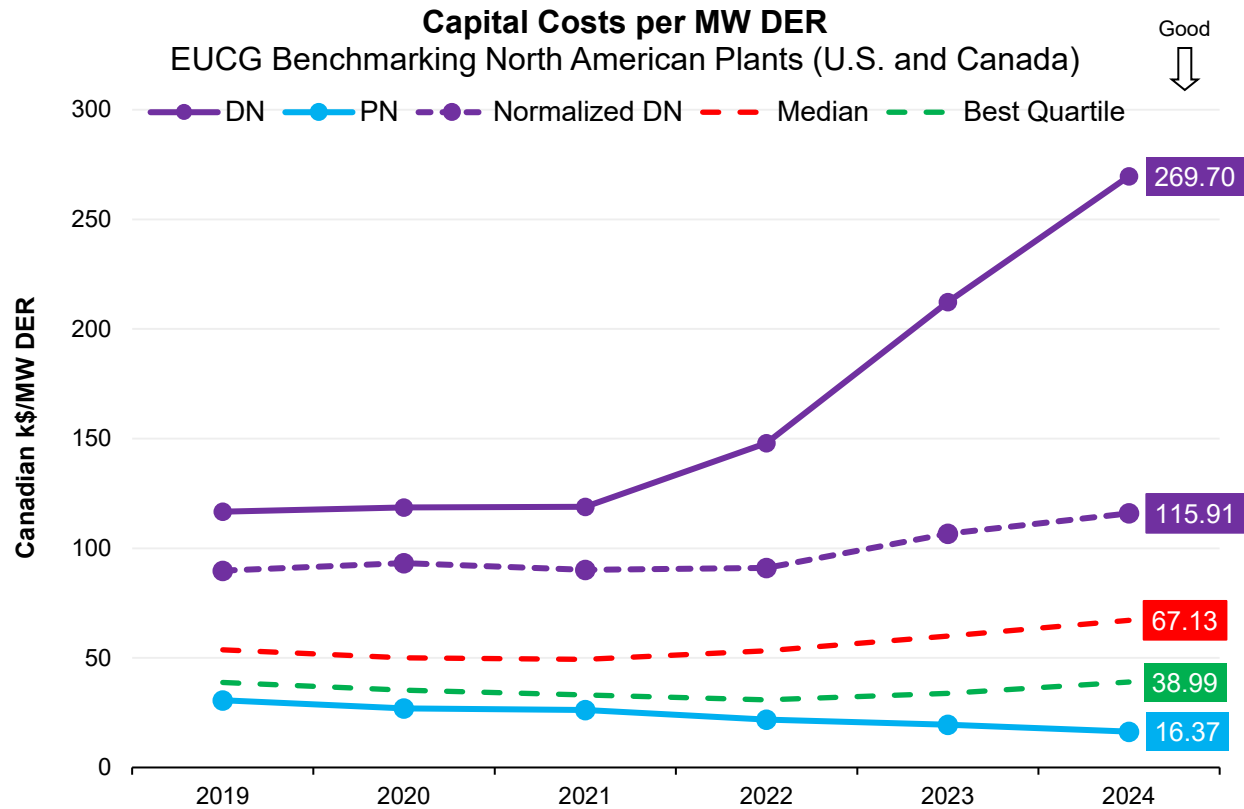
- Fuel costs are lower for OPG than most North American Pressurized Water Reactors or Boiling Water Reactors (PWR/BWR) reactors as CANDUs do not require enriched uranium like PWRs and BWRs.
 - Raw uranium is processed directly into uranium dioxide to make fuel pellets, without the additional cost and process complexity of enriching the fuel as required in light water reactors.
 - CANDU reactors are also the most efficient reactors in using uranium, requiring less uranium than PWRs and BWRs for each megawatt hour of electricity.
 - These two factors provide a significant advantage for OPG and other CANDUs in this cost category.

- Regular entry into the uranium market has allowed OPG to reduce uranium input costs year over year for the past several years. Historical multi-year contracts signed between 2015 and 2021, and for which deliveries were made in 2022, 2023 and 2024, have allowed OPG to take deliveries of uranium on both fixed price and market price basis during a period of historically low uranium spot market prices (2015-2021) not seen since 2005 and earlier.
- In 2017, the uranium spot market price reached its cyclical low point and has continued an increasing trend up to the present, and this trend is projected to continue. Over the coming years, as historical uranium contracts are completed and new contracts are entered into, the effect of the more recent increasing uranium price trend is expected to place upward pressure on the 3-year rolling average fuel cost per MWh. The increase in fuel costs at PNGS and DNGS from 2023 to 2024 can be attributed to this uranium price trend and by general escalation in fuel conversion and fuel fabrication costs.

