SCOTTMADDEN PHASE 1 NUCLEAR BENCHMARKING REPORT

1.0 INTRODUCTION

In 2009, OPG undertook a major new nuclear benchmarking initiative in conjunction with the development of its 2010-2014 nuclear business plan. This initiative was undertaken by OPG Nuclear, with the assistance of ScottMadden Inc. (“ScottMadden”), a general management consulting firm specializing in the provision of benchmarking and business planning consulting services to nuclear utilities.

Given the importance of this initiative, OPG sought to have incorporated into the reports the best comparative data available. As a result, the ScottMadden Phase 1 and Phase 2 reports rely extensively upon data extracted from leading industry association databases.

Data provided by the World Association of Nuclear Operators (WANO) was the primary source of benchmarking data for operational performance indicators. For financial performance comparisons, data was compiled from the database of the Electric Utility Cost Group (EUCG). Data was also obtained from the Canadian Electricity Association (CEA) for the all-injury rate metric and from a workgroup of the Institute for Nuclear Power Operations (INPO) for maintenance backlog comparisons. OPG, as a member of these industry associations, is bound by the confidentiality provisions that these associations have with respect to the use of their data.

OPG sought and obtained permission to file EUCG, WANO, and INPO comparisons on the condition that it not identify any company names, other than OPG, associated with the data. With the agreement of ScottMadden, OPG produced the report filed at Ex. F5-T1-S1 with company names from EUCG, WANO, and INPO removed from the charts and graphs showing OPG’s relative performance. For EUCG charts, markings indicating CANDU reactors have also been removed as they would allow identification of Bruce Power data, by inference. The CEA also requires that OPG not disclose the first quartile performance for the all-injury metric and this has been removed from the report filed at Ex. F5-T1-S1.

The report is marked "Confidential" because when it was originally produced it included confidential information. The report as filed, with the names of the companies associated with the comparative data removed, is no longer confidential.

SCOTTMADDEN
Management Consultants

July 2, 2009

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Reference: **OPG Nuclear 2009 Benchmarking Report**

Dear Sirs:

By means of this transmittal letter, we are submitting to Ontario Power Generation (OPG) the final version of the *OPG Nuclear 2009 Benchmarking Report*. This report presents a comparison of OPG Nuclear's financial and non-financial performance to that of nuclear industry peer groups both in Canada and the Unites States. The report was prepared as part of OPG's commitment to "performance informed" business management and responds to the Ontario Energy Board's desire for a clear and consistent approach to industry benchmarking.

In preparing this report ScottMadden personnel, assisted by OPG, (a) identified the key performance metrics which would be benchmarked, (b) identified the most appropriate peer groups for comparison, and (c) prepared supporting analyses, charts and the report document. OPG personnel supplied the OPG data used for comparison and provided insight regarding key factors believed to contribute to specific performance gaps.

Effective benchmarking requires the selection of appropriate performance indicators and appropriate peer groups. A total of 19 performance indicators were chosen for comparison. They cover three of the four OPG cornerstone value areas (safety, reliability and value for money)[1]. Each performance indicator is a standard nuclear industry metric, with standard definitions and comparable year-over-year data. In

[1] Robust, consistent benchmark metrics are currently not available for OPG's cornerstone value of human performance.

preparing this report, we used five different peer groups which varied depending upon the performance indicator in question. The data for these peer groups was provided by recognized industry sources[2] and represent comparative data that have stood the test of time within the industry.

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

Finally, it was our intent in developing this report to foster OPG's internal ability to undertake comprehensive performance benchmarking on a recurring basis. Accordingly, we worked with OPG personnel to prepare a formal OPG Nuclear "Benchmarking Report Procedure" and trained OPG personnel in how to access data and compile the report in the future. This procedure, and the accompanying training, should allow OPG to update the *Nuclear Benchmarking Report* on an annual basis as part of its revised business planning process.

Yours very truly,

John H. Sequeira, Ph.D.
Partner

[2] Data sources included the World Association of Nuclear Operators (WANO), the CANDU Owners Group (COG), the Canadian Electricity Association (CEA) and the Electric Utility Cost Group (EUCG).

July 2, 2009

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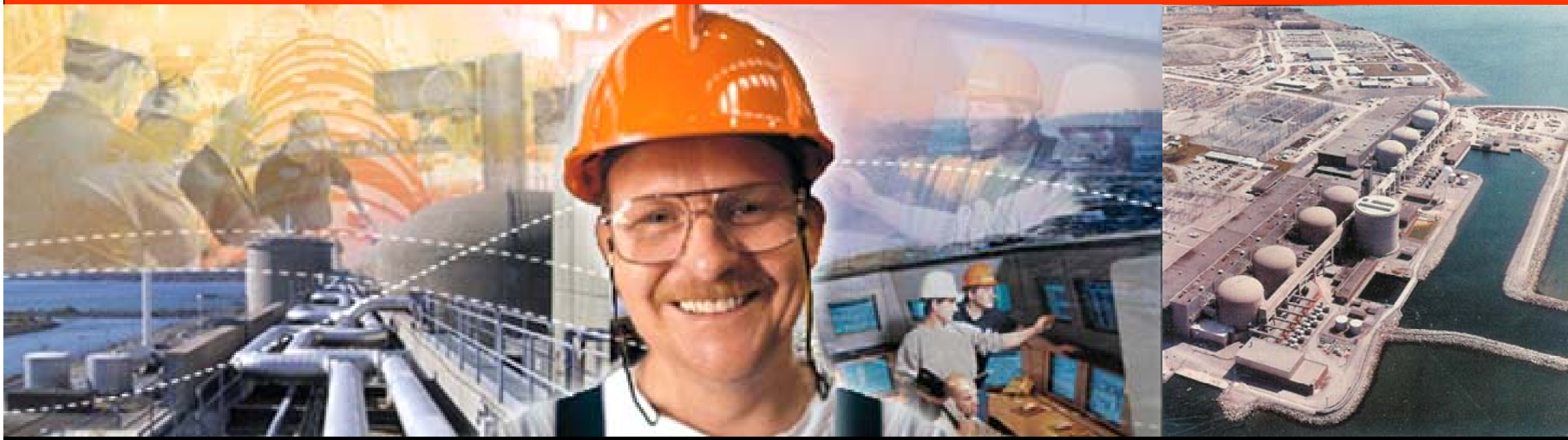
OPG Nuclear

2009 Benchmarking Report



ONTARIO POWER GENERATION

SCOTTMADDEN
Management Consultants

1.0 EXECUTIVE SUMMARY

Background

This report presents a comparison of Ontario Power Generation (OPG) Nuclear's financial and non-financial performance to that of nuclear industry peer groups both in Canada and the United States. The report was prepared as part of OPG's commitment to "performance informed" business management and to the requests of the Ontario Energy Board for a clear and consistent approach to industry benchmarking. The results of this report will be used during the 2010-2014 business planning cycle to help drive a "gap-based" approach to business improvement.

ScottMadden, Inc. (ScottMadden) is an external consulting company with recognized leadership in nuclear business planning and benchmarking. ScottMadden personnel worked side-by-side with OPG personnel during the period March 24 through May 22, 2009 to prepare this report. ScottMadden, assisted by OPG, (a) identified key performance metrics which would be benchmarked, (b) identified the most appropriate peer groups for comparison, and (c) prepared supporting analyses, charts and the final report. OPG personnel responsible for the designated performance metrics assisted the effort by supplying the OPG data used for benchmarking and providing insight into the factors contributing to current operational performance so that gap analysis could be performed.

In addition to this report, ScottMadden worked with OPG personnel to develop a *Benchmarking Report Procedure* which will be incorporated into OPG's standard business planning procedures. This procedure will enable OPG to prepare annual updates to this report. OPG personnel will be trained in this procedure and will independently update the benchmarking effort on an ongoing basis.

Industry Peer Groups

Effective comparison of performance requires both the selection of appropriate performance indicators and the selection of appropriate peer groups for comparison. ScottMadden recommended that OPG use different peer groups depending upon the performance measure to be compared. ScottMadden also recommended that OPG utilize standard data sources that have stood the test of time and are widely utilized within the nuclear industry. In all, five different peer groups were used as illustrated in Table 1.

Table 1: Benchmarking Indicators

	All COG CANDUs (WANO)	All North American PWR and PHWRs (WANO)	INPO AP928 Workgroup	CEA Tier 1	All Plants in EUCG
Safety					
All Injury Rate				X	
2-Year Industrial Safety Accident Rate*		X			
Fuel Reliability*	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			
2-Year Collective Radiation Exposure*	X	X			
Airborne Tritium Emissions per Unit	X				
Reliability					
WANO NPI	X	X			
2-Year Forced Loss Rate*	X	X			
2-Year Unit Capability Factor*	X	X			
2-Year Chemistry Performance Indicator*	X	X			
1-Year On-line Elective Maintenance Backlog (OEMB)			X		
1-Year On-line Corrective Maintenance Backlog (OCMB)			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 (OM&A) / MWh					X
3-Year Capital Costs / MW DER					X

* Subindicator of WANO NPI

Data provided by the World Association of Nuclear Operators (WANO, see Section 6.0, Table 10 for membership) was the primary source of benchmarking data for operational performance indicators. Three peer groups were established using WANO data: (a) CANDU Owners Group (COG) CANDUs (Section 6.0, Table 12), (b) All North American Pressurized Water Reactors (PWRs) and Pressurized Heavy Water Reactors (PHWRs) which includes CANDU plants as PHWRs, and (c) All North American plants which includes all those above plus Boiling Water Reactors (BWRs). Some WANO performance indicators are measured at the unit level while others are measured at the plant level.

For a few of the specialized operating metrics different peer groups were used since WANO data is not available for these metrics. For comparing maintenance backlog, ScottMadden recommended using a peer group consisting of all plants participating in the INPO AP928 workgroup (participants are listed within the review of the metrics, Section 3.0). For injury rate comparison, ScottMadden recommended using data available from the Canadian Electricity Association (CEA) with the members listed in Section 6.0, Table 13.

For financial performance comparisons, ScottMadden recommended using data compiled by the Electric Utility Cost Group (EUCG). EUCG is a nuclear industry operating group covering 69 nuclear plants (Section 6.0, Table 11), of which 63 provided 2008 data in time for the production of this report. EUCG cost indicators are available at the plant level only and were compared on a net MWh generated basis (will be referred to as just MWh for the remainder of the document) and a per MW design electrical rating (DER) basis.

The only CANDU operators reporting EUCG data (available as of March 2009) were OPG and Bruce Power. ScottMadden does not consider this to be a sufficiently large panel to provide a basis for comparison. Should more CANDU operators choose to join EUCG in the future, comparisons to this panel should be reconsidered. Specific one-on-one comparisons to Bruce Power are still useful and may be undertaken as appropriate during the development of business planning targets.

Performance Indicators

Good benchmarked performance indicators are defined by ScottMadden as metrics with standard definitions, reliable data sources, and utilization across a good 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, ScottMadden believes in a balanced approach with metrics covering all key areas of the business, as possible.

ScottMadden recommended the comparison of 19 key performance indicators to provide a balanced view of performance and for which consistent, comparable data is available. These indicators are listed in Table 1. In this report, they are divided into three categories which align with three of OPG's four cornerstone values. OPG's four cornerstone values are safety, human performance, reliability, and value for money. The three cornerstone areas included in the report are safety, reliability, and value for money.

Robust, consistent benchmark metrics are currently not available for OPG's cornerstone value of human performance. Internal metrics for this cornerstone value will continue to be used by OPG but cannot be compared to reliable industry standards at this time. Additionally, the effects of good or poor human performance manifest within many of the safety and reliability cornerstone metrics. Results in areas like 2-Year Industrial Safety Accident Rate, 2-Year Forced Loss Rate and 2-Year Unit Capability Factor can be directly impacted by human performance events.

Report Structure

The report is structured to first focus on the three cornerstone value areas, with detailed comparisons at the plant, and where applicable, unit level (Sections 2.0-4.0). Within each section, each of the metrics and corresponding peer groups have a specific format. First, each indicator is displayed graphically from best to worst (in bar chart format) for the most recent year for which data is available; in this case 2008. Next, the historical trend is graphed (in line chart format) using data for the last three to five years (depending upon availability and metric). Each graph also includes median and best quartile results, and for some WANO operating metrics, the graph also shows the values required to achieve full WANO NPI points. Following the graphical representation of performance are observations regarding the data as well as insights into the key factors driving performance at OPG.

The last section of the report is designed to provide an operator level summary across a few high-level metrics (Section 5.0). The operator level analysis looks at fleet operators across North America, utilizing a simple average of the results (mean) from each of their units/plants. WANO (operations related) results are averaged at the unit level and EUCG (cost related) results are averaged at the plant level. Included are a few key operational metrics and total generating costs.

Section 6.0 provides an appendix of supporting information, including common acronyms, definitions and panel composition details. Zero values are excluded from all calculations except where zero is a valid result. Missing data was imputed by averaging the prior and subsequent year if possible. If this was not possible, the average of the two most recent years was used.

Benchmarking Results – Plant Level Summary

Table 2 provides a summary of OPG's performance compared to the benchmark panel. For the WANO metrics with two panels (i.e. all COG CANDU; all North American PWR and PHWR), the all COG CANDU panel was used. Calculations in the table are at the plant level.

For reference, green shaded boxes indicate that performance is above best quartile or maximum NPI points are achieved if applicable, white shaded boxes indicate between best quartile and median, yellow shaded boxes indicate that performance is between median and the worst quartile, and red shaded boxes indicate that performance is within the worst quartile. Each metric represented here is analyzed in this report.

Table 2: Plant Level Performance Summary

Metric	Best Quartile*	Median*	Pickering A	Pickering B	Darlington
Safety					
All Injury Rate			0.73 ⇧	0.96 ⇧	1.04 ⇧
2-Year Industrial Safety Accident Rate	0.05	0.09	0.14 ⇩	0.07 ⇧	0.04 ⇧
2-Year Collective Radiation Exposure (man-rem per unit)	62.15	81.84	44.2 ⇧	95.81 ⇧	72.83 ⇧
Airborne Tritium (TBq) Emissions per Unit	48.0	101.0	101.0 ⇧	50.7 ⇧	40.0 ⇩
Fuel Reliability (microcuries per gram)	0.000001	0.000165	0.00059 ⇧	0.00159 ⇩	0.00025 ⇧
2-Year Reactor Trip Rate (# per 7,000 hrs)	0.00	0.33	1.22 ⇩	0.26 ⇔	0.00 ⇔
3-Year Auxiliary Feedwater System Unavailability	0.0014	0.0020	0.0119 ⇧	0.0040 ⇧	0.0017 ⇧
3-Year Emergency AC Power Unavailability	0.0024	0.0076	0.0081 ⇩	0.0091 ⇧	0.0020 ⇔
3-Year High Pressure Safety Injection Unavailability	0.0001	0.0037	0.0012 ⇧	0.0001 ⇧	0.0001 ⇧
Reliability					
WANO NPI (Index)	96.19	62.46	60.84 ⇧	60.93 ⇔	95.67 ⇔
2-Year Forced Loss Rate (%)	0.68	3.79	37.90 ⇩	18.19 ⇩	0.93 ⇧
2-Year Unit Capability Factor (%)	90.97	84.31	56.6 ⇩	73.17 ⇔	91.99 ⇔
2-Year Chemistry Performance Indicator (Index)	1.00	1.01	1.13 ⇧	1.25 ⇩	1.00 ⇔
1-Year Online Elective Maintenance (work orders/unit)	218	278	425 ⇧	695 ⇧	311 ⇧
1-Year Online Corrective Maintenance (work orders/unit)	4	7	14 ⇧	28 ⇧	11 ⇧
Value for Money					
3-Year Total Generating Costs per MWh ($/Net MWh)	28.66	32.31	92.27 ⇧	58.68 ⇔	30.08 ⇔
3-Year Non-Fuel Operating Costs per MWh ($/Net MWh)	18.06	21.28	82.62 ⇧	50.95 ⇔	25.10 ⇔
3-Year Fuel Costs per MWh ($/Net MWh)	5.02	5.37	2.64 ⇔	2.68 ⇔	2.62 ⇔
3-Year Capital Costs per MW DER	32.79	46.22	32.07 ⇩	32.44 ⇧	18.79 ⇔

*Panel used for WANO quartile and median data was All COG CANDU

⇧ = overall upward trend during reporting period

⇩ = overall declining trend during reporting period

⇔ = consistent performance during the reporting period

Green = best quartile performance/max NPI points achieved if applicable
White = 2nd quartile performance
Yellow = 3rd quartile performance
Red = lowest quartile performance

Benchmarking Results – Operator Summary

Operator level summary results for a specific metric are the average (mean) of the results across all plants managed by the given nuclear operator, providing a comprehensive overview of a nuclear operator's financial and operating performance. While the operator level summary results presented in Section 5.0 include a calculation for Unit Capability Factor (UCF) as well as WANO Nuclear Performance Index (WANO NPI) and Total Generating Costs per MWh, this executive summary only addresses WANO NPI and Total Generating Costs per MWh. This is because UCF is a subcomponent of WANO NPI. Full details of the operator summary results can be found in Section 5.0.

i) WANO Nuclear Performance Index (NPI): WANO NPI is designed to provide a comprehensive overview of a nuclear operator's overall operating performance. OPG's results for this indicator (at the operator level) are highlighted in Table 3 below. Rankings were calculated using the average (mean) results for the units in operation during the given year. The WANO data set is comprised of 20 major operators. A listing of the operators and plants can be found in the appendix (Table 10). The results are not weighted averages in any way.

OPG's WANO NPI ranking is low in comparison to other operators within the group. OPG ranked 17 out of a list of 20 fleet operators. Low unit capability factor (UCF) and high forced loss rate (FLR) are the primary contributors to this relative ranking.

Table 3: Average WANO NPI Rankings

	2006	2007	2008
	9	8	1
	4	5	2
	2	1	3
	7	3	4
	19	17	5
	12	13	6
	5	9	7
	3	4	8
	6	10	9
	11	6	10
	8	11	11
	10	7	12
	1	2	13
	13	12	14
	14	14	15
	15	15	16
OPG	17	16	17
	20	19	18
	16	20	19
	18	18	20

It should be pointed out that operator level data masks the wide disparity in plant performance found at OPG. Darlington consistently performed better than Pickering A and Pickering B, typically by a wide margin, for key operating indicators. The plant level detail contained in Section 2.0 and Section 3.0 provides a more detailed look into these differences. Clearly the challenges faced by each of the OPG stations are not consistent.

Additionally, the WANO NPI results of all CANDU operators are concentrated at the bottom of the peer group for the period 2006-2008.

ii) Total Generating Cost per MWh: Total Generating Cost per MWh is the highest indicator of an operator's overall financial performance. This metric is the sum of non-fuel operating costs per MWh, fuel costs per MWh, and capital costs per MWh, and represents the "all in" cost of producing each MWh of power.

The EUCG data set is comprised of 16 major operators. A listing of the operators and plants can be found in the appendix (Table 11). OPG's standing among these 16 North American fleet operators is highlighted in Table 4 below.

Table 4: Three-Year Total Generating Costs per MWh Rankings

	2005	2006	2007	2008
	2	1	3	1
	6	3	2	2
	1	9	9	3
	3	5	4	4
	10	14	10	5
	14	7	8	6
	4	6	5	7
	7	4	1	8
	9	11	6	9
	8	2	12	10
	13	8	11	11
	11	10	7	12
	12	12	15	13
	5	13	14	14
	15	15	13	15
OPG	16	16	16	16

It should be noted that OPG's financial performance is reported on a "per MWh" basis and is influenced by low capability factors at both Pickering A and Pickering B.

Consistent with the WANO NPI, the operator level data masks the wide disparity in plant performance found at OPG. Darlington consistently performed better than Pickering A and Pickering B, typically by a wide margin, for key cost indicators.

Section 4.0, Value for Money, of this report examines the components of Total Generating Cost that contribute to the above observations.

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2.0 SAFETY

Methodology and Sources of Data

The majority of safety metrics were calculated using the data from the WANO website. Any data labeled as invalid by WANO was ignored and 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 period 2001-2008 was obtained and averages are as provided by WANO.

The all-injury rate was calculated using data from the Canadian Electricity Association (CEA). Median information and individual company information was not available for this metric, therefore only trend and best quartile information is presented. The peer group for this metric is limited to members of CEA (Section 6.0, Table 13).

Airborne Tritium Exposure per Unit data was collected from COG. Data from 2003 to 2007 was collected. The peer group for this metric is all CANDUs which are members of COG (Section 6.0, Table 12).

Discussion

Nine metrics are included in this benchmarking report to reflect safety performance, including seven of the ten metrics which comprise the WANO NPI index: industrial safety accident rate, fuel reliability, unplanned automatic reactor trips, auxiliary feedwater safety system, emergency AC power safety system, high pressure safety injection and collective radiation exposure. The remaining WANO NPI metrics are included in the Reliability section. Additionally, the safety metrics include the CEA all-injury rate and airborne tritium emissions per unit.

Overall, OPG's performance in the WANO NPI safety metrics is strong, achieving full NPI points for many of the metrics. However, collective radiation exposure (CRE) performance is mixed among OPG plants.

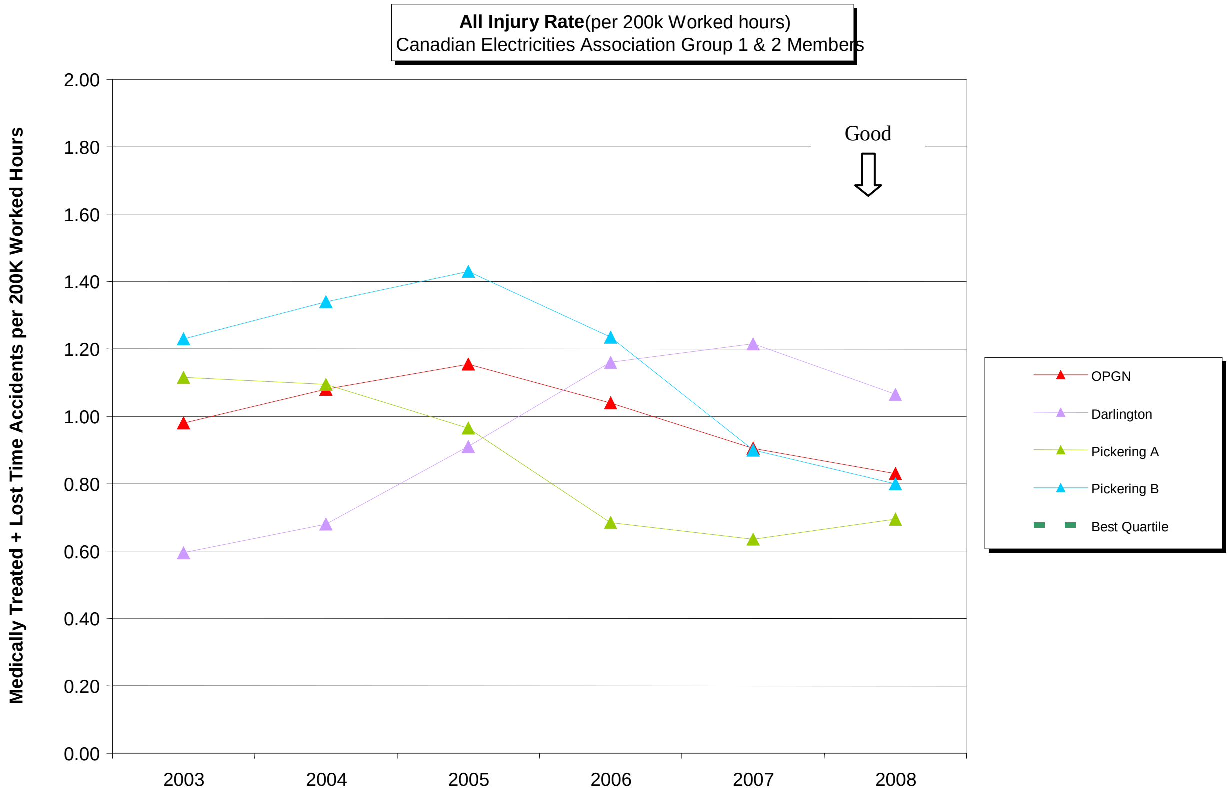
Key drivers for OPG performance for CRE are outage duration and scope, plant design, radiation source term and use of technology to reduce radiation source term, and human performance. Darlington has historically performed near the median but fell below median in 2007 primarily due to two planned outages and three forced outages. It is anticipated that Darlington can achieve best quartile against the CANDU panel, but significant work would be required to achieve best quartile among North American plants.

Pickering A's performance is expected to drop below median as a result of a change in exposure reporting. Until 2007, Pickering A's CRE performance was reported on a four-unit basis, although P2 and P3 were in safe storage. Beginning in 2008, Pickering A is be reported on a two unit basis. In addition, Pickering A's performance is negatively impacted by plant age, high radiation source term, and outage work and scope.

Pickering B's performance is below median. This performance is attributed to extensive planned outages in 2007 and 2008, a forced outage in 2007, and high radiation source term. Future performance of Pickering B will be determined by decisions on scope of continued operations maintenance activities.

Relative to the non WANO NPI safety metrics, OPG's performance for the all-injury rate is strong, performing in the best quartile since 2003. Performance in the airborne tritium emissions per unit has also been fairly strong, with Darlington performing in the best quartile and Pickering B finishing one position outside of the best quartile. Pickering A is performing worse than median by one position.

All-Injury Rate



Observations – All-Injury Rate

Trend

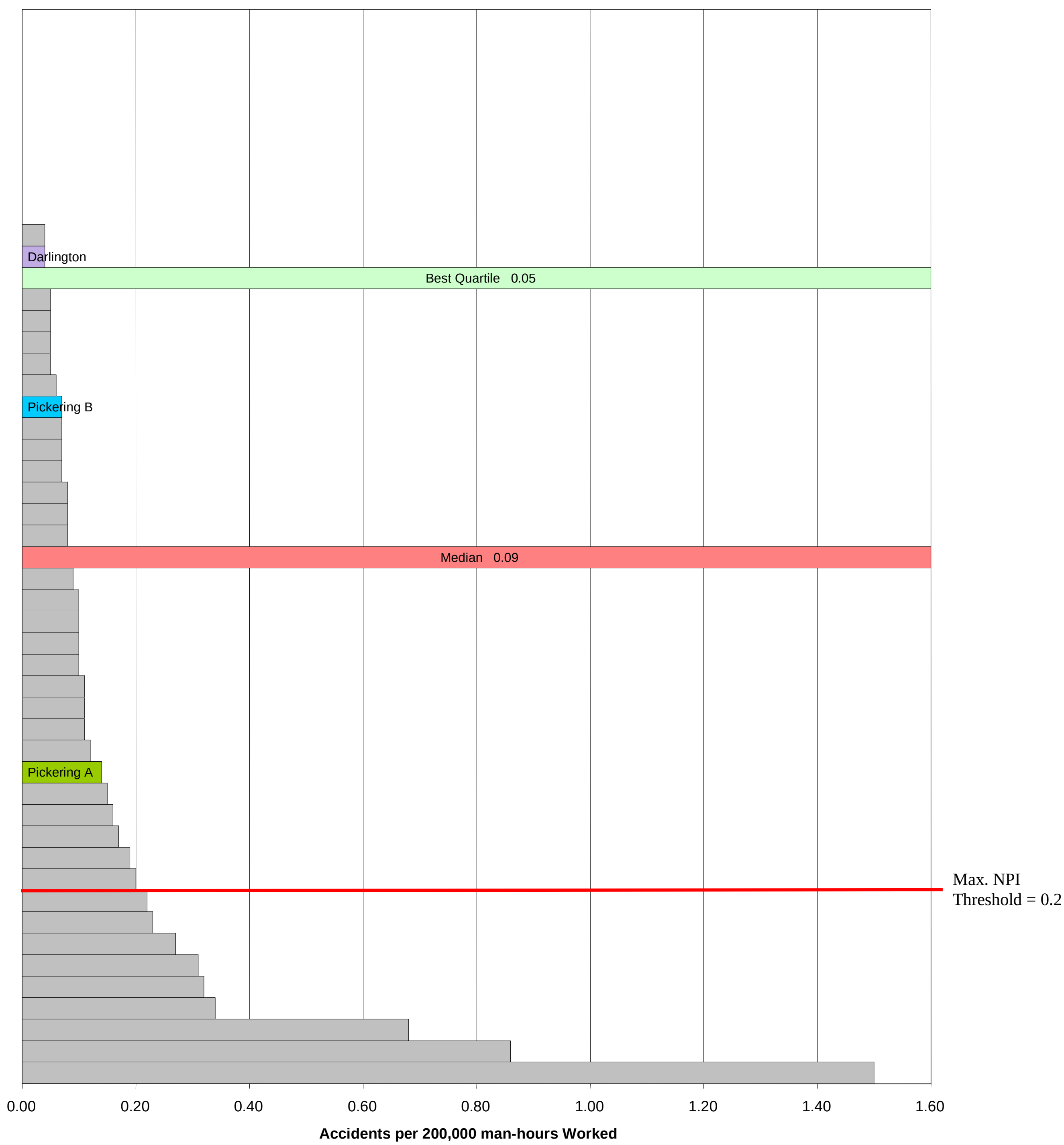
- All OPG plants are above best quartile in terms of all-injury rate and have been since 2003
- OPG has shown improvement in the number of medically treated and lost time accidents since 2004
- Darlington experienced increasing injuries from 2003-2006, but has steadily improved since 2006

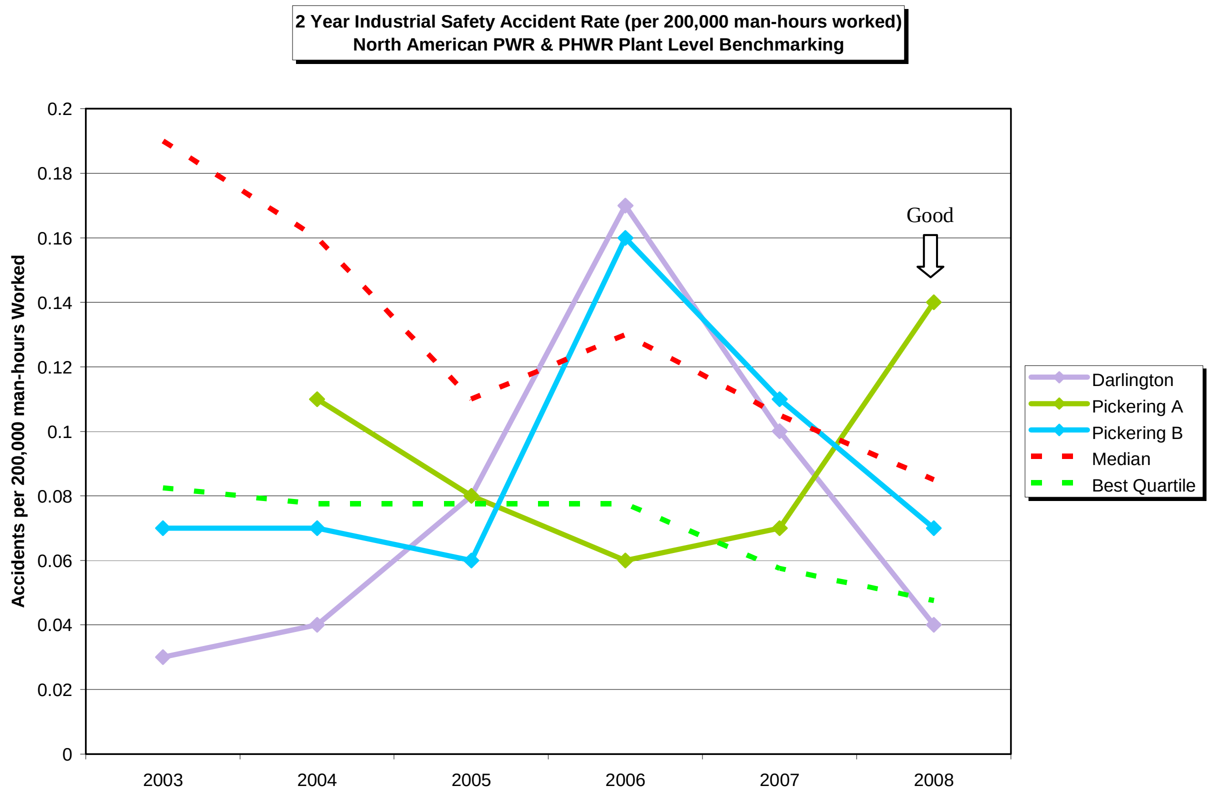
Factors Contributing to Performance

- Providing more rapid medical services on-site and with preferred service providers in the community, as other Canadian Electricity Association (CEA) member utilities have done, would reduce the number of lost time accidents and help to maintain best quartile performance
- Targeted programs and initiatives addressing common injuries, such as musculoskeletal disorders, reduce the frequency of these type of injuries and lost time
- OPG has a very robust reporting culture for all injuries, including minor, repetitive, and chronic injuries that exceed other utilities in the benchmarking panel
- This metric is more integrated than the Industrial Safety Accident Rate (ISAR) and includes transmission and distribution personnel

2-Year Industrial Safety Accident Rate

2008 2 Year Industrial Safety Accident Rate (per 200,000 man-hours worked)
North American PWR & PHWR Plant Level Benchmarking




2 Year Industrial Safety Accident Rate (per 200,000 man-hours worked)
North American PWR & PHWR Plant Level Benchmarking
Accidents per 200,000 man-hours Worked
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
2003
2004
2005
2006
2007
2008
Good
Darlington
Pickering A
Pickering B
Median
Best Quartile

Observations – 2-Year Industrial Safety Accident Rate

- The performance of OPG's units has been shown relative to best quartile, median, and the threshold established by WANO to achieve full WANO NPI points. Since achievement of full WANO NPI points is recognized within the industry as a measure of desirable performance, performance gaps are assessed against full WANO NPI points in addition to median and best quartile

2008 (2-Year Rolling Average)
- Best quartile for 2008 was 0.05
- Darlington ISAR performance is in the best quartile for 2008 at .04
- Pickering A is below the median of 0.09 for 2008
- Pickering B is above median of 0.09 for 2008

Trend
- Darlington fell to below best quartile in 2005 and continued sliding in 2006, but returned to best quartile in 2008
- Pickering A performance remained close to best quartile for 2004-2007, but declined in 2008
- Pickering B performance was within best quartile for 2003-2005, declining in 2006, but returning to better than the median in 2008

Factors Contributing to Performance

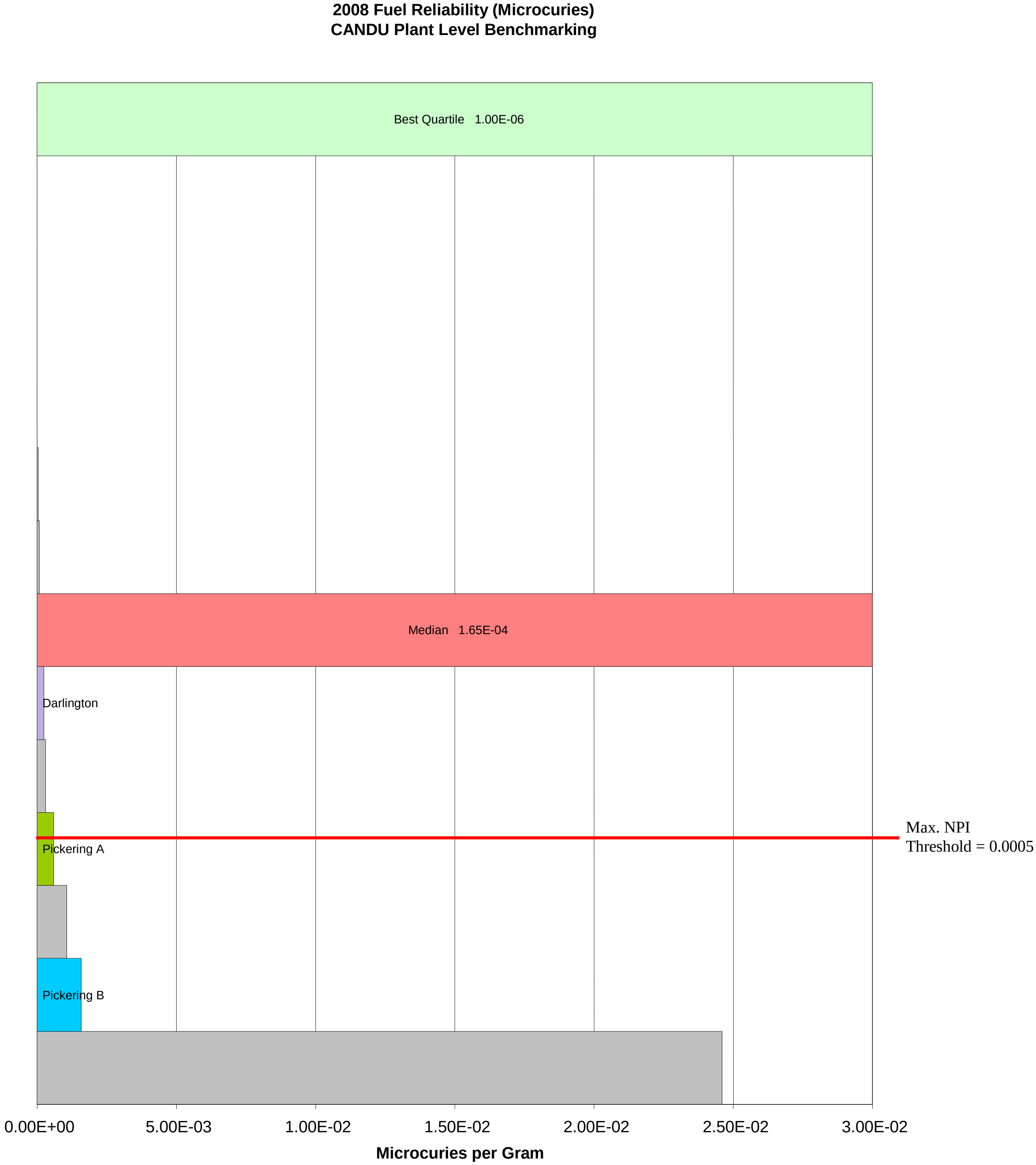
- Greater focus on lost time accident prevention through targeted initiatives on sources of lost time accidents, such as musculoskeletal injury prevention, will improve OPG performance
- Reviewing hazard control programs of other utilities in the benchmarking panel for possible implementation at OPG may be beneficial and lead to reduced injuries
- ISAR is a measure of "permanent utility personnel" and does not include contractors. Many of the utilities in the benchmarking panel utilize contractors to a greater extent than OPG for higher risk work activities (e.g. outages)

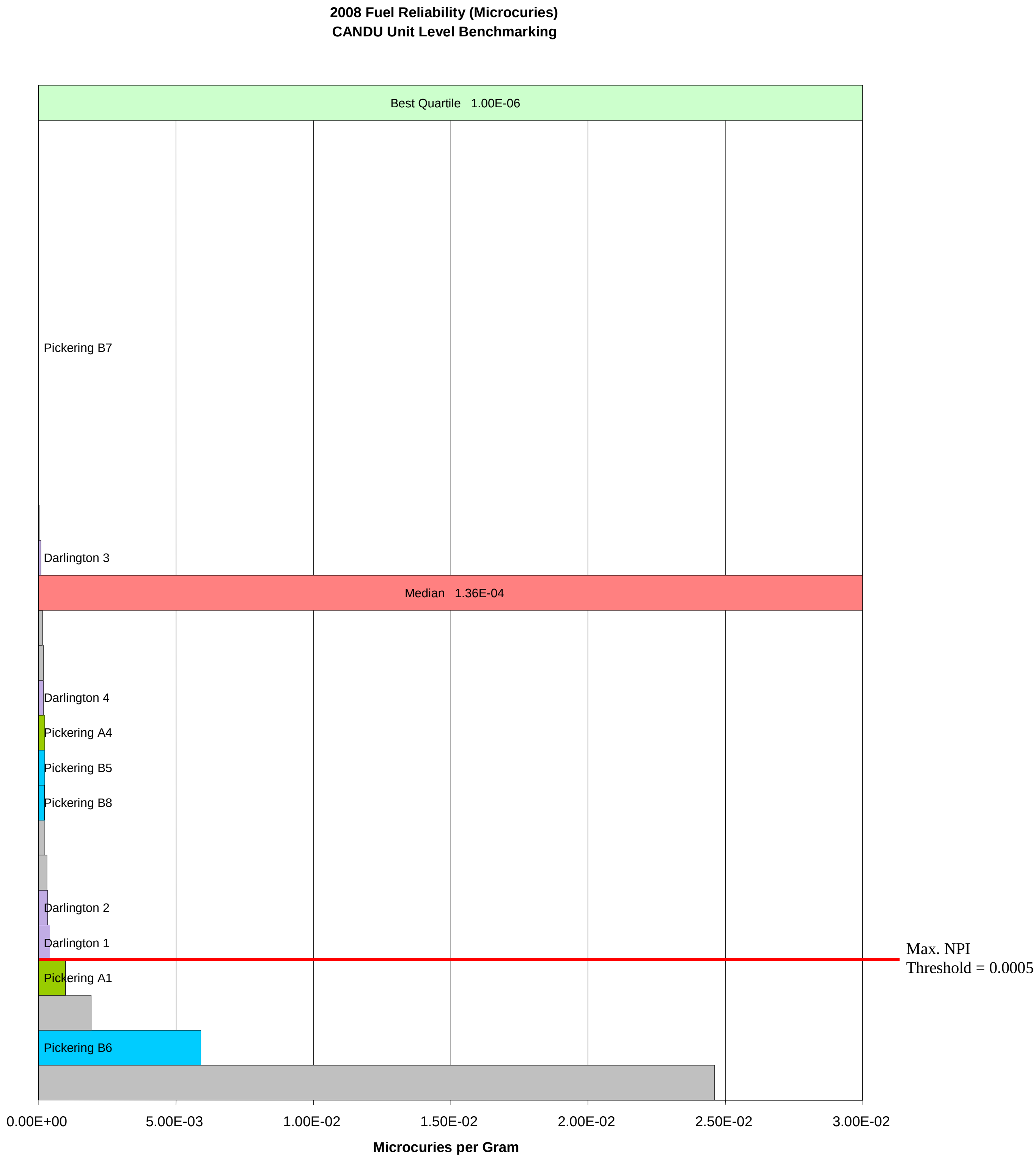
Darlington
- Darlington has no performance gap

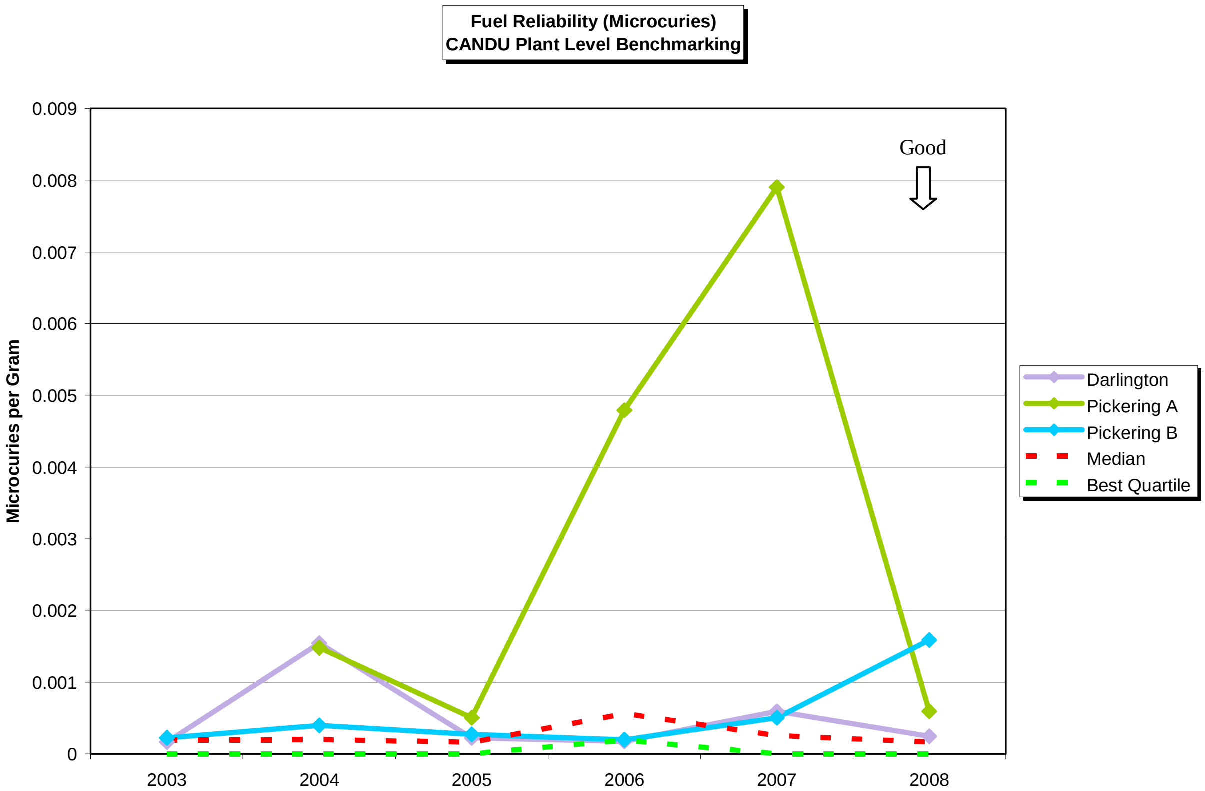
Pickering A
- Pickering A must have zero lost-time injuries to achieve best quartile
- Pickering A experienced two lost-time accidents in 2008, which put Pickering A ISAR significantly worse than median