Initiatives to Improve and Sustain Favourable Performance

- Certain factors are expected to place upward cost pressures on nuclear fuel supply chains over the next several years, including:
 - Resurgence in global demand for nuclear power due to carbon emissions targets of world governments, leading to increased global demand for uranium, conversion, and enrichment services.
 - Uranium supply constrained by many years of under-investment in new mine development due to low prices, as well as constrained Western conversion and enrichment capacities.
 - Global conflicts, including the war in Ukraine, leading to a bifurcation of global nuclear fuel supply chains, along with legislative actions such as the recent U.S. ban on the import of Russian nuclear fuel products.
- OPG will continue to seek improvements in contract pricing for its nuclear fuel supply to sustain favourable comparative fuel costs, while also ensuring a resilient and robust nuclear fuel supply chain, given recent and ongoing geopolitical and economic events

3-Year Capital Cost per MW DER (Design Electrical Rating)



+ DNGS – Unit 2 RTS Q2 2020, Unit 3 RTS Q3 2023, Unit 1 RTS Q4 2024. (U4 in Refurbishment)

	2024 Non-Normalized Value	2024 Normalized Value
DN	269.70	115.91
PN	16.37	-
Best Quartile	38.99	38.99
Median	67.13	67.13

Factors Contributing to Performance:

- DNGS performance in 2024 remained the same on a normalized basis compared to 2023, as the station remained in the third quartile. The large increase in the absolute DNGS Capital Cost per MW in 2024 is mainly due to the reduction in available MW as units were in refurbishment outages throughout the majority of the 3-year period as well as increased spending on sustaining investments to ensure long term reliability. The changes over the trend period reflects increased spending, steam generator replacements, sustaining investments, and infrastructure. The change over the trend period reflects increased spending on life extension, performance improvements, sustaining investments, information technology and capital spares to support operations before, during and after Darlington refurbishment.

- Historically, DNGS capital expenditures were better than the industry median. Once the decision to refurbish Darlington and extend end of life was made, OPG began an extensive program to replace obsolete and/or life-expired plant equipment to support performance and reliability of Darlington's unit's post-refurbishment. Once these investments have been made, DNGS performance is expected to improve.
- PNGS is performing in the first quartile with a slight improvement in 2024 and improvement over the trend period. This reflects reductions in spending while maintaining reliable operations leading up to the end of commercial operations (Units 1 & 4) which is consistent with spending trends observed at other nuclear facilities approaching their end of commercial operations and a planned refurbishment of four generating units (Units 5-8). However, as with investments related to DNGS and its refurbishment, this trend is not expected to continue as planned investments in PNGS are expected to increase with the plant life extension.

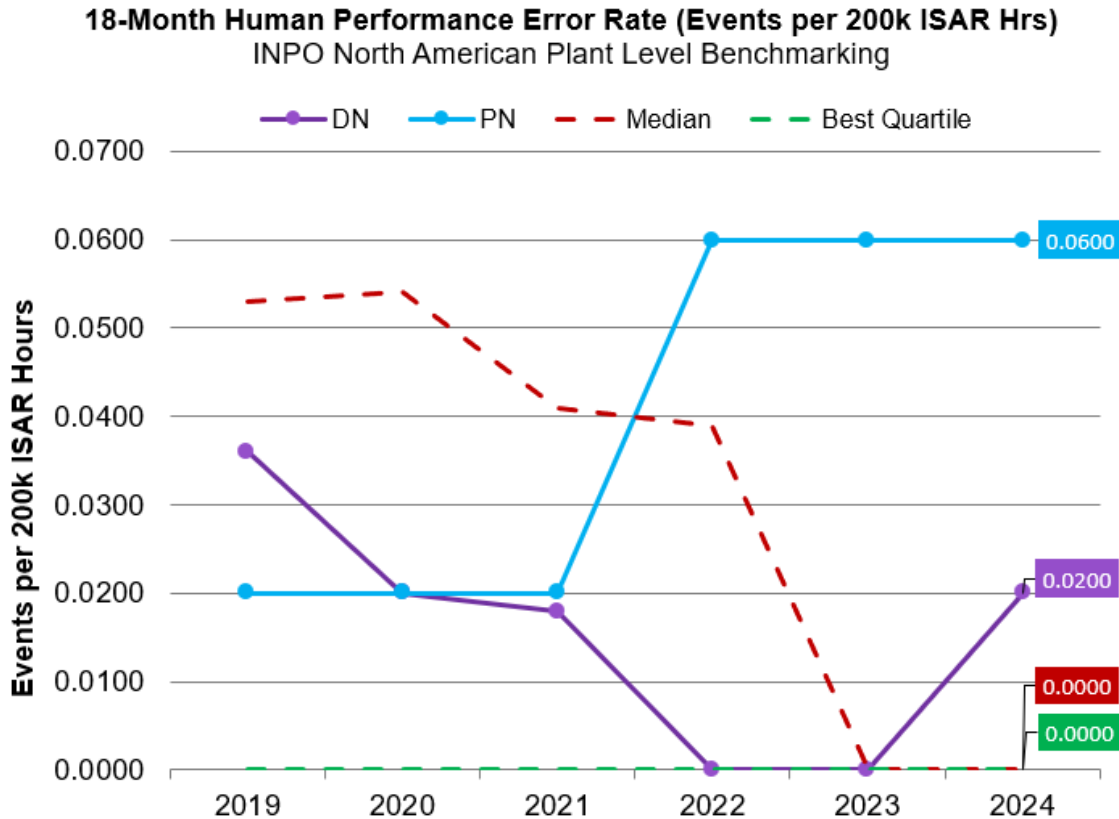
Initiatives to Improve and Sustain Favourable Performance Include:

- OPG continues to prioritize an integrated portfolio and asset management approach to assess, prioritize, and deliver all nuclear operations projects which are developed to meet regulatory commitments (i.e. from the Canadian Nuclear Safety Commission), increase system or unit reliability, address system obsolescence, optimize station generation, focus on investments in life extension and critical system upgrades, and enhanced project delivery practices.
- Enhanced project management practices, combined with the adoption of digital technologies and continuous improvement efforts, enable OPG to deliver capital projects more efficiently.

Methodology and Sources of Data

The Human Performance Error Rate metric is used to benchmark the performance of OPG’s Nuclear fleet against other INPO utilities in the area of Human Performance.

18-Month Human Performance Error Rate



	2024 Value
DN	0.0200
PN	0.0600
Best Quartile	0.0000
Median	0.0000

Factors Contributing to Performance:

- DNGS performance declined from best quartile in 2023 to third quartile in 2024 due to two Site Event Free Day Resets (S-EFDR) compared to zero in 2023. Event causes were identified, and corrective actions were implemented to address the gaps.
- PNGS experienced two Site Event Free Day Resets (S-EFDR) compared to one in 2023. Event causes were identified, and corrective actions were implemented to address the gaps.

Initiatives to Improve and Sustain Favourable Performance Include:

- Use of Trend Vision to provide key insights and trends based on Station Condition Records (SCR) and Observation & Coaching (O&C) for stations.
- Continuing to build upon Fail Safe Strategies across the fleet through Pre-Job Briefs (PJB) and O&C programs.
- Renewed Trigger training licenses to end of 2026 for DNGS & PNGS
- PNGS continued to complete the “Coaching to Enhance Performance” training for Supervisors.
- Proactive strategies and actions taken around heightened periods of risk, such as Holiday and Outage planning, as well as more proactive activities including Safety Light and communications.
- Continued focus on the Stop When Unsure campaign as part of O&C improvement plan.
- TPI (Trending, Prevention, and Intervention) program to provide additional oversight on identified trends, with key actions put in place.
- Utilization of Validation of Trend (VOT) process to proactively identify and verify emerging trends adverse to safety and quality.
- Human performance is being further enhanced by continuing to build a positive stop culture that recognizes workers who stop work due to unknown or unexpected events.