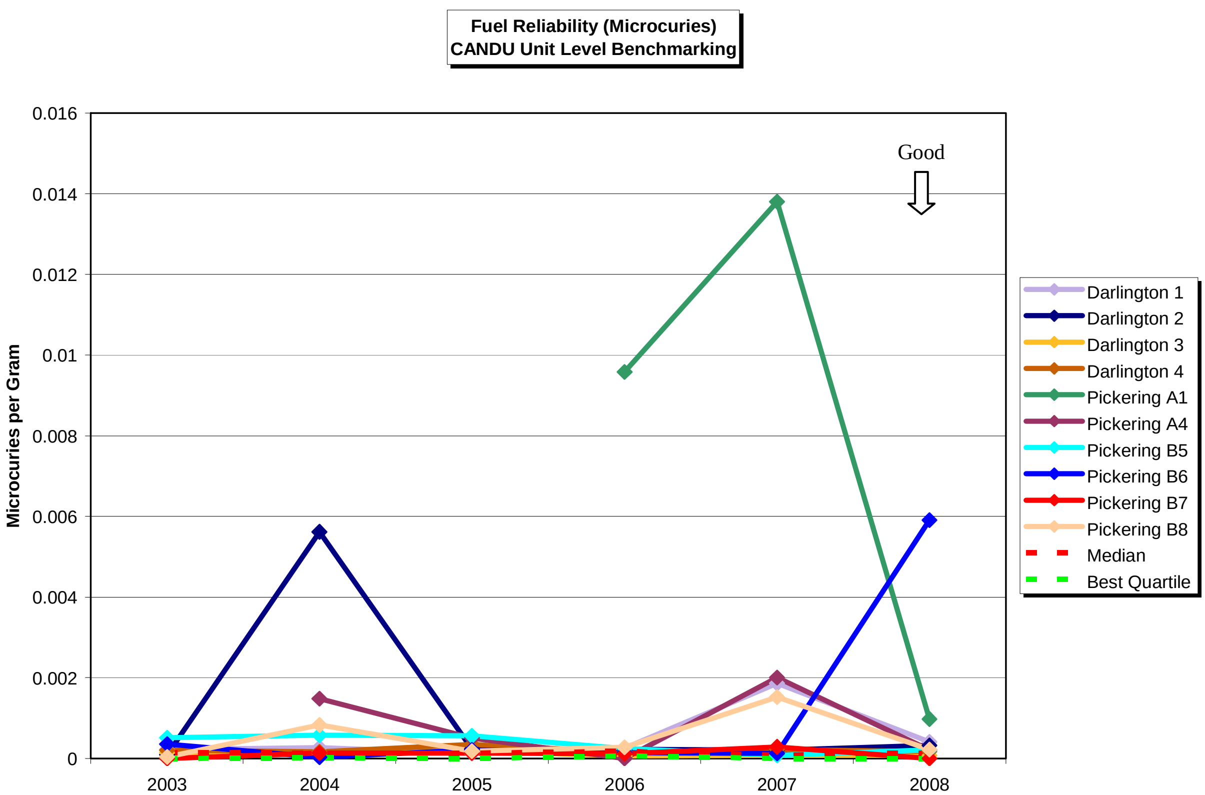
Pickering B
- Pickering B must have no more than one lost time injury to achieve best quartile
- Pickering B experienced two ISAR recordable events in 2008, which put Pickering B ISAR between best quartile and median

Fuel Reliability




2008 Fuel Reliability (Microcuries)
CANDU Unit Level Benchmarking
Best Quartile 1.00E-06
Pickering B7
Darlington 3
Median 1.36E-04
Darlington 4
Pickering A4
Pickering B5
Pickering B8
Darlington 2
Darlington 1
Pickering A1
Pickering B6
Max. NPI
Threshold = 0.0005
0.00E+00
5.00E-03
1.00E-02
1.50E-02
2.00E-02
2.50E-02
3.00E-02
Microcuries per Gram


Fuel Reliability (Microcuries)
CANDU Plant Level Benchmarking
Microcuries per Gram
0.009
0.008
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0
2003
2004
2005
2006
2007
2008
Good
Darlington
Pickering A
Pickering B
Median
Best Quartile


Fuel Reliability (Microcuries)
CANDU Unit Level Benchmarking
Microcuries per Gram
0.016
0.014
0.012
0.01
0.008
0.006
0.004
0.002
0
2003
2004
2005
2006
2007
2008
Good
Darlington 1
Darlington 2
Darlington 3
Darlington 4
Pickering A1
Pickering A4
Pickering B5
Pickering B6
Pickering B7
Pickering B8
Median
Best Quartile

Observations – Fuel Reliability (CANDU)

- The performance of OPG's units has been shown relative to best quartile, median, and the threshold established by WANO to achieve full WANO NPI points. Since achievement of full WANO NPI points is recognized within the industry as a measure of desirable performance, performance gaps are assessed against full WANO NPI points in addition to median and best quartile. In the case of Fuel Reliability, there is essentially no mathematical difference between achieving best quartile and median performance

2008

- Fuel reliability at best quartile worldwide CANDU plants was 0.000001 for plant and equally negligible for units
- All units at Darlington performed well, although not all are at best quartile. Darlington did receive full WANO NPI points
- Pickering A showed significant improvement in 2008 and looks to be moving back toward median or best quartile performance
- Pickering B, and specifically unit 6, showed a negative trend upward to worse than median in 2008

Trend

- Best quartile results were consistently low
- Darlington performance was consistently strong for the review period
- Pickering A performance spiked negatively in 2007 but improved in 2008
- Pickering B performance was overall strong for the review period but showed a negative trend in 2008

Factors Contributing to Performance

Darlington

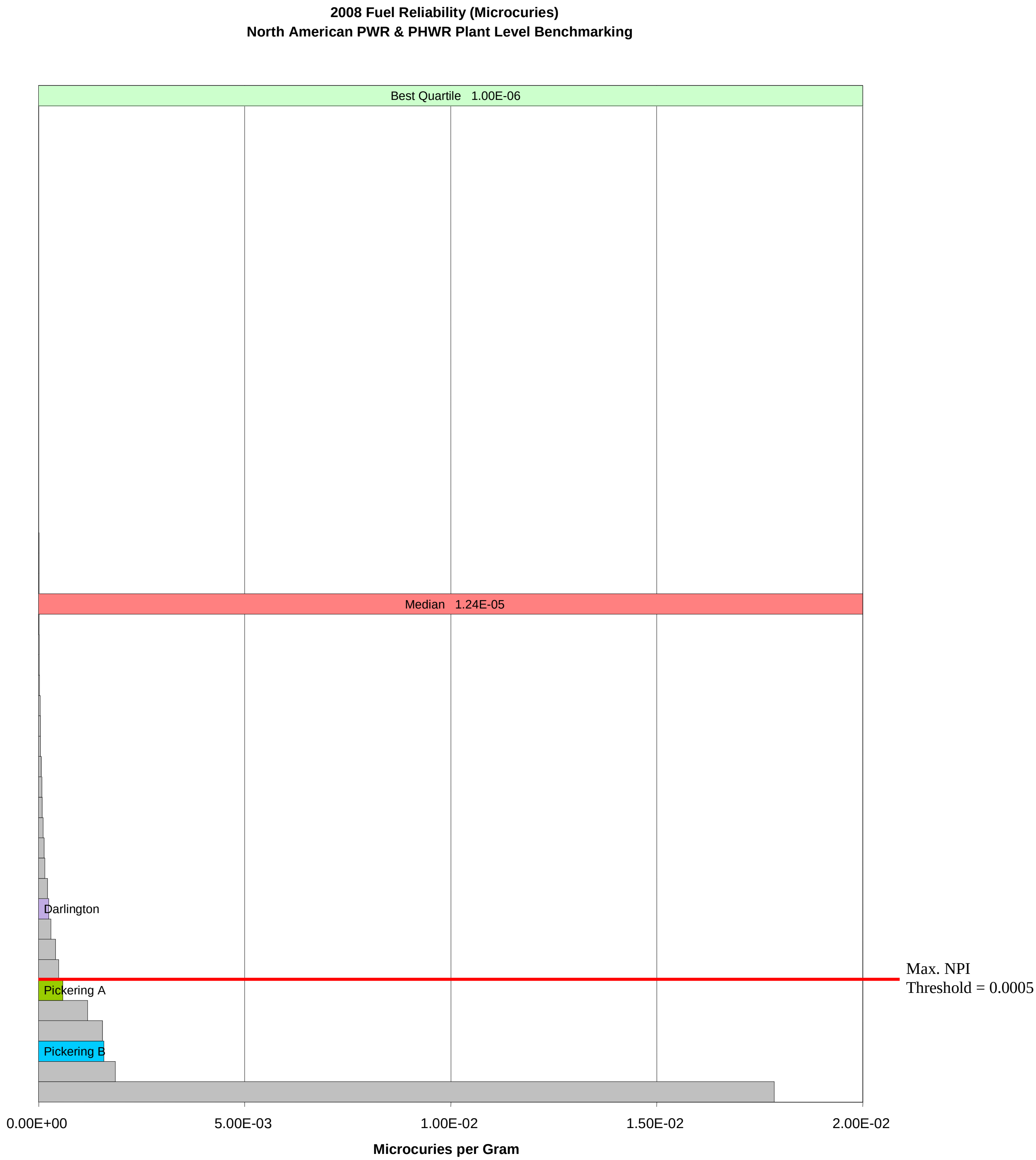
- Darlington received full WANO NPI points for fuel reliability

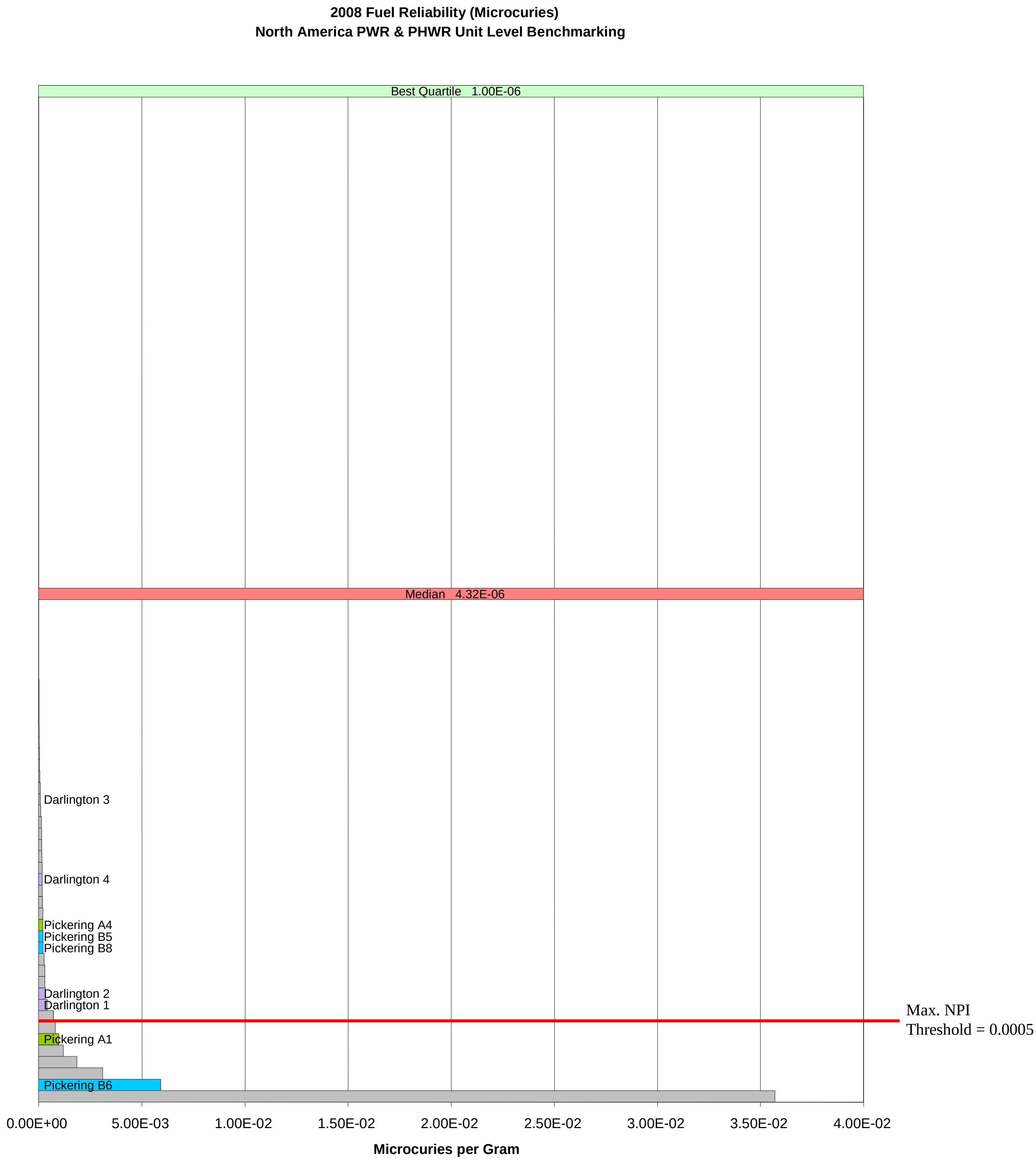
Pickering A

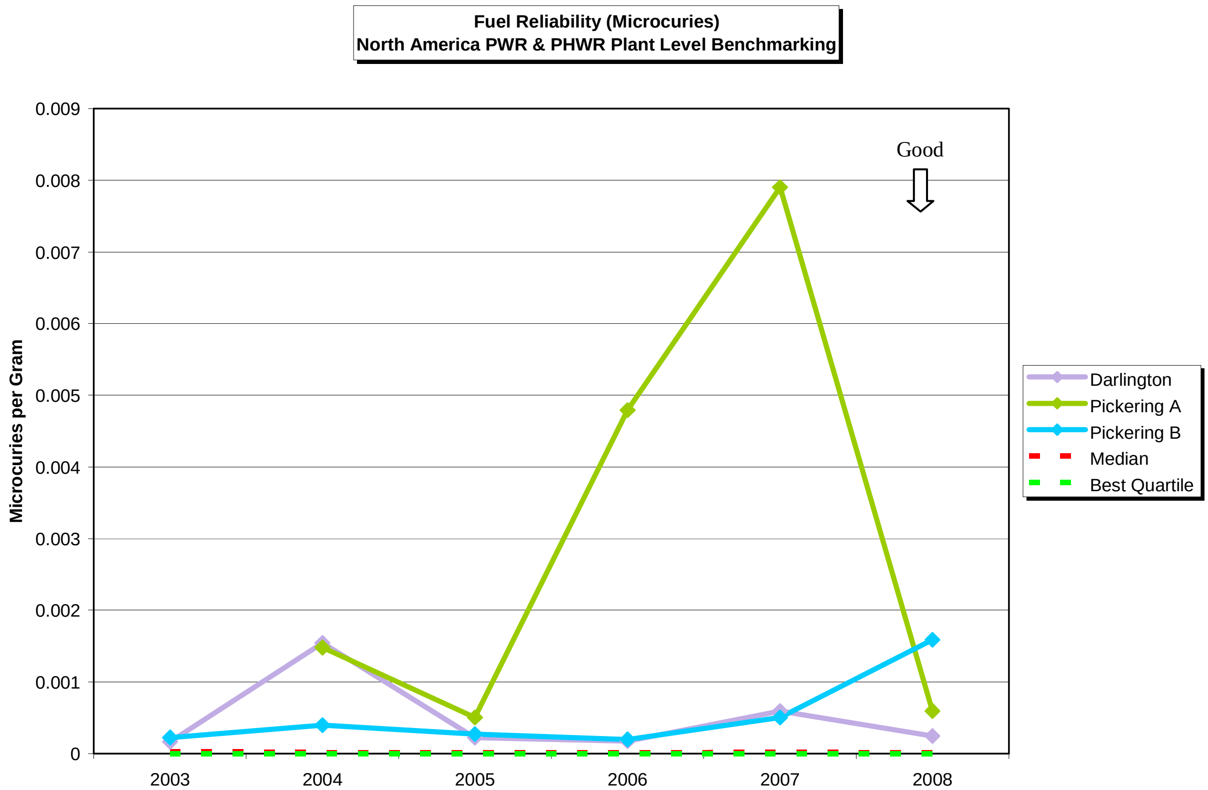
- Pickering A received 9.5 of 10 WANO NPI points
- Performance has significantly improved recently due to Foreign Material Exclusion improvements

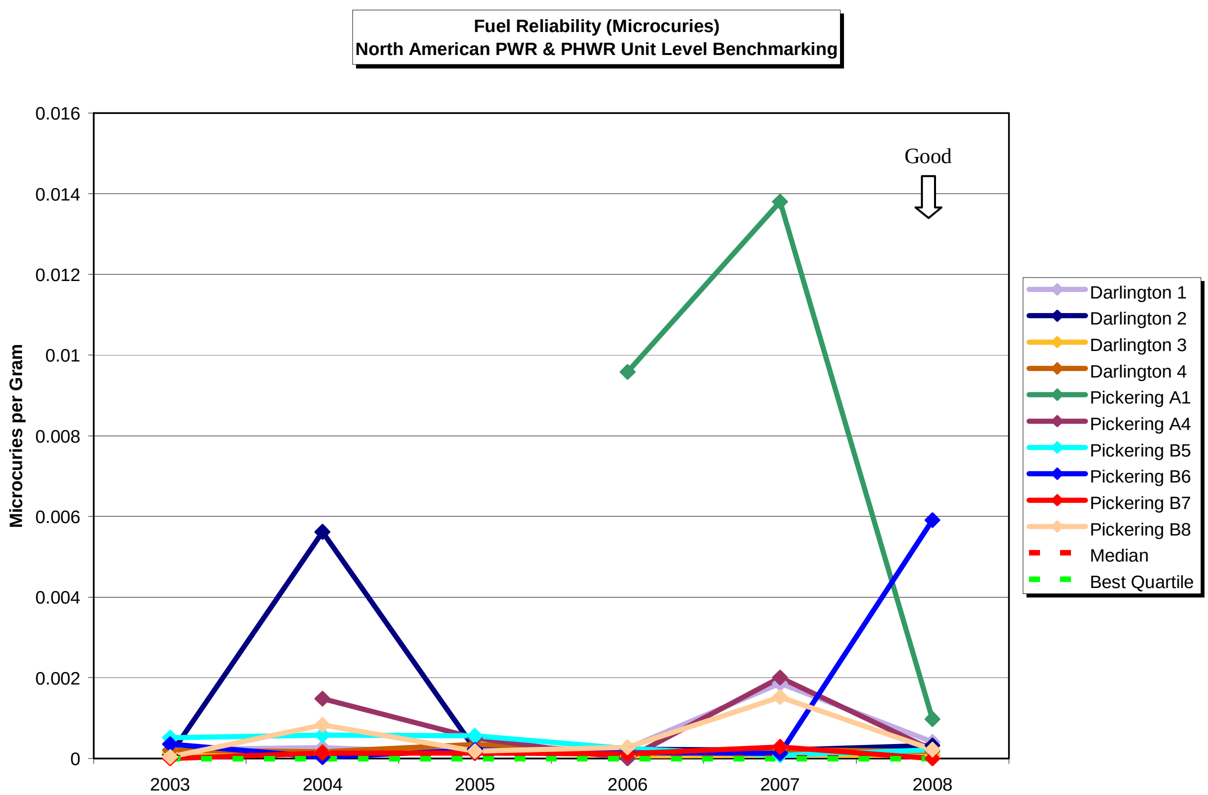
Pickering B

- Pickering B received 7.5 of 10 WANO NPI points
- The performance is expected to improve due to actions taken to improve Foreign Material Exclusion, but results are still pending


2008 Fuel Reliability (Microcuries)
North American PWR & PHWR Plant Level Benchmarking
Best Quartile 1.00E-06
Median 1.24E-05
Darlington
Pickering A
Pickering B
Max. NPI Threshold = 0.0005
0.00E+00
5.00E-03
1.00E-02
1.50E-02
2.00E-02
Microcuries per Gram


2008 Fuel Reliability (Microcuries)
North America PWR & PHWR Unit Level Benchmarking
Best Quartile 1.00E-06
Median 4.32E-06
Darlington 3
Darlington 4
Pickering A4
Pickering B5
Pickering B8
Darlington 2
Darlington 1
Max. NPI Threshold = 0.0005
Pickering A1
Pickering B6
0.00E+00
5.00E-03
1.00E-02
1.50E-02
2.00E-02
2.50E-02
3.00E-02
3.50E-02
4.00E-02
Microcuries per Gram


Fuel Reliability (Microcuries)
North America PWR & PHWR Plant Level Benchmarking
Microcuries per Gram
0.009
0.008
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0
2003
2004
2005
2006
2007
2008
Good
Darlington
Pickering A
Pickering B
Median
Best Quartile


Fuel Reliability (Microcuries)
North American PWR & PHWR Unit Level Benchmarking
Microcuries per Gram
0.016
0.014
0.012
0.01
0.008
0.006
0.004
0.002
0
2003
2004
2005
2006
2007
2008
Good
Darlington 1
Darlington 2
Darlington 3
Darlington 4
Pickering A1
Pickering A4
Pickering B5
Pickering B6
Pickering B7
Pickering B8
Median
Best Quartile

Observations – Fuel Reliability (North American PWR and PHWR)

- The performance of OPG's units has been shown relative to best quartile, median, and the threshold established by WANO to achieve full WANO NPI points. Since achievement of full WANO NPI points is recognized within the industry as a measure of desirable performance, performance gaps are assessed against full WANO NPI points in addition to median and best quartile. In the case of Fuel Reliability, there is essentially no mathematical difference between achieving best quartile and median performance

2008

- Fuel reliability at best quartile for all North American PWR/PHWRs plants was 0.000001 for plant and equally negligible for units
- All OPG units at Darlington performed well, although not all best quartile but received full WANO NPI points
- Pickering A showed significant improvement in 2008 and looks to be moving back toward median or best quartile performance
- Pickering B, specifically unit B6, showed a negative trend upward to worse than median in 2008

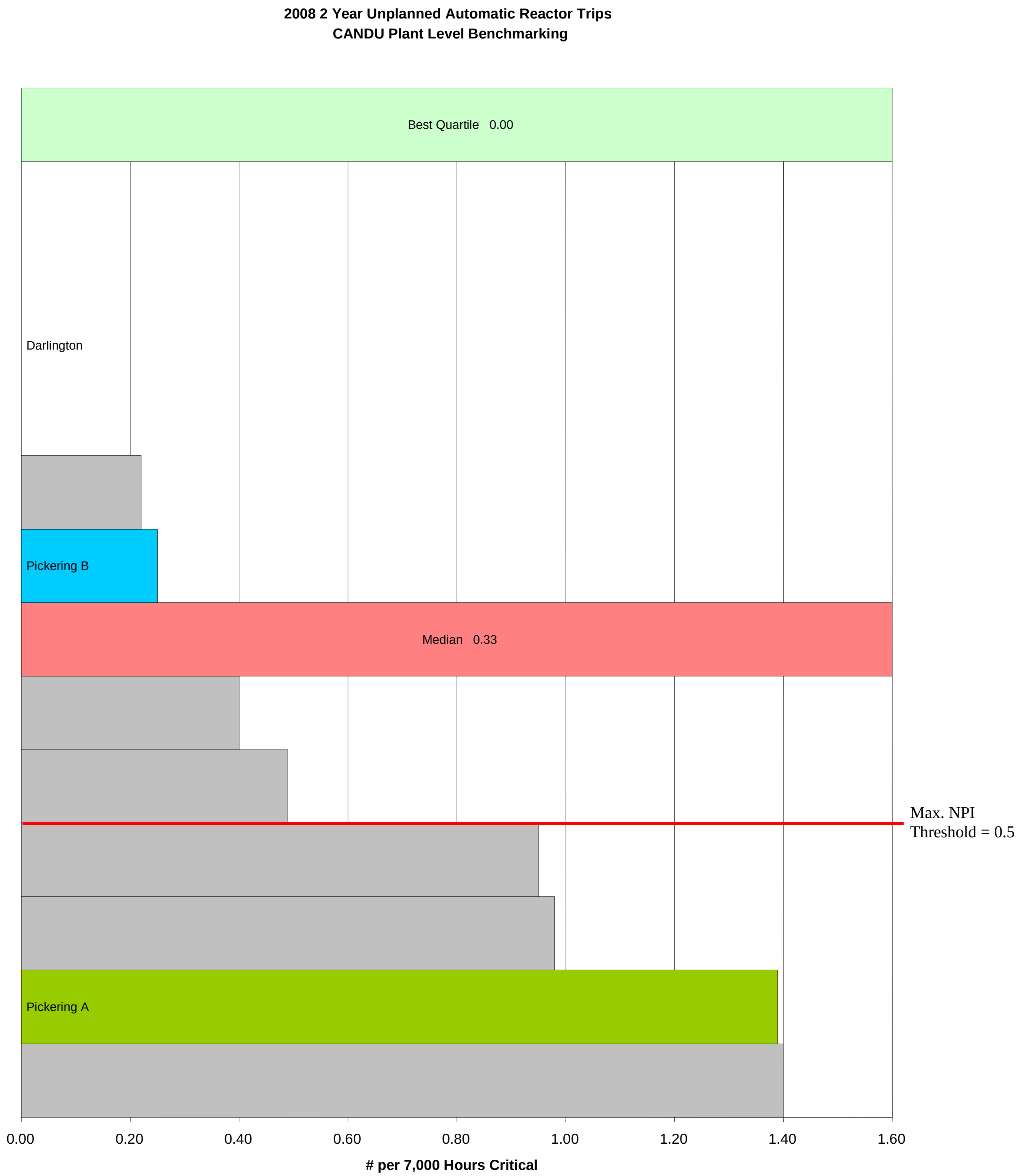
Trend

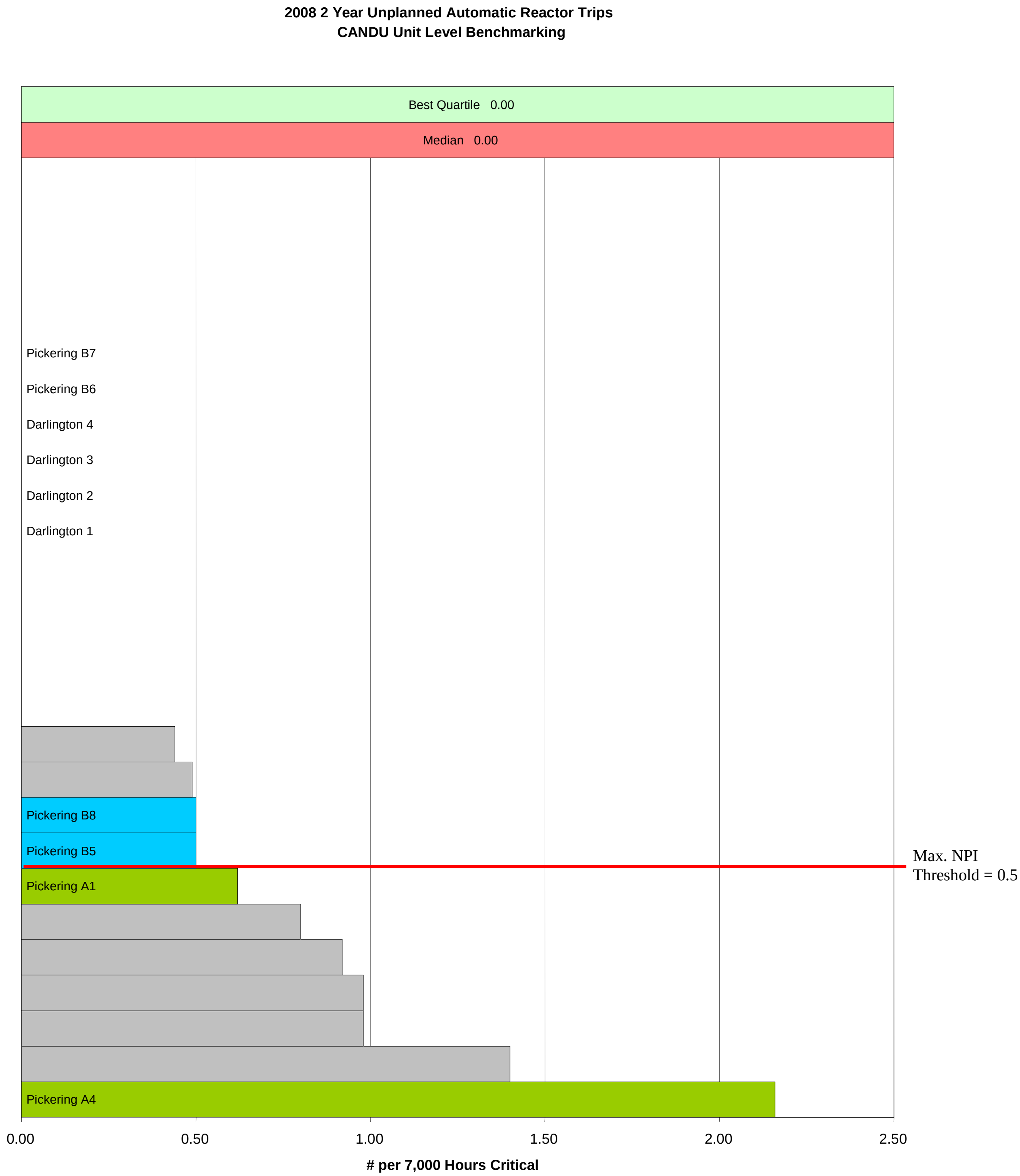
- Best quartile results were consistently low
- Darlington performance was consistently strong for the review period
- Pickering A performance spiked negatively in 2007 but improved significantly in 2008
- Pickering B performance was overall strong for the review period but showed a negative trend in 2008

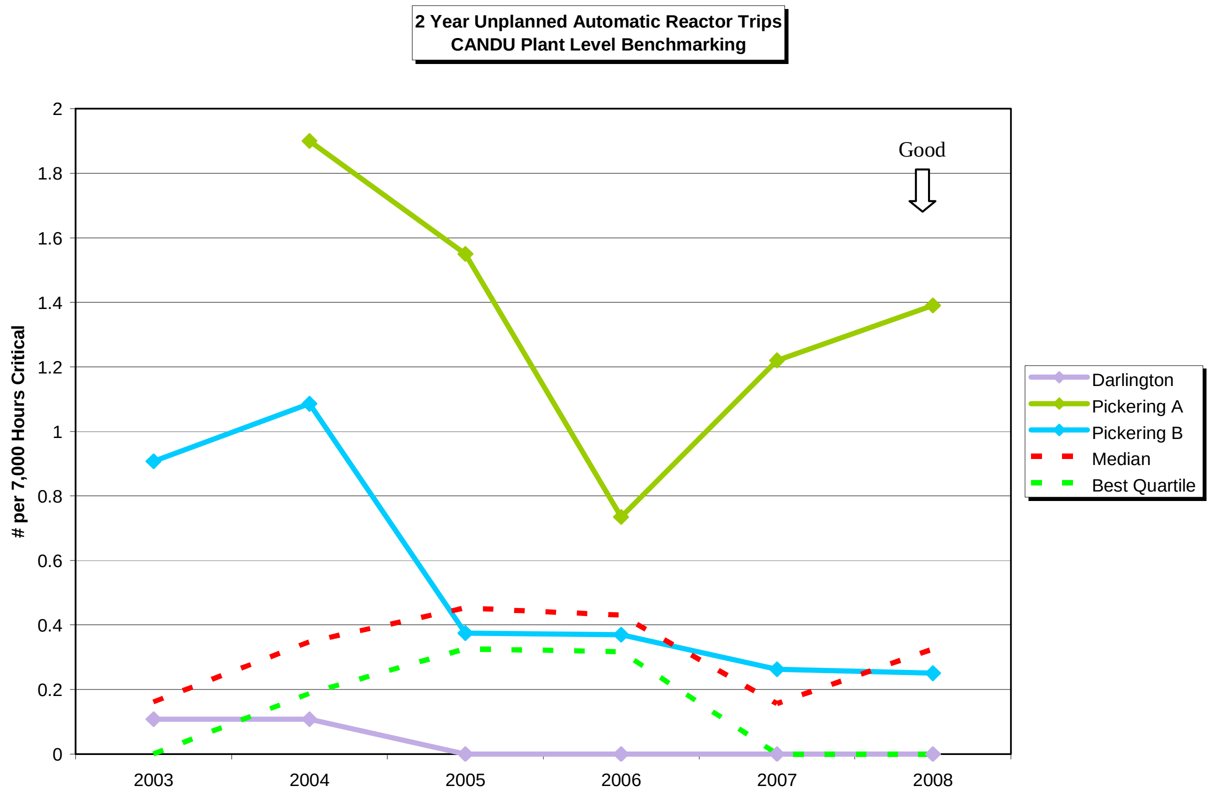
Factors Contributing to Performance

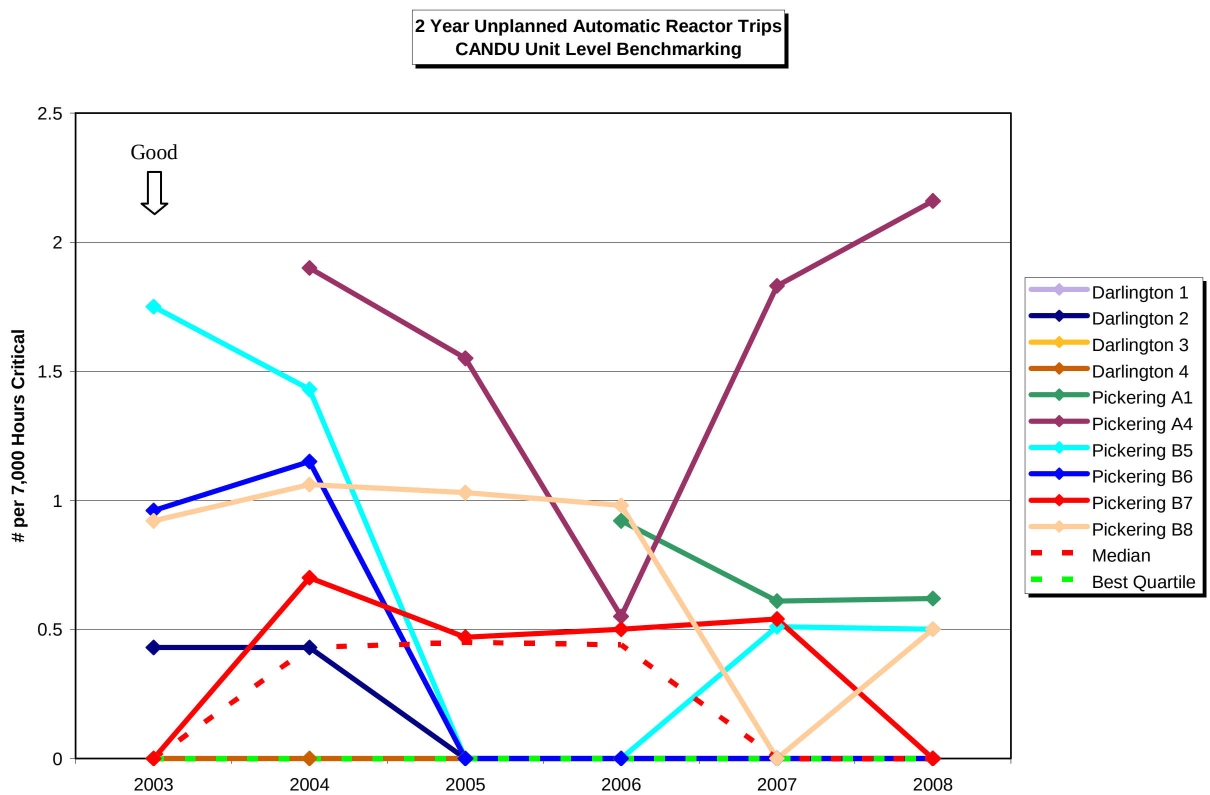
- All analysis is as included in CANDU benchmarking panel section

2-Year Unplanned Automatic Reactor Trips




2008 2 Year Unplanned Automatic Reactor Trips
CANDU Unit Level Benchmarking
Best Quartile 0.00
Median 0.00
Pickering B7
Pickering B6
Darlington 4
Darlington 3
Darlington 2
Darlington 1
Pickering B8
Pickering B5
Pickering A1
Pickering A4
Max. NPI
Threshold = 0.5
0.00
0.50
1.00
1.50
2.00
2.50
per 7,000 Hours Critical


2 Year Unplanned Automatic Reactor Trips
CANDU Plant Level Benchmarking
per 7,000 Hours Critical
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
2003
2004
2005
2006
2007
2008
Good
Darlington
Pickering A
Pickering B
Median
Best Quartile


2 Year Unplanned Automatic Reactor Trips
CANDU Unit Level Benchmarking
per 7,000 Hours Critical
2.5
2
1.5
1
0.5
0
2003
2004
2005
2006
2007
2008
Good
Darlington 1
Darlington 2
Darlington 3
Darlington 4
Pickering A1
Pickering A4
Pickering B5
Pickering B6
Pickering B7
Pickering B8
Median
Best Quartile

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

- The performance of OPG's units has been shown relative to best quartile, median, and the threshold established by WANO to achieve full WANO NPI points. Since achievement of full WANO NPI points is recognized within the industry as a measure of desirable performance, performance gaps are assessed against full WANO NPI points in addition to median and best quartile. In the case of Unplanned Automatic Reactor Trips, there is essentially no mathematical difference between achieving best quartile and median performance

2008 (2-Year Rolling Average)

- Unplanned automatic reactor trips at best quartile worldwide CANDU plants was 0.40 for the plant average and 0 for individual units
- Darlington performed better than best quartile as a station and all units performed at zero reactor trips
- Pickering A performed worse than median as a plant and all units were worse than median for the most recent data point
- Pickering B performed at best quartile for plant average and two of four units were at zero for the most recent period with two units performing worse than median for units with 0.50 trips

Trend

- Best quartile for the panel started and ended the review period at consistent levels with a decline in performance in the middle of the period
- Darlington performance overall improved from better than median at the beginning of the review period to achieve best quartile for the last five data points consecutively
- Pickering A had a limited time period compared to the other stations due to the restart of unit 4 in September 2003 and unit 1 in November 2005
- Pickering A performance improved from just under 2.0 trips at the beginning of the time period to under 0.8 trips by 2006 but then worsened to 1.4 trips
- Pickering B performance improved over the review period from worse than median at 0.9 trips, to better than median for the most recent time period

Factors Contributing to Performance

- Key performance drivers for this metric include: general equipment reliability, material condition, and human performance as defined in Forced Loss Rate and Unit Capability Factor

Darlington

- Darlington achieved best quartile performance in unplanned automatic reactor trips against the panel and received full WANO NPI points

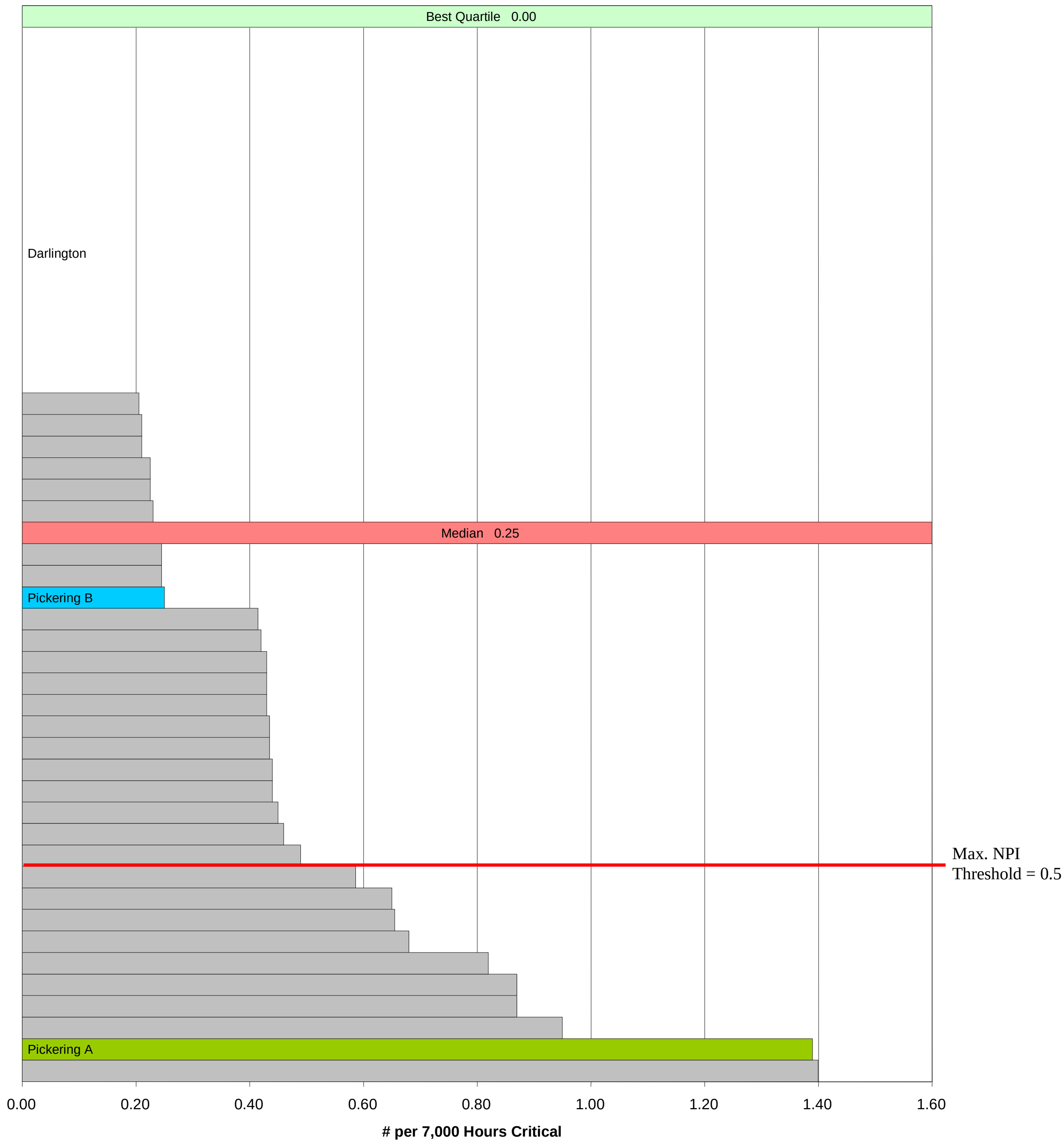
Pickering A

- Pickering A received 4.4 of 10 WANO NPI points for unplanned automatic reactor trips
- Six reactor trips have occurred at Pickering A since 2005. Causes are four due to equipment reliability problems and two due to human performance

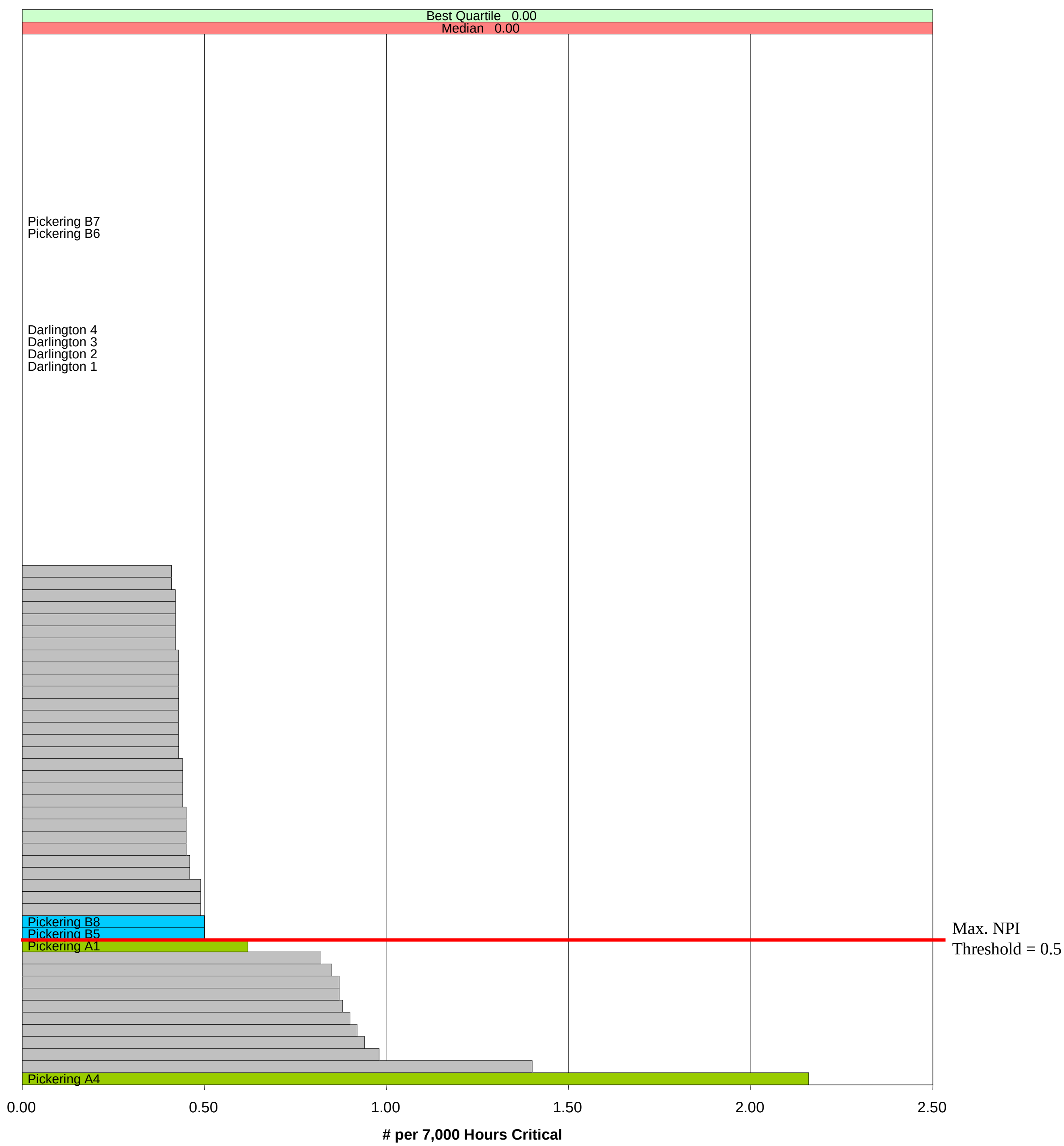
Pickering B

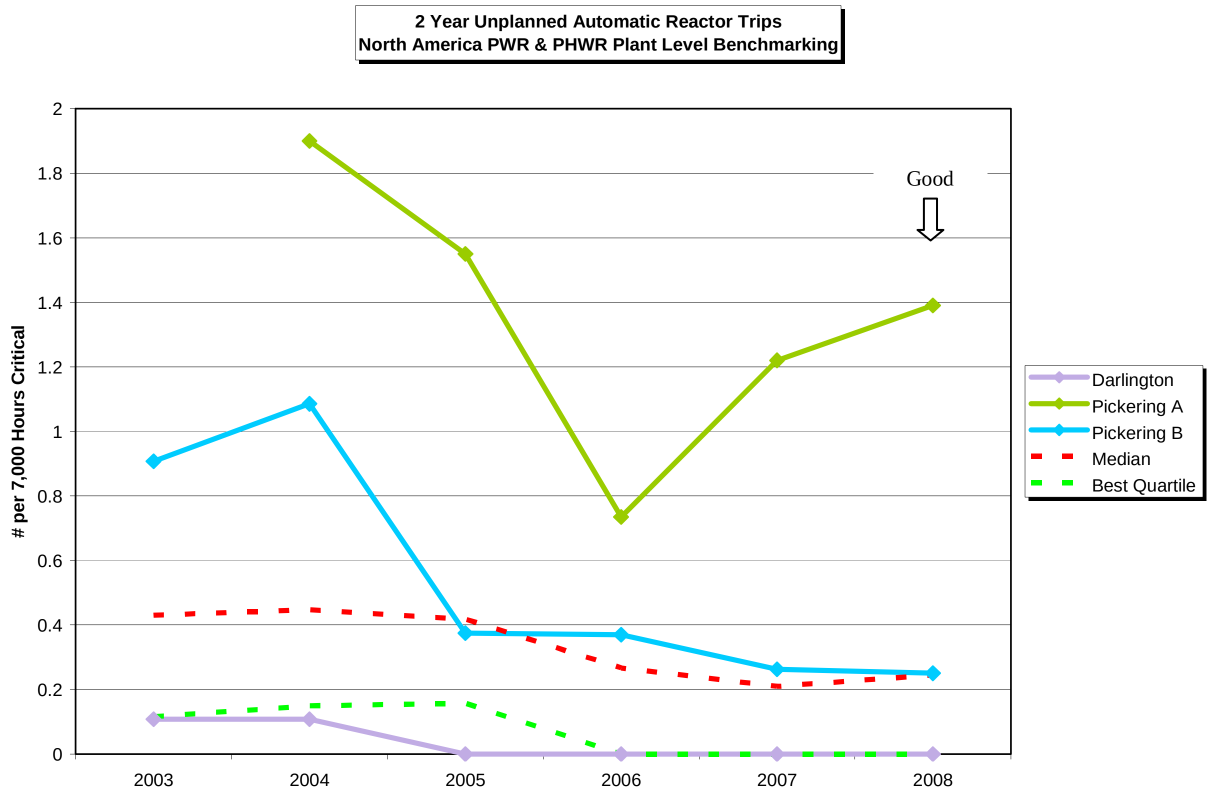
- Pickering B received full WANO NPI points for unplanned automatic reactor trips

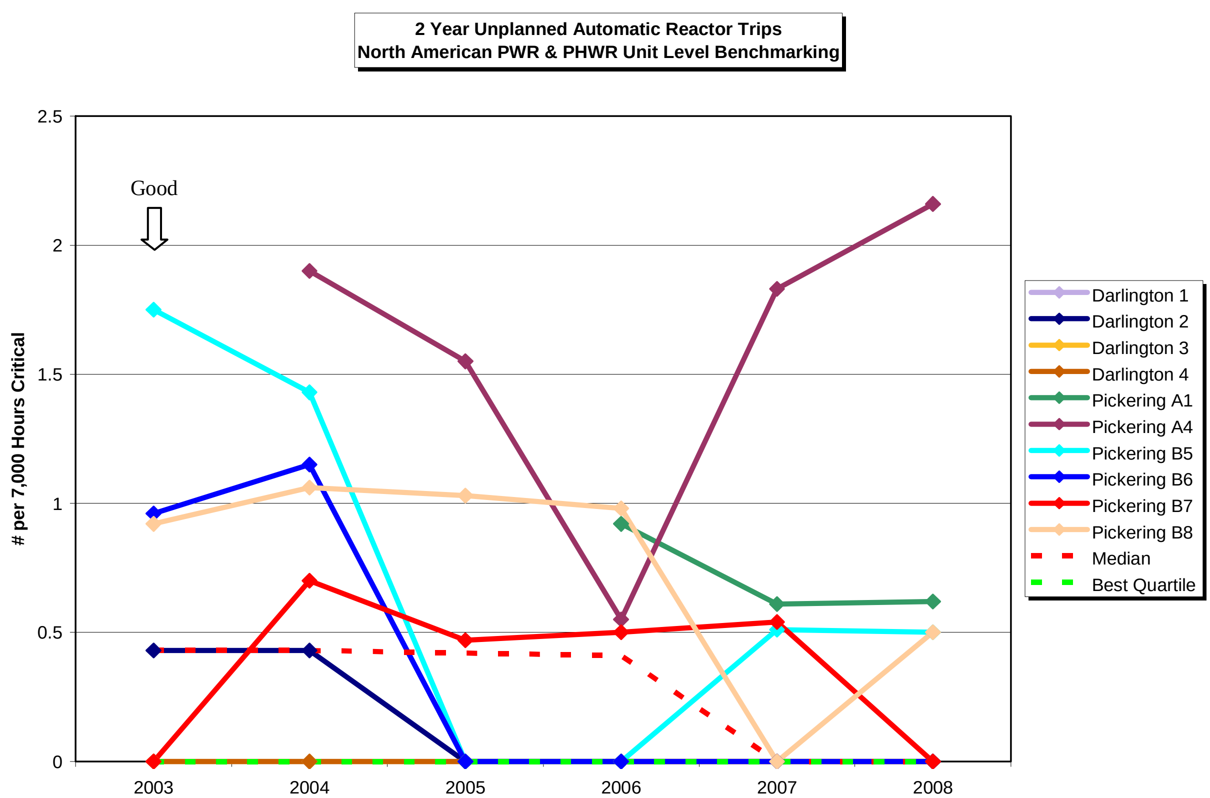
2008 2 Year Unplanned Automatic Reactor Trips
North America PWR & PHWR Plant Level Benchmarking



2008 2 Year Unplanned Automatic Reactor Trips
North America PWR & PHWR Unit Level Benchmarking




2 Year Unplanned Automatic Reactor Trips
North America PWR & PHWR Plant Level Benchmarking
per 7,000 Hours Critical
Good
Darlington
Pickering A
Pickering B
Median
Best Quartile


2 Year Unplanned Automatic Reactor Trips
North American PWR & PHWR Unit Level Benchmarking
per 7,000 Hours Critical
Good
Darlington 1
Darlington 2
Darlington 3
Darlington 4
Pickering A1
Pickering A4
Pickering B5
Pickering B6
Pickering B7
Pickering B8
Median
Best Quartile

Observations – 2-Year Unplanned Automatic Reactor Trips (North American PWR and PHWR)

- The performance of OPG's units has been shown relative to best quartile, median, and the threshold established by WANO to achieve full WANO NPI points. Since achievement of full WANO NPI points is recognized within the industry as a measure of desirable performance, performance gaps are assessed against full WANO NPI points in addition to median and best quartile. In the case of Unplanned Automatic Reactor Trips, there is essentially no mathematical difference between achieving best quartile and median performance

2008 (2-Year Rolling Average)

- Unplanned automatic reactor trips at best quartile for the North American PWR and PHWR panel was zero for the plant average and zero for individual units
- Darlington performed better than best quartile as a station and all units performed at zero unplanned automatic reactor trips
- Pickering A performed worse than median as a plant and all units were worse than median for the most recent data point
- Pickering B performed worse than median as a plant and all units were worse than median for the most recent data point

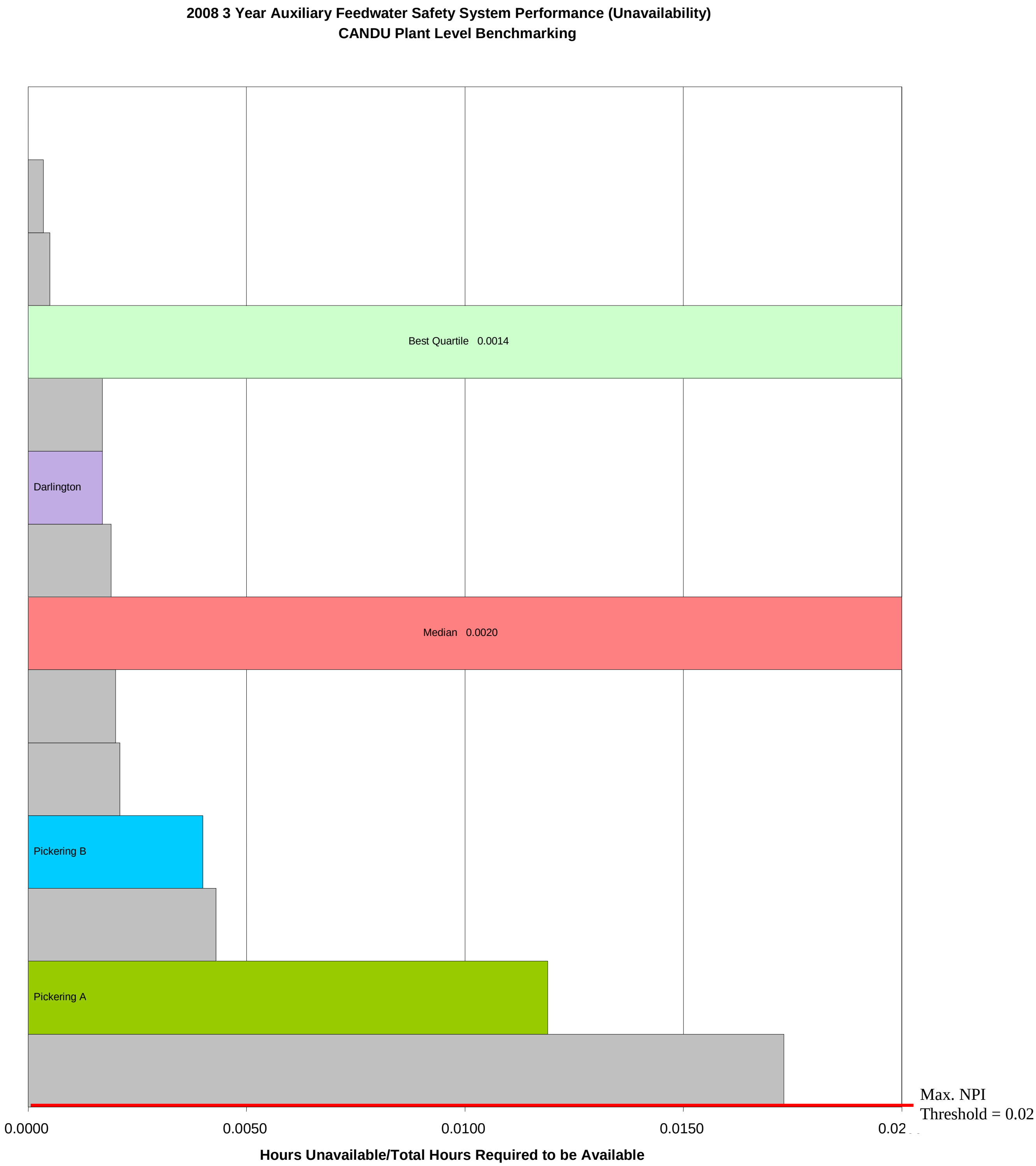
Trend

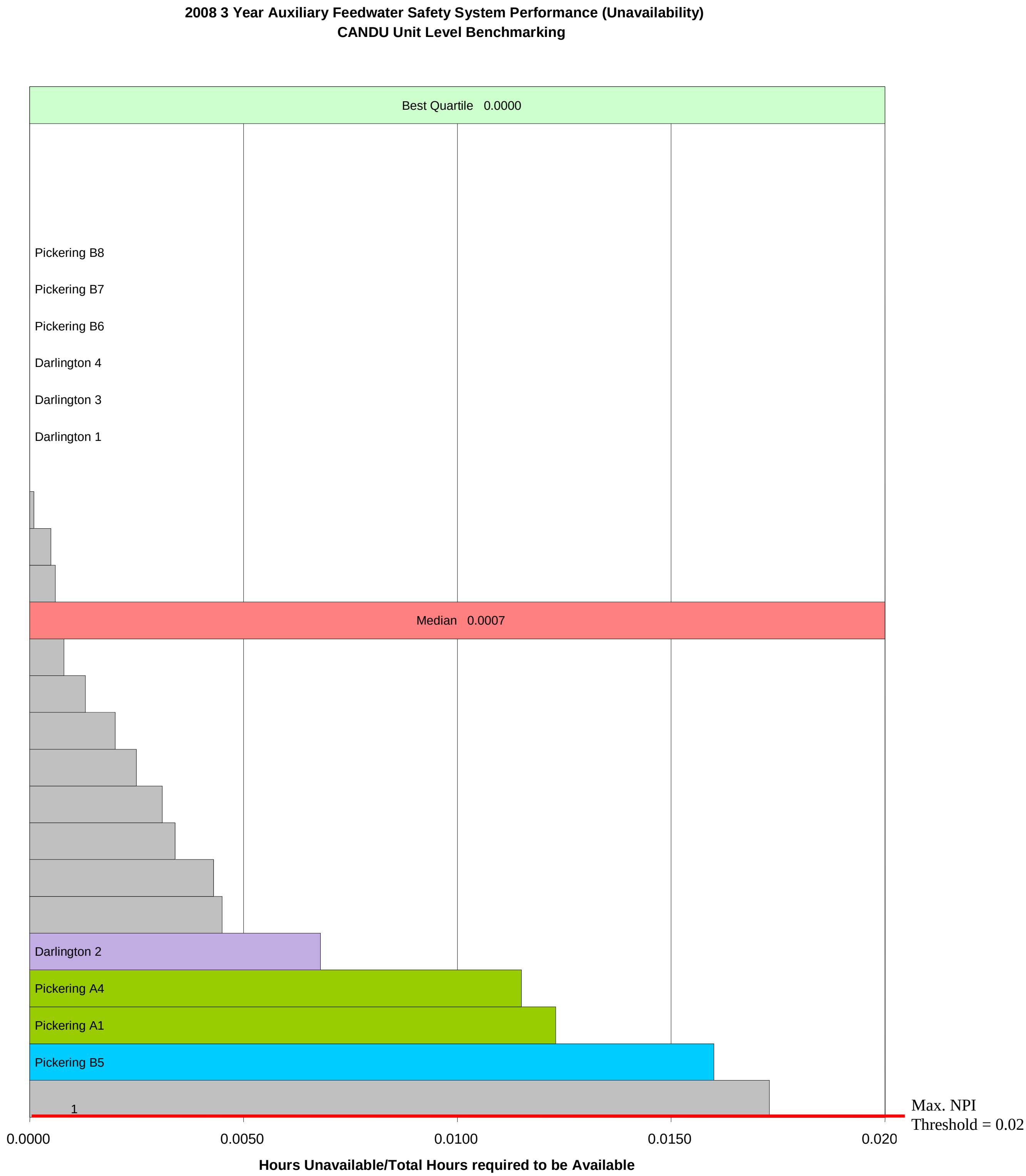
- Best quartile for the panel improved from 0.1 to 0.0 trips for the time period
- Darlington performance overall improved for the review period but remained best quartile for the duration
- Pickering A had a limited time period compared to the other stations due to the restart of unit 4 in September 2003 and unit 1 in November 2005
- Pickering A performance improved from just under 2.0 trips at the beginning of the time period to under 0.8 trips by 2006 but then worsened to 1.4 trips
- Pickering B performance improved over the review period from 0.9 trips to better than 0.3 trips but remained worse than median against the panel

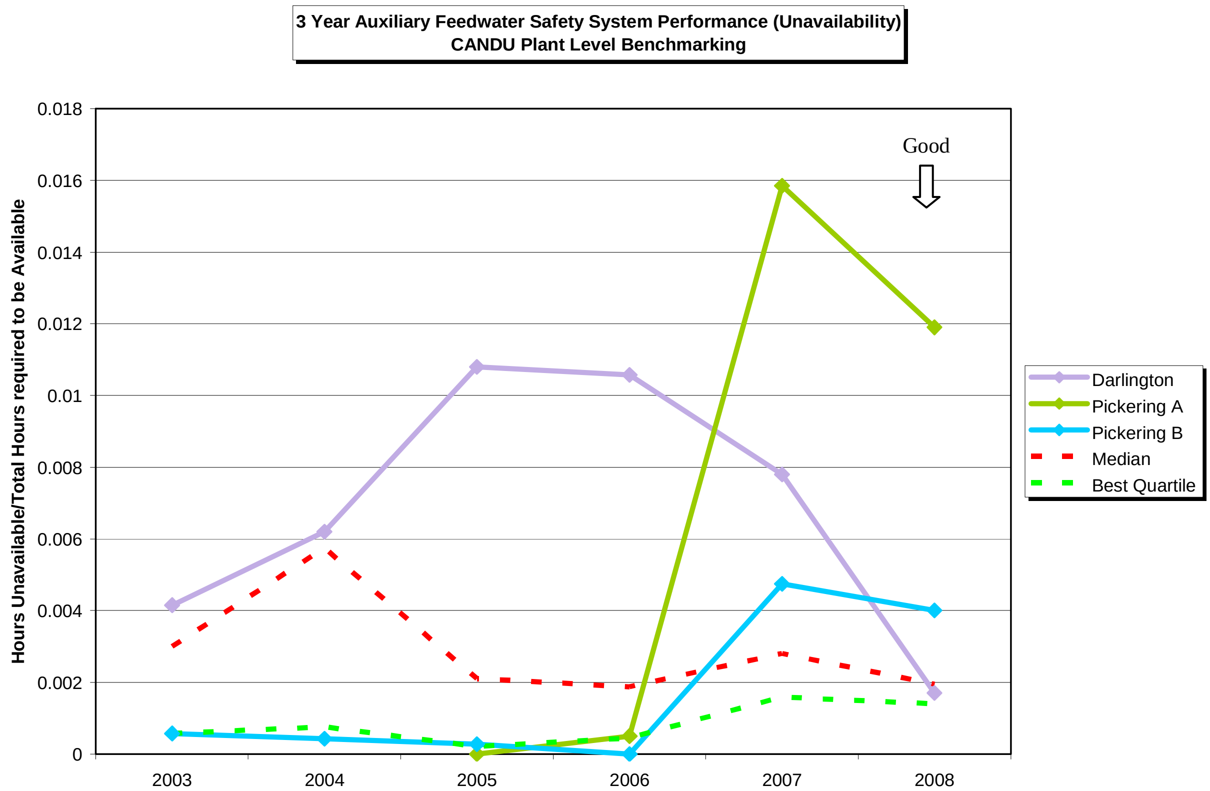
Factors Contributing to Performance

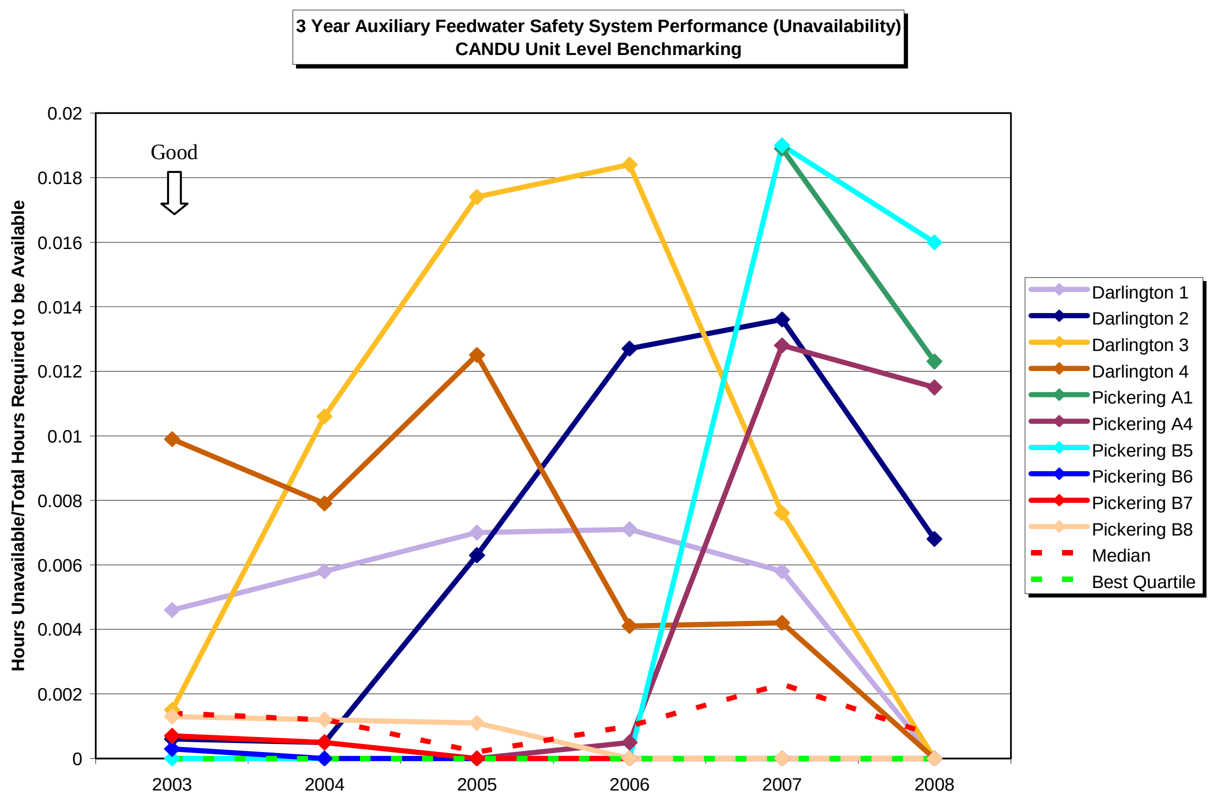
- Technology difference between PWR and CANDU should not impact unplanned automatic reactor trips
- All analysis of gap and WANO NPI points lost for the OPG plants documented in the worldwide CANDU benchmark panel section

3-Year Auxiliary Feedwater Safety System Unavailability




2008 3 Year Auxiliary Feedwater Safety System Performance (Unavailability)
CANDU Unit Level Benchmarking
Best Quartile 0.0000
Pickering B8
Pickering B7
Pickering B6
Darlington 4
Darlington 3
Darlington 1
Median 0.0007
Darlington 2
Pickering A4
Pickering A1
Pickering B5
1
Max. NPI
Threshold = 0.02
0.0000
0.0050
0.0100
0.0150
0.020
Hours Unavailable/Total Hours required to be Available


3 Year Auxiliary Feedwater Safety System Performance (Unavailability)
CANDU Plant Level Benchmarking
Hours Unavailable/Total Hours required to be Available
0.018
0.016
0.014
0.012
0.01
0.008
0.006
0.004
0.002
0
2003
2004
2005
2006
2007
2008
Good
Darlington
Pickering A
Pickering B
Median
Best Quartile


3 Year Auxiliary Feedwater Safety System Performance (Unavailability)
CANDU Unit Level Benchmarking
Hours Unavailable/Total Hours Required to be Available
0.02
0.018
0.016
0.014
0.012
0.01
0.008
0.006
0.004
0.002
0
2003
2004
2005
2006
2007
2008
Good
Darlington 1
Darlington 2
Darlington 3
Darlington 4
Pickering A1
Pickering A4
Pickering B5
Pickering B6
Pickering B7
Pickering B8
Median
Best Quartile

Observations – 3-Year Auxiliary Feedwater System (CANDU)

- The performance of OPG's units has been shown relative to best quartile, median, and the threshold established by WANO to achieve full WANO NPI points. Since achievement of full WANO NPI points is recognized within the industry as a measure of desirable performance, performance gaps are assessed against full WANO NPI points in addition to median and best quartile. In the case of Auxiliary Feedwater System, there is essentially no mathematical difference between achieving best quartile and median performance

2008 (3-Year Rolling Average)

- Auxiliary feedwater safety system performance at best quartile worldwide CANDU plants was 0.0014 for plant level and 0.0000 for units
- Darlington performed better than median
- Pickering A and Pickering B both performed worse than median

Trend

- Best quartile was consistently mathematically low, variation in line not displaying any trend
- Darlington performance showed consistent improvement to reach better than median performance by 2008
- Pickering A was well worse than median for 2007 and 2008
- Pickering B performance worsened over the last two years of the review period

Factors Contributing to Performance

Darlington

- Darlington received full WANO NPI points for auxiliary feedwater safety system performance therefore no performance gap exists

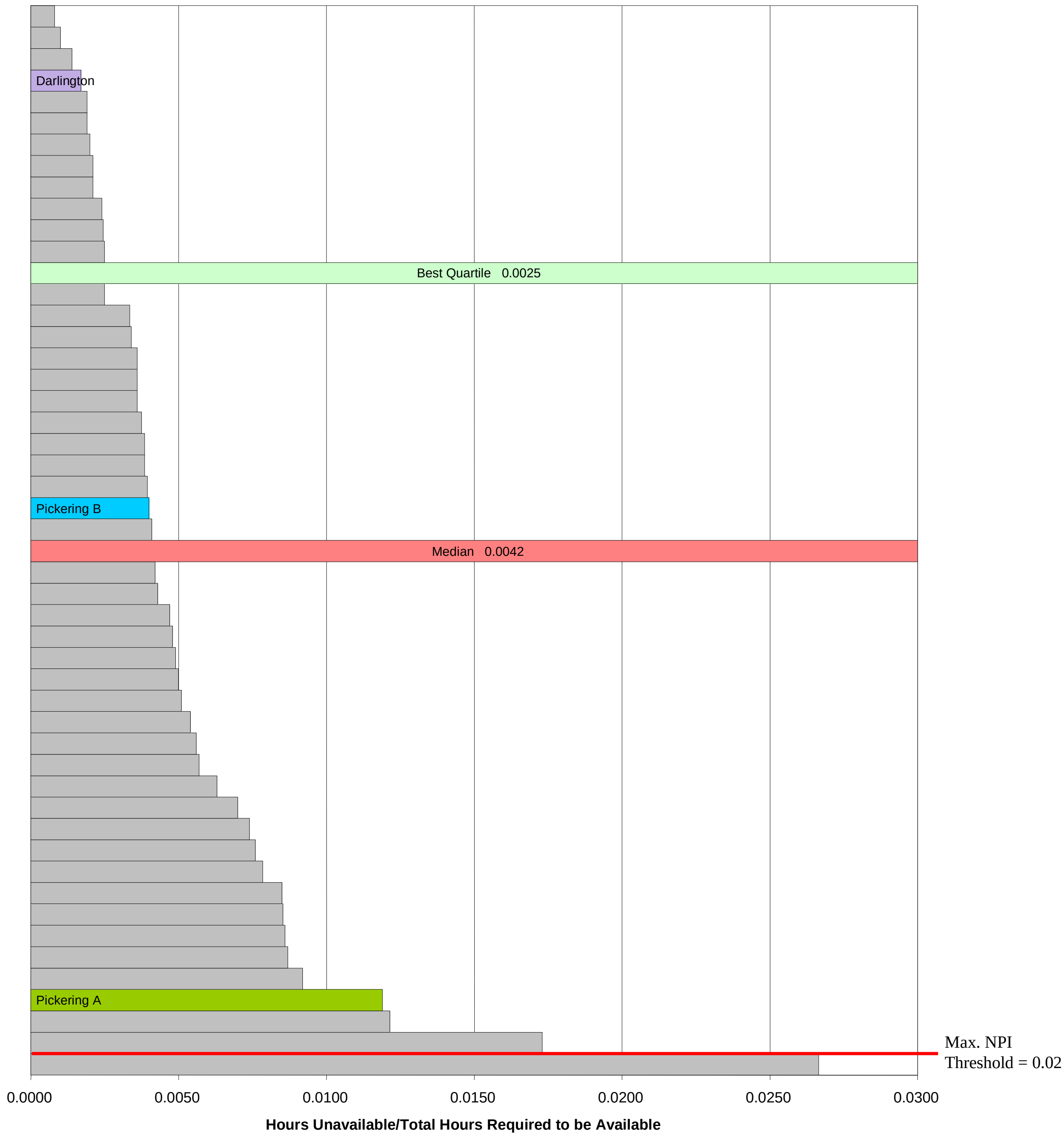
Pickering A

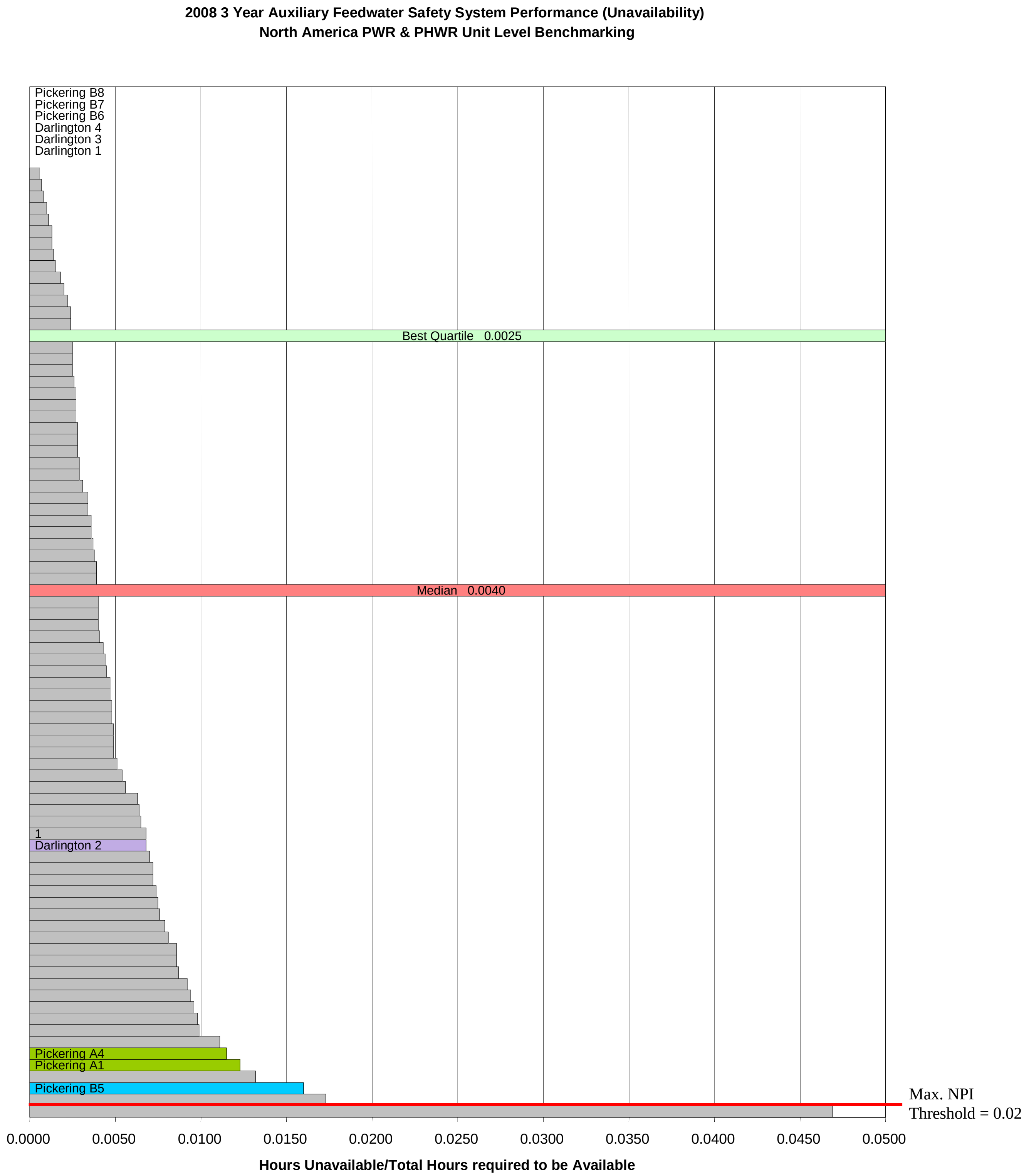
- Pickering A received full WANO NPI points for auxiliary feedwater safety system performance

Pickering B

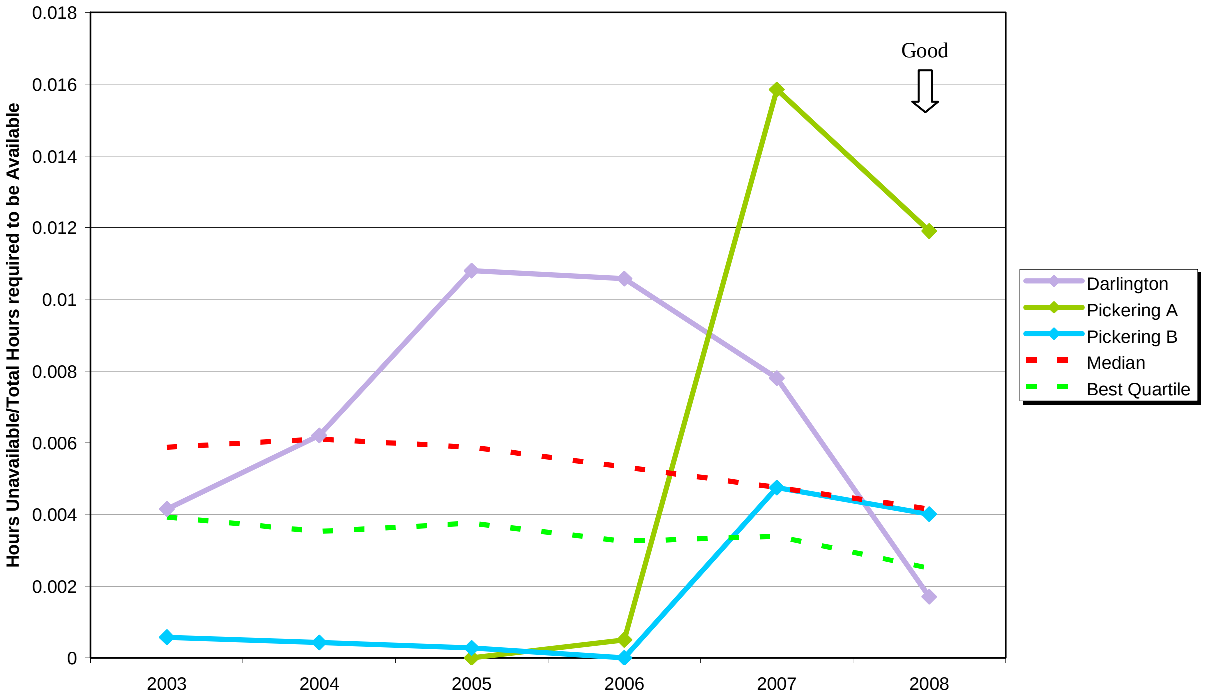
- Pickering B received full WANO NPI points for auxiliary feedwater safety system performance

2008 3 Year Auxiliary Feedwater Safety System Performance (Unavailability)
North American PWR & PHWR Plant Level Benchmarking

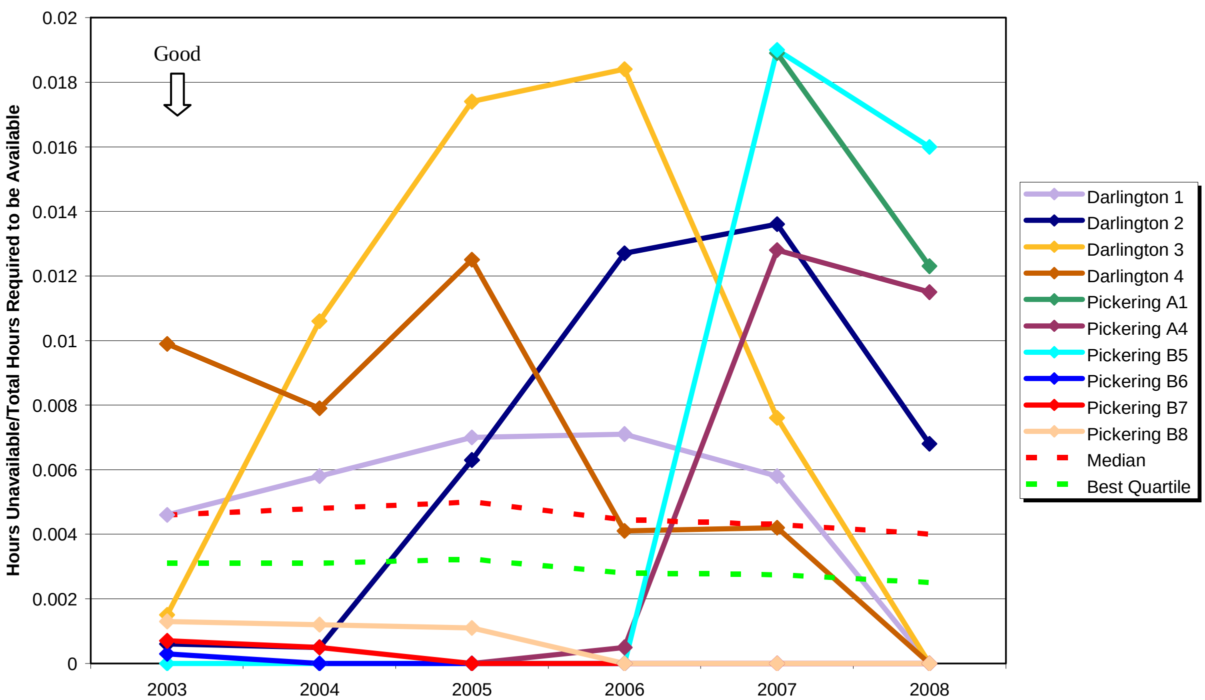



2008 3 Year Auxiliary Feedwater Safety System Performance (Unavailability)
North America PWR & PHWR Unit Level Benchmarking
Pickering B8
Pickering B7
Pickering B6
Darlington 4
Darlington 3
Darlington 1
Best Quartile 0.0025
Median 0.0040
1
Darlington 2
Pickering A4
Pickering A1
Pickering B5
Max. NPI
Threshold = 0.02
0.0000
0.0050
0.0100
0.0150
0.0200
0.0250
0.0300
0.0350
0.0400
0.0450
0.0500
Hours Unavailable/Total Hours required to be Available

3 Year Auxiliary Feedwater Safety System Performance (Unavailability)
North America PWR & PHWR Plant Level Benchmarking



3 Year Auxiliary Feedwater Safety System Performance (Unavailability)
North American PWR & PHWR Unit Level Benchmarking



Observations – 3-Year Auxiliary Feedwater System (North American PWR and PHWR)

- The performance of OPG's units has been shown relative to best quartile, median, and the threshold established by WANO to achieve full WANO NPI points. Since achievement of full WANO NPI points is recognized within the industry as a measure of desirable performance, performance gaps are assessed against full WANO NPI points in addition to median and best quartile. In the case of Auxiliary Feedwater System, there is essentially no mathematical difference between achieving best quartile and median performance

2008 (3-Year Rolling Average)

- Auxiliary feedwater safety system performance at best quartile North American PWR/PHWRs was 0.0025 for plant level and 0.0025 for units
- Darlington performed at best quartile
- Pickering A performed worse than median
- Pickering B performed better than median

Trend

- Best quartile was consistently mathematically low, showed downward trend in recent years
- Darlington performance showed consistent improvement to reach better than median performance by 2008
- Pickering A was well worse than median for 2007 and 2008
- Pickering B performance worsened over the last two years of the review period

Factors Contributing to Performance

Darlington

- Darlington received full WANO NPI points for auxiliary feedwater safety system performance therefore no performance gap exists

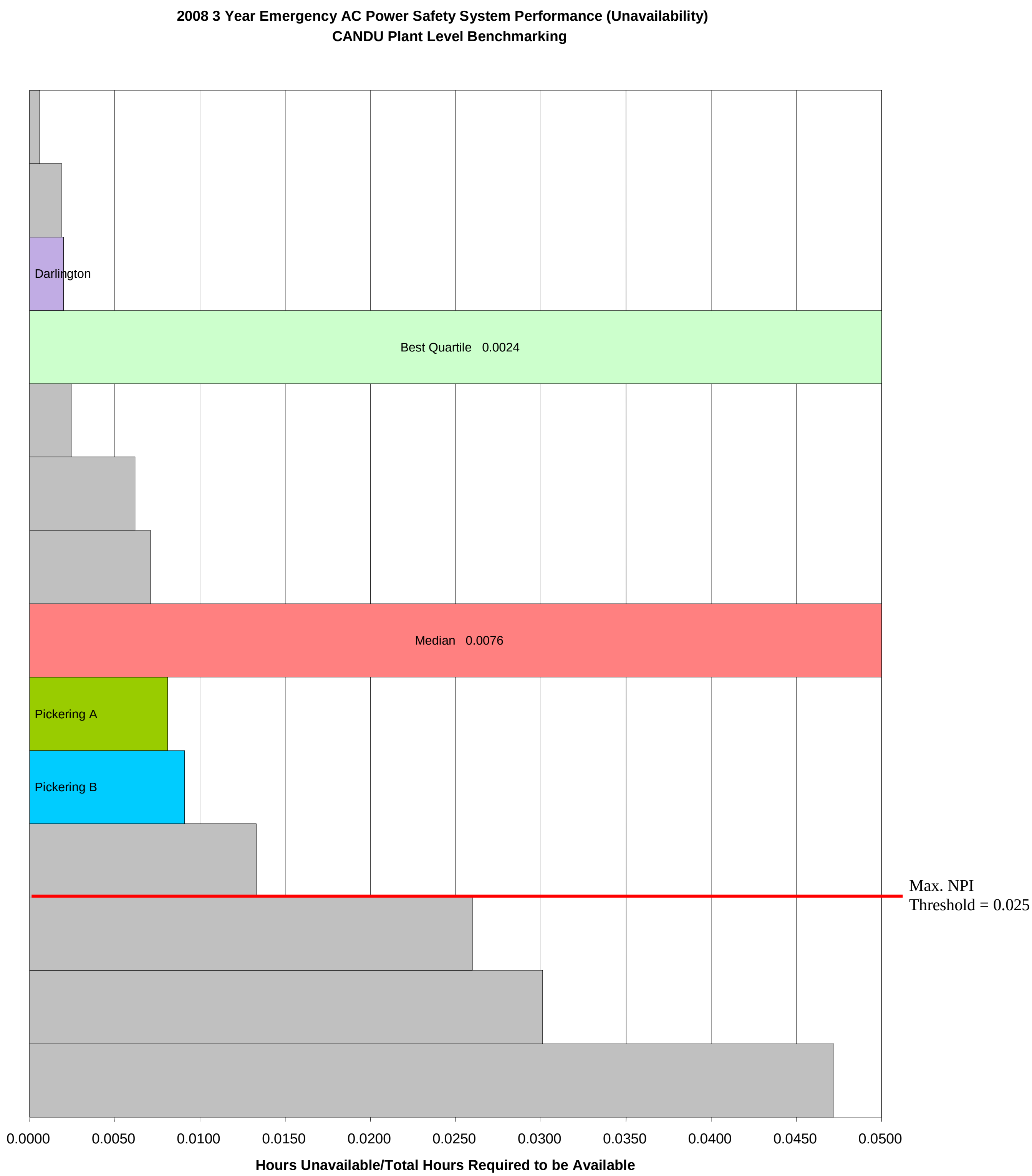
Pickering A

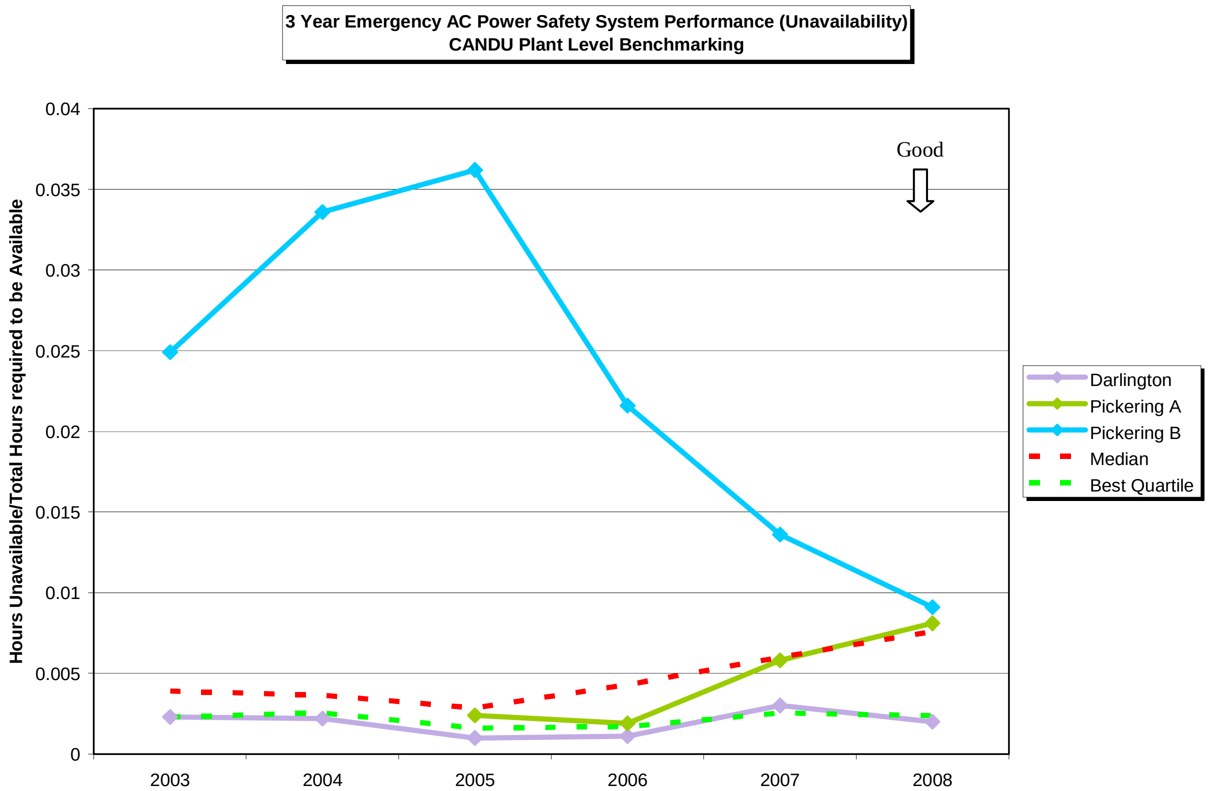
- Pickering A received full WANO NPI points for auxiliary feedwater safety system performance