Acronyms

Acronym	Meaning
ABF	Auxiliary Boiler Feed
ABFP	Auxiliary Boiler Feedwater Pump
AC	Alternating Current
ACU	Air Conditioning Units
ALARA	As Low as Reasonably Achievable
AMCA	Accumulator Control Module
ANDE	Advanced Non-Destructive Examination
BLC	Boiler Level Control
BLL	Boiler Low Level
BWR	Boiling Water Reactor
CANDU	CANada Deuterium Uranium (type of PHWR)
CC	Corrective Critical
CM	Corrective Maintenance
CN	Corrective Non-Critical
CNSC	Canadian Nuclear Safety Commission
CPI	Chemistry Performance Index
CRE	Collective Radiation Exposure
CTCS	Condenser Tube Cleaning System
D2O	Heavy Water
DC	Deficient Critical
DER	Design Electrical Rating
DM	Deficient Maintenance
DN	Deficient Non-Critical
DNGS	Darlington Nuclear Generating Station
EACP	Emergency AC Power
EC	Electricity Canada
ECI	Emergency Coolant Injection
ECR	Engineering Change Request
EPS	Emergency Power Supply
eSWP	Electronic Safe Work Plans
EUCG	Electric Utility Cost Group
FIN	Fix It Now
FLR	Forced Loss Rate
FME	Foreign Material Exclusion
FRI	Fuel Reliability Index
GWH	Gigawatt Hours
HIT	High Impact Team
HPER	Human Performance Error Rate

Acronym	Meaning
HPSI	High Pressure Safety Injection
HPU	Hydraulic Power Unit
HTHT	Heat Transport High Temperature
HTLF	Heat Transport Low Flow
HTS	Heat Transport System
HU	Human Performance
INPO	Institute of Nuclear Power Operators
ISAR	Industrial Safety Accident Rate
ISB	Integrated Station Brief
LBL	Low Boiler Level
MDS	Machine Delivered Scrape
MW	Mega-Watt
NFOC	Non-Fuel Operating Cost
NPI	Nuclear Performance Index
O&C	Observation & Coaching
OM&A	Operating, Maintenance & Administrative
OPEX	Operating Experience
OPG	Ontario Power Generation
PAWCS	Post-Accident Water Cooling System
PJB	Pre Job-Brief
PNGS	Pickering Nuclear Generating Station
PHTS	Primary Heat Transport System
PHWR	Pressurized Heavy Water Reactor
PM	Preventive Maintenance
PPP	Purchasing Power Parity
PRL	Plant Reliability List
PWR	Pressurized Water Reactor
QSP	Quality of Safety Practices
RDM	Rapid Delivery Machine
RTR	Reactor Trip Rate
RWPB	Retube Waste Processing Building
SATPS	Systematic Approach to Technical Problem Solving
SCL	Safety Classification and Learning
SDS	Shutdown System
SDSE	Shutdown System Enhancement
S-EFDR	Site event free day resets
SFCR	Single Fuel Channel Replacement
SG	Standby Generators
SPNMDI	System Does Not Meet Design Intent

Acronym	Meaning
SIF	Serious Injuries and Fatalities
SIR	Significant Issue Response
SPOC	Single Point of Contact
TGC	Total Generating Costs
TGC/MWH	Total Generating Costs per Mega-Watt Hour
TISA	Total Industrial Safety Accident Rate
TPI	Trending, Prevention, and Intervention
TRF	Tritium Removal Facility
TRIF	Total Recordable Injury Frequency
UCF	Unit Capability Factor
UCR	Unit Capability Rate
VOT	Validation of Trend
VVRS	Vault Vapour Recovery System
WANO	World Association of Nuclear Operators
WM	Work Management
WPII	WANO Performance Indicator Index

Safety and Reliability Definitions

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

Total Recordable Injury Frequency (TRIF)

The number of fatalities, lost time injuries, medical treatment injuries and restricted work injuries per 200,000 hours worked.

Total Industrial Safety Accident Rate (TISA)

This indicator is defined as the number of accidents for personnel at the station, including all utility personnel (permanent or temporary staff and except contractor personnel) assigned to the station, contractors, supplemental personnel and all other non-utility personnel working onsite that result in one or more days away from work (excluding the day of the accident) or one or more days or restricted work (excluding the day of the accident) or fatalities per 200,000 person-hours worked. TISA will combine site Industrial Safety Accident (ISA) rate and Contractor Safety Industrial Accident (CISA) rate.

Collective Radiation Exposure (CRE)

Total external and internal whole-body exposure determined by a dose control device (e.g., electronic personal dosimeter, dose recording device, etc.) 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.

Fuel Reliability Index (FRI)

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.