Pickering B

- Pickering B received full WANO NPI points for auxiliary feedwater safety system performance

3-Year Emergency AC Power Safety Unavailability




3 Year Emergency AC Power Safety System Performance (Unavailability)
CANDU Plant Level Benchmarking
Hours Unavailable/Total Hours required to be Available
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
2003
2004
2005
2006
2007
2008
Good
Darlington
Pickering A
Pickering B
Median
Best Quartile

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

- The performance of OPG's units has been shown relative to best quartile, median, and the threshold established by WANO to achieve full WANO NPI points. Since achievement of full WANO NPI points is recognized within the industry as a measure of desirable performance, performance gaps are assessed against full WANO NPI points in addition to median and best quartile. In the case of Emergency AC Power Safety System, there is essentially no mathematical difference between achieving best quartile and median performance

2008 (3-Year Rolling Average)

- Emergency AC power system safety performance at best quartile worldwide CANDU was 0.0024
- Darlington performed at best quartile
- Pickering A performed worse than median
- Pickering B performed worse than median

Trend

- Best quartile was consistently mathematically low, showed downward trend in recent years
- Darlington performed consistently at best quartile
- Pickering A trended worse in 2007 and 2008
- Pickering B improved performance consistently from 2005 to 2008

Factors Contributing to Performance

Darlington

- Darlington received full WANO NPI points for emergency AC power system safety performance therefore no performance gap exists

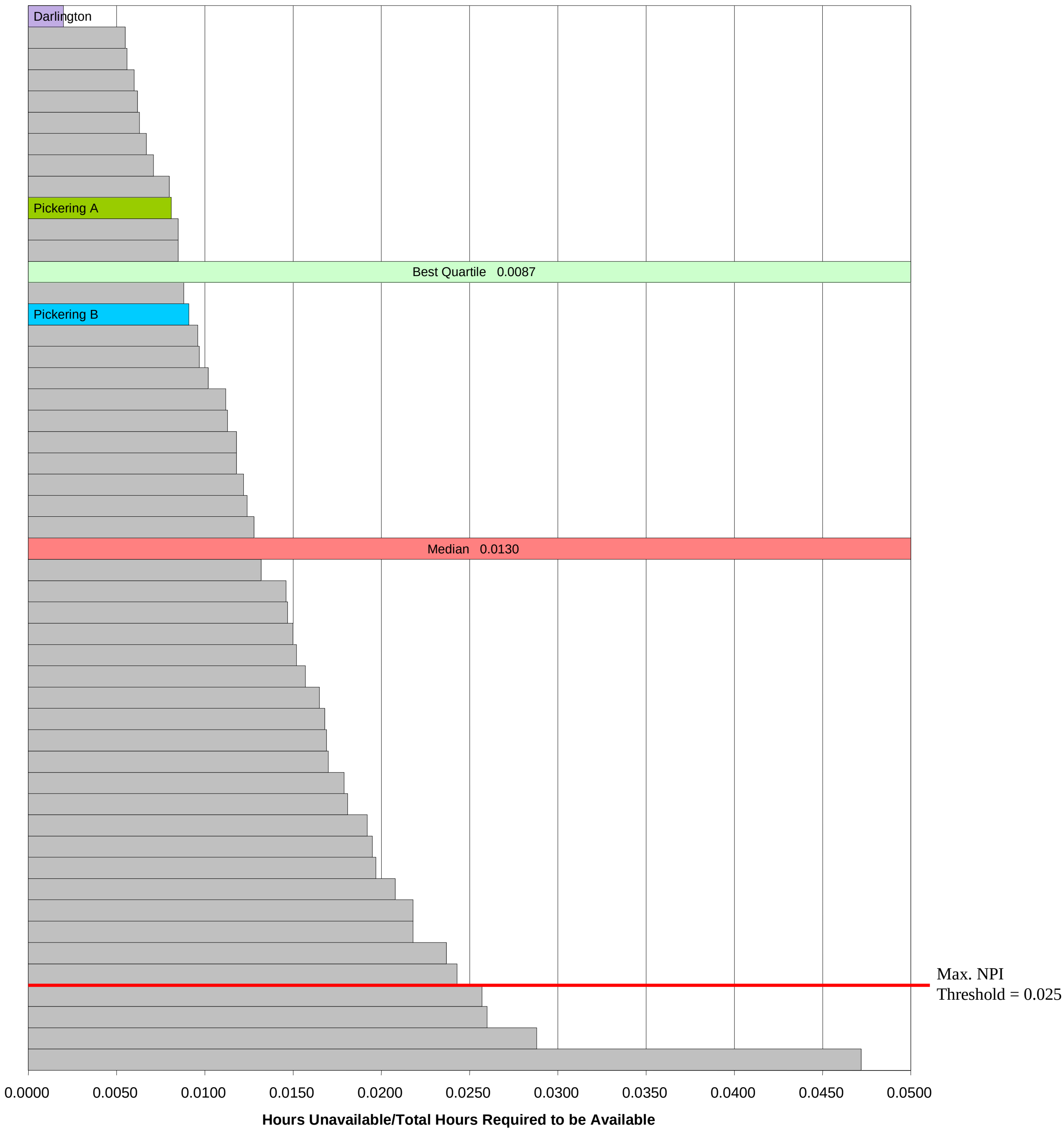
Pickering A

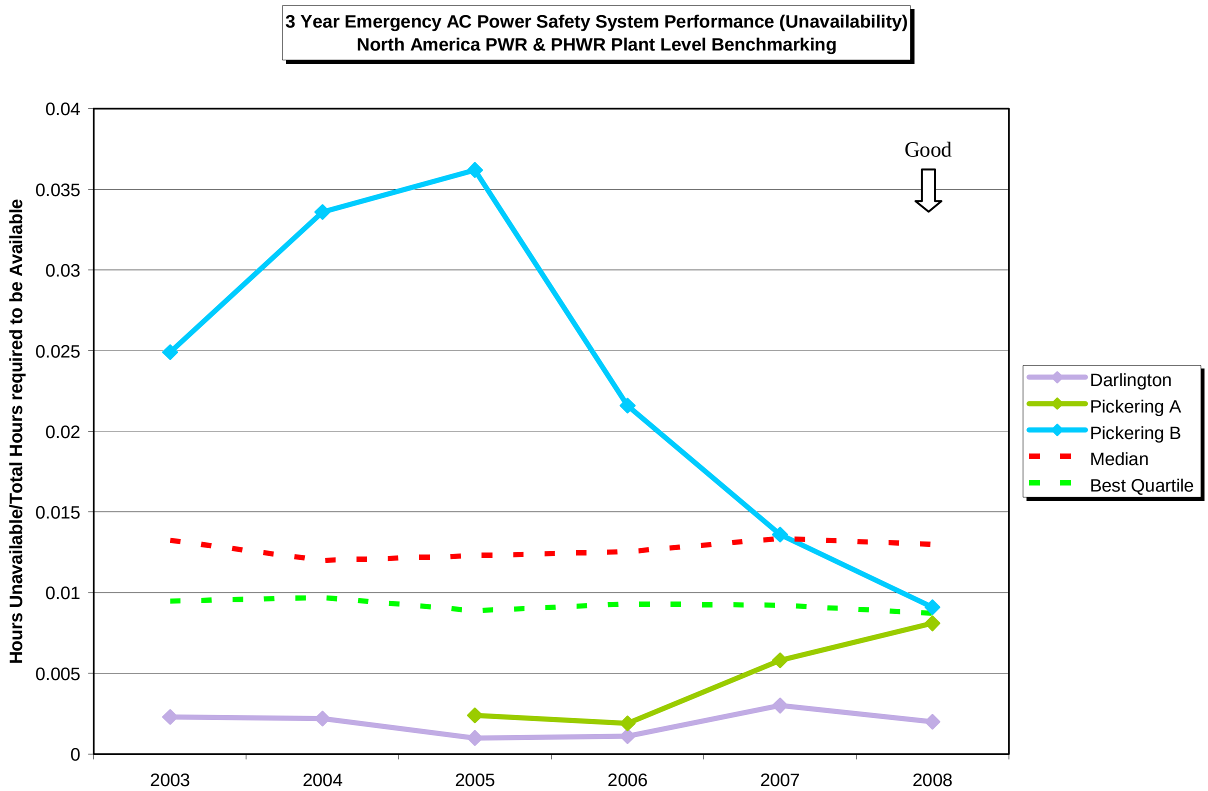
- Pickering A received full WANO NPI points for emergency AC power system safety performance

Pickering B

- Pickering B received full WANO NPI points for emergency AC power system safety performance

2008 3 Year Emergency AC Power Safety System Performance (Unavailability)
North American PWR & PHWR Plant Level Benchmarking




3 Year Emergency AC Power Safety System Performance (Unavailability)
North America PWR & PHWR Plant Level Benchmarking
Hours Unavailable/Total Hours required to be Available
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
2003
2004
2005
2006
2007
2008
Good
Darlington
Pickering A
Pickering B
Median
Best Quartile

Observations – 3-Year Emergency AC Power Safety System (North American PWR/PHWR)

- The performance of OPG's units has been shown relative to best quartile, median, and the threshold established by WANO to achieve full WANO NPI points. Since achievement of full WANO NPI points is recognized within the industry as a measure of desirable performance, performance gaps are assessed against full WANO NPI points in addition to median and best quartile. In the case of Emergency AC Power Safety System, there is essentially no mathematical difference between achieving best quartile and median performance

2008 (3-Year Rolling Average)
- Emergency AC power system safety performance at best quartile North America PWR and PHWR was 0.0087
- Darlington performed at best quartile
- Pickering A performed at best quartile
- Pickering B performed worse than median

Trend
- Best quartile was consistently mathematically low
- Darlington performed consistently at best quartile
- Pickering A trended worse in 2007 and 2008
- Pickering B improved performance consistently from 2005 to 2008

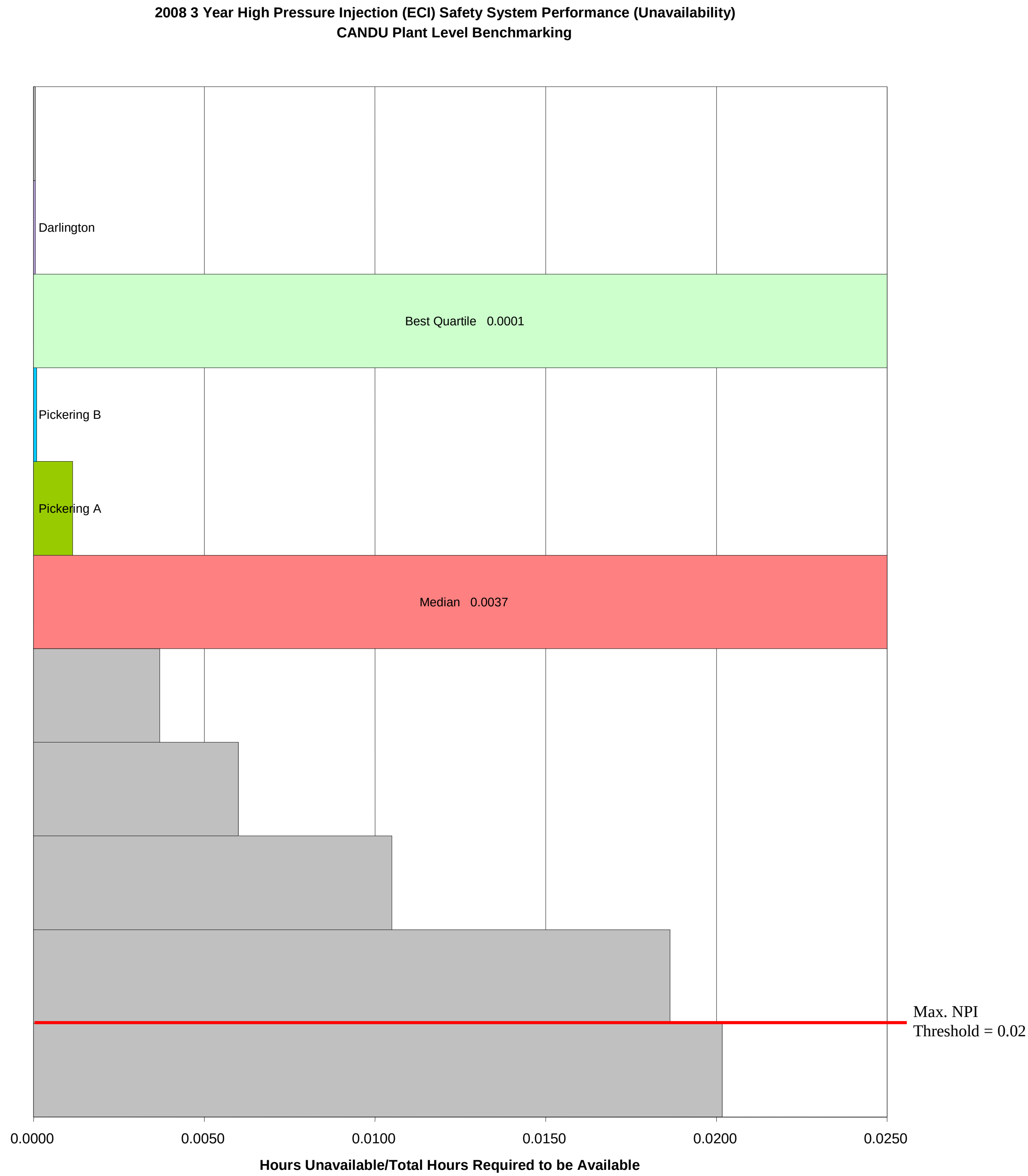
Factors Contributing to Performance

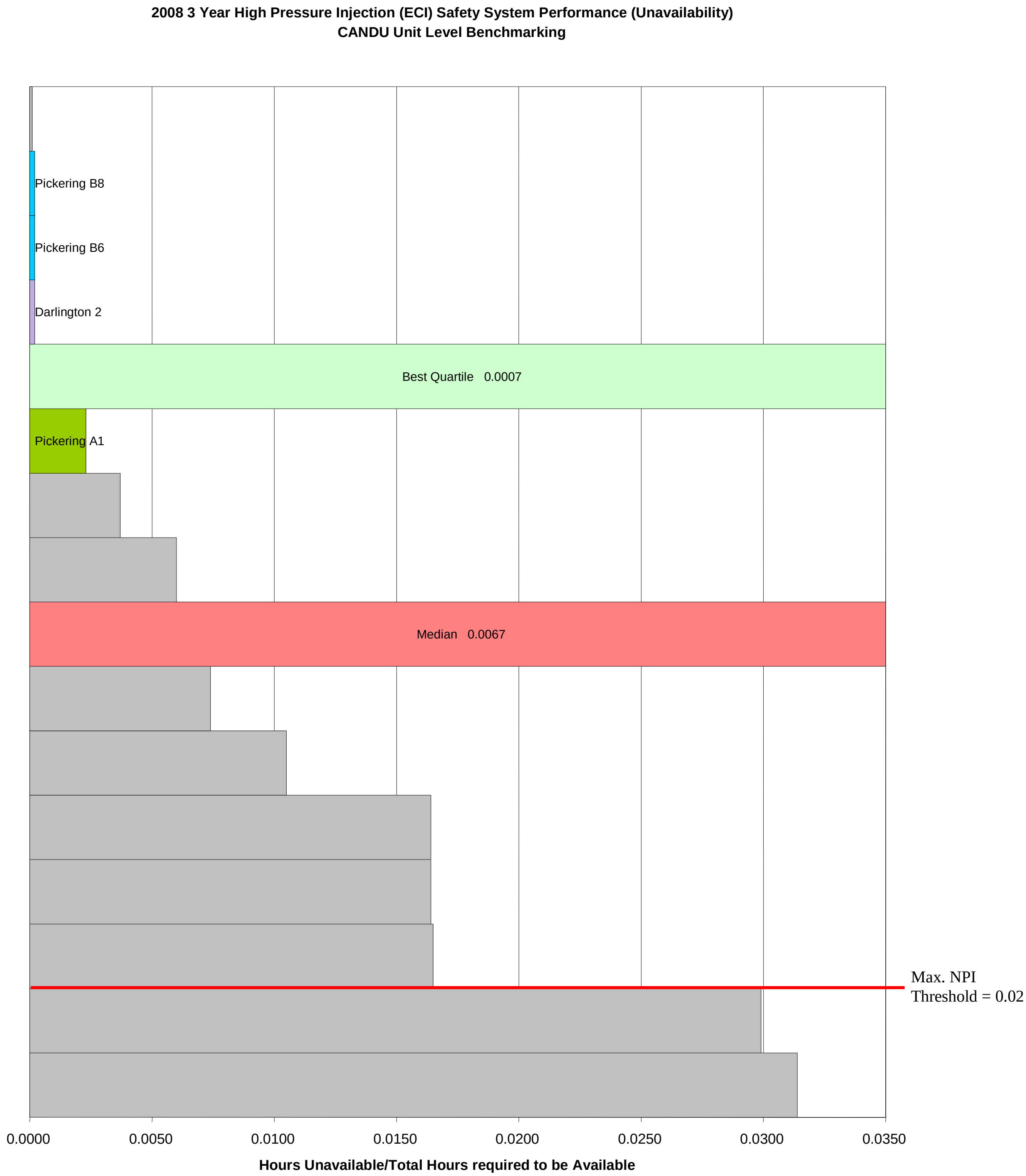
Darlington
- Darlington received full WANO NPI points for emergency AC power system safety performance therefore no performance gap exists

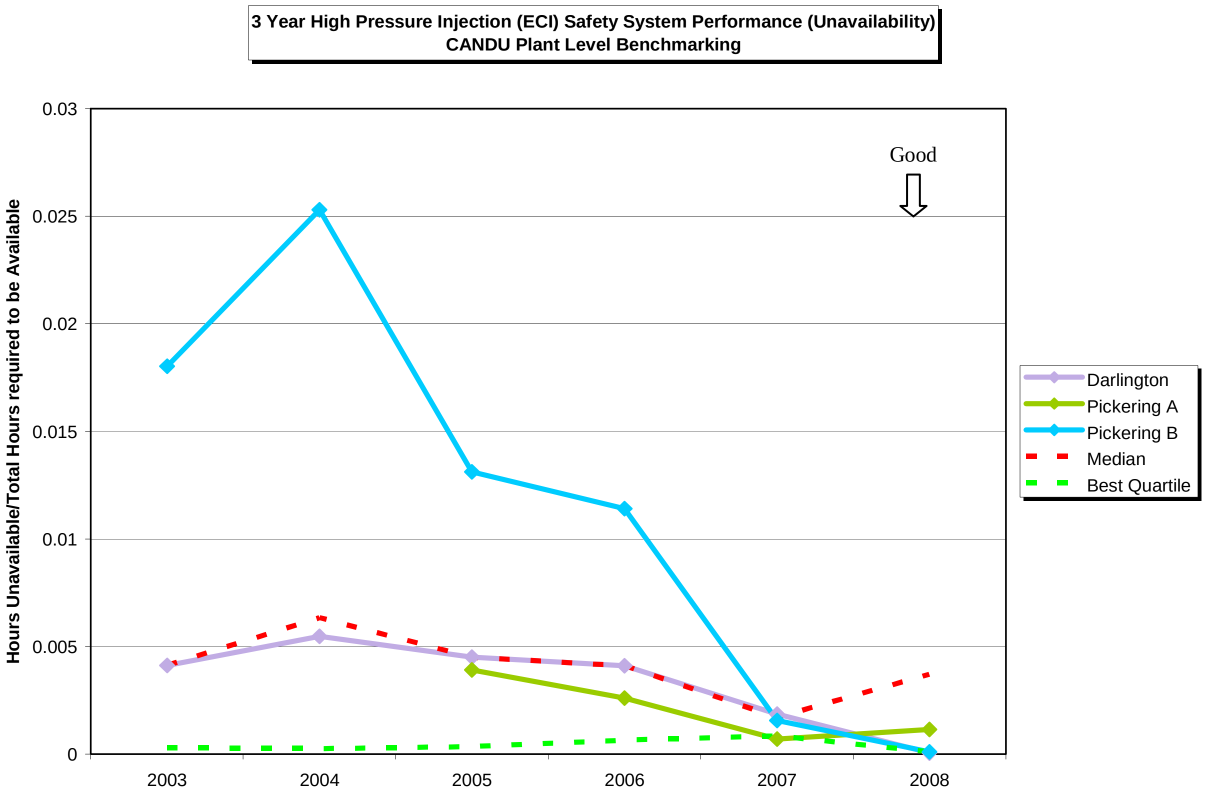
Pickering A
- Pickering A received full WANO NPI points for emergency AC power system safety performance

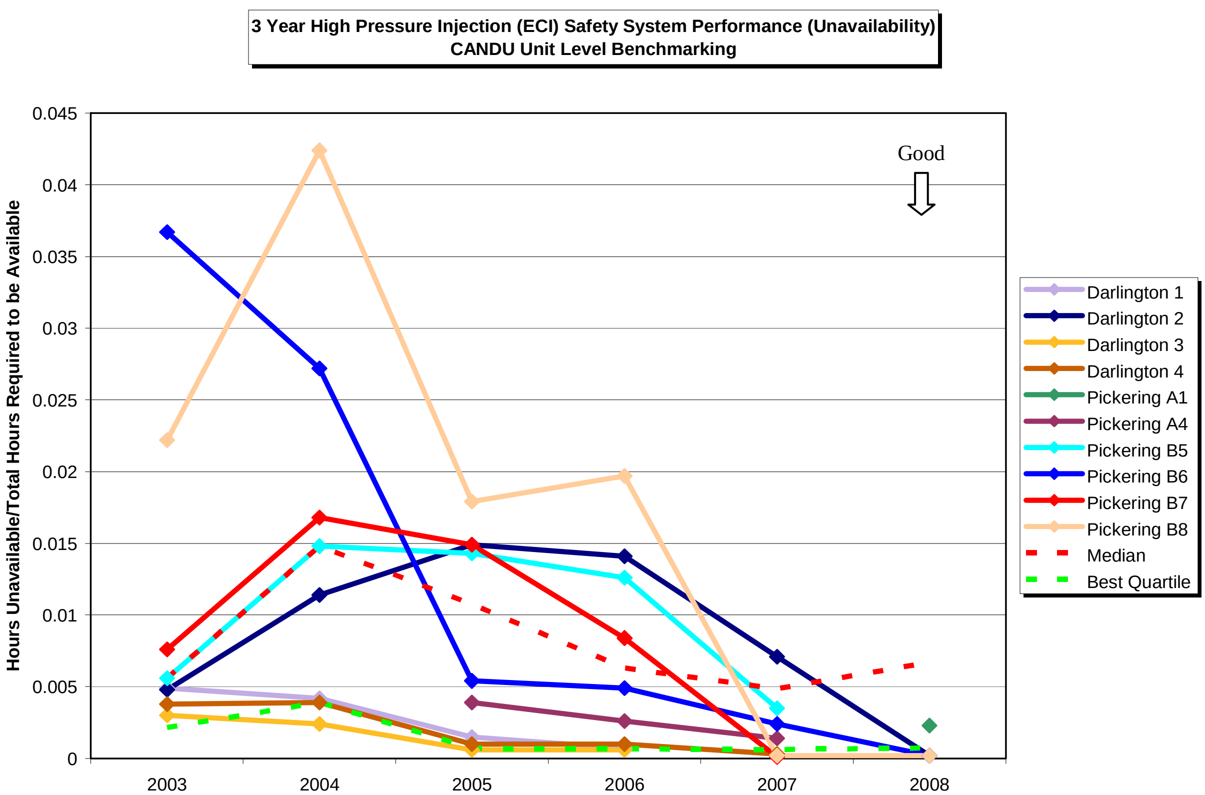
Pickering B
- Pickering B received full WANO NPI points for emergency AC power system safety performance

3-Year High Pressure Safety Injection




2008 3 Year High Pressure Injection (ECI) Safety System Performance (Unavailability)
CANDU Unit Level Benchmarking
Pickering B8
Pickering B6
Darlington 2
Best Quartile 0.0007
Pickering A1
Median 0.0067
Max. NPI Threshold = 0.02
0.0000
0.0050
0.0100
0.0150
0.0200
0.0250
0.0300
0.0350
Hours Unavailable/Total Hours required to be Available


3 Year High Pressure Injection (ECI) Safety System Performance (Unavailability)
CANDU Plant Level Benchmarking
Hours Unavailable/Total Hours required to be Available
0.03
0.025
0.02
0.015
0.01
0.005
0
2003
2004
2005
2006
2007
2008
Good
Darlington
Pickering A
Pickering B
Median
Best Quartile


3 Year High Pressure Injection (ECI) Safety System Performance (Unavailability)
CANDU Unit Level Benchmarking
Hours Unavailable/Total Hours Required to be Available
0.045
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
2003
2004
2005
2006
2007
2008
Good
Darlington 1
Darlington 2
Darlington 3
Darlington 4
Pickering A1
Pickering A4
Pickering B5
Pickering B6
Pickering B7
Pickering B8
Median
Best Quartile

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

- The performance of OPG's units has been shown relative to best quartile, median, and the threshold established by WANO to achieve full WANO NPI points. Since achievement of full WANO NPI points is recognized within the industry as a measure of desirable performance, performance gaps are assessed against full WANO NPI points in addition to median and best quartile. In the case of High Pressure Safety Injection Unavailability, there is essentially no mathematical difference between achieving best quartile and median performance

2008 (3-Year Rolling Average)

- High pressure safety injection system performance at best quartile worldwide CANDU was 0.0001 for plant and .0007 for unit
- Darlington performed at best quartile
- Pickering A performed better than median
- Pickering B performed better than median

Trend

- Best quartile was consistently mathematically low
- Darlington performance trended better over the review period
- Pickering A performance trended better over the review period
- Pickering B performance trended better over the review period

Factors Contributing to Performance

Darlington

- Darlington received full WANO NPI points for high pressure safety injection system performance therefore no performance gap exists

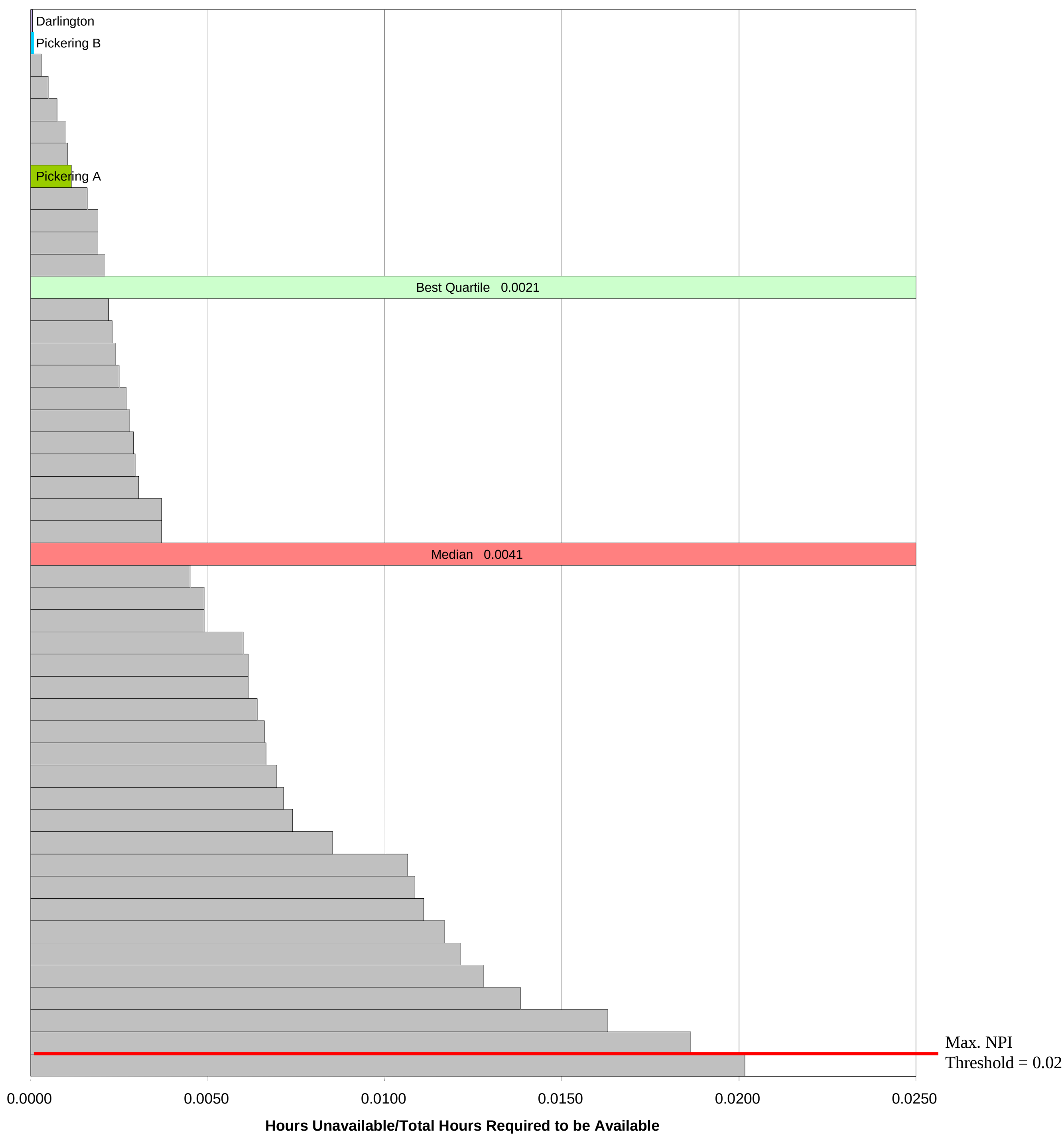
Pickering A

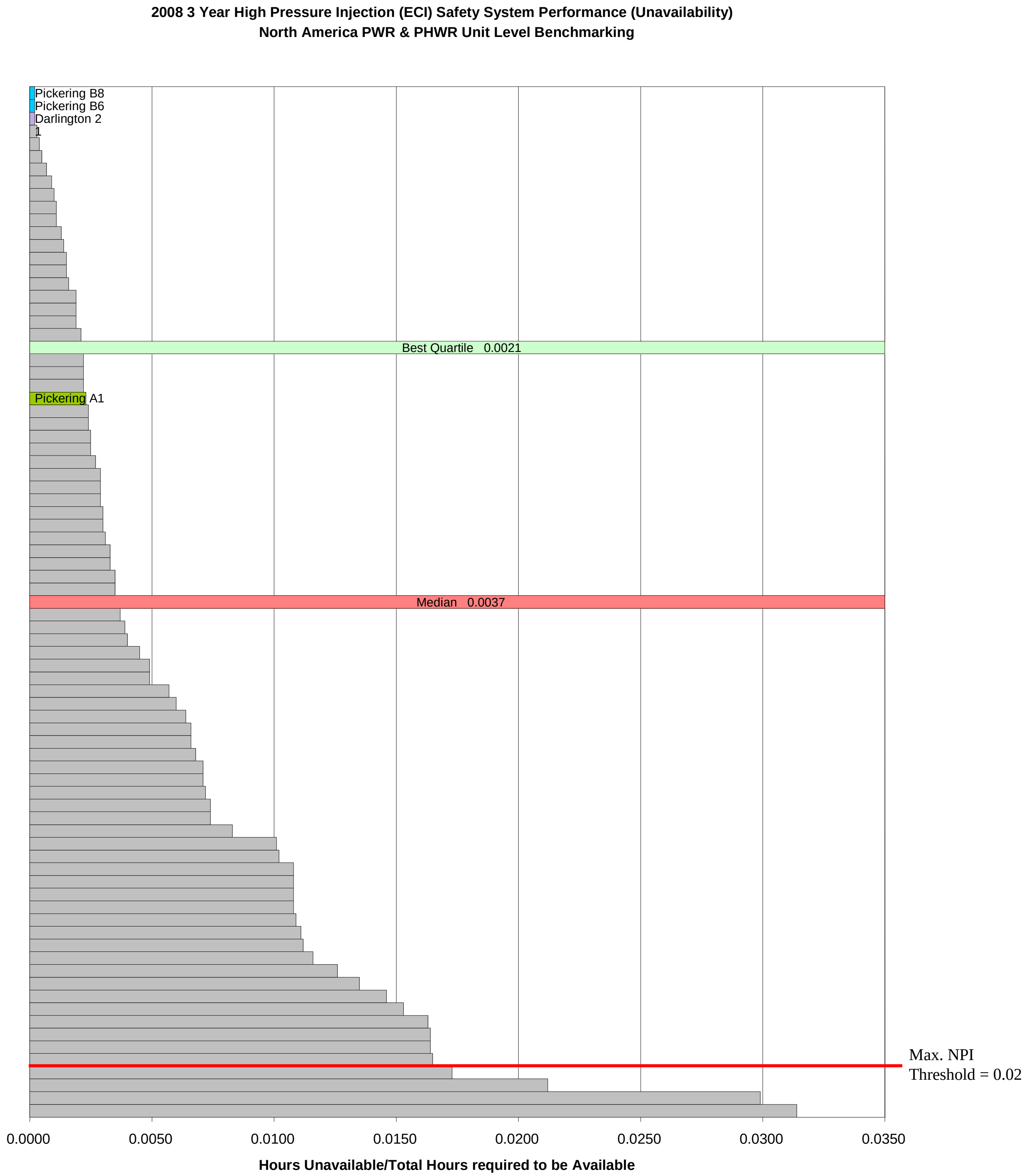
- Pickering A received full WANO NPI points for high pressure safety injection system performance

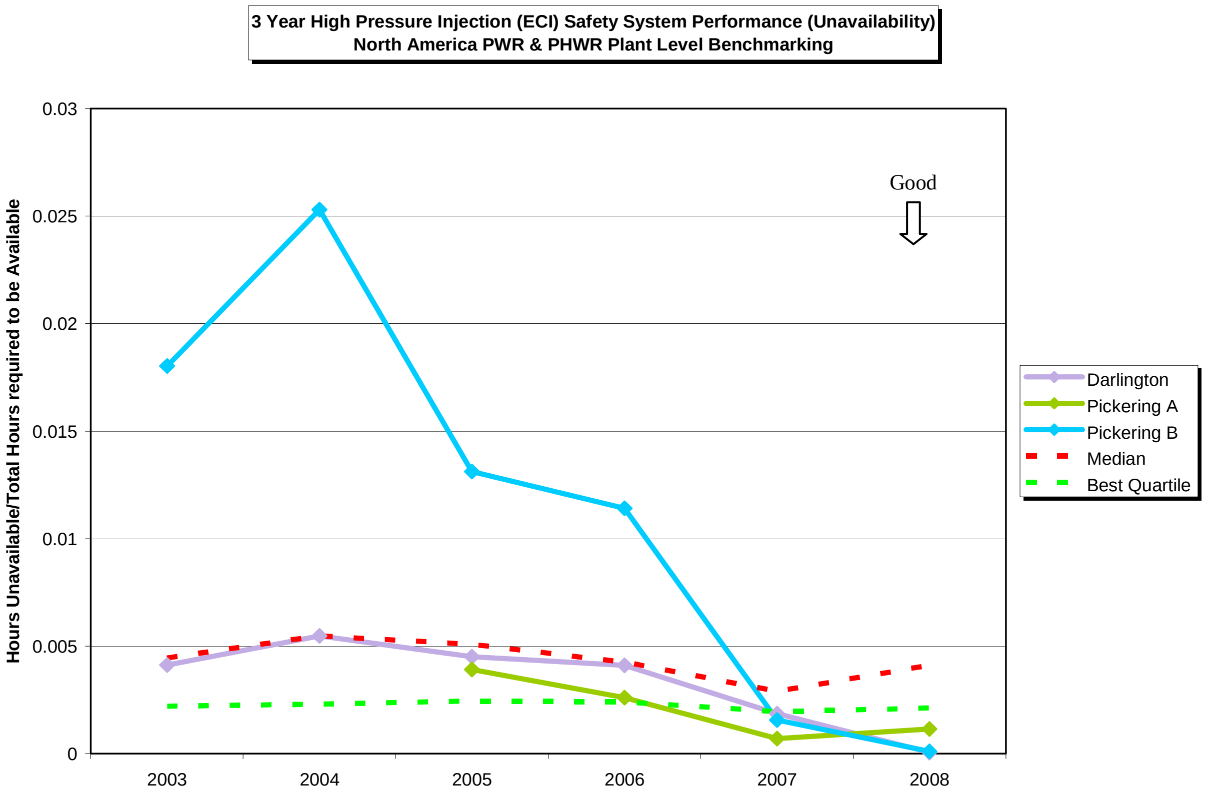
Pickering B

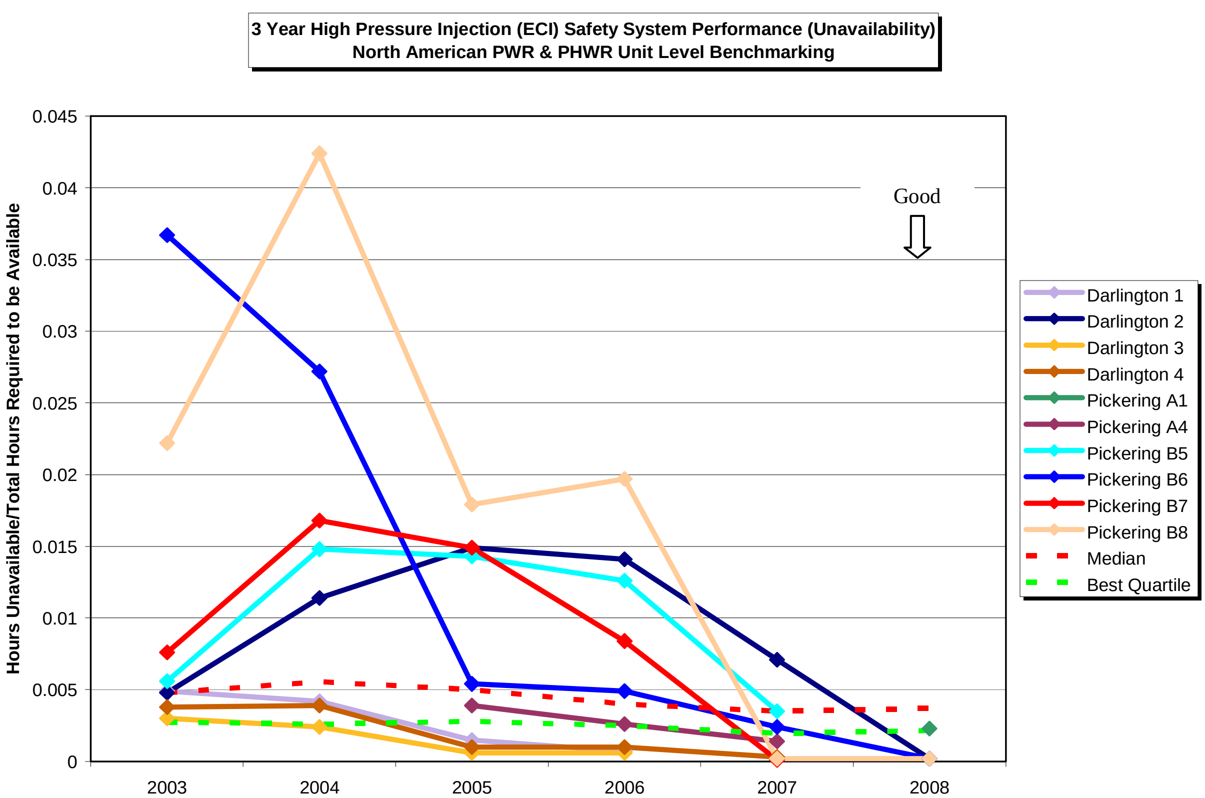
- Pickering B received full WANO NPI points for high pressure safety injection system performance

2008 3 Year High Pressure Injection (ECI) Safety System Performance (Unavailability)
North American PWR & PHWR Plant Level Benchmarking




2008 3 Year High Pressure Injection (ECI) Safety System Performance (Unavailability)
North America PWR & PHWR Unit Level Benchmarking
Pickering B8
Pickering B6
Darlington 2
1
Best Quartile 0.0021
Pickering A1
Median 0.0037
Max. NPI
Threshold = 0.02
0.0000
0.0050
0.0100
0.0150
0.0200
0.0250
0.0300
0.0350
Hours Unavailable/Total Hours required to be Available


3 Year High Pressure Injection (ECI) Safety System Performance (Unavailability)
North America PWR & PHWR Plant Level Benchmarking
Hours Unavailable/Total Hours required to be Available
0.03
0.025
0.02
0.015
0.01
0.005
0
2003
2004
2005
2006
2007
2008
Good
Darlington
Pickering A
Pickering B
Median
Best Quartile


3 Year High Pressure Injection (ECI) Safety System Performance (Unavailability)
North American PWR & PHWR Unit Level Benchmarking
Hours Unavailable/Total Hours Required to be Available
0.045
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
2003
2004
2005
2006
2007
2008
Good
Darlington 1
Darlington 2
Darlington 3
Darlington 4
Pickering A1
Pickering A4
Pickering B5
Pickering B6
Pickering B7
Pickering B8
Median
Best Quartile

Observations – 3-Year High Pressure Safety Injection Unavailability (North American PWR/PHWR)

- The performance of OPG's units has been shown relative to best quartile, median, and the threshold established by WANO to achieve full WANO NPI points. Since achievement of full WANO NPI points is recognized within the industry as a measure of desirable performance, performance gaps are assessed against full WANO NPI points in addition to median and best quartile. In the case of High Pressure Safety Injection Unavailability, there is essentially no mathematical difference between achieving best quartile and median performance

2008 (3-Year Rolling Average)

- High pressure injection system safety performance at best quartile North American PWR and PHWR was 0.0021 for plant and .0021 for unit
- Darlington performed at best quartile
- Pickering A performed at best quartile
- Pickering B performed at best quartile

Trend

- Best quartile was consistently mathematically low
- Darlington performance trended better over the review period
- Pickering A performance trended better over the review period
- Pickering B performance trended better over the review period

Factors Contributing to Performance

Darlington

- Darlington received full WANO NPI points for high pressure injection system safety performance and therefore no performance gap exists

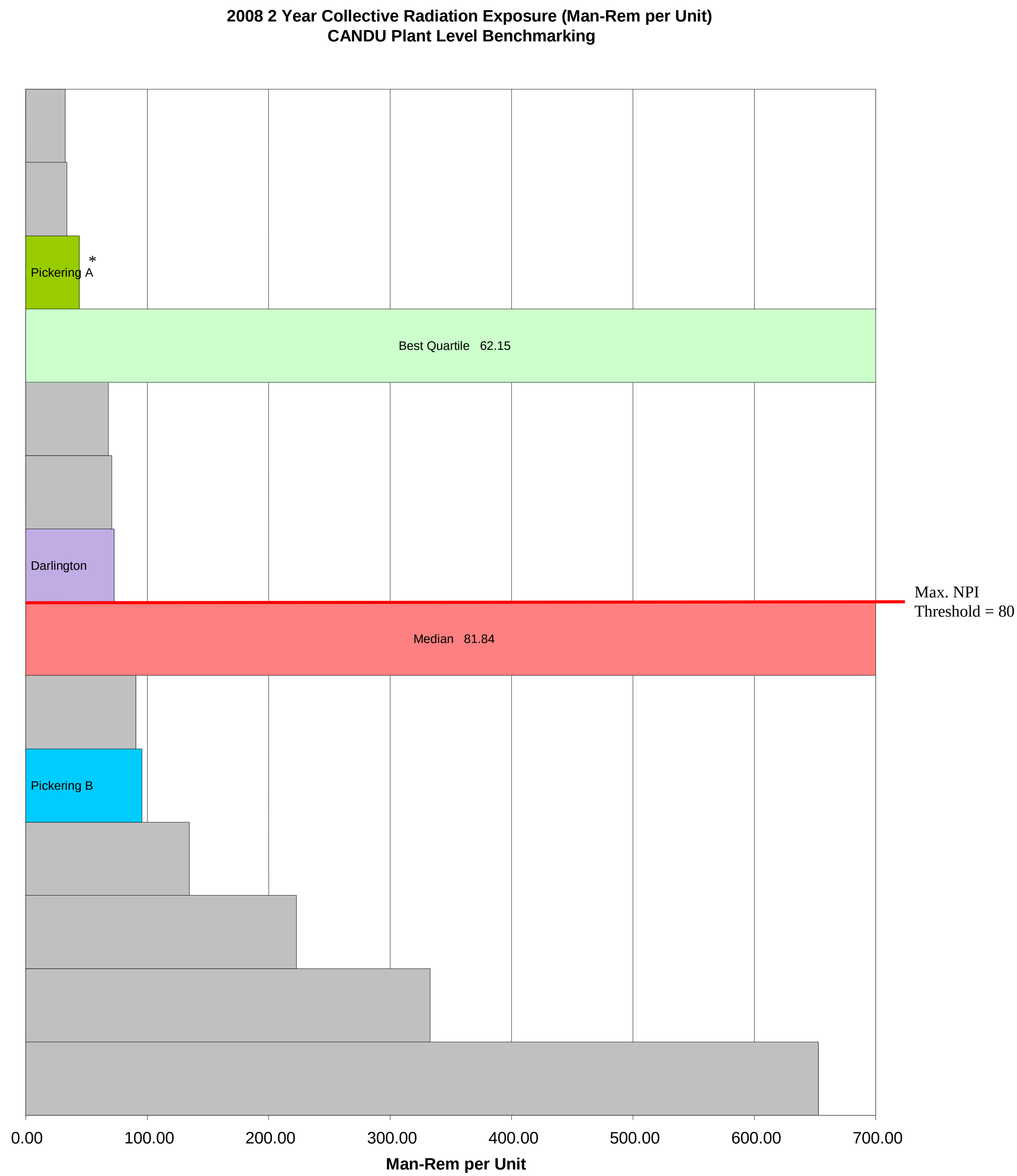
Pickering A

- Pickering A received full WANO NPI points for high pressure injection system safety performance

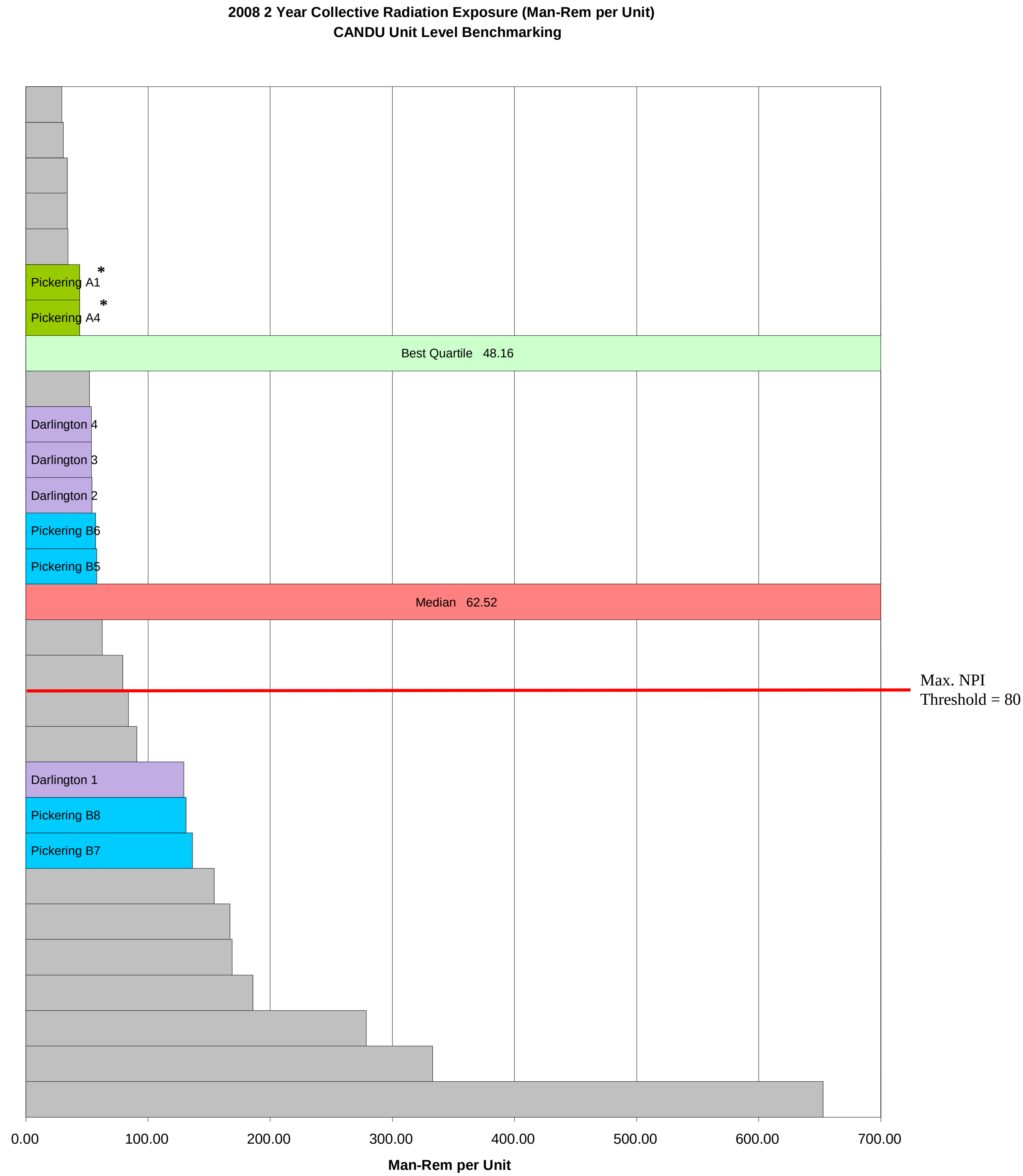
Pickering B

- Pickering B received full WANO NPI points for high pressure injection system safety performance

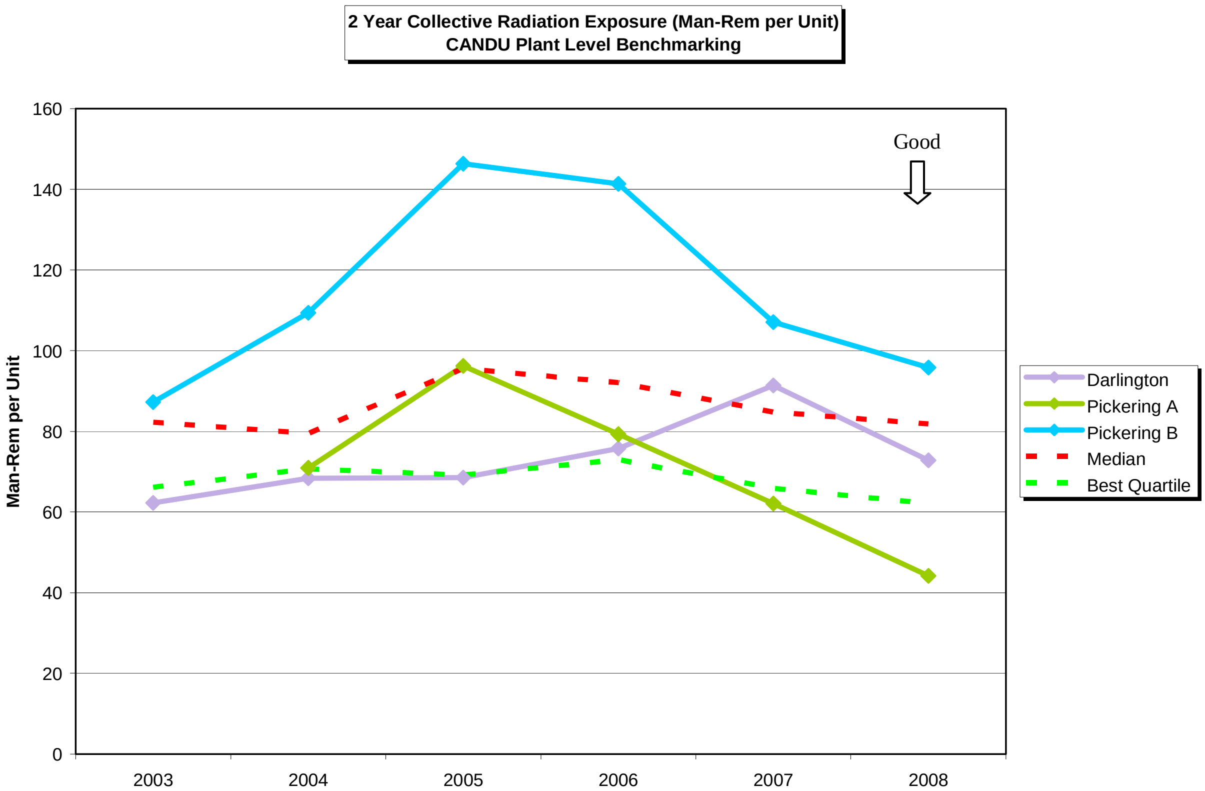
2-Year Collective Radiation Exposure

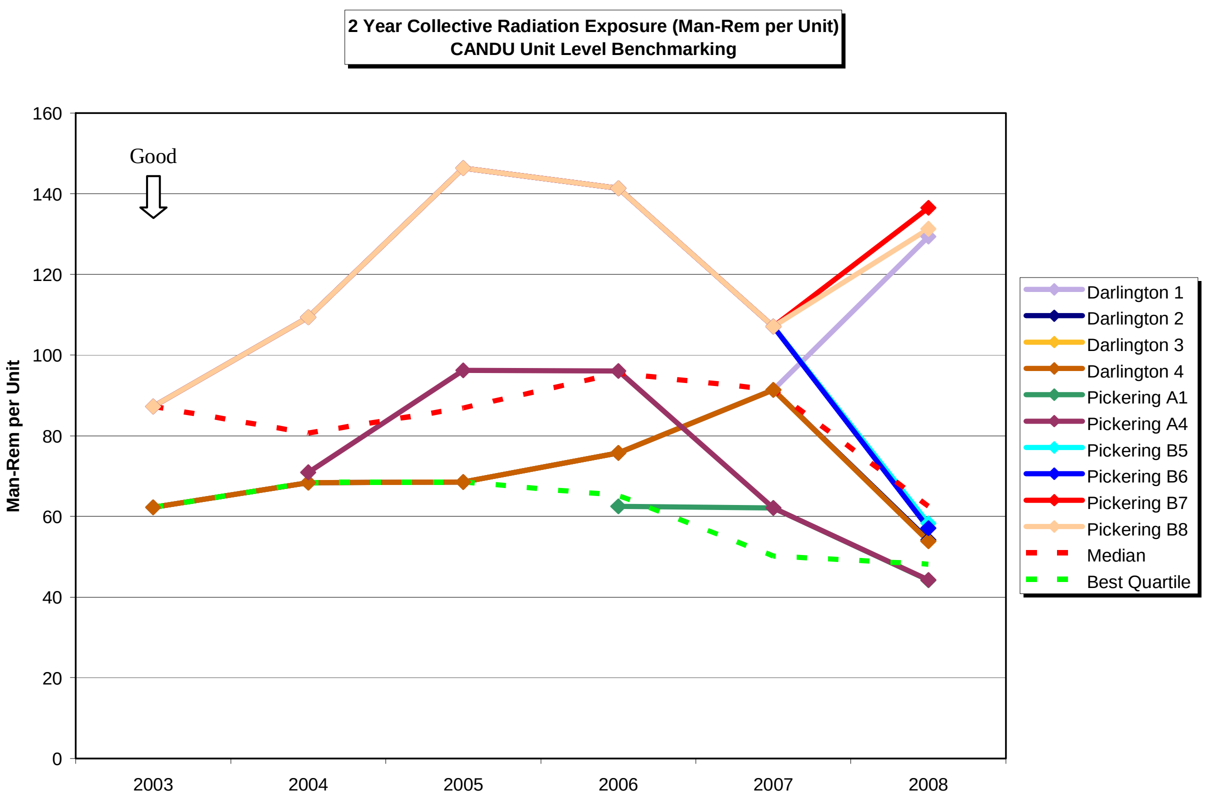


* See Observations and Analysis for information on Pickering A performance



*** See Observations and Analysis for information on Pickering A performance**


2 Year Collective Radiation Exposure (Man-Rem per Unit)
CANDU Plant Level Benchmarking
Man-Rem per Unit
Good
Darlington
Pickering A
Pickering B
Median
Best Quartile
2003
2004
2005
2006
2007
2008


2 Year Collective Radiation Exposure (Man-Rem per Unit)
CANDU Unit Level Benchmarking
Man-Rem per Unit
Good
Darlington 1
Darlington 2
Darlington 3
Darlington 4
Pickering A1
Pickering A4
Pickering B5
Pickering B6
Pickering B7
Pickering B8
Median
Best Quartile
2003
2004
2005
2006
2007
2008

Observations – 2-Year Collective Radiation Exposure (CANDU)

- The performance of OPG's units has been shown relative to best quartile, median, and the threshold established by WANO to achieve full WANO NPI points. Since achievement of full WANO NPI points is recognized within the industry as a measure of desirable performance, performance gaps are assessed against full WANO NPI points in addition to median and best quartile

2008 (2-Year Rolling Average)

- Darlington is currently better than median (81.8.) but worse than the best quartile (62.2)
- Pickering A appears in the best quartile (see below for change in reporting)
- Pickering B is currently worse than the median

Trend

- In 2007, Darlington had two planned outages, D721 and D741, and three forced outages. Collective Radiation Exposure (CRE) performance was 102.7 man-rem/unit vs a target of 94
- In 2008, Darlington had one planned outage, D811 and one forced outage D821 resulting in a CRE performance of 43.4 man-rem/unit vs. a target of 75 due to some significant ALARA improvements in shielding and reducing vault tritium during outages. Even with the extensive amount of work being performed during the planned outage, Darlington scored full NPI points in 2008
- The 2-year CRE CANDU unit level benchmarking graph provided shows an increasing trend in CRE since 2003. However, the radiation levels within the vault and associated systems have been decreasing since 2004. This is attributed to the change in pH level from 10.8 to 10.2, and the introduction of submicron filtration in the primary heat transport (PHT). The reason for the increasing trend in CRE is increased workload associated with outages, i.e. single fuel channel replacement (SFCR), horizontal flux detector (HFD) cable replacement, and feeder inspections and replacement
- In 2009, WANO accepted Darlington's request to use a three-year rolling average for determining NPI. This change does not impact the WANO NPI analysis in this report but will impact future benchmarking comparisons
- In 2007, Pickering A CRE was measured by dividing total plant dose by four units. This is different from how other plants measure CRE – based only on operating units. Two of the units had been laid up for about a decade. Since 2007, they had been undergoing a process called safe storage which required some dose expenditure, but significantly less than for an operating unit. If only two units were accounted for, CRE would have changed from 53.7 (full NPI points) to 107 man-rem/unit
- In 2008, the CRE measure was changed to align with industry standard and to reflect two operating units, however, CRE performance benefited short term when the planned outage for Unit 4 (P841) was deferred from 2008 until Q1 2009. As a result, Pickering A once again received full NPI points based on a CRE performance of 35 man-rem/unit. Additionally, human performance is also a factor both in direct worker radiation protection performance and in cases where human performance events triggered forced outages (also impacting forced loss rate) and resulting in increased radioactive work requirements

- Factoring in a 2-unit CRE in 2007, combined with 2008 CRE, would drop Pickering A to second quartile vs CANDUs, and third quartile vs North American PWRs and PHWRs
- Beginning in 2008, CRE performance began to be reported individually by unit
- The 2009 CRE performance in Q1 is 99.2 man-rem/unit and is expected to reach about 129.5 by year-end, reflecting the impact of a unit maintenance outage
- Pickering A plant age (oldest OPG units) and design (including more stellite components and poor dryer performance) results in higher radiation source term and dose rates
- Pickering B had one planned outage in 2007, P761, and one forced outage, P751 that resulted in a year end CRE performance of 93.1 man-rem/unit vs. a target of 110.8. Included in P761 was an Single Fuel Channel Replacement which resulted in a dose of 26 rem
- In 2008, Pickering B had two planned outages, P871 and P881, which resulted in a year-end CRE performance of 98.8 man-rem/unit vs a target of 98.8. Included in P871 was a Single Fuel Channel Replacement which resulted in a dose of 37 rem
- The 2-year CRE CANDU unit level benchmarking graph provided shows a decreasing trend in CRE since 2005 for Pickering B. This is believed to be attributed to the change in pH from 10.8 to 10.2 and the introduction of submicron filtration in the PHT system. Like Darlington, Pickering B has been seeing a decreasing trend in radiation levels inside their reactor buildings and associated systems since 2005

Factors Contributing to Performance

- The number of outages are a significant driver of CRE due to extended exposure during specific maintenance activities performed only during outages. Other key performance drivers for this metric include: source term, outage duration, human performance, and technology

Darlington

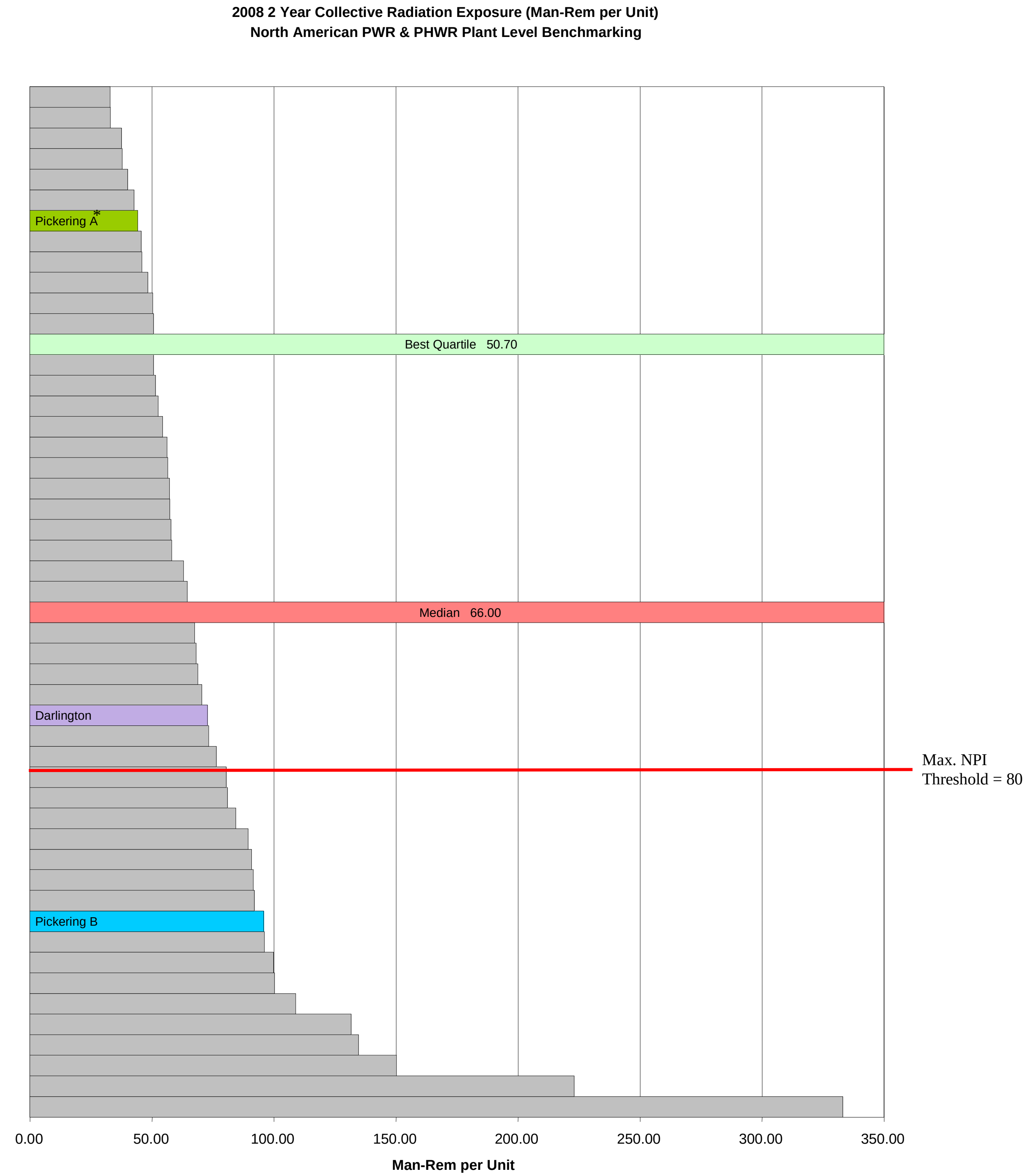
- Darlington may be able to reach best quartile vs CANDUs with relatively small reduction in dose. For example, reduction of vault tritium levels would enable less restrictive protective equipment which, in turn, enables shorter work times within the vault and less radiation exposure

Pickering A

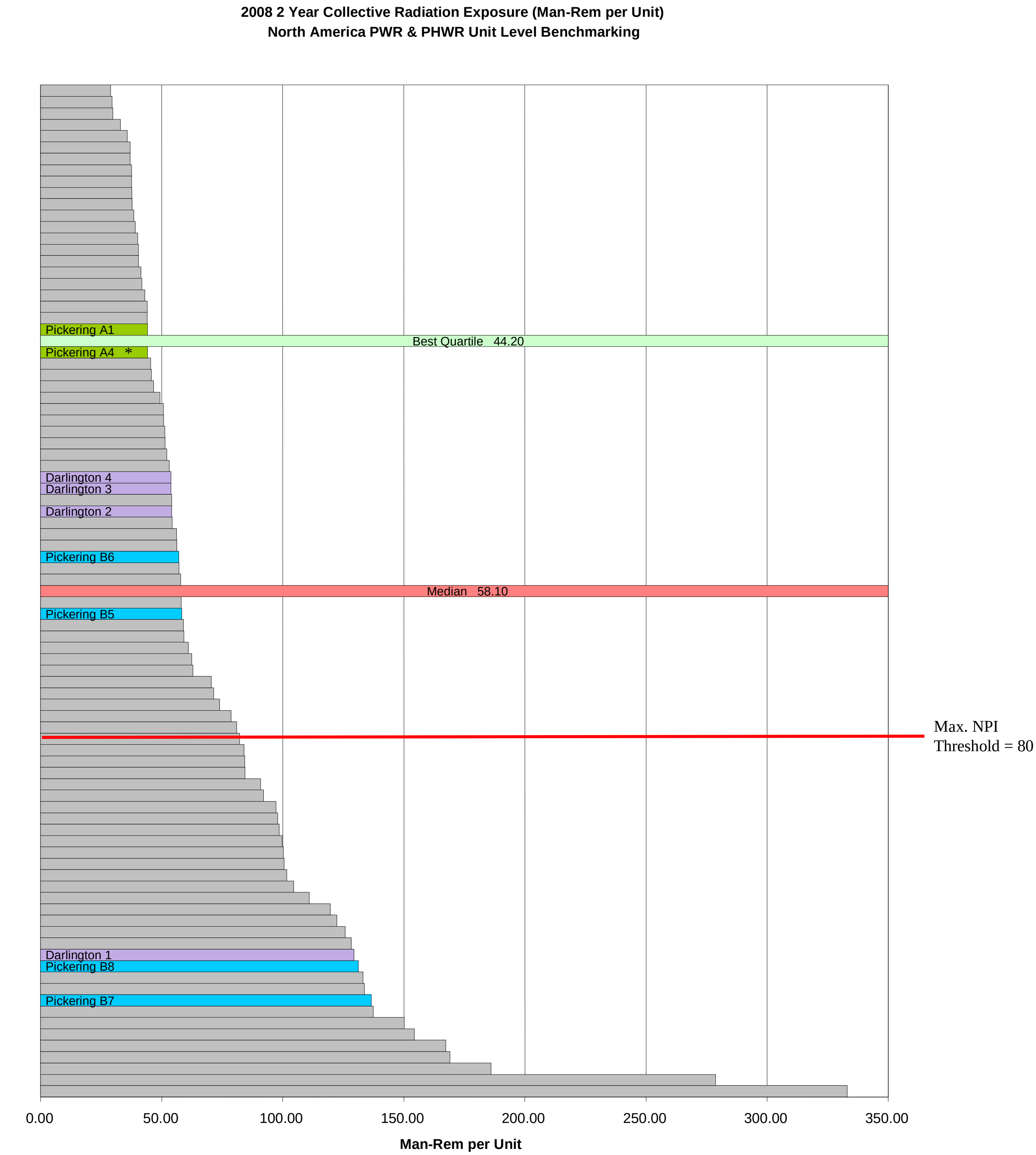
- Reviewing Pickering A outage plans for 2010 through 2012, we should expect few NPI points for CRE to be achieved due to outage scope combined with high source term (probably third quartile vs CANDUs and fourth quartile vs North American PWRs and PHWRs)

Pickering B

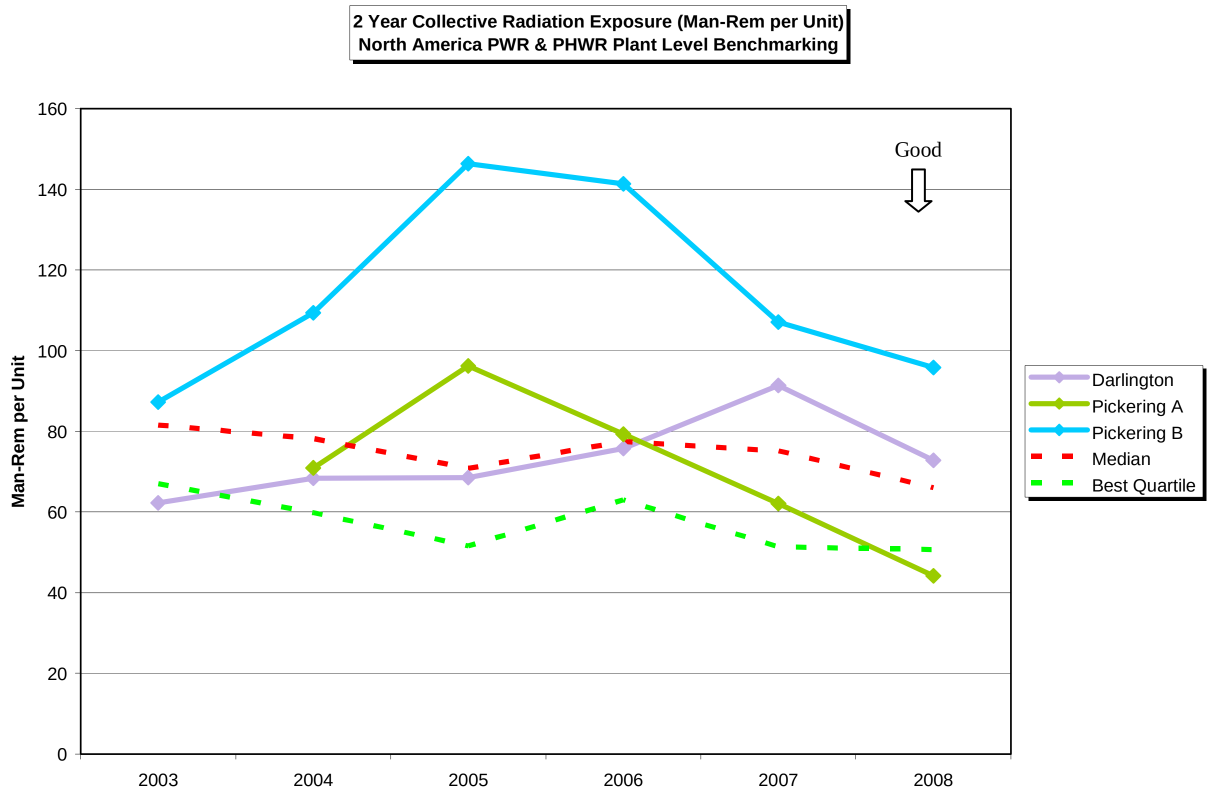
- Proceeding with continued operations may require increased maintenance outage activities, negatively impacting CRE performance
- Implementation of dose reduction technologies can mitigate to some extent, however the overall plant age and design works against it. No technology improvements have been identified which would enable reduction of radiation source term sufficient to reach top quartile, due to long Cobalt 60 decay time combined with limited number of years of operation under life extension

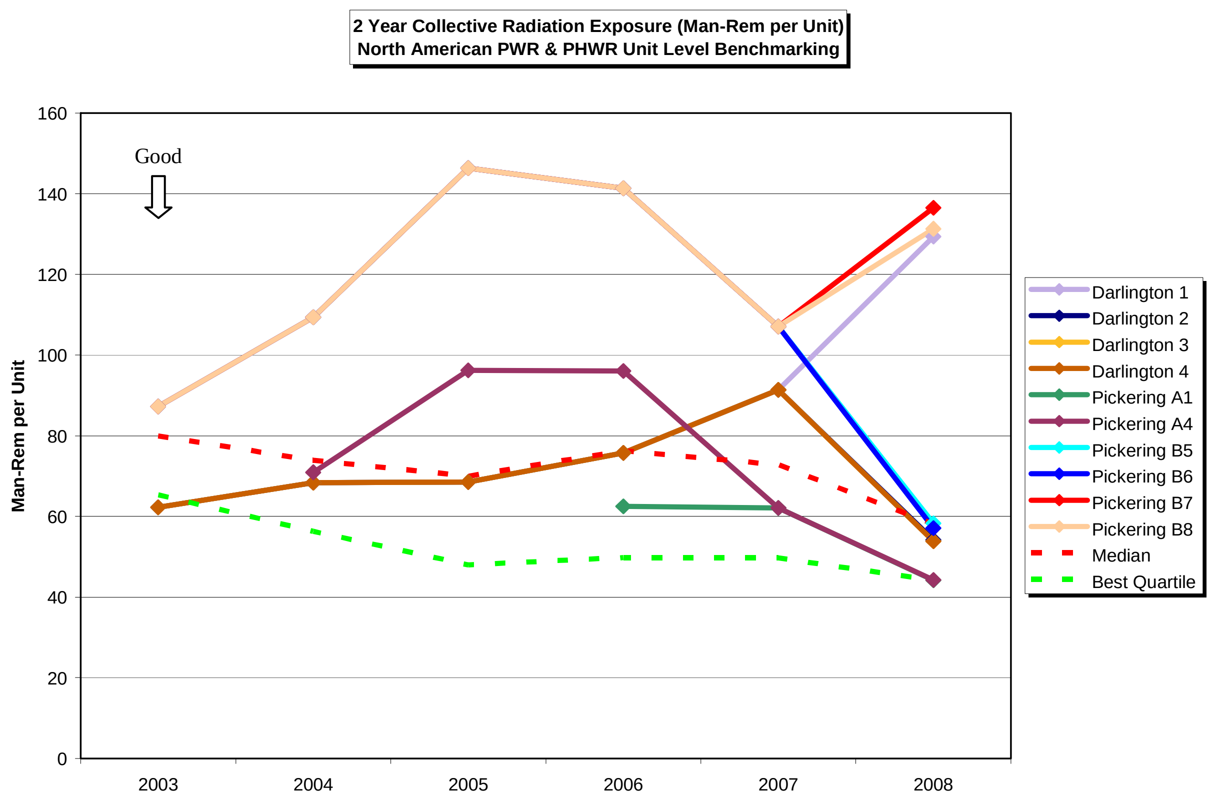


* See Observations and Analysis for information on Pickering A performance



* See Observations and Analysis for information on Pickering A performance


2 Year Collective Radiation Exposure (Man-Rem per Unit)
North America PWR & PHWR Plant Level Benchmarking
Man-Rem per Unit
Good
160
140
120
100
80
60
40
20
0
2003
2004
2005
2006
2007
2008
Darlington
Pickering A
Pickering B
Median
Best Quartile


2 Year Collective Radiation Exposure (Man-Rem per Unit)
North American PWR & PHWR Unit Level Benchmarking
Man-Rem per Unit
Good
160
140
120
100
80
60
40
20
0
2003
2004
2005
2006
2007
2008
Darlington 1
Darlington 2
Darlington 3
Darlington 4
Pickering A1
Pickering A4
Pickering B5
Pickering B6
Pickering B7
Pickering B8
Median
Best Quartile

Observations – 2-Year Collective Radiation Exposure (North American PWR and PHWR)

- The performance of OPG's units has been shown relative to best quartile, median, and the threshold established by WANO to achieve full WANO NPI points. Since achievement of full WANO NPI points is recognized within the industry as a measure of desirable performance, performance gaps are assessed against full WANO NPI points in addition to median and best quartile

2008 (2-Year Rolling Average)

- Best quartile for all North American PWR and PHWRs was 50.7, with a median of 66 man-rem/unit
- Darlington is below median at the plant level; however units 2, 3, and 4 performed above median at the unit level. Unit 1 performed below median
- Pickering A is in the best quartile (see CANDU panel for information regarding performance measuring)
- Pickering B performed below median at the plant level. Unit 6 performed above the median and unit 5, 7, and 8 performed below the median at the unit level

Trend

- See trend analysis section of CANDU panel

Factors Contributing to Performance

- Key performance drivers for this metric include: source term, outage duration, human performance, and technology

Darlington

- Darlington will not be able to reach top quartile vs North American PWRs and PHWRs without substantially reducing the Cobalt 60 source term. This will require either major gains from use of new macroporous resins (untested in CANDUs), replacement of stellite FM ram balls with another material (not yet tested or qualified) along with time for radioactive decay of existing Cobalt 60, or installation of new FM filtration and IX combined with time for decay, or some other improvement technology or initiative

Pickering A

- Reviewing Pickering A outage plans for 2010 through 2012, we should expect few NPI points for CRE to be achieved due to outage scope combined with high source term (probably third quartile vs CANDUs and fourth quartile vs North American PWRs and PHWRs)

Pickering B

- Proceeding with continued operations may increase maintenance outage activities negatively impacting CRE. Implementation of dose reduction technologies can mitigate to some extent, however the overall plant age and design works against it. Currently, no technology improvements have been identified which would enable reduction of radiation source term sufficient to reach best quartile vs PWRs and PHWRs plants, due to long Cobalt 60 decay time

General Comments Regarding Technology

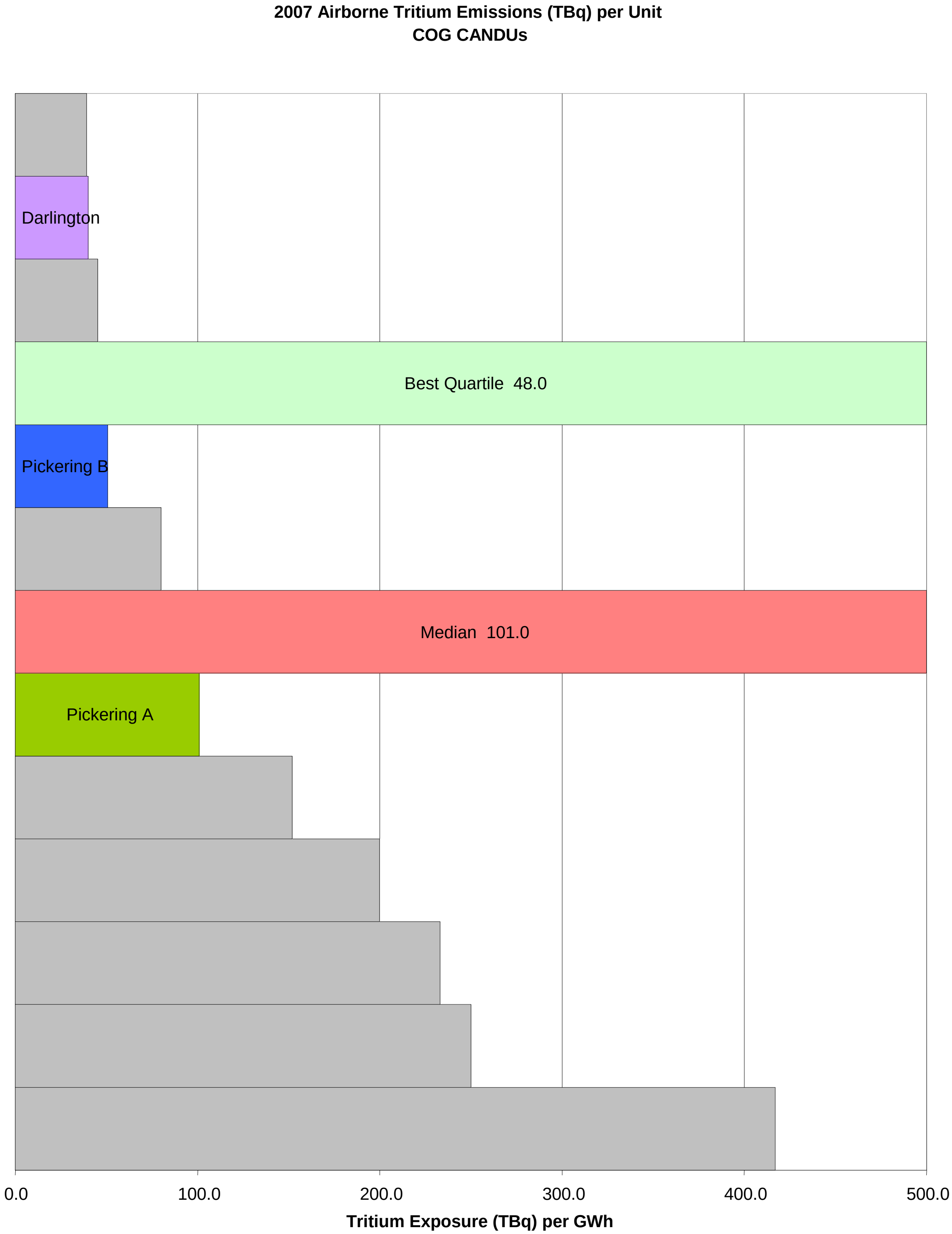
PWRs

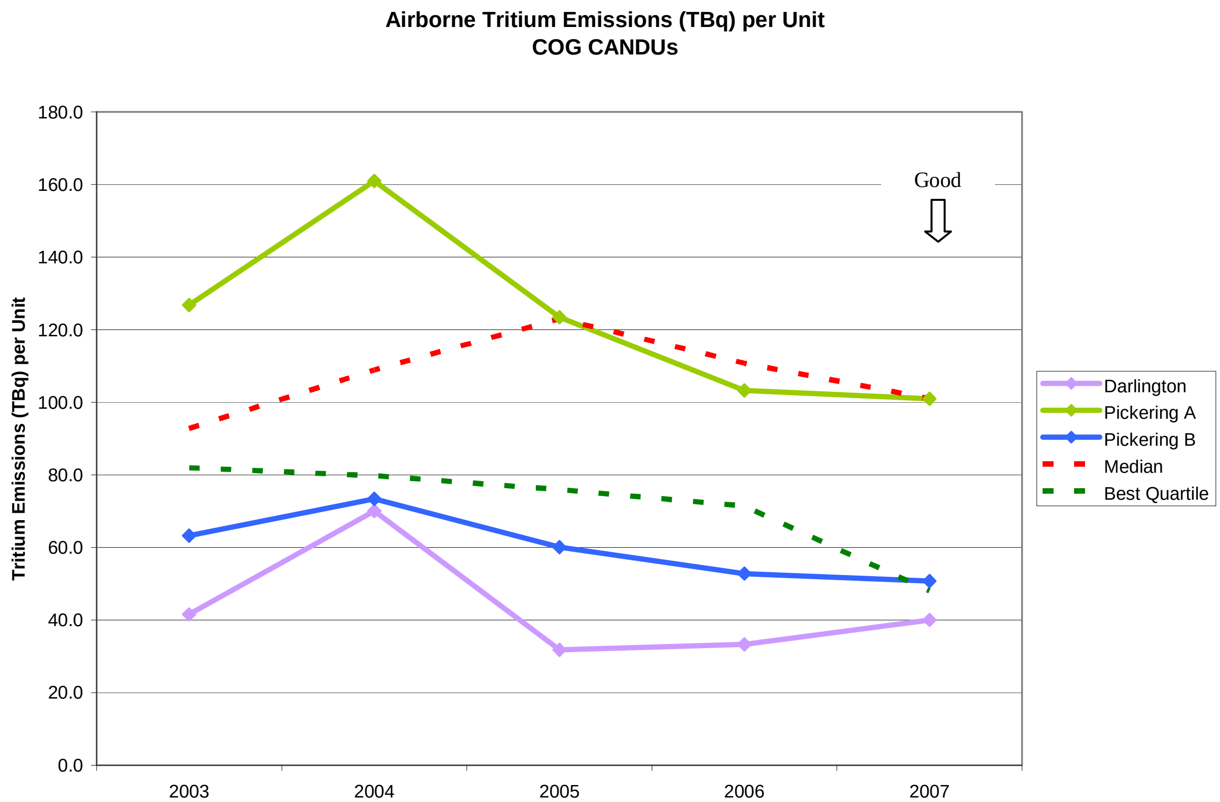
- Over the last 20 years, industry groups along with PWR station chemistry and RP groups have worked together to find the best methods for reducing source term to reduce worker dose ALARA (as noted below, a similar concerted historical effort did not occur for CANDUs)
- PWRs have less tritium exposure hazard for employees
- PWRs do not have online fueling machines, thereby reducing radiation exposure to employees
- Outages for PWRs have been historically shorter than CANDUs, thereby reducing radiation exposure to employees

CANDU Reactors (Note: a CANDU is a type of PHWR)

- PWR-approved technologies for dose control including zinc or hydrogen peroxide addition have not been approved for use at OPG or other CANDUs due to chemistry department concerns that these are either not applicable to CANDU metallurgy and/or chemistry regimes, may cause plant damage, or at least would require an extensive qualification program. OPG has learned through operating experience to be very cautious with large-scale programs that inject chemicals into heat transport systems
- Due to small purification flow rates in CANDU plants (typically operating even less than original design), even if steps are taken to improve flow, there are long lead-times (years) required to reduce radiation source term
- At OPG, Radiation Protection (RP) ALARA sections were first formed in 2000. RP and chemistry departments have generally not been well integrated historically. As a result, source term initiatives have only been in place for the last seven to eight years. Some of these initiatives include:
  - Submicron filtration, (starting about 2002 at one plant; work continues to reach best industry standards)
  - pH change from 10.8 to 10.2 (driven by feeder thinning teams)

Airborne Tritium Emissions per Unit




Airborne Tritium Emissions (TBq) per Unit
COG CANDUs
Tritium Emissions (TBq) per Unit
180.0
160.0
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
2003
2004
2005
2006
2007
Good
Darlington
Pickering A
Pickering B
Median
Best Quartile

Observations – Airborne Tritium Emissions (TBq) per Unit

2007 Performance

- TBq/Unit at best quartile worldwide CANDU plants was 48 or lower
- Darlington performed better than best quartile as a site
- Pickering B nuclear was nearly best quartile
- Pickering A was virtually at median

Trend

- Darlington and Pickering B sites have demonstrated consistent performance over the last five years. As such with modest improvements Darlington can continue as best quartile and Pickering B can reach best quartile if it addresses its minor performance gaps
- The industry trend shows the best plants continuing to improve while median performance is near static. Median performance is likely reflective of both aging and higher tritium source terms in facilities without access to detritiation capability

Factors Contributing to Performance

- Facilities with access to a tritium removal facility (Darlington, Pickering, Bruce Power) fare better in this measure having the benefit of a reduced source term
- Darlington being attached to a tritium removal facility would be expected to benefit the most but this effect will be mitigated somewhat by the emissions from the tritium removal facility itself which is also processing tritiated water from other sites
- Sites having units that are in the process of being placed in a long-term “safe state” (Pickering A) are hindered by emissions from those units

Darlington

- Darlington is better than best quartile and there is no gap in that sense. Performance could still be improved by initiatives to operate the associated Tritium Removal Facility with fewer unplanned outages and the resultant transient emission

Pickering A

- In 2007, Pickering A emitted as much tritium as Pickering B but operated half as many units indicating performance gaps are more significant with Pickering A
- A comparison of the emission events at Pickering A to those at Pickering B suggests a focus on tracking and aggressively repairing leaks, and keeping dryers in service or even augmenting them would reduce the site gap to best quartile
- The tritium source term in Pickering Units 2 and 3 produces emissions without generation and its removal is essential for Pickering sites to move toward best quartile.
- Consistently executing moderator swaps, thereby taking full advantage of access to detritiation capabilities, would also reduce Pickering’s gap to best quartile

Pickering B

- Pickering B units are virtually best quartile and as such performance gaps are small
- Reducing source term through moderator swaps during outages offers the biggest single potential for emissions reduction

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3.0 RELIABILITY

Methodology and Sources of Data

The majority of reliability metrics were calculated using the data from the WANO website. Any data labeled 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 period 2001-2008 was obtained and averages are as provided by WANO.

The two backlog metrics, elective and corrective maintenance, are also included within this section and the data comes from an industry sponsored INPO AP-928 subcommittee rather than from a more formal third-party source. The years included are 2006 to 2008 because the data is most reliable over that period. Data points benchmarked are a single point in time, not a rolling average. All of the data is self-reported.