Reactor Automatic & Manual Trip Rate

The number of unplanned automatic reactor trips (reactor protection system logic actuations) and unplanned manual trips that occur per 7,000 hours of critical operation. For the purposes of the WANO Performance Indicator Index, the indicator is calculated over a rolling two years, on a unit basis. It is noted that to attain the maximum allotted points towards the WANO Performance Indicator Index, the Reactor Trip indicator must be less than or equal to 0.5. The Reactor Automatic and Manual Trip indicator contributes a maximum of 15% towards the WANO Performance Indicator Index.

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 set point 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.

Safety System Performance Indicators include the following:

- 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. 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).

WANO Performance Indicator Index (WPII)

INPO sponsored performance measure and is a weighted composite of 10 WANO Performance Indicators related to safety and production performance reliability. Effective January 01, 2024, Method 10 is replacing the previous Method 4.

Forced Loss Rate (FLR)

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

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

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

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 Outage Energy Losses

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

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 Rate (UCR)

Ratio of the available energy generation over a given time period to the reference energy generation over the same time period but not counting planned energy losses in the denominator. UCR, like UCF, is expressed as a percentage. All energy generation terms are determined relative to reference ambient conditions.

Available Energy Generation

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

Energy that could be produced if the unit were operated continuously at full power under reference ambient conditions.

Reference Ambient Conditions

Environmental conditions representative of the annual mean (or typical) ambient conditions for the unit.

Unit Capability Factor (UCF)

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.

Chemistry Performance Indicator (CPI)

CPI 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. 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 for 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

Online Deficient Maintenance (DM) Backlog

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 (CM) Backlog

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

Performed with the main generator connected to the grid.

Value for Money Definitions

The following definition summaries are taken from the January 2022 EUCG Nuclear Committee Data Definitions and Nuclear Integrated Information Database.

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), spent fuel storage costs and/or reimbursements, capital write-off expenditures, taxes (except Payroll), and COVID response costs.

Nuclear Fuel Costs

Total cost associated with a load of fuel in the reactor which is burned up in a given year. Fuel burn costs should NOT include spent fuel storage costs or fuel impairment.

Fuel impairment is the write-down of the value of the Nuclear fuel and thus reduces the amortization or fuel expense, occurs in plants either announcing shutdown or are in a pending shutdown.

Net Generation

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).

Design Electrical Rating (DER)

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 (Non-Fuel Operating Costs - NFOC)

All costs associated with normal operations, maintenance, and outage periods that occur within the current EUCG data reporting year. These costs should be fully burdened and reflect the total operating costs for labour, materials & equipment, outside services and other costs, but exclude depreciation, interest, taxes (except Payroll), COVID response costs, spent fuel storage costs and/or reimbursements, capital write-off expenditures, and new plant expenditures

New Plant Expenditures

All costs for supporting new nuclear generation and licensing efforts

Total Generating Costs (TGC)

Sum of operating costs, fuel costs and capital costs

Total Generating Costs (TGC) per MWh

Sum of operating costs, fuel costs and capital costs divided by Net Generation

Total Generating Costs (TGC) per Unit

Sum of operating costs, fuel costs and capital costs divided by Number of Units at Station

Non-Fuel Operating Costs (NFOC) per MWh

Operating costs divided by Net Generation

Fuel Costs per MWh

Nuclear Fuel costs divided by Net Generation

Capital Cost per MW DER

Capital costs divided by Design Electrical Rating (DER)

Human Performance Definitions

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

Human Performance Error Rate (HPER)

Represents the number of site level human performance events in an 18-month period per 200,000 Industrial Safety Accident Rate (ISAR) hours worked (including on site supplemental personnel).

Formula = $\{(\# \text{ of S-EFDRs}) / (\text{Total ISAR Hours} + \text{Total Contractor Hours})\} \times 200,000 \text{ Hours}$
(*Calculated as an 18-month rolling average*)

Non-utility Personnel

Includes contractors, 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.

Event

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.

Industry Peer Groups

All data provided by the peer groups (WANO, INPO, EC, and EUCG) is confidential. A redacted version of this report, which removes individual plant and unit names, is available from Nuclear Business Planning and Benchmarking should there be a requirement to publicly release this report.