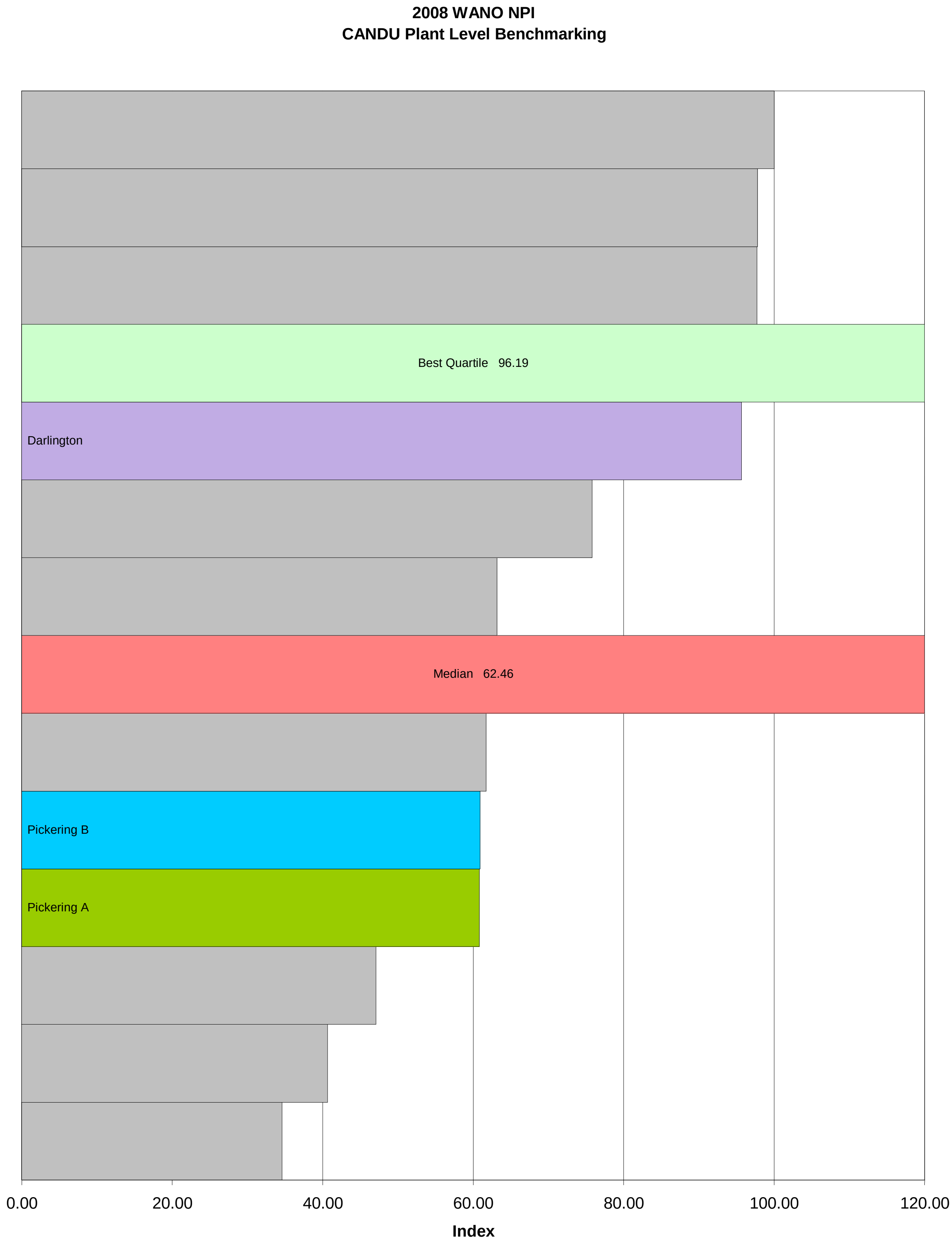
Discussion

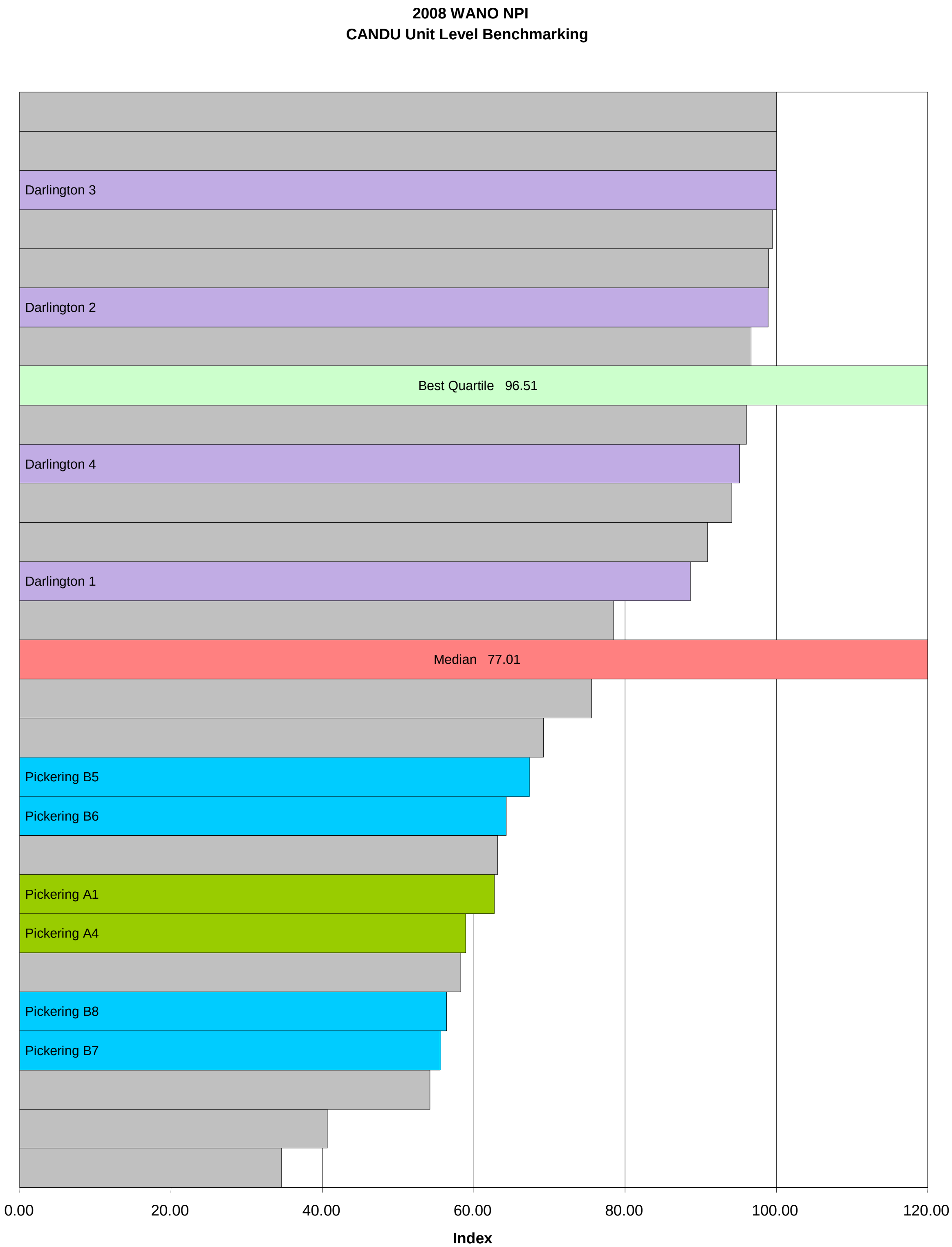
The primary metric within the reliability section is the WANO NPI. The WANO NPI is an operational performance indicator comprised of 10 metrics, three of which are also analyzed in this section: forced loss rate, unit capability factor, and chemistry performance indicator. The remainder of the WANO NPI components are analyzed in the Safety section (Section 2.0).

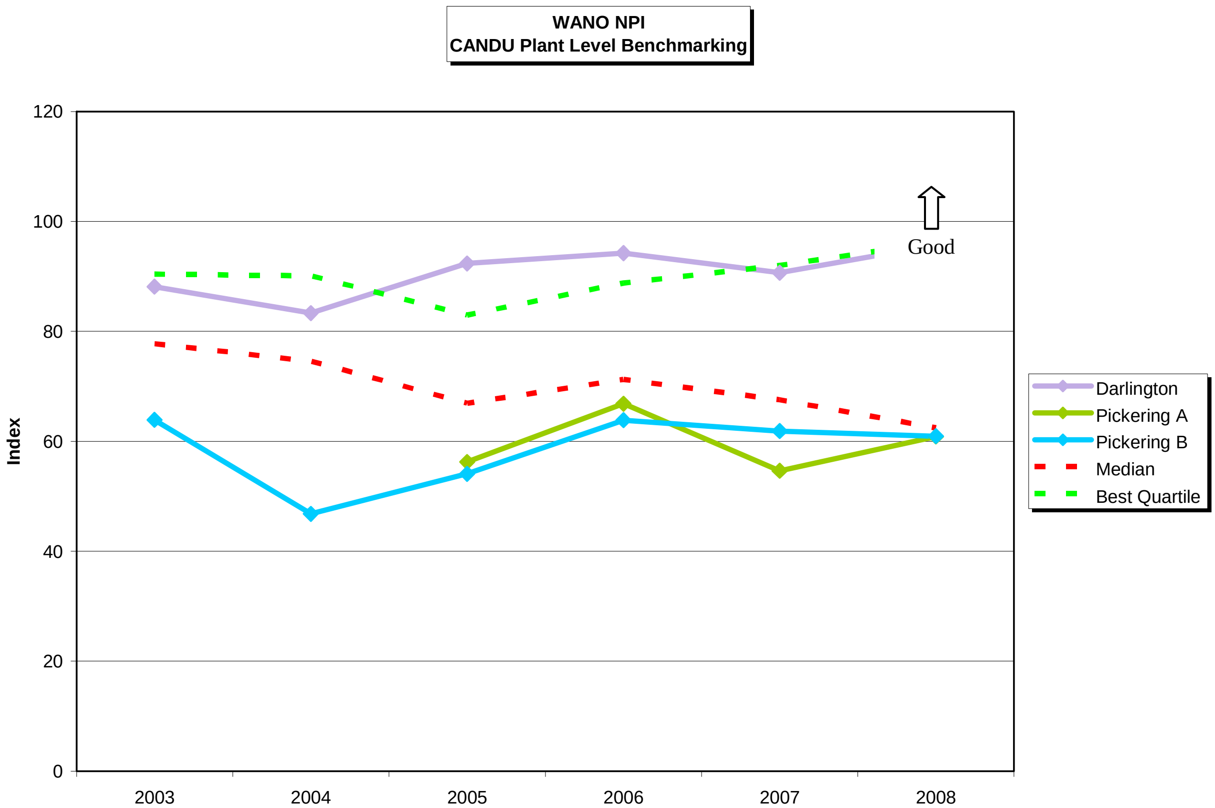
For WANO NPI, Darlington performed well against both the CANDU worldwide panel and the North American PWR and PHWR panel, achieving best quartiles for part of the review period and falling just outside of best quartile for the most recent data point. Pickering A and Pickering B both need to improve performance significantly to achieve best quartile. The areas in which the Pickering stations have performed the poorest are capability factor and forced loss rate. Both areas require attention in order to improve their WANO NPI metric.

All of the plants have shown consistent improvement for the elective and corrective backlog metrics, but because of simultaneous industry level improvement, best quartile has not yet been achieved by Darlington, Pickering A, or Pickering B.

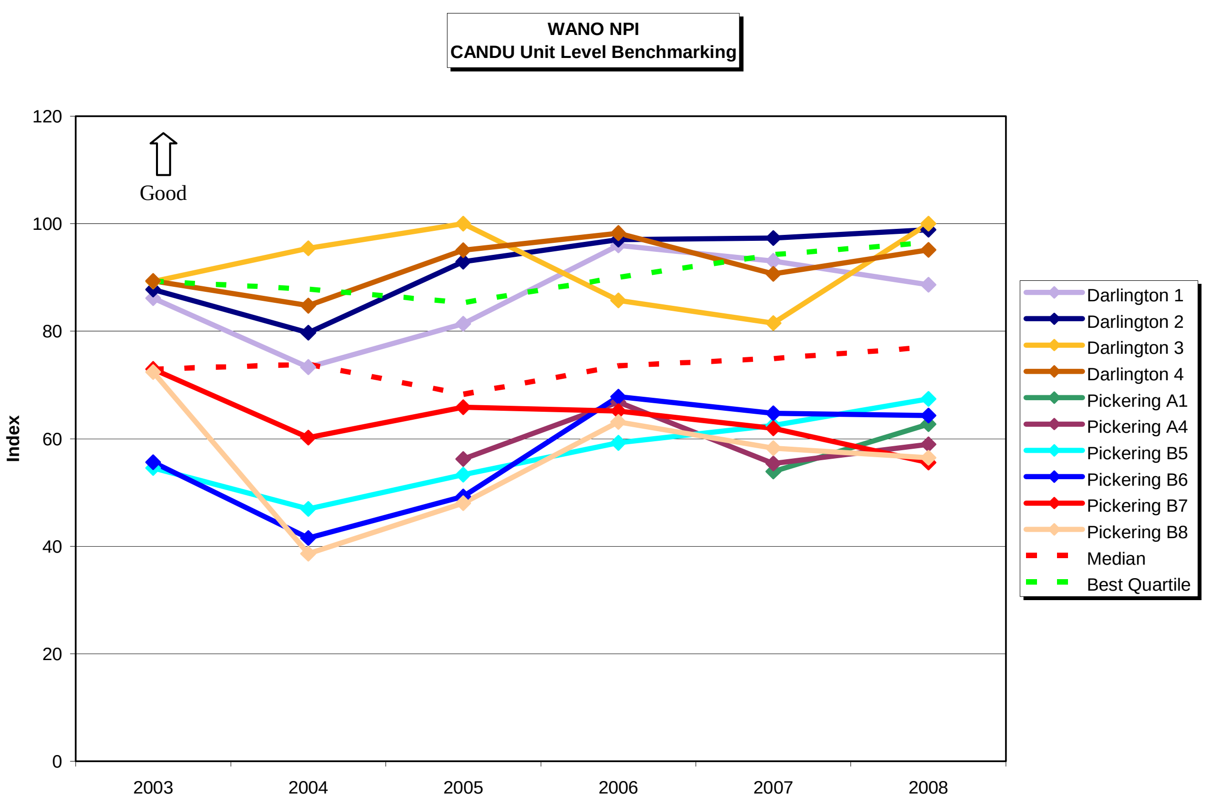
WANO NPI


2008 WANO NPI
CANDU Plant Level Benchmarking
Best Quartile 96.19
Darlington
Median 62.46
Pickering B
Pickering A
0.00
20.00
40.00
60.00
80.00
100.00
120.00
Index


2008 WANO NPI
CANDU Unit Level Benchmarking
Darlington 3
Darlington 2
Best Quartile 96.51
Darlington 4
Darlington 1
Median 77.01
Pickering B5
Pickering B6
Pickering A1
Pickering A4
Pickering B8
Pickering B7
0.00
20.00
40.00
60.00
80.00
100.00
120.00
Index



Note: Only Pickering A Unit 4 received a WANO NPI score in 2005 and 2006



Observations – WANO NPI (CANDU)

2008

- The current best quartile level for WANO NPI is 95.67 and has consistently risen within the CANDU comparison panel since 2005
- It is also worth noting that the performance of Pickering Units B5 and B6 are noticeably better than that of Pickering Units B7 and B8

Trend

- The median value for the panel has actually decreased slightly since 2005. This indicates that the performers outside of best quartile are performing worse
- Darlington is the strongest OPG performer achieving best quartile over most of the review period
- Both Pickering A and Pickering B have performed consistently below median over the review period
- The recent move closer to median is a result of the scores for the comparison panel moving lower rather than Pickering A and Pickering B moving higher
- Pickering A has shown the most improvement since 2005 achieving Pickering B levels by 2008
- Pickering B performance demonstrated considerable improvement from 2004 through 2006, but then has declined slightly since then

Factors Contributing to Performance

- The WANO NPI is a composite index reflecting the weighted sum of the scores of 10 separate performance measures. A maximum score of 100 is possible. All of the sub-indicators in this index are reviewed separately in this benchmarking report
- The method to analyze the gap to top quartile for the composite index is to specifically indicate points gained or lost for each sub-indicator for each station during the most recent period (2008)

Darlington

- For 2008, Darlington received maximum scores for 7 out of 10 NPI sub-indicators
- For the key safety system related metrics, high pressure injection, auxiliary feedwater, and emergency AC power, Darlington received 10 of 10 points for each
- Darlington also received perfect scores for fuel reliability (10 of 10), chemistry performance (5 of 5) and industrial safety accident rate (5 of 5)
- Darlington received 13.3 of a possible 15 points for unit capability factor; 14.4 of a possible 15 points for forced loss rate; and 7.9 of a possible 10 points for collective radiation exposure. Refer to unit capability factor, forced loss rate, and collective radiation sections for detailed information regarding performance on these indicators

Factors Contributing to Performance (Cont'd)

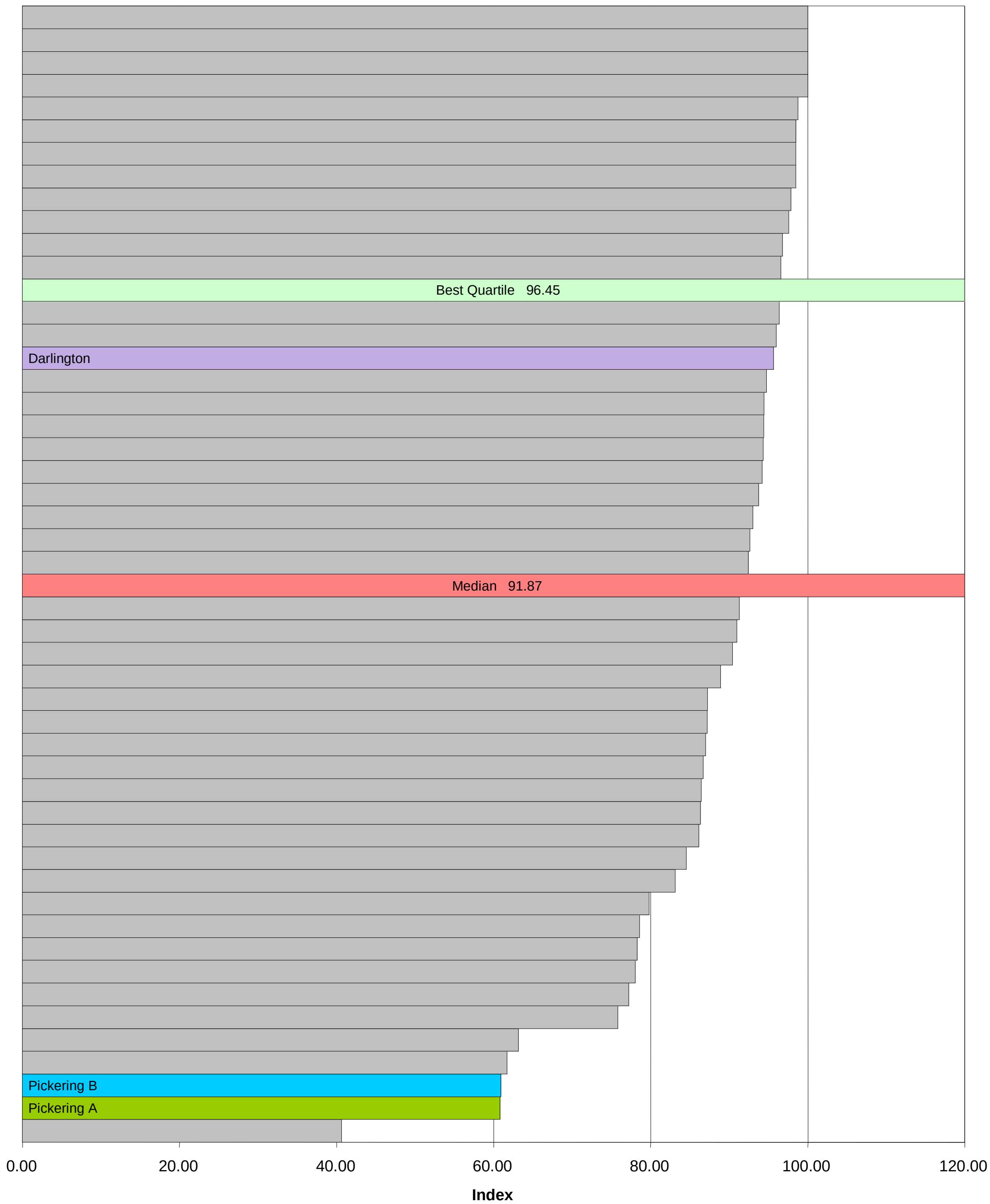
Pickering A

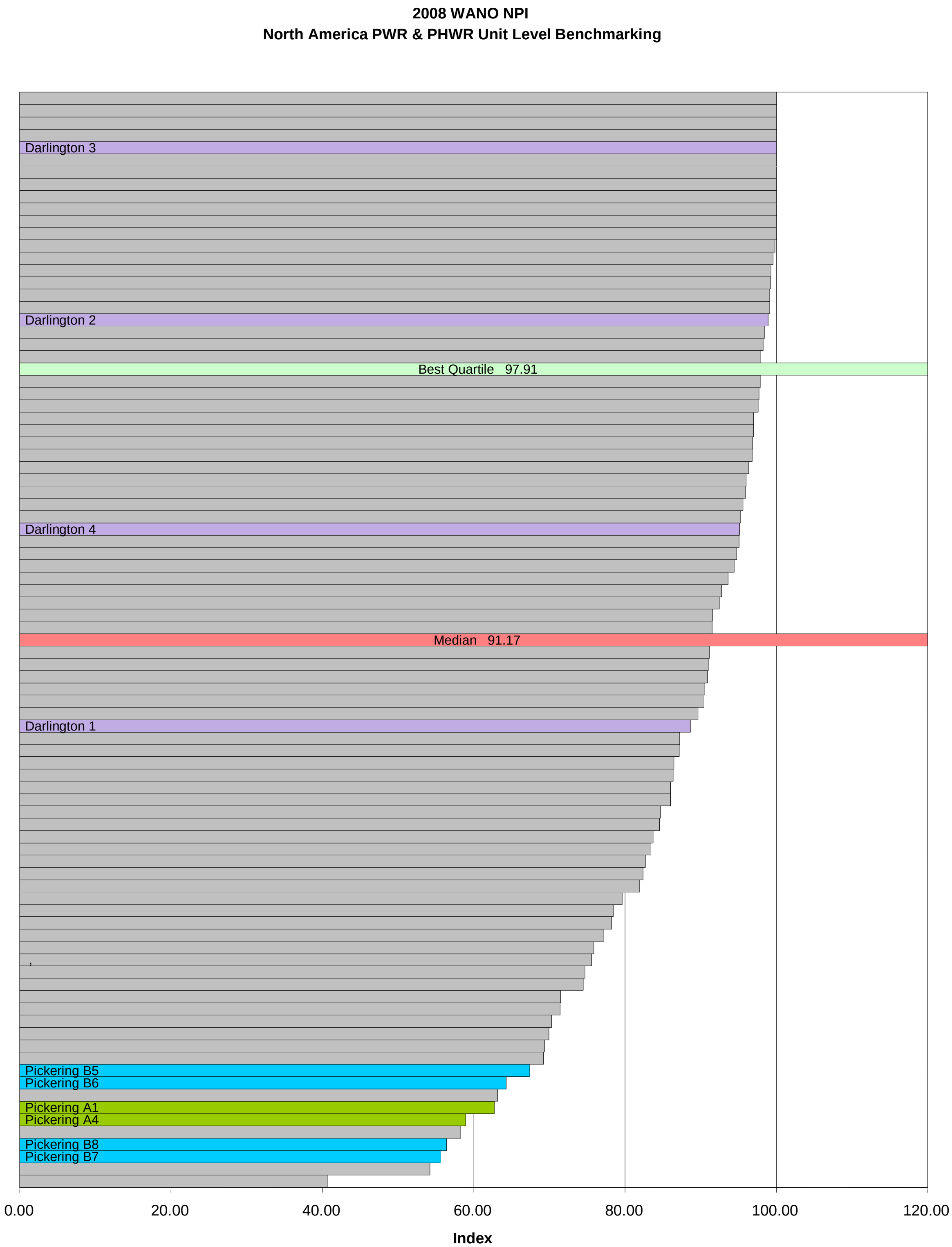
- For 2008, Pickering A received maximum scores for 5 out of 10 NPI sub-indicators
- For the key safety system related metrics, high pressure injection, auxiliary feedwater, and emergency AC power, Pickering A received 10 of 10 points for each
- Pickering A gained 5 of 5 points for industrial safety accident rate and 10 of a possible 10 points for collective radiation exposure
- Pickering A earned 4.4 of 10 points for reactor trips; fuel reliability yielded 9.5 of 10 points, and chemistry performance yielded 2 of 5 points. Refer to reactor trips, fuel reliability, and chemistry performance for detailed information regarding performance on these indicators
- Due to challenges with generation, Pickering A received 0 of 15 possible points for both unit capability factor and forced loss rate. Refer to unit capability factor and forced loss rate sections for detailed information regarding performance on these indicators

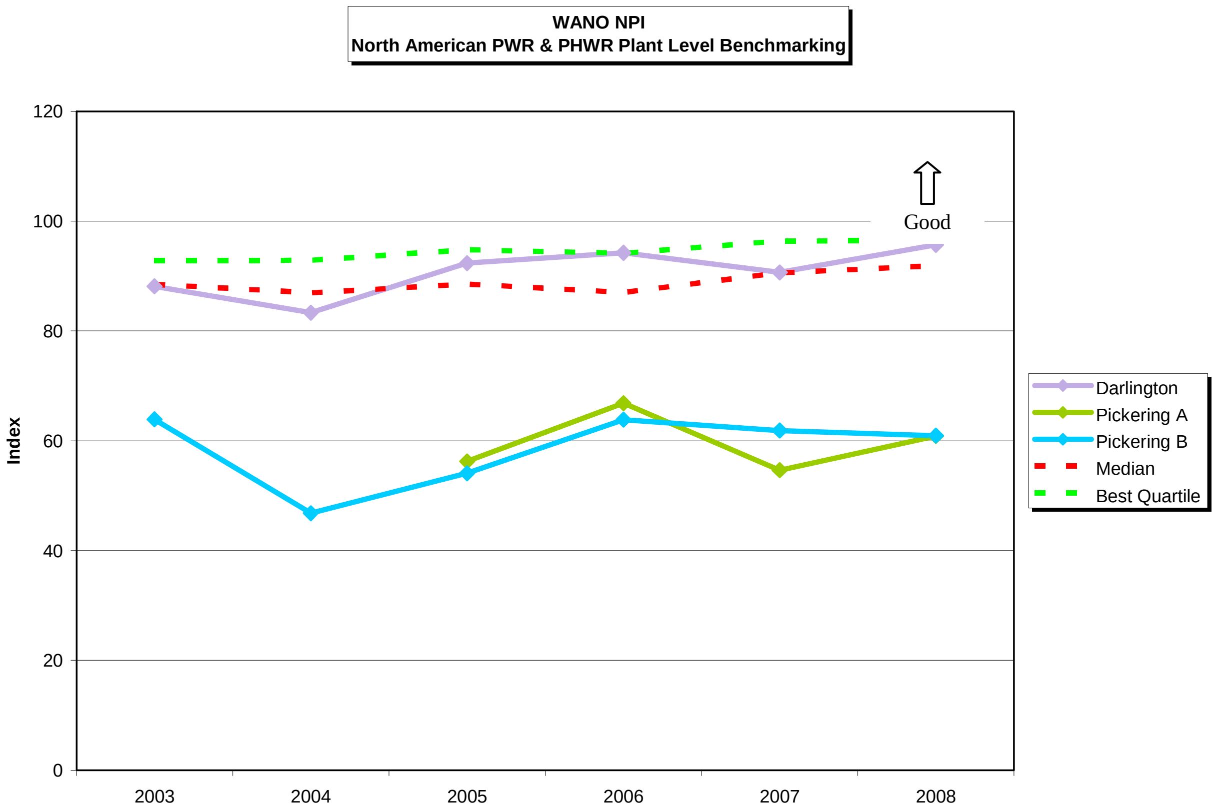
Pickering B

- For 2008, Pickering B received maximum scores for 5 out of 10 NPI sub-indicators
- For the key safety system related metrics, high pressure injection, auxiliary feedwater, and emergency AC power, Pickering B received 10 of 10 points for each
- Pickering B earned 5 of 5 points for industrial safety accident rate
- Pickering B earned 10 of 10 points for reactor trips
- Due to challenges with generation, Pickering B received 1.2 of 15 possible points for both unit capability factor and forced loss rate. Refer to unit capability factor and forced loss rate sections for detailed information regarding performance on these indicators
- Pickering B achieved scores of 7.5 of 10 points for fuel reliability, 0.6 of 5 points for chemistry performance, and 5.5 of a possible 10 points for collective radiation exposure. Refer to fuel reliability, chemistry performance, and collective radiation exposure sections for detailed information regarding performance on these indicators

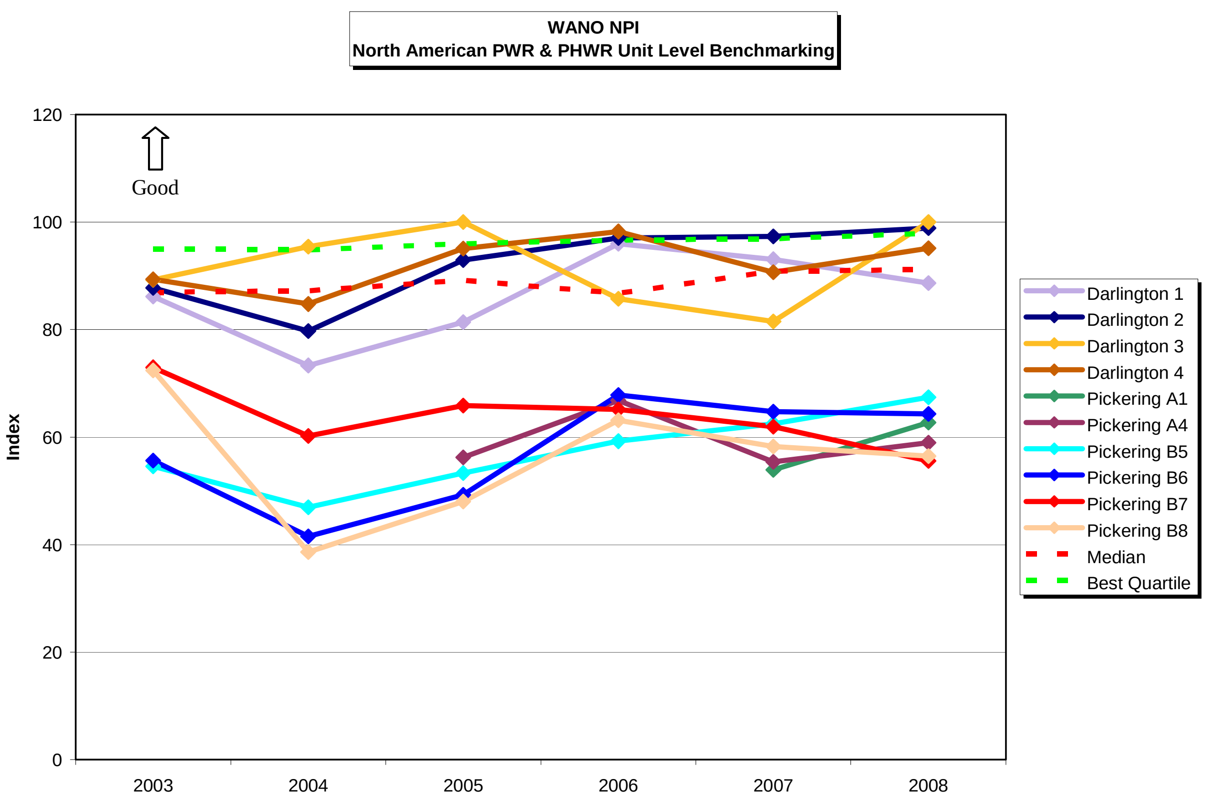
2008 WANO NPI
North American PWR & PHWR Plant Level Benchmarking




2008 WANO NPI
North America PWR & PHWR Unit Level Benchmarking
Darlington 3
Darlington 2
Best Quartile 97.91
Darlington 4
Median 91.17
Darlington 1
Pickering B5
Pickering B6
Pickering A1
Pickering A4
Pickering B8
Pickering B7
0.00
20.00
40.00
60.00
80.00
100.00
120.00
Index



Note: Only Pickering A Unit 4 received a WANO NPI score in 2005 and 2006



Observations – WANO NPI (N. American PWR and PHWR)

2008

- Both the best quartile level and the median values for the North American PWR comparison panel have risen slightly for WANO NPI since 2006 indicating steady improvement in the North American reactor fleet
- Darlington is the strongest OPG performer and achieved scores higher than the peer group median value in four of the six years reviewed. Two of the Darlington units (units 2 and 3) achieved NPI scores above best quartile levels

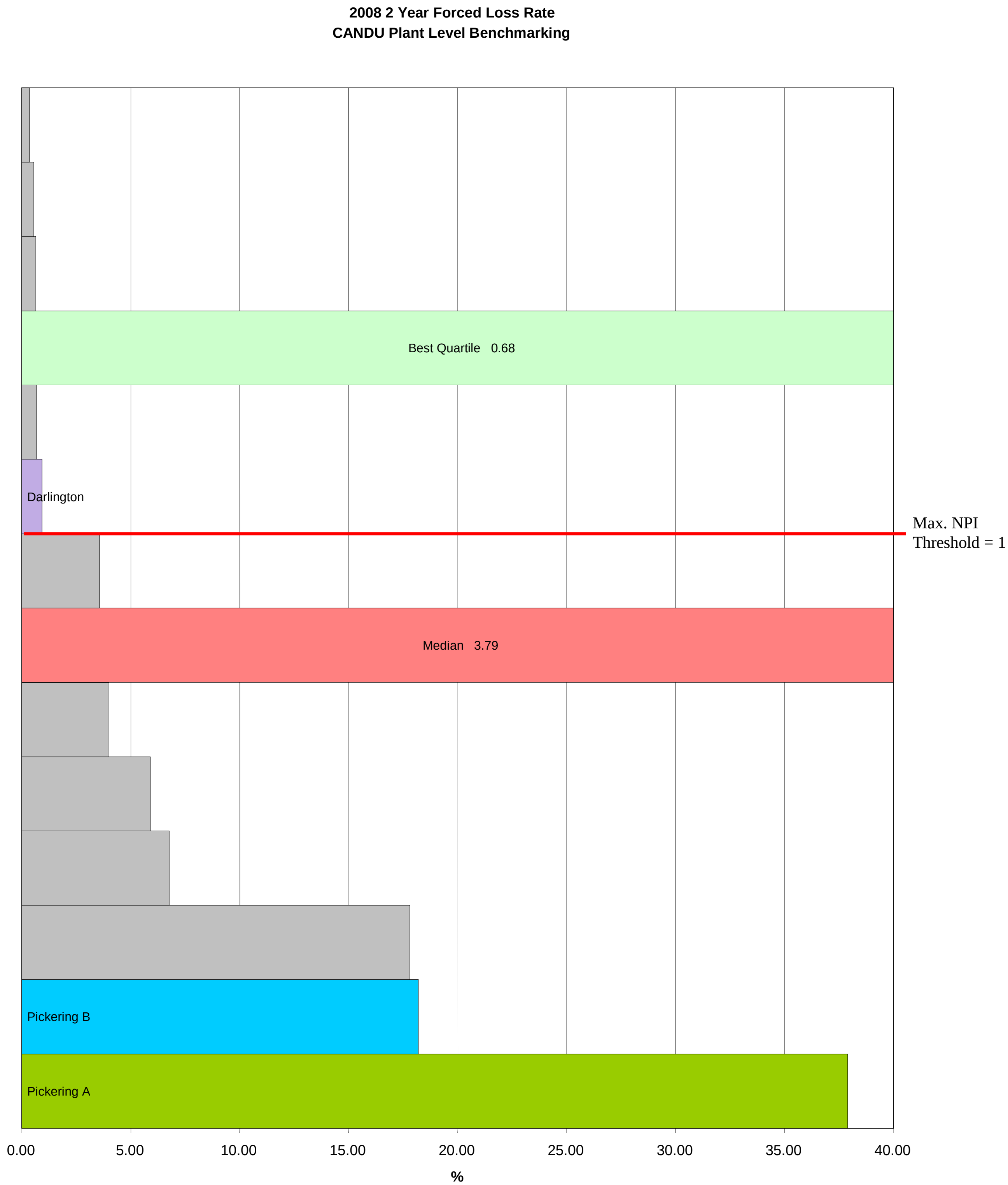
Trend

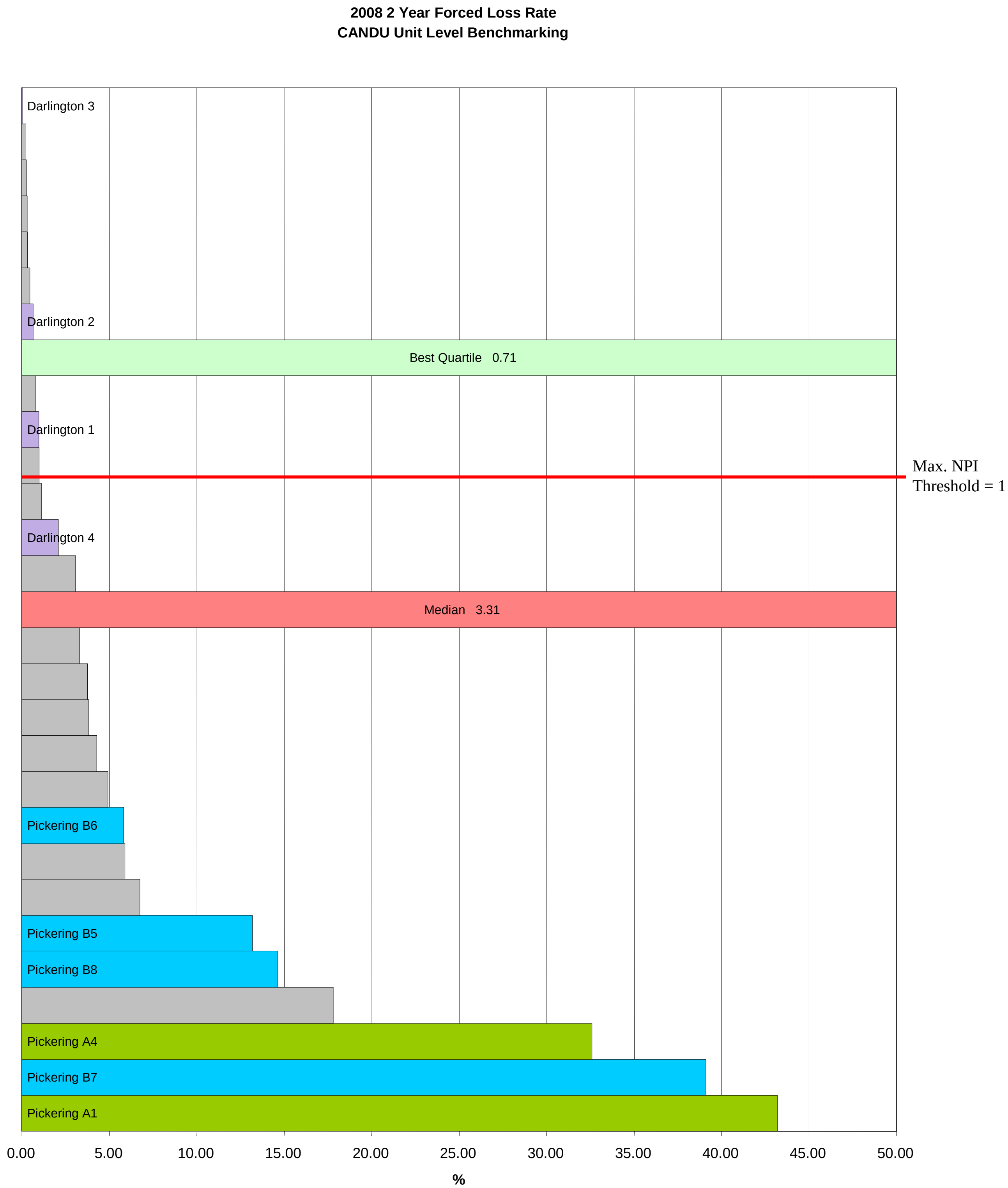
- All of the units at Pickering A and Pickering B have performed consistently below median over the review period. The six Pickering units were among the lowest 10 units surveyed in North America

Factors Contributing to Performance

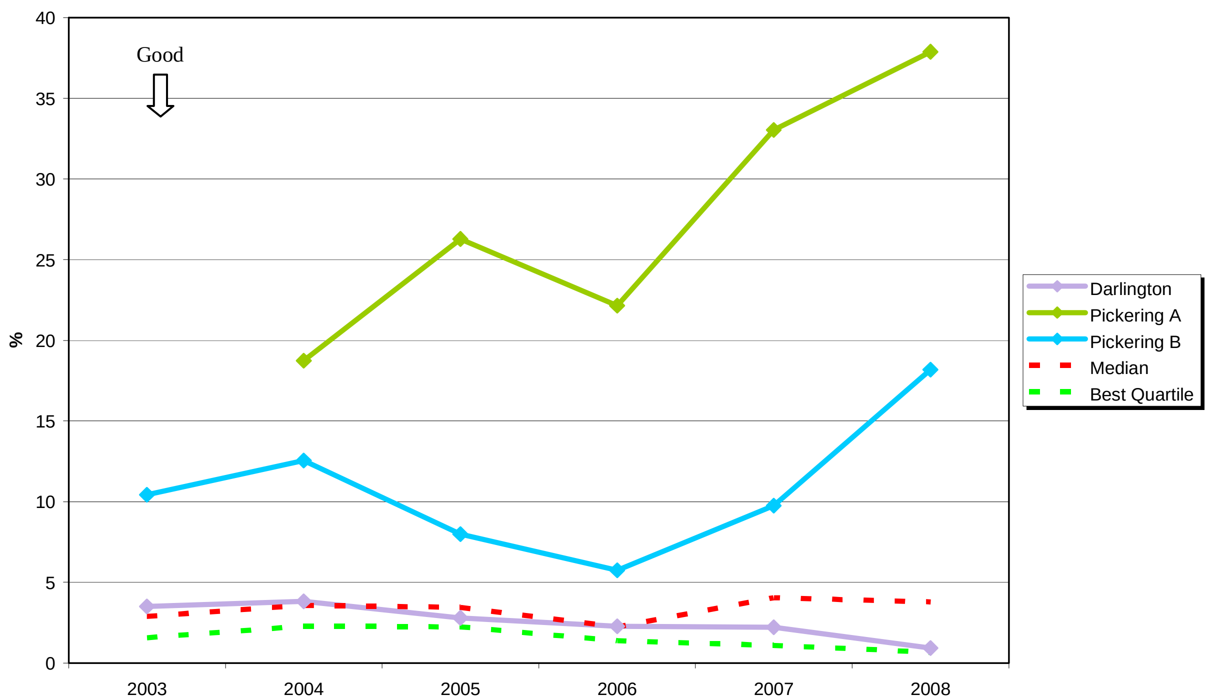
- The method to analyze the gap to top quartile for the composite index is to specifically indicate points gained or lost for each sub-indicator for each station during the most recent period (2008). This comparison was provided above in the section describing the CANDU benchmarking panel

2-Year Forced Loss Rate

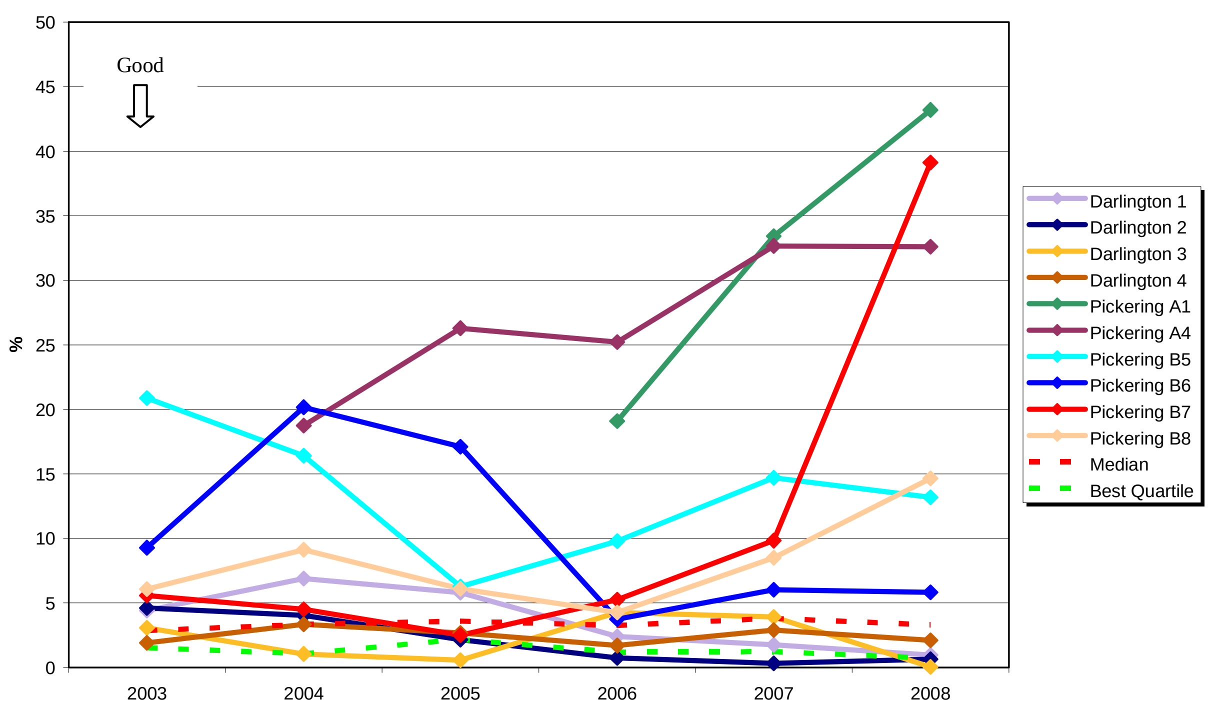



2008 2 Year Forced Loss Rate
CANDU Unit Level Benchmarking
Darlington 3
Darlington 2
Best Quartile 0.71
Darlington 1
Max. NPI
Threshold = 1
Darlington 4
Median 3.31
Pickering B6
Pickering B5
Pickering B8
Pickering A4
Pickering B7
Pickering A1
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
40.00
45.00
50.00
%

2 Year Forced Loss Rate
CANDU Plant Level Benchmarking



2 Year Forced Loss Rate
CANDU Unit Level Benchmarking



Observations – 2-Year Forced Loss Rate (CANDU)

- The performance of OPG's units has been shown relative to best quartile, median, and the threshold established by WANO to achieve full WANO NPI points. Since achievement of full WANO NPI points is recognized within the industry as a measure of desirable performance, performance gaps are assessed against full WANO NPI points in addition to median and best quartile

2008 (2-Year Rolling Average)

- Forced loss rate (FLR) at best quartile worldwide CANDU plants was 0.68% for the plant average and 0.71% for individual units
- Darlington performed better than median but worse than best quartile as a station and all units performed better than median individually with two units performing better than best quartile
- Both Pickering A and B were below median as a plant, and each unit performed below median individually

Trend

- Best quartile improved slightly for the review period for both unit and plant level while median became slightly worse for both unit and plant over the review period
- Darlington performance overall improved from just worse than median performance at the start of the review period to just worse than top quartile for the most recent time period
- Pickering A had a limited time period compared to the other stations due to the restart of unit 4 in September 2003 and unit 1 in November 2005
- Pickering A's FLR performance worsened significantly, almost doubling from a FLR just under 20% to 37.90%
- Pickering B FLR performance over the review period also worsened, almost doubling from a FLR just under 10% to 18.19%

Factors Contributing to Performance

- FLR is defined as the ratio of all unplanned forced energy losses during a given period of time to the reference energy generation minus energy generation losses corresponding to planned outages and any unplanned outage extensions of planned outages
- To analyze performance for capability factor and forced loss rate, for 2005 to 2008 all incidents causing of loss of generation were assigned to categories (defined below) so primary drivers of performance could be identified
- Equipment Reliability: Failure of component or equipment which directly forced or extended an outage (includes material condition problems)
- Design Basis: Equipment operated as per design. Inadequate design margin directly forced or extended an outage
- Human Performance (HP): Event caused by HP issues which directly forced or extended an outage, but HP event had to be in recent past (i.e. no HP on design basis errors in the past). This included contractors inside or outside plant (i.e. Water Treatment) that directly impacted plant operations

Factors Contributing to Performance (Cont'd)

Darlington

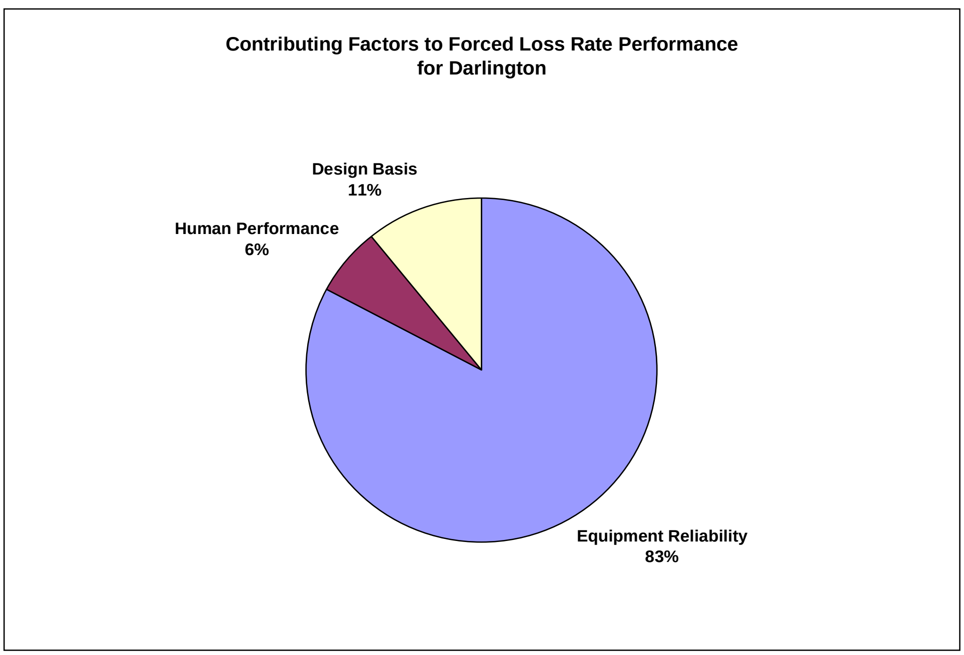
- Darlington gap to best quartile against the worldwide CANDU panel for 2008 was 0.25%
- The contributing factors to Darlington FLR on a percentage basis over the review period were 83% equipment reliability, 11% material condition, and 6% human performance

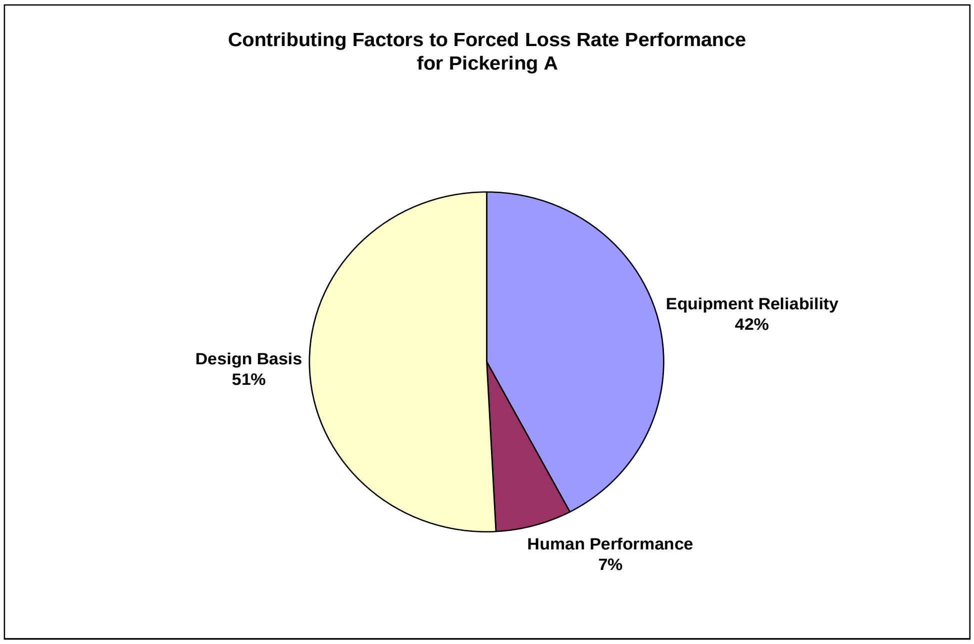
Pickering A

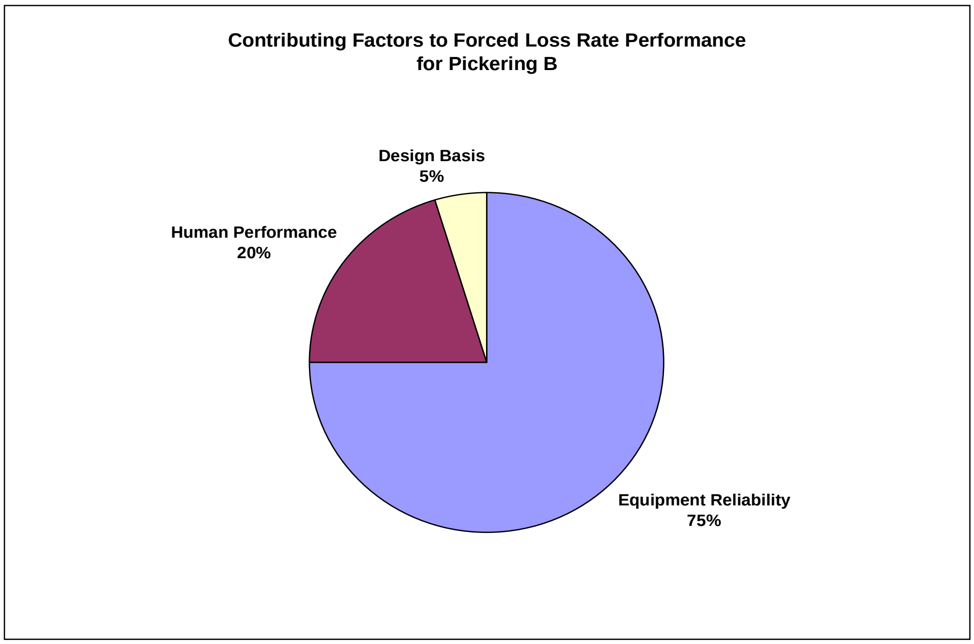
- Pickering A gap to best quartile was 37.22% against the worldwide CANDU panel for 2008.
- For the review period, approximately 7% of the Pickering A FLR was attributable to human performance, 42% to equipment reliability, and 51% percent to design basis

Pickering B

- Pickering B gap to best quartile was 17.51% against the worldwide CANDU panel for 2008
- For the review period, approximately 20% of the Pickering FLR was attributable to human performance, 75% to equipment reliability, and 5% percent to design basis



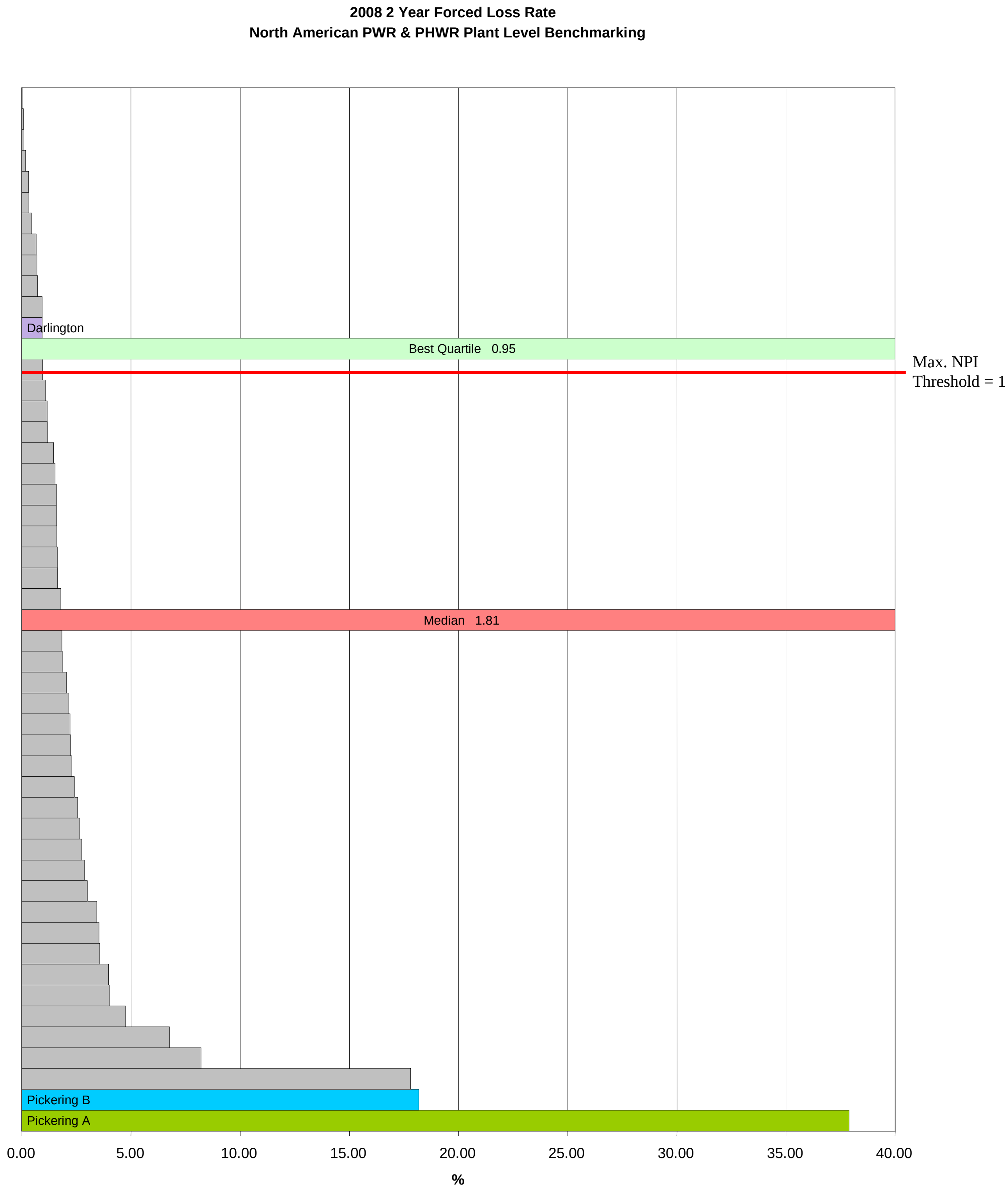


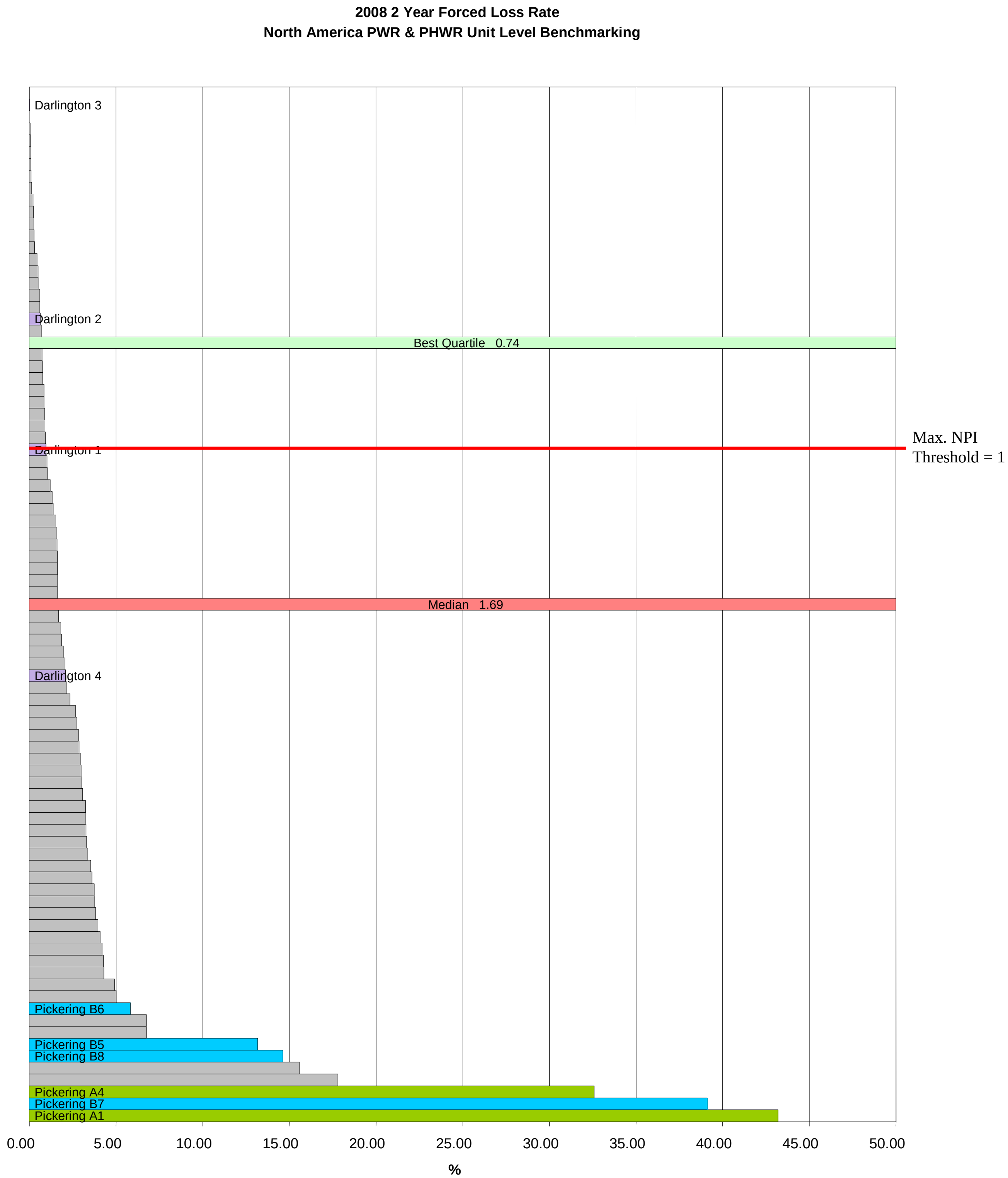


Factors Contributing to Performance (Cont'd)

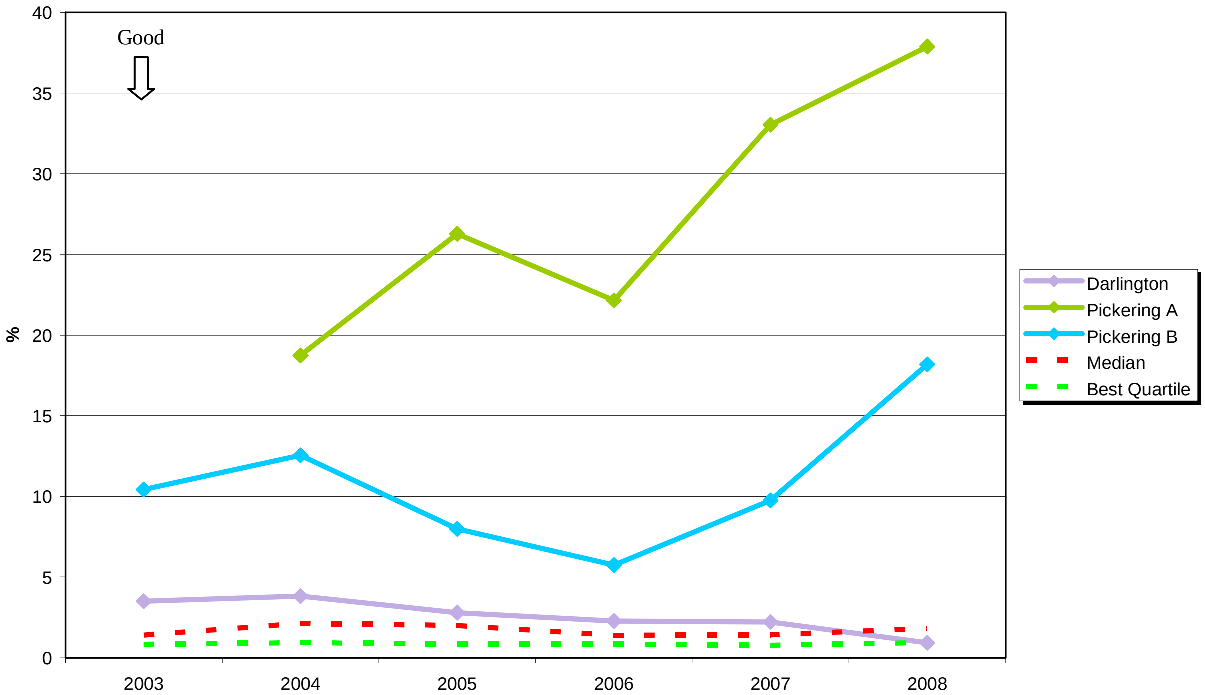
Examples of Contributing Incidents

- Equipment Reliability incidents contributing to FLR included a Calandria Tube failure, a heat transport system leak, a faulty feeder cabinet door latch, and pipe elbow inspections due to new information on feeder thinning rates
- Design Basis incidents contributing to FLR included an inter-station transfer bus (ISTB) problem, inadequate pipe seal design, and a system configuration problem
- Human Performance incidents contributing to FLR included resin ingress to the system caused by a contractor error, a voltage transient caused during the execution of routine steps, and a troubleshooting error while resolving a leakage problem

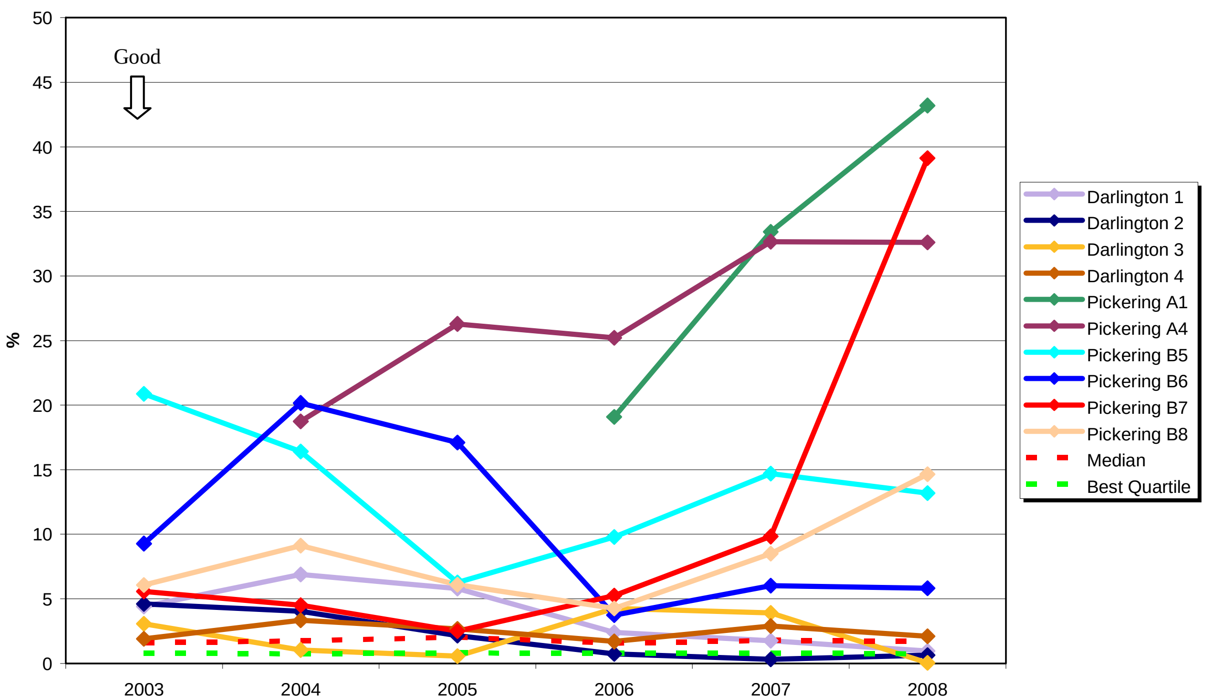

2008 2 Year Forced Loss Rate
North American PWR & PHWR Plant Level Benchmarking
Darlington
Best Quartile 0.95
Max. NPI
Threshold = 1
Median 1.81
Pickering B
Pickering A
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
40.00
%


2008 2 Year Forced Loss Rate
North America PWR & PHWR Unit Level Benchmarking
Darlington 3
Darlington 2
Best Quartile 0.74
Darlington 1
Max. NPI Threshold = 1
Median 1.69
Darlington 4
Pickering B6
Pickering B5
Pickering B8
Pickering A4
Pickering B7
Pickering A1
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
40.00
45.00
50.00
%

2 Year Forced Loss Rate
North America PWR & PHWR Plant Level Benchmarking



2 Year Forced Loss Rate
North American PWR & PHWR Unit Level Benchmarking



Observations – 2-Year Forced Loss Rate (North American PWR and PHWR)

- The performance of OPG's units has been shown relative to best quartile, median, and the threshold established by WANO to achieve full WANO NPI points. Since achievement of full WANO NPI points is recognized within the industry as a measure of desirable performance, performance gaps are assessed against full WANO NPI points in addition to median and best quartile

2008 (2-Year Rolling Average)

- FLR at best quartile for the North American PWR/PHWR panel was 0.95% for the plant average and 0.74% for individual units
- Darlington performed within than best quartile as a station with two units performing in best quartile, one unit performing better than median, and one unit performing worse than median
- Both Pickering A and B were below median as a plant, and each unit performed below median individually

Trend

- Best quartile and median for the panel remained relatively stable for the review period under review with a slight decline in performance during the middle of the period
- Darlington performance improved from worse than median performance at the start of the review period best quartile for the most recent data point
- Pickering A had a limited time period compared to the other stations due to the restart of unit 4 in September 2003 and unit 1 in November 2005
- Pickering A FLR performance worsened significantly, almost doubling from a FLR just under 20% to 37.90%
- Pickering B FLR performance also worsened, almost doubling from a FLR just under 10% to 18.19%

Factors Contributing to Performance

Darlington

- Darlington performed within the best quartile for the panel

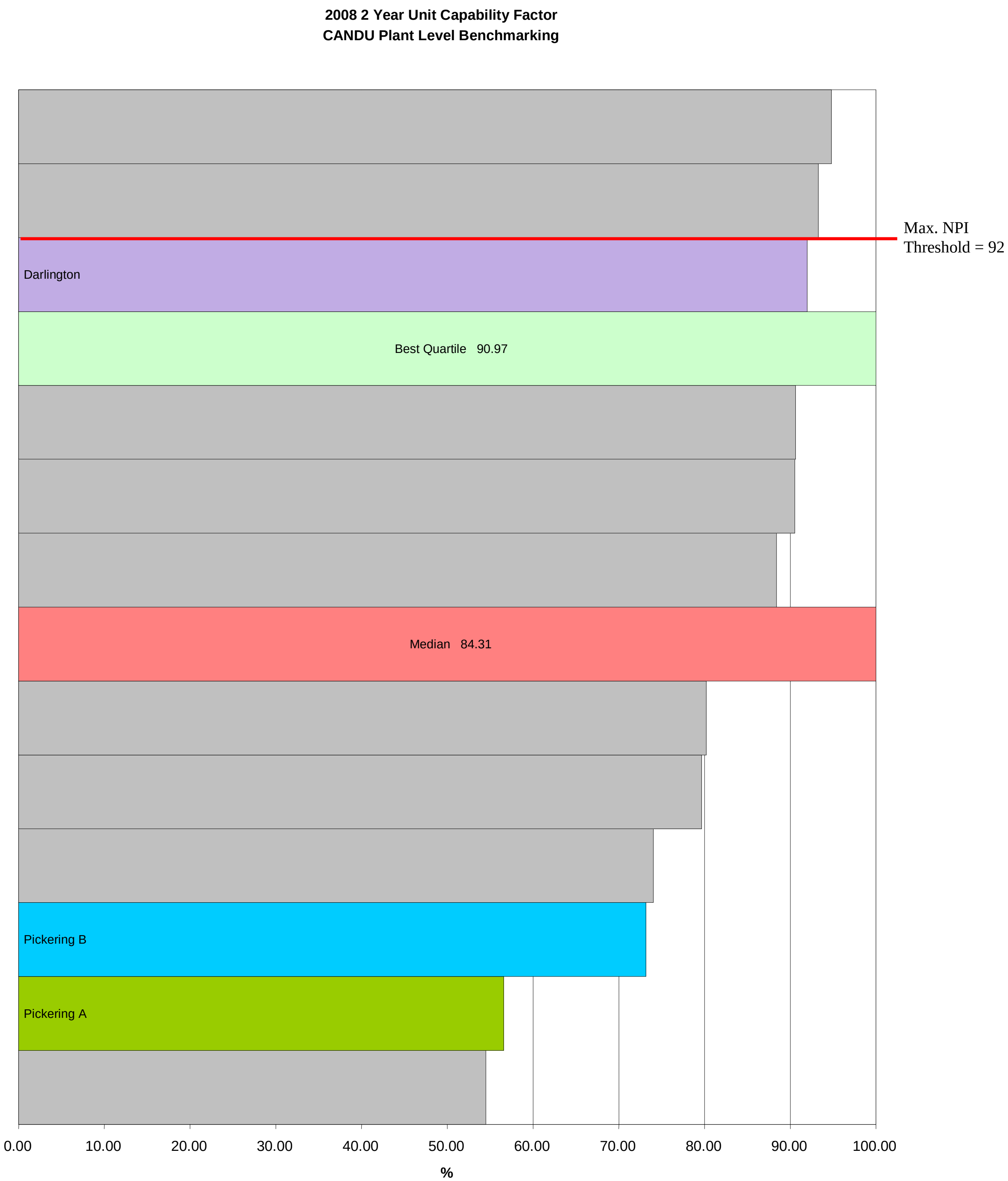
Pickering A

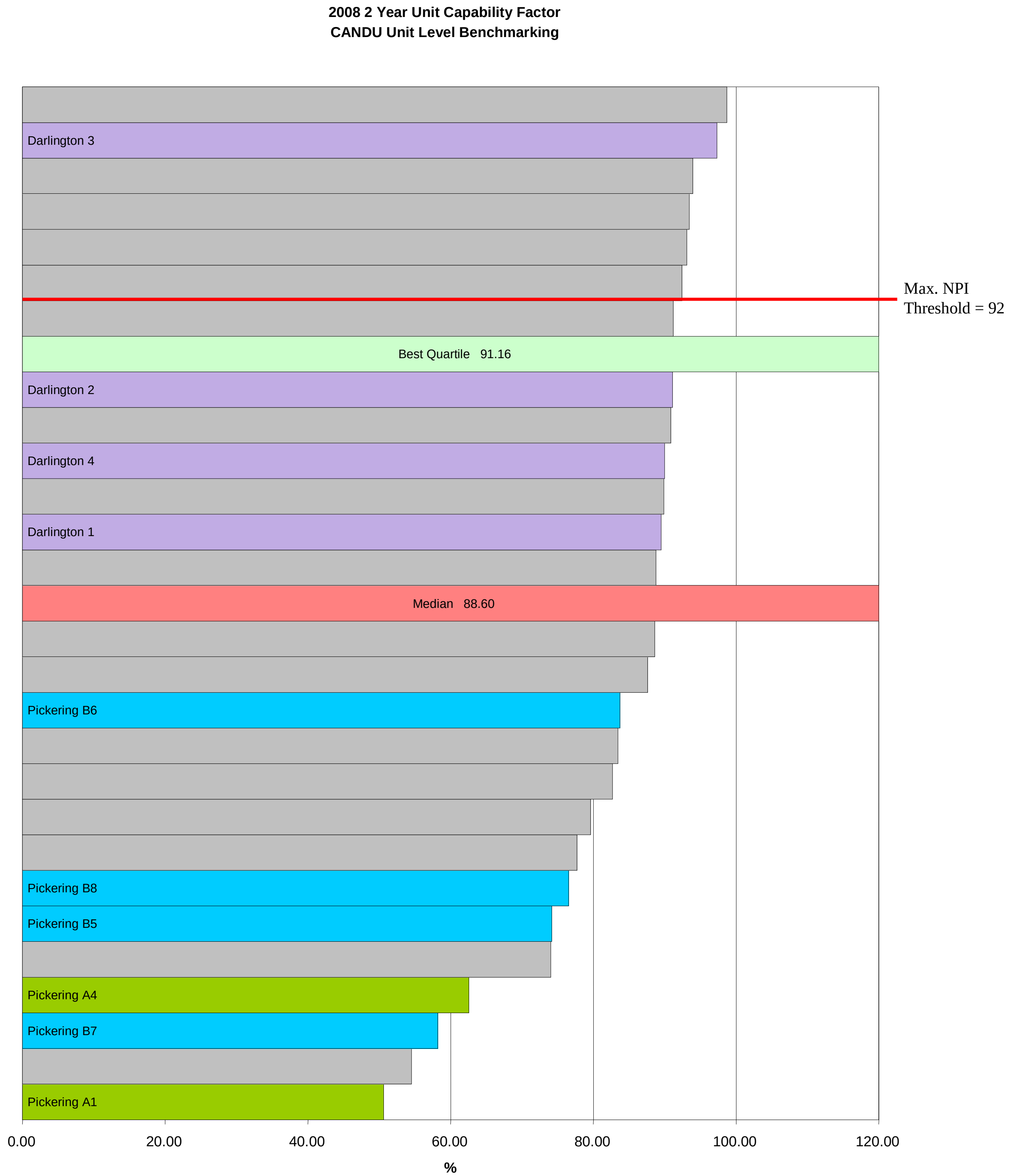
- Pickering A gap to best quartile was 36.95% for the most recent time period under review
- The contributing factors for Pickering A FLR were listed within the analysis of the worldwide CANDU panel results

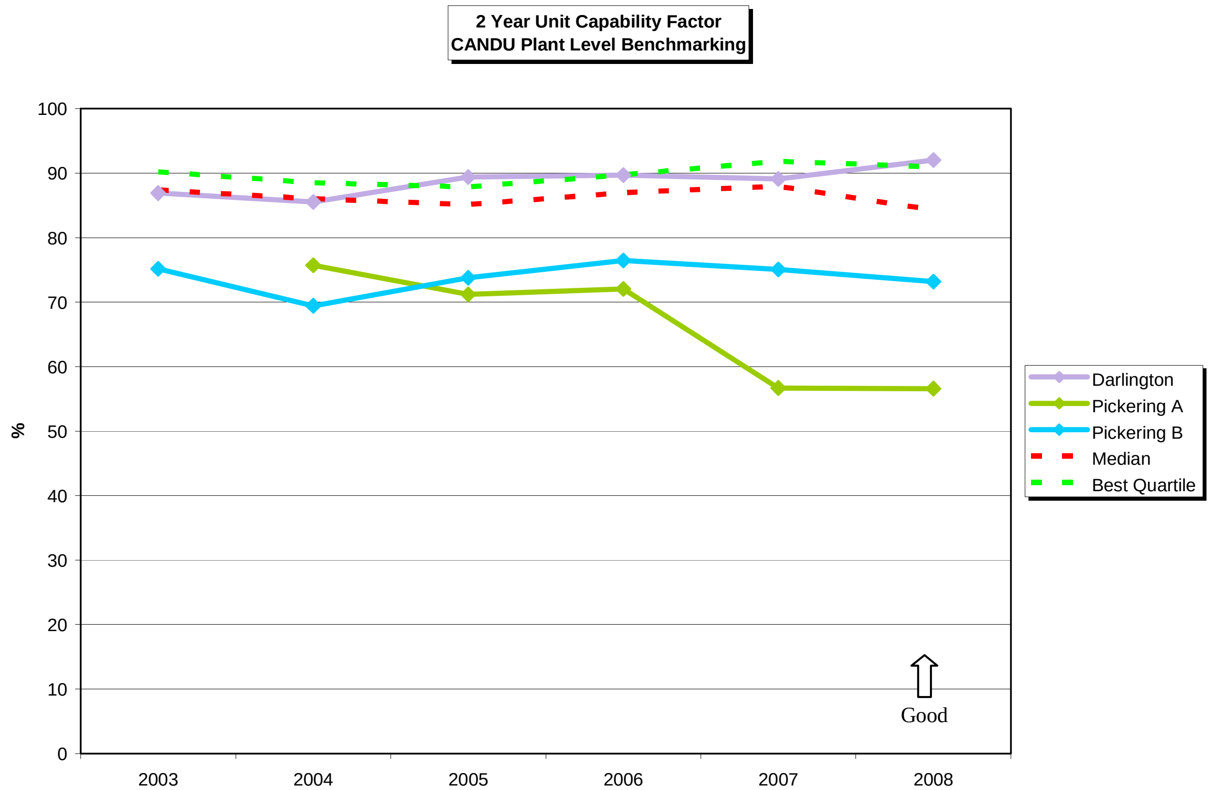
Pickering B

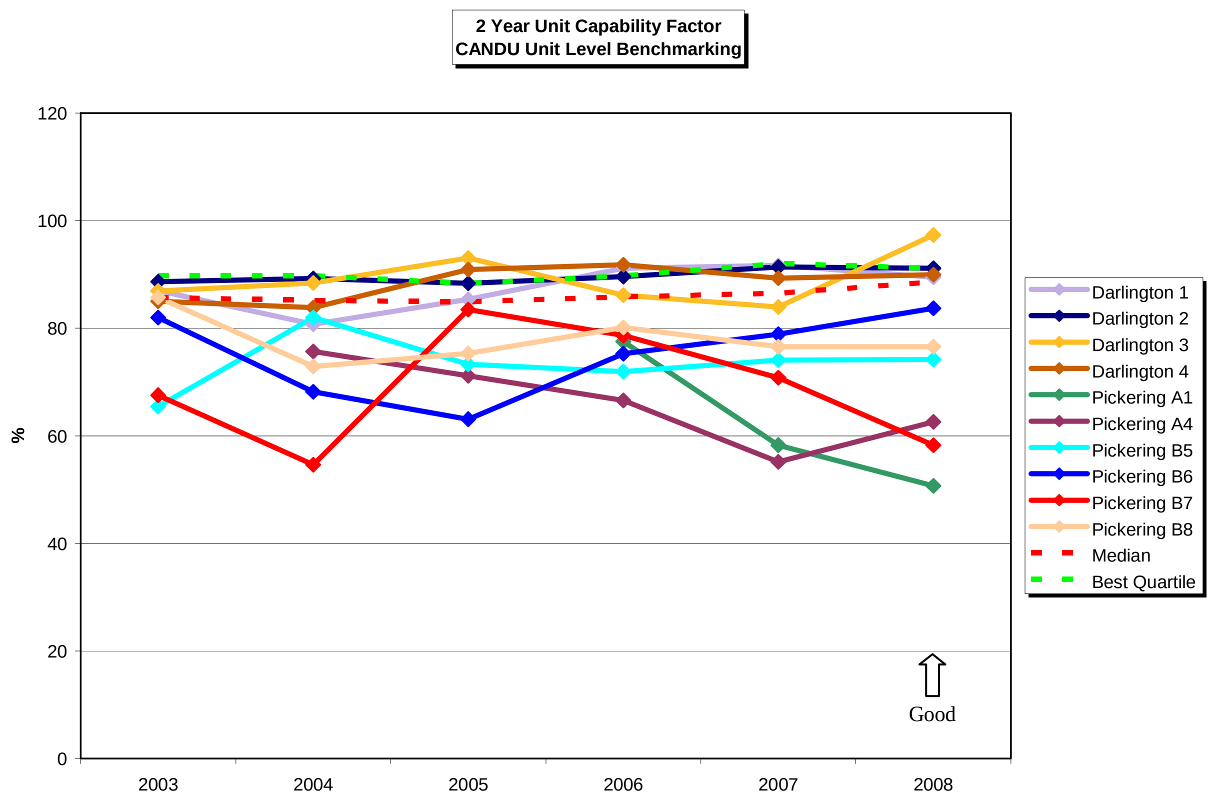
- Pickering B gap to best quartile was 17.24% for the most recent time period under review
- The contributing factors for Pickering B FLR were listed within the analysis of the worldwide CANDU panel results

2-Year Unit Capability Factor




2008 2 Year Unit Capability Factor
CANDU Unit Level Benchmarking
Darlington 3
Max. NPI
Threshold = 92
Best Quartile 91.16
Darlington 2
Darlington 4
Darlington 1
Median 88.60
Pickering B6
Pickering B8
Pickering B5
Pickering A4
Pickering B7
Pickering A1
0.00
20.00
40.00
60.00
80.00
100.00
120.00
%


2 Year Unit Capability Factor
CANDU Plant Level Benchmarking
100
90
80
70
60
50
40
30
20
10
0
%
2003
2004
2005
2006
2007
2008
Good
Darlington
Pickering A
Pickering B
Median
Best Quartile


2 Year Unit Capability Factor
CANDU Unit Level Benchmarking
120
100
80
60
40
20
0
%
2003
2004
2005
2006
2007
2008
Good
Darlington 1
Darlington 2
Darlington 3
Darlington 4
Pickering A1
Pickering A4
Pickering B5
Pickering B6
Pickering B7
Pickering B8
Median
Best Quartile

Observations – 2-Year Unit Capability Factor (CANDU)

- The performance of OPG's units has been shown relative to best quartile, median, and the threshold established by WANO to achieve full WANO NPI points. Since achievement of full WANO NPI points is recognized within the industry as a measure of desirable performance, performance gaps are assessed against full WANO NPI points in addition to median and best quartile

2008 (2-Year Rolling Average)

- UCF at best quartile worldwide CANDU plants was 90.97% for the plant average and 91.16% for individual units
- Darlington performed better than best quartile as a station and all units performed better than median individually
- Both Pickering A and B were below median as a plant and each unit performed below median individually

Trend

- Best quartile and median for both plant average and unit performance have remained relatively flat over the review period
- Darlington performance overall has remained above median for the review period with at least three of the last four periods performing above best quartile
- Pickering A had a limited time period compared to the other stations due to the restart of unit 4 in September 2003 and unit 1 in November 2005
- Pickering A performance declined significantly over the most recent two data points for the review period with no individual or plant average data points at median level for the review period
- Pickering B performance remained relatively stable over the review period but all data points for unit level and plant level results are below the median level

Factors Contributing to Performance

- To analyze performance for capability factor and forced loss rate, for 2005 to 2008 all incidents causing of loss of generation were assigned to categories (defined below) so primary drivers of performance could be identified
- Planned Outage: The specific scope and timeframe for an outage designated in advance and not including forced extensions of planned outages planned outages and extensions of planned outages reduce Unit Capability Factor. Outage extensions are further defined by the root cause categories of Equipment Reliability, Design Basis and Human Performance as defined below
- Equipment Reliability: Failure of component or equipment which directly forced or extended an outage (includes material condition problems)
- Design Basis: Equipment operated as per design. Inadequate design margin directly forced or extended an outage
- Human Performance (HP): Event caused by HP issues which directly forced or extended an outage, but HP event had to be in recent past (i.e. no HP on design basis errors in the past). This included contractors inside or outside plant (i.e. Water Treatment) that directly impacted plant operations

Factors Contributing to Performance (Cont'd)

Darlington

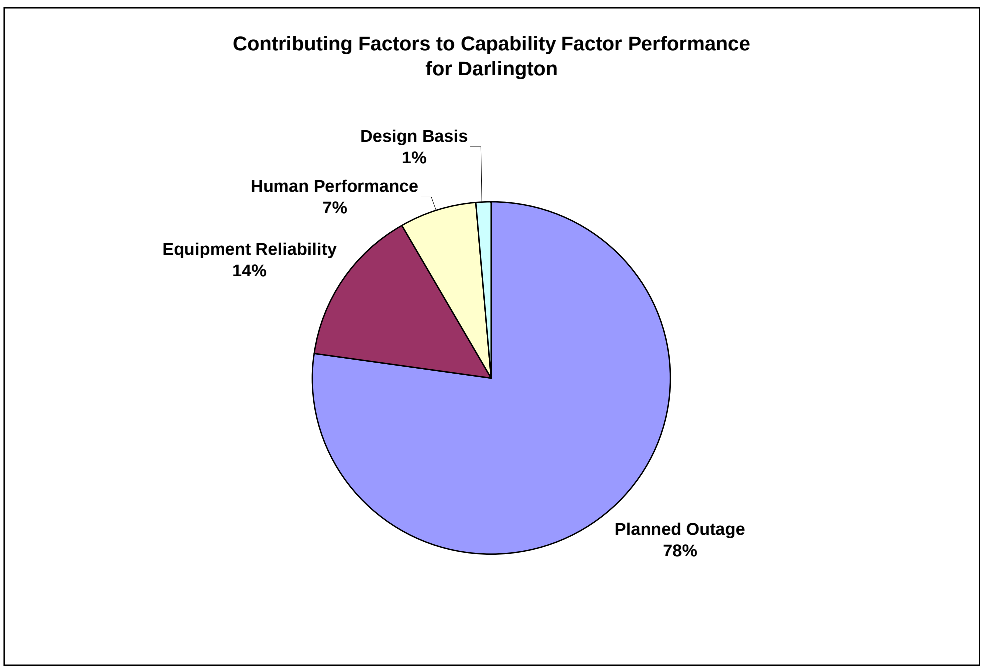
- Darlington achieved best quartile performance in UCF against the panel