Table 2: Industry Peer Groups

	Conexus Nuclear Inc. CANDU (WANO)	All North American PWR and PHWRs	INPO AP-928 Workgroup	INPO	EC	EUCG North American Plants (US and Canada)
Safety						
Total Recordable Injury Frequency					X	
Rolling Average Total Industrial Safety Accident Rate**x		X				
Rolling Average Collective Radiation Exposure**x	X					
Airborne Tritium Emissions	X					
Fuel Reliability Index*x	X					
2-Year Reactor Trip Rate*x	X					
3-Year Auxiliary Feedwater System Unavailability*x	X					
3-Year Emergency AC Power Unavailability*x	X					
3-Year High Pressure Safety Injection Unavailability*x	X					
Reliability						
Rolling Average WANO WPPI *x	X					
Rolling Average Forced Loss Rate**x	X					
Rolling Average Unit Capability Rate**x	X					
Rolling Average Unit Capability Factor**x	X					
Rolling Average Chemistry Performance Indicator**x	X					
1-Year On-line Deficient Maintenance Backlog*			X			
1-Year On-line Deficient Critical Backlog*			X			
1-Year On-line Corrective Maintenance Backlog*			X			
1-Year On-line Corrective Critical Backlog*			X			
Value for Money						
3-Year Total Generating Costs / MWh						X
3-Year Non-Fuel Operating Costs (OM&A) / MWh						X
3-Year Fuel Costs / MWh						X
3-Year Capital Costs / MW DER						X
Human Performance						
18-Month Human Performance Error Rate*				X		

* Sub-indicator of WANO WPPI

** Rolling 2 Year Average PNGS ; Rolling 3 Year Average DNGS

* Metric data is available in the INPO PIC/IRIS software systems.

Safety and Reliability Peer Groups

Primary source of benchmarking data for operational performance (Safety and Reliability) indicators is the World Association of Nuclear Operators (WANO). Eleven out of the twenty benchmarking metrics have been compared to the Conexus Nuclear Inc. CANDU (WANO) panel. Industrial Safety Accident Rate (ISAR) is compared to the All North American PWR and PHWR (WANO) panel.

All WANO performance indicators are presented at the unit and plant levels except the Industrial Safety Accident Rate (ISAR) and Emergency AC Power Unavailability which are only measured at the plant level.

Different peer groups were used for 5 specialized operating metrics which are not tracked through WANO:

- *Total Recordable Injury Frequency*: Electricity Canada panel was utilized. OPG benchmarks against EC Group 1 peers (a subset of all EC members), which incorporates organizations with more that 1,500 employees, including most provincial utilities.

- *On-line Deficient Maintenance Backlog, On-line Deficient Critical Backlog, On-line Corrective Maintenance Backlog, On-line Corrective Critical Backlog:* Institute of Nuclear Power Operations (INPO) AP-928 working group was utilized.

Value for Money Peer Group

For financial performance comparisons, data compiled by the Electric Utility Cost Group (EUCG) was utilized. 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 and on a per megawatt (MW) design electrical rating (DER) basis. The only CANDU operators reporting data to EUCG were OPG 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.

Human Performance Peer Group

For human performance comparisons, data was obtained from INPO.

Panels/Members

Table 3: WANO Panel

Operator	Plant	Operator	Plant
Ameren Missouri	Callaway	New Brunswick Power	Point Lepreau
Arizona Public Service Co.	Palo Verde	NextEra Energy Inc	Point Beach Seabrook St Lucie Turkey Point
Bruce Power	Bruce A Bruce B		
Dominion Energy	Millstone North Anna Surry V.C. Summer		
Duke Energy	Catawba Harris Mcguire Oconee Robinson		
Entergy Nuclear	Waterford ANO	Ontario Power Generation	Darlington Pickering
		Pacific Gas & Electric Co.	Diablo Canyon
Constellation Energy	Braidwood Byron Calvert Cliffs R.E. Ginna	Public Service Enterprise Group Nuclear	Salem
		Southern Nuclear Operating Co.	Farley Vogtle
American Electric Power Co.	Cook	STP Nuclear Operating Co.	South Texas
		Tennessee Valley Authority	Sequoyah Watts Bar
International CANDU	Cernavoda Embalse Qinshan 3 Wolsong A Wolsong B	Vistra Corp	Beaver Valley Comanche Peak Davis-Besse
		Wolf Creek Generating Station	Wolf Creek
		Xcel Energy Inc	Prairie Island

Table 4: EUCG Panel

Operator	Plant	Operator	Plant
AmerenUE	Callaway	FirstEnergy Nuclear Operating Co.	Beaver Valley
American Electric Power Co. Inc.	Cook		Davis-Besse
Arizona Public Service Co.	Palo Verde	Florida Power & Light Co.	Perry
			St Lucie
Bruce Power	Bruce	Luminant Generation	Turkey Point
			Comanche Peak
Dominion Generation	Millstone	Nebraska Public Power District	Cooper
	North Anna		Point Beach
	Surry	NextEra Energy Resources	Seabrook
	V.C. Summer		Monticello
DTE Energy	Fermi	Northern States Power Company	Prairie Island
Duke Energy	Brunswick		Ontario Power Generation
	Catawba	Pickering	
	Harris	Pacific Gas & Co.	Diablo Canyon
	Mcguire		Hope Creek
	Oconee	Public Service Enterprise Group Nuclear	Salem
	Robinson		Farley
Energy Northwest	Columbia	Southern Nuclear Operating Co.	Hatch
Entergy Nuclear	Arkansas Nuclear One		STP Nuclear Operating Co.
	Grand Gulf	South Texas	
	River Bend	Talen Energy	Susquehanna
	Waterford		Browns Ferry
Constellation Energy	Braidwood	Tennessee Valley Authority	Sequoyah
	Byron		Watts Bar
	Calvert Cliffs	Wolf Creek Nuclear Operations Corp.	Wolf Creek
	Clinton		
	Dresden		
	Fitzpatrick		
	Lasalle		
	Limerick		
	Nine Mile		
	Peach Bottom		
	Quad Cities		
R.E. Ginna			

Table 5: Conexus Nuclear Inc. CANDU (WANO)

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

Table 6: Electricity Canada Members

Companies	Companies
Alectra Inc.	London Hydro
AltaLink	Manitoba Hydro
ATCO Electric (Alberta Power Ltd.)	Maritime Electric
BC Hydro	New Brunswick Power
Bluewater Power Distribution Corporation	Newfoundland and Labrador Hydro
Canadian Power Holdings	Newfoundland Power Inc.
Capital Power	Northwest Territories Power Corporation
City of Medicine Hat	Nova Scotia Power/Emera
City of Red Deer	Oakville Enterprises Corporation
Clearlight Energy	Ontario Power Generation
Elexicon	Qulliq Energy Corporation
ENMAX Corporation	Rio Tinto
EPCOR Utilities Inc.	Saint John Energy
Evolugen	Saskatoon Light & Power
FortisAlberta Inc.	SaskPower
FortisBC Inc.	TC Energy
FortisOntario	Toronto Hydro Corporation
Hydro One Inc.	TransAlta Corporation
Hydro Ottawa	Utilities Kingston
Hydro-Québec	Wataynikaneyap Power
IESO	Yukon Energy Corporation
Invenergy	

Table 7: INPO Members for On-Line Maintenance Backlogs

Plant	
Arkansas Nuclear One (ANO)	McGuire
Barakah	Millstone
Beaver Valley	Monticello
Braidwood	Nine Mile Point
Browns Ferry	North Anna
Bruce	Oconee
Brunswick	Oyster Creek
Byron	Palo Verde
Callaway	Peach Bottom
Calvert Cliffs	Perry
Catawba	Pickering
Clinton	Pilgrim
Columbia Gen	Point Beach
Comanche Peak	Point Lepreau
Cook	Prairie Island
Cooper	Quad Cities
Darlington	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	Turkey Point
Hatch	Vogtle
Hope Creek	Waterford
Koeberg	Watts Bar
LaSalle	Wolf Creek
Limerick	

Table 8: INPO Members for Human Performance Error Rate

Plant	
Arkansas Nuclear One (ANO)	McGuire
Barakah	Millstone
Beaver Valley	Monticello
Braidwood	Nine Mile Point
Browns Ferry	North Anna
Bruce	Oconee
Brunswick	Oyster Creek
Byron	Palo Verde
Callaway	Peach Bottom
Calvert Cliffs	Perry
Catawba	Pickering
Clinton	Pilgrim
Columbia Gen	Point Beach
Comanche Peak	Point Lepreau
Cook	Prairie Island
Cooper	Quad Cities
Darlington	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	Turkey Point
Hatch	Vogtle
Hope Creek	Waterford
Koeberg	Watts Bar
LaSalle	Wolf Creek
Limerick	