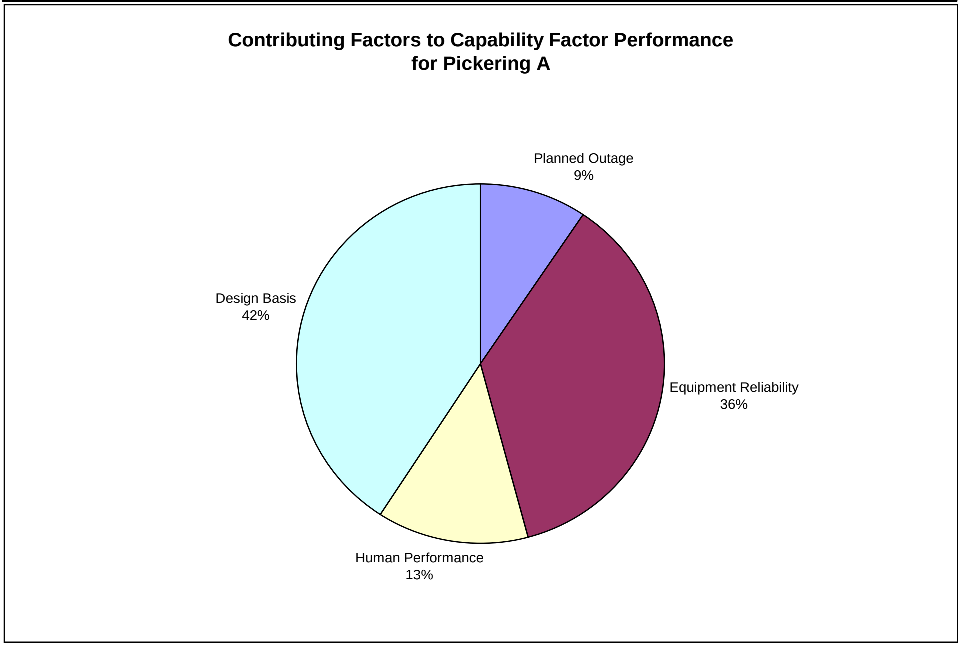
Pickering A

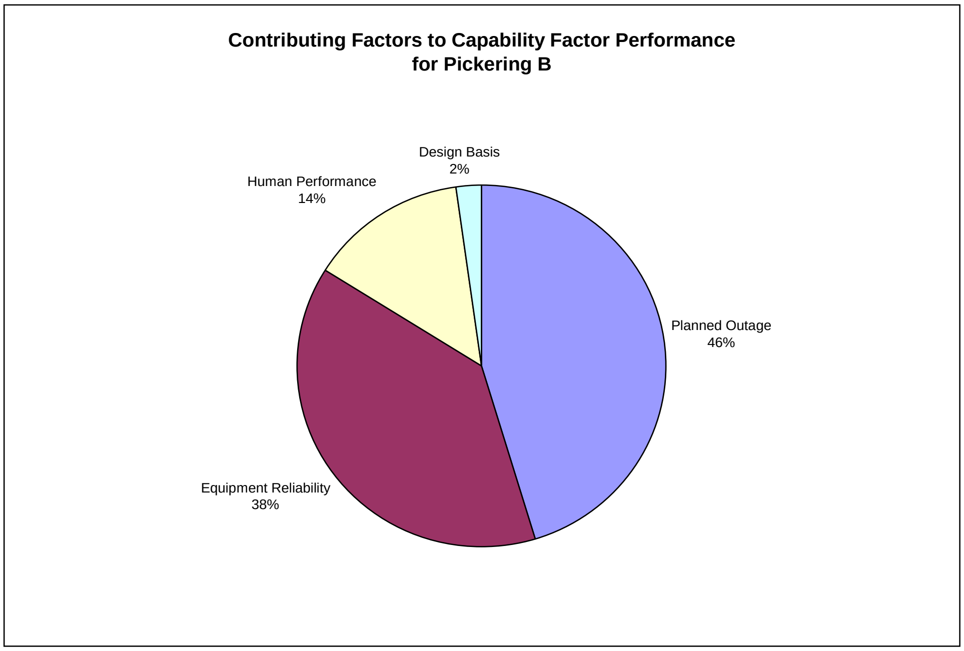
- Pickering A gap to best quartile was over 30% for 2008
- For the review period (2005-2008), approximately 13% of the Pickering gap to best quartile was attributable to human performance, approximately 36% to equipment reliability, 9% to planned outages, and 42% percent to design basis
- Pickering A had one short, planned outage of 14 days within the time period but the other two outages averaged 62 days in length
- Every planned outage during the review period had an associated forced extension

Pickering B

- Pickering B gap to best quartile was over 15% for 2008
- For the review period (2005-2008), approximately 46% of the Pickering gap to best quartile was attributable to planned outages, approximately 14% to human performance, 38% to equipment reliability, and 2% percent to design basis of the facility
- Pickering B planned outage length averaged over 64 days per outage for the review period and the data included two short, planned outages of 6.5 and 1.7 days
- Each of the eight planned outage during the review period had an associated forced extension



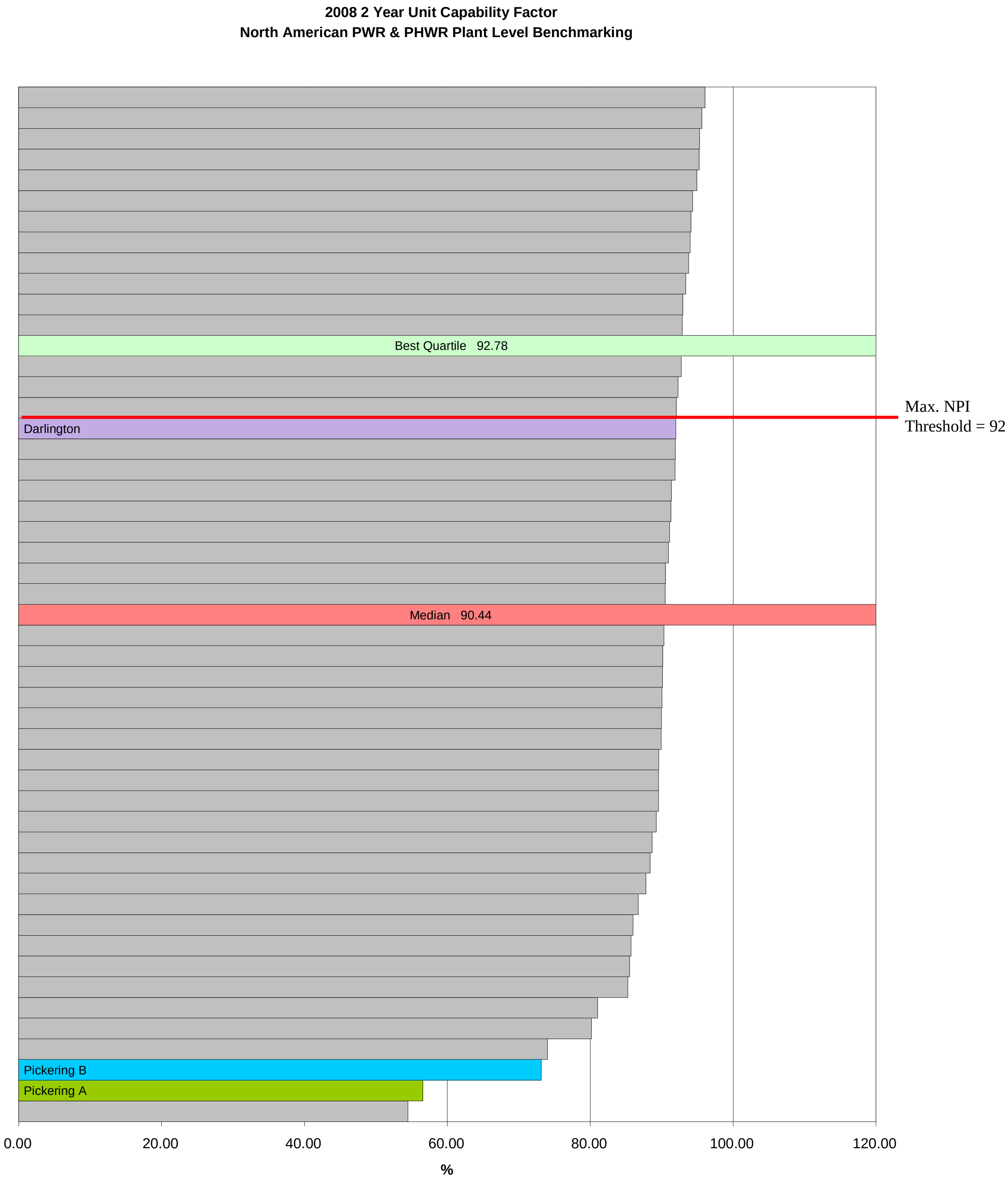




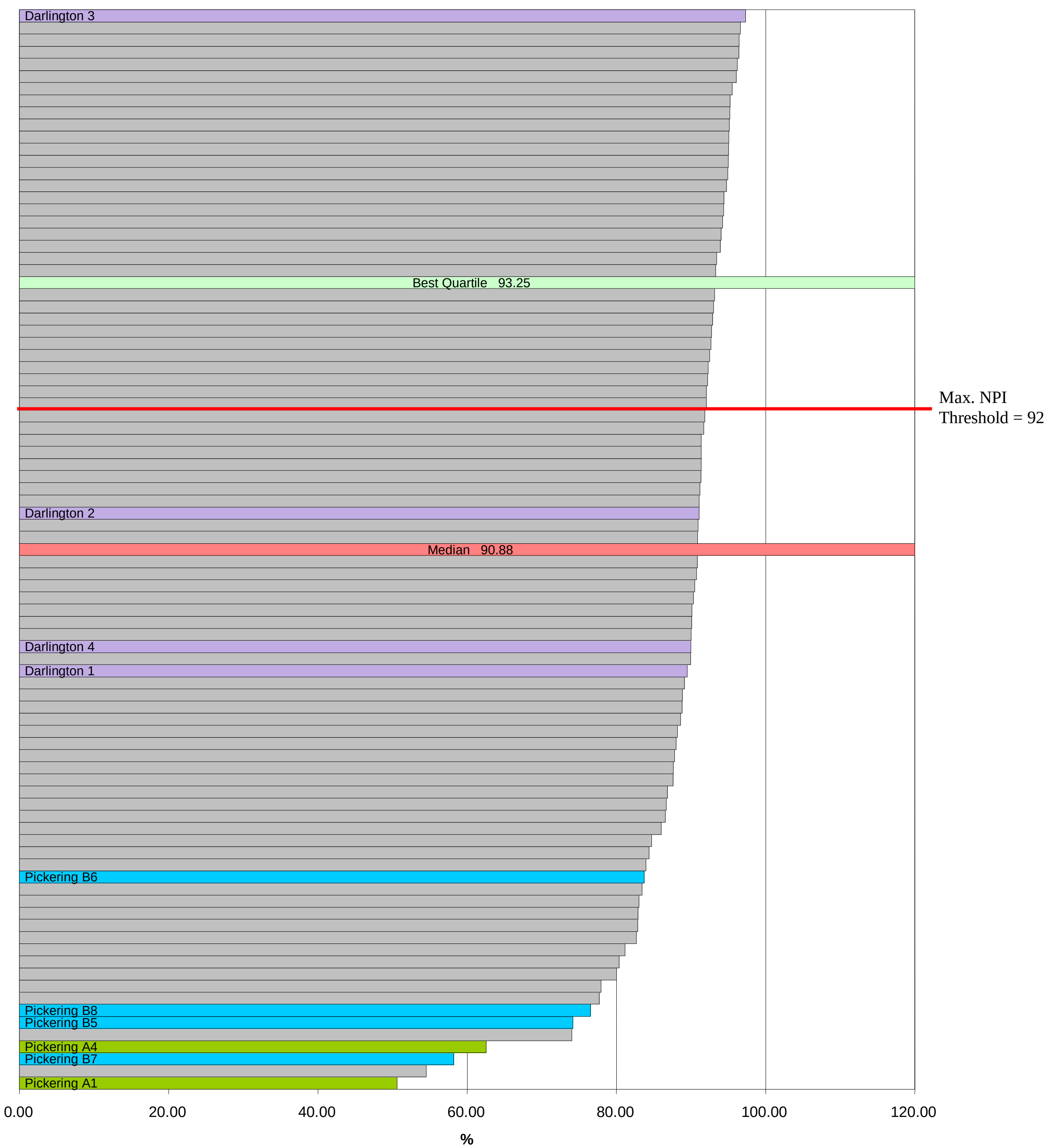
Factors Contributing to Performance (Cont'd)

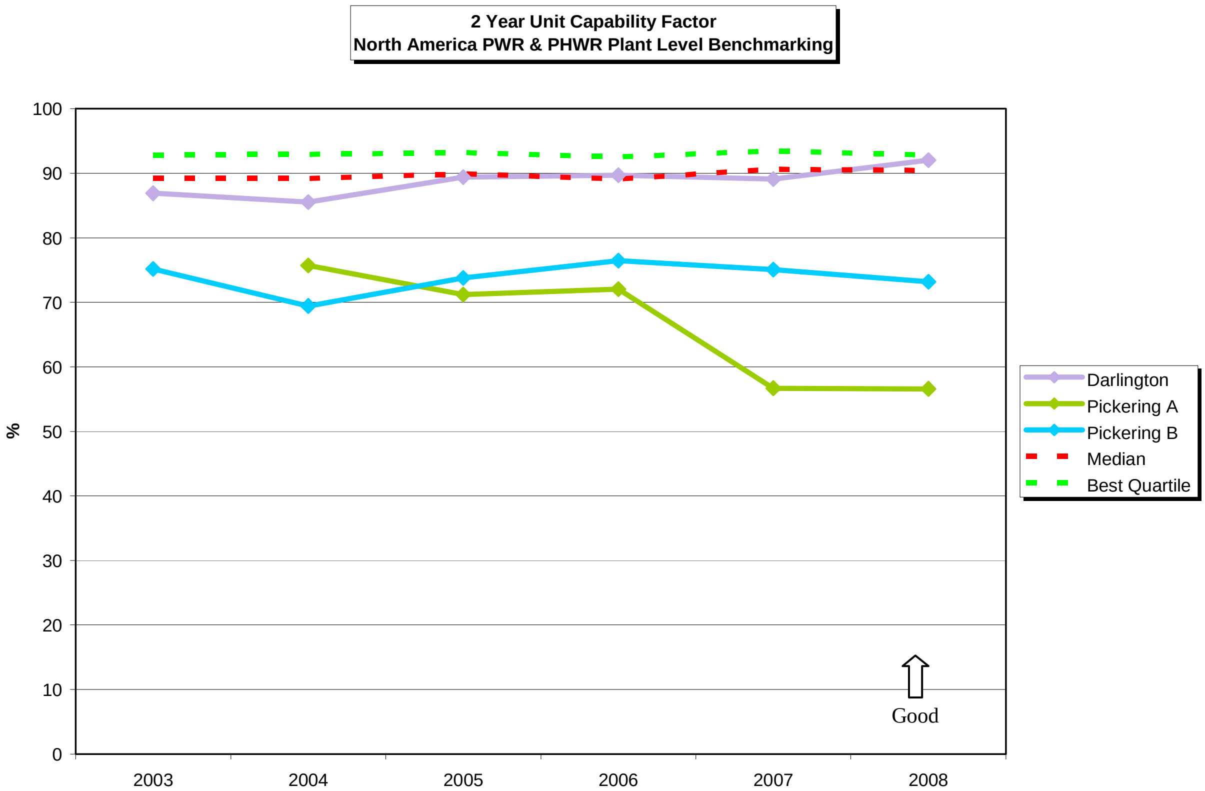
Examples of Contributing Incidents

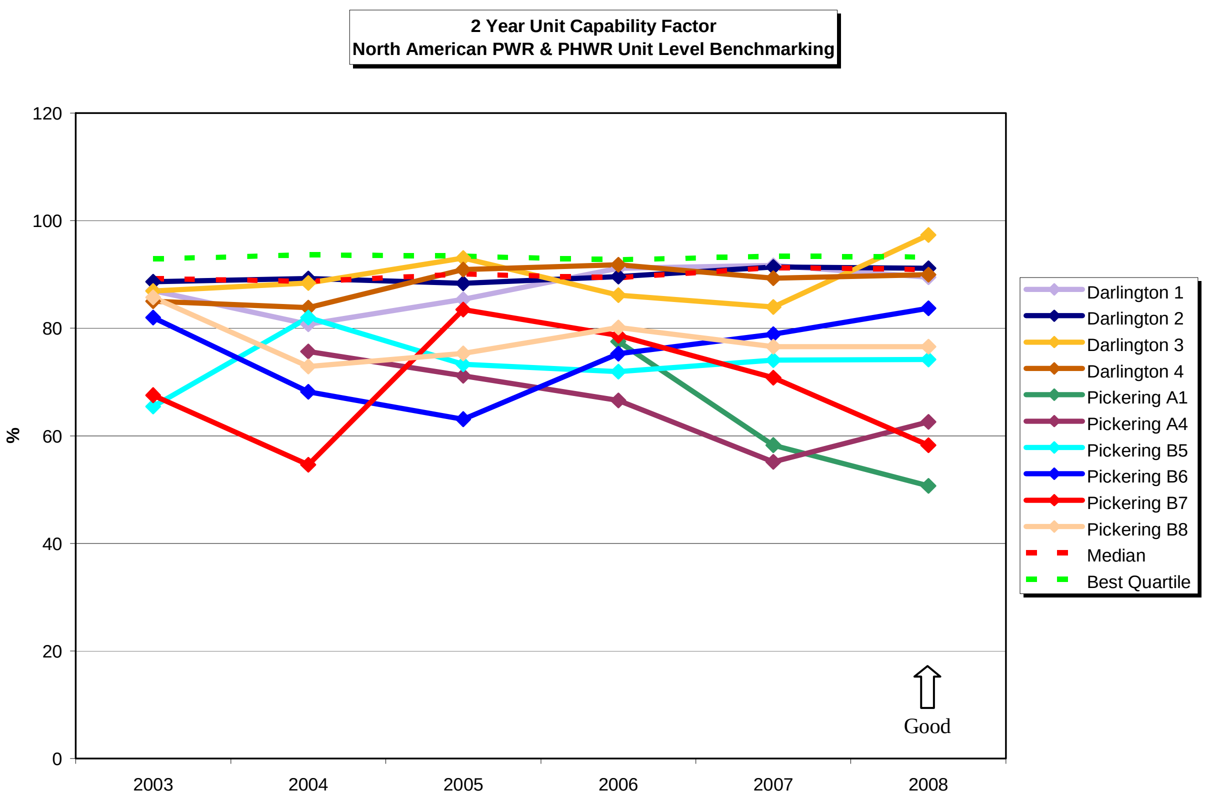
- Equipment Reliability, Design Basis and Human Performance contributors to UCF are consistent with Forced Loss Rate and are discussed under that metric
- Planned outage critical scope items driving outage length included boiler tube inspections, feeder inspections, feeder replacements, CIGAR inspections, and turbine work


2008 2 Year Unit Capability Factor
North American PWR & PHWR Plant Level Benchmarking
Best Quartile 92.78
Max. NPI
Threshold = 92
Darlington
Median 90.44
Pickering B
Pickering A
0.00
20.00
40.00
60.00
80.00
100.00
120.00
%

2008 2 Year Unit Capability Factor
North America PWR & PHWR Unit Level Benchmarking




2 Year Unit Capability Factor
North America PWR & PHWR Plant Level Benchmarking
100
90
80
70
60
50
40
30
20
10
0
%
2003
2004
2005
2006
2007
2008
Good
Darlington
Pickering A
Pickering B
Median
Best Quartile


2 Year Unit Capability Factor
North American PWR & PHWR Unit Level Benchmarking
120
100
80
60
40
20
0
%
2003
2004
2005
2006
2007
2008
Good
Darlington 1
Darlington 2
Darlington 3
Darlington 4
Pickering A1
Pickering A4
Pickering B5
Pickering B6
Pickering B7
Pickering B8
Median
Best Quartile

Observations – 2-Year Unit Capability Factor (North American PWR and PHWR)

- The performance of OPG's units has been shown relative to best quartile, median, and the threshold established by WANO to achieve full WANO NPI points. Since achievement of full WANO NPI points is recognized within the industry as a measure of desirable performance, performance gaps are assessed against full WANO NPI points in addition to median and best quartile

2008 (2-Year Rolling Average)

- UCF at best quartile North American PWR and PHWR plants was 92.78% for the plant average and 93.25% for individual units
- The overall standard for best quartile is higher for the North American PWR and PHWR panel than the worldwide CANDU panel
- Darlington performed better than median as a station but not at best quartile level
- One Darlington unit individually was the best overall for the unit panel, with one unit better than median and the remaining two units below median
- Both Pickering A and B were below median as a plant and each unit performed below median individually

Trend

- Best quartile and median for both plant average and unit performance remained relatively flat over the review period
- Darlington performance improved over the review period, moving from below median to within a relatively small margin of best quartile
- Pickering A had a limited time period compared to the other stations due to the restart of unit 4 in September 2003 and unit 1 in November 2005
- Consistent with Pickering A performance against the worldwide CANDU panel, Pickering A performance declined significantly over the most recent two data points for the review period with no individual or plant average data points at median level for the review period
- Consistent with Pickering B performance against the worldwide CANDU panel, Pickering B performance remained relatively stable over the review period but all data points for unit level and plant level results are below the median level

Factors Contributing to Performance

Darlington

- Darlington achieved gap to best quartile was approximately 1% for the most recent time period under review
- Approximately 78% of the Darlington gap to best quartile was due to planned outages, with 7% related to human performance, 14% related to equipment reliability of the plant, and 1% to design basis
- For the review period, Darlington averaged 57 days for six longer outages and averaged 18 days for three shorter outages
- Five of the nine planned outages during the review period required forced extensions

Factors Contributing to Performance (Cont'd)

Darlington (Cont'd)

- The PWR members of the panel (all but four CANDU plants) typically experience shorter planned outages for several reasons including technological differences, outage scope, and radiological challenges of fuel remaining in the core for CANDU. As a result, although variation occurs, average planned outage length for PWRs typically runs 30-35 days with some plants achieving even shorter outages
- PWRs function on a 18- to 24-month outage cycle and Darlington operated on a 24-month outage cycle for the review period

Pickering A

- Pickering A gap to best quartile was over 30% for the most recent time period under review
- The factors driving Pickering A outages were described in the previous section comparing Pickering A to the worldwide CANDU panel
- The difference in planned outage length for PWRs as compared to CANDUs also applies to Pickering A
- PWRs function on a 18- to 24-month outage cycle and Pickering A operated on a 24-month outage cycle for the review period

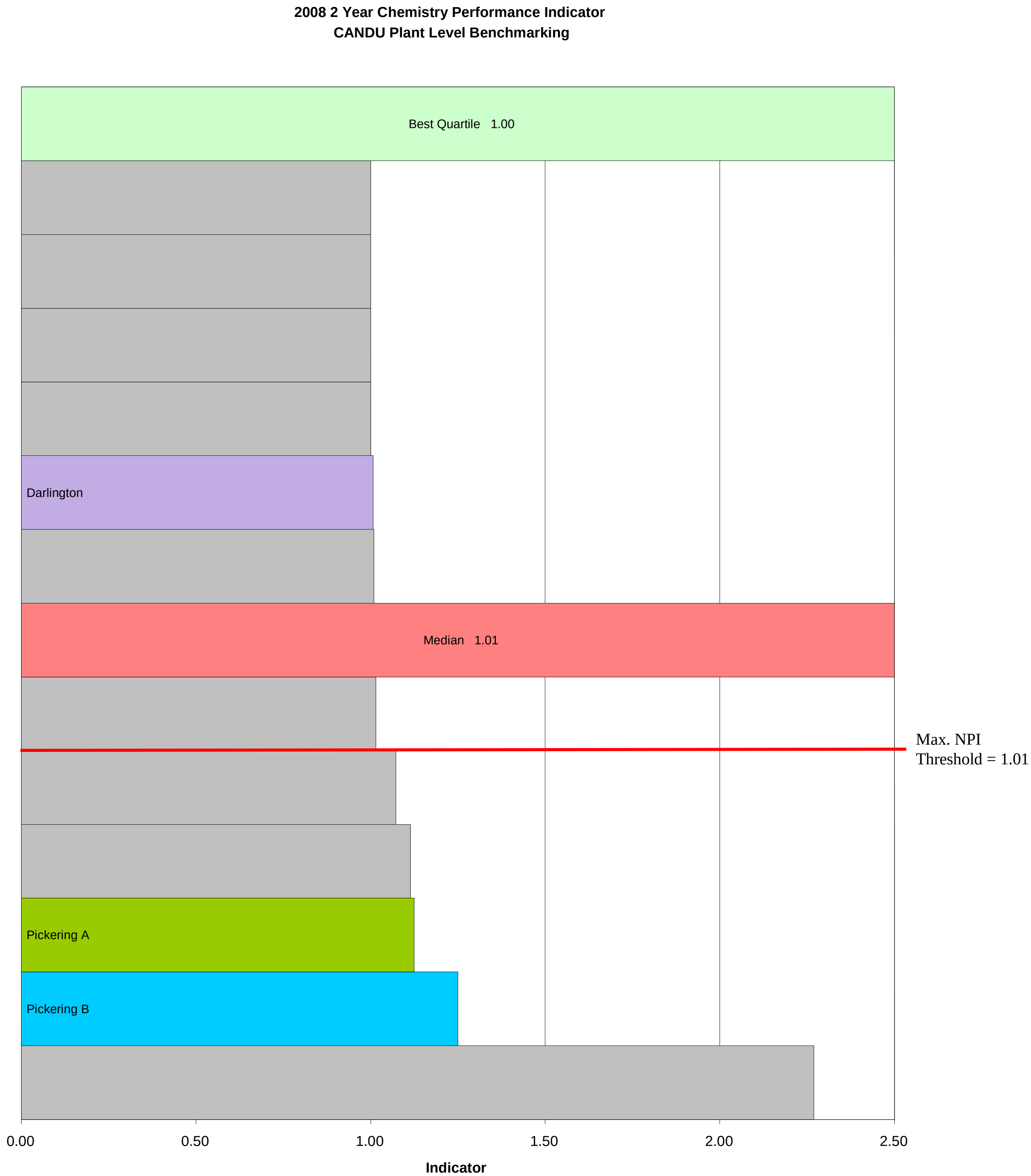
Pickering B

- Pickering B gap to best quartile was just under 20% for the most recent time period under review
- The factors driving Pickering B outages were described in the previous section comparing Pickering B to the worldwide CANDU panel
- The difference in planned outage length for PWRs as compared to CANDUs also applies to Pickering B
- PWRs function on a 18- to 24-month outage cycle and Pickering B operated on a 24-month outage cycle for the review period

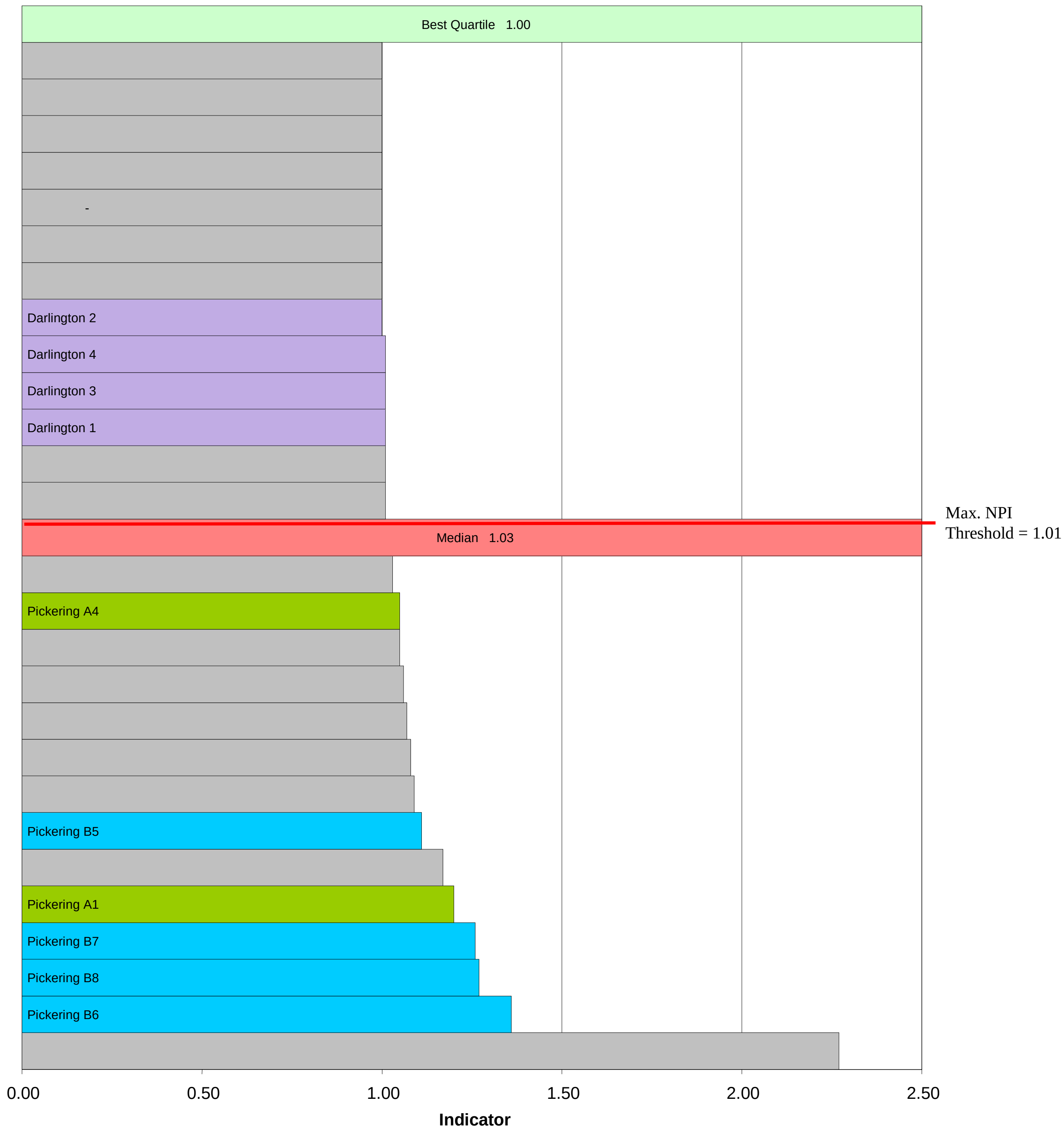
General Comments on selection of Unit Capability Factor versus Capacity Factor

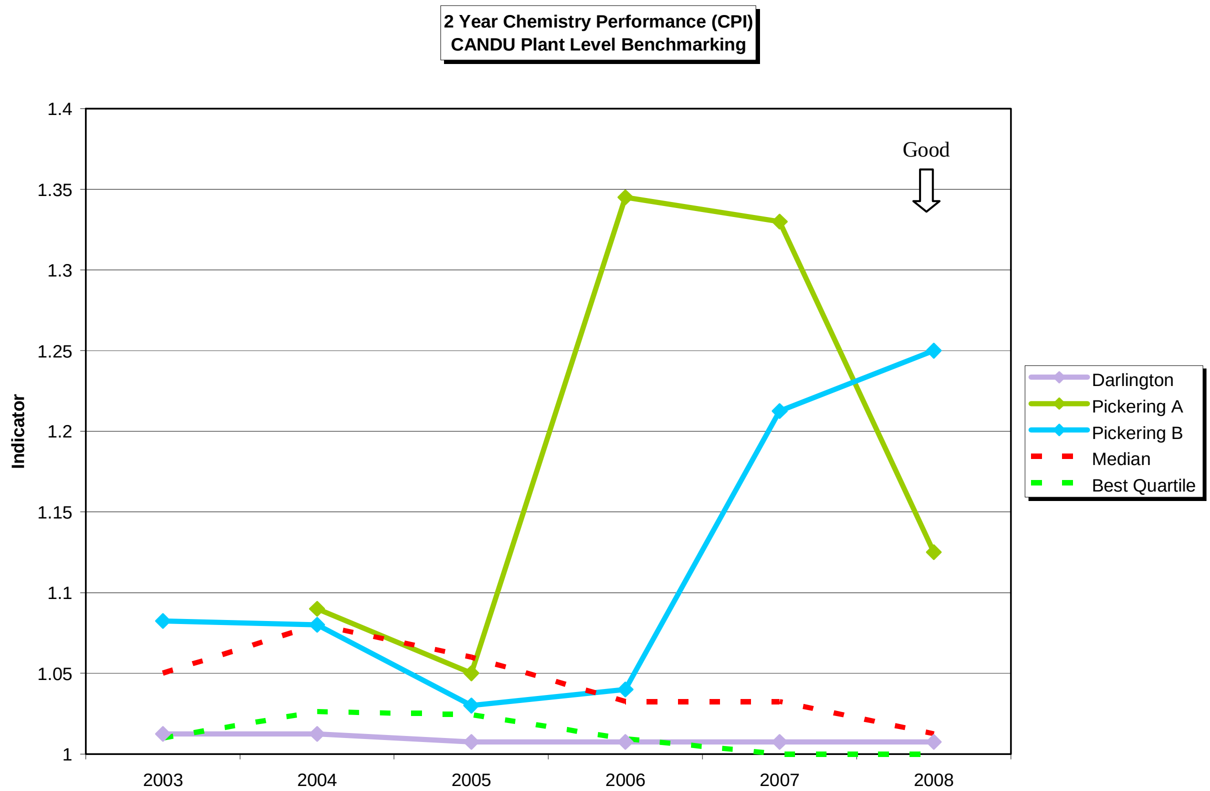
- UCF and CF are metrics used in the nuclear industry to measure generation performance. UCF was selected for benchmarking reliability in preference to capacity factor, due to the similarity of metrics (only one metric was preferred) and the availability and reliability of data. The calculation of the metrics is similar, the primary difference between UCF and CF is that CF reflects grid losses (which is not a reflection of plant performance). UCF 2008 data is also available now whereas CF 2008 from EUCG will be published in the summer of 2008. Additionally, the submission guidance and data reliability is better for WANO's Unit Capability Factor compared to EUCG's Capacity Factor

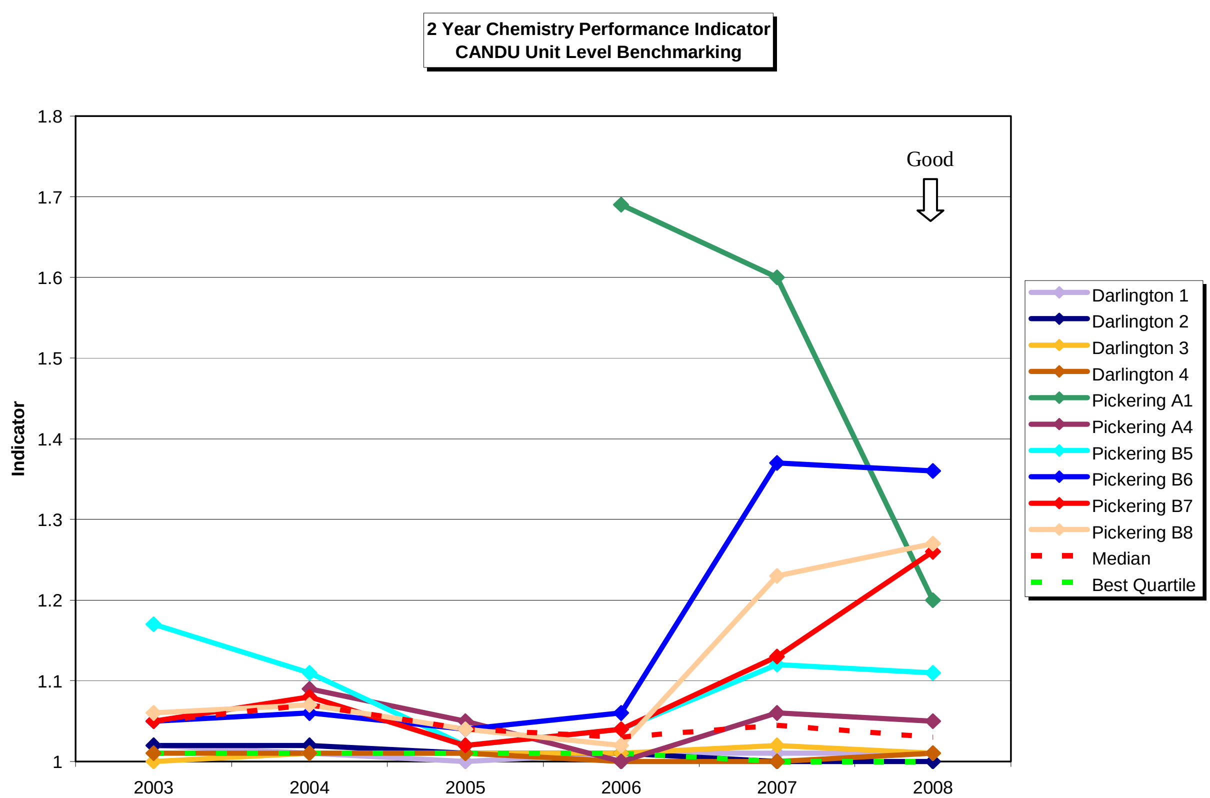
2-Year Chemistry Performance Indicator (CPI)



2008 2 Year Chemistry Performance (CPI)
CANDU Unit Level Benchmarking




2 Year Chemistry Performance (CPI)
CANDU Plant Level Benchmarking
Indicator
1.4
1.35
1.3
1.25
1.2
1.15
1.1
1.05
1
2003
2004
2005
2006
2007
2008
Good
Darlington
Pickering A
Pickering B
Median
Best Quartile


2 Year Chemistry Performance Indicator
CANDU Unit Level Benchmarking
Indicator
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
2003
2004
2005
2006
2007
2008
Good
Darlington 1
Darlington 2
Darlington 3
Darlington 4
Pickering A1
Pickering A4
Pickering B5
Pickering B6
Pickering B7
Pickering B8
Median
Best Quartile

Observations – 2-Year Chemistry Performance Indicator (CANDU)

- The performance of OPG's units has been shown relative to best quartile, median, and the threshold established by WANO to achieve full WANO NPI points. Since achievement of full WANO NPI points is recognized within the industry as a measure of desirable performance, performance gaps are assessed against full WANO NPI points in addition to median and best quartile. In the case of Chemistry Performance Indicator, there is essentially no mathematical difference between achieving best quartile and median performance

2008 (2-Year Rolling Average)

- The plant level best quartile of the CANDU panel is 1.01
- Darlington units are in the best quartile
- Pickering A units are below the median, with unit 4 nearing the median
- Pickering B units are below the median

Trend

- Darlington has shown improvement toward the maximum score since 2003
- Pickering A units have shown improvement since 2006
- Pickering B units were close to median prior to 2006, but declined in 2007
- CANDU best quartile performance is the maximum score (1.00), while median for individual units is just 1.04, showing little differentiation among units
- Since 2003, the top quartile and median scores, already close to the maximum, have converged even closer to 1.00
- Relative ranking may be dramatically changed by just a few tenths of a part per billion (ppb) for a single chemical species. For example, for a Pickering unit an additional 1 ppb sulphate (2.7 ppb vs. 1.7 ppb) could move performance from top quartile (1.00) to bottom quartile (1.10). Similarly an additional 0.2 ppb sodium could move performance from top quartile to median (1.04)

Factors Contributing to Performance

- Unit start-ups negatively impact the indicator, therefore, sustained periods of continuous operation will assist in maximizing the indicator score
- There have been examples of defective blowdown valves requiring blowdown of individual boilers to be taken out of service. This causes boiler impurity concentrations to temporarily rise and can negatively impact the indicator score

Darlington

- Darlington has no performance gap

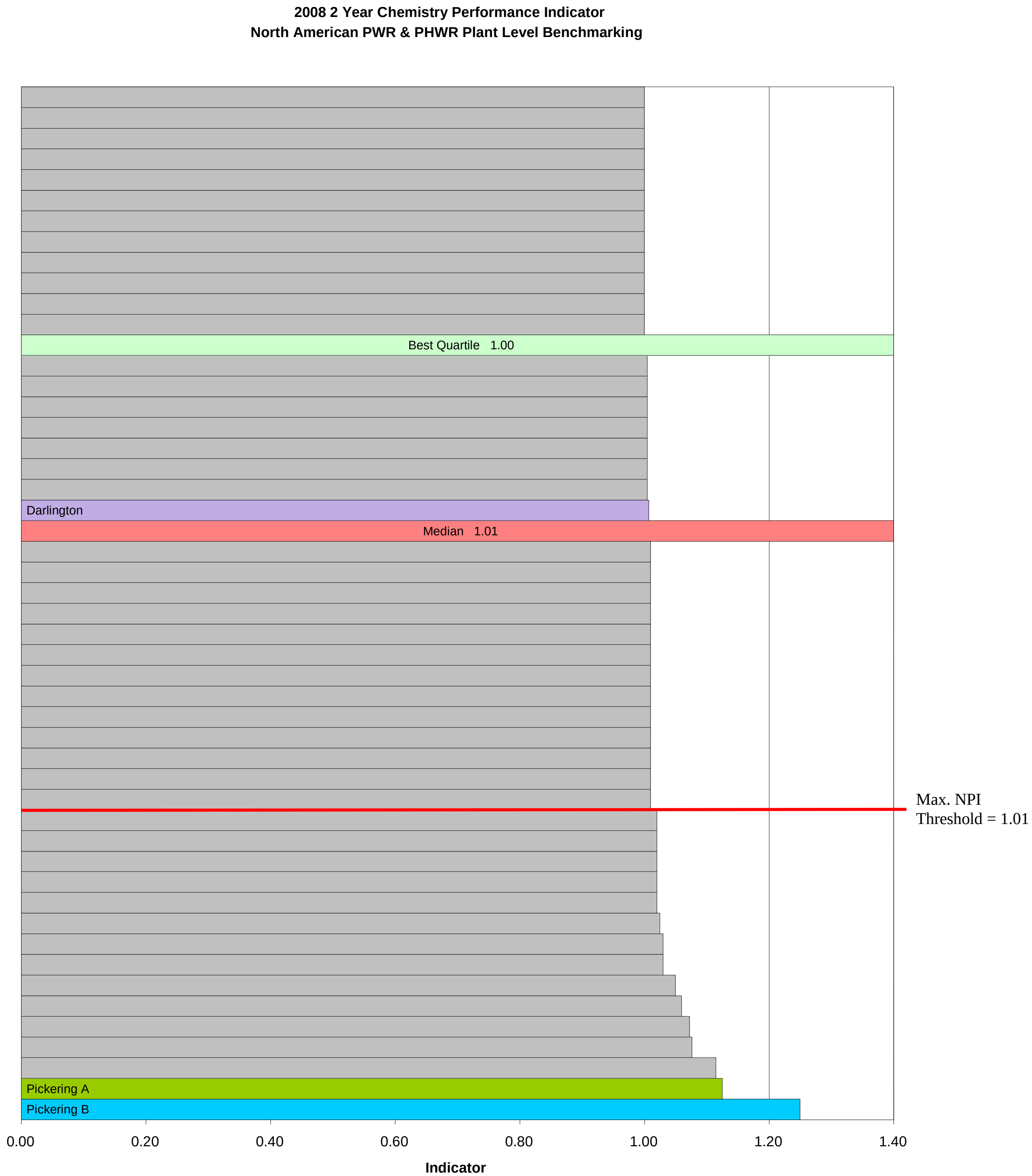
Factors Contributing to Performance (Cont'd)

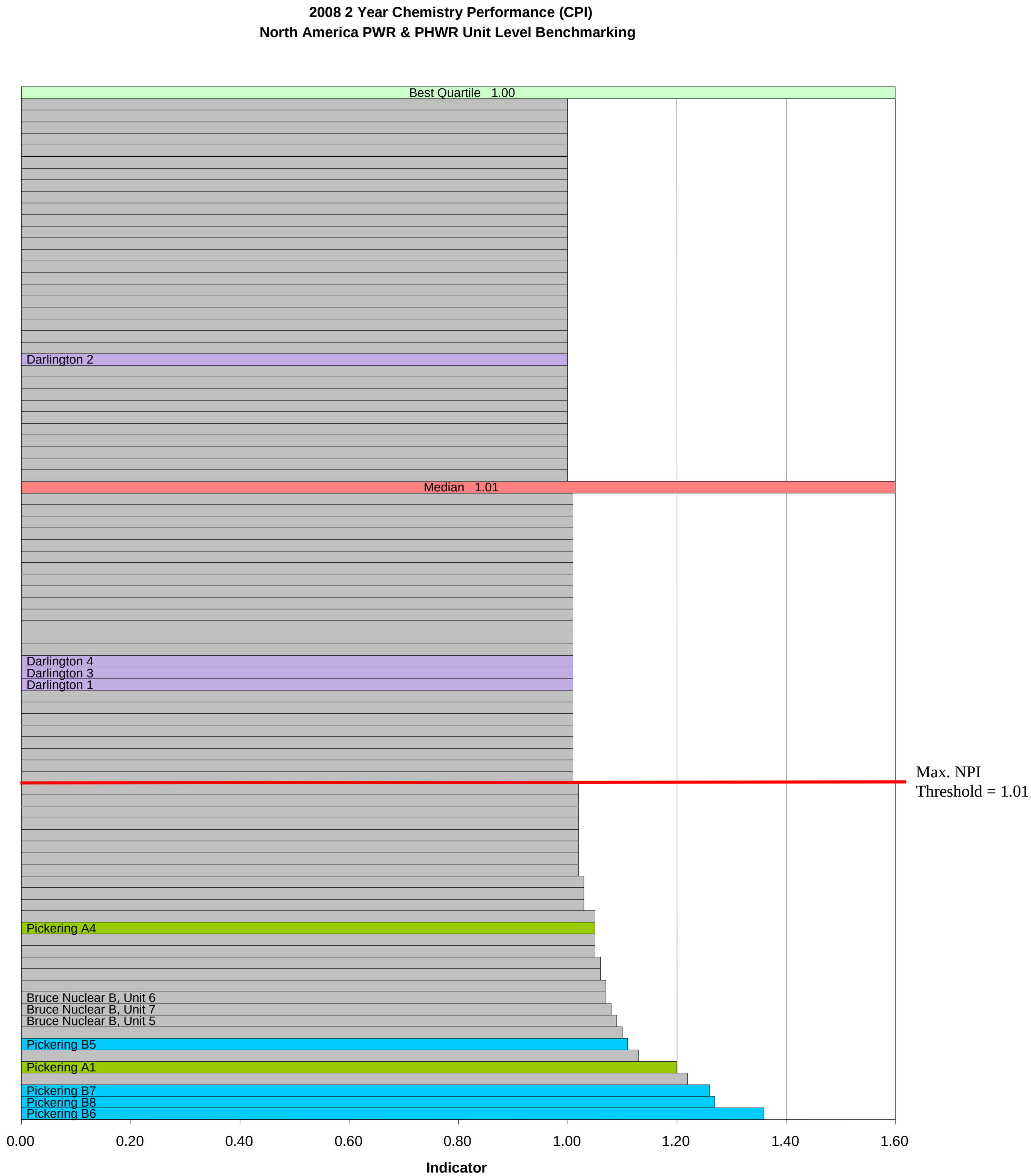
Pickering A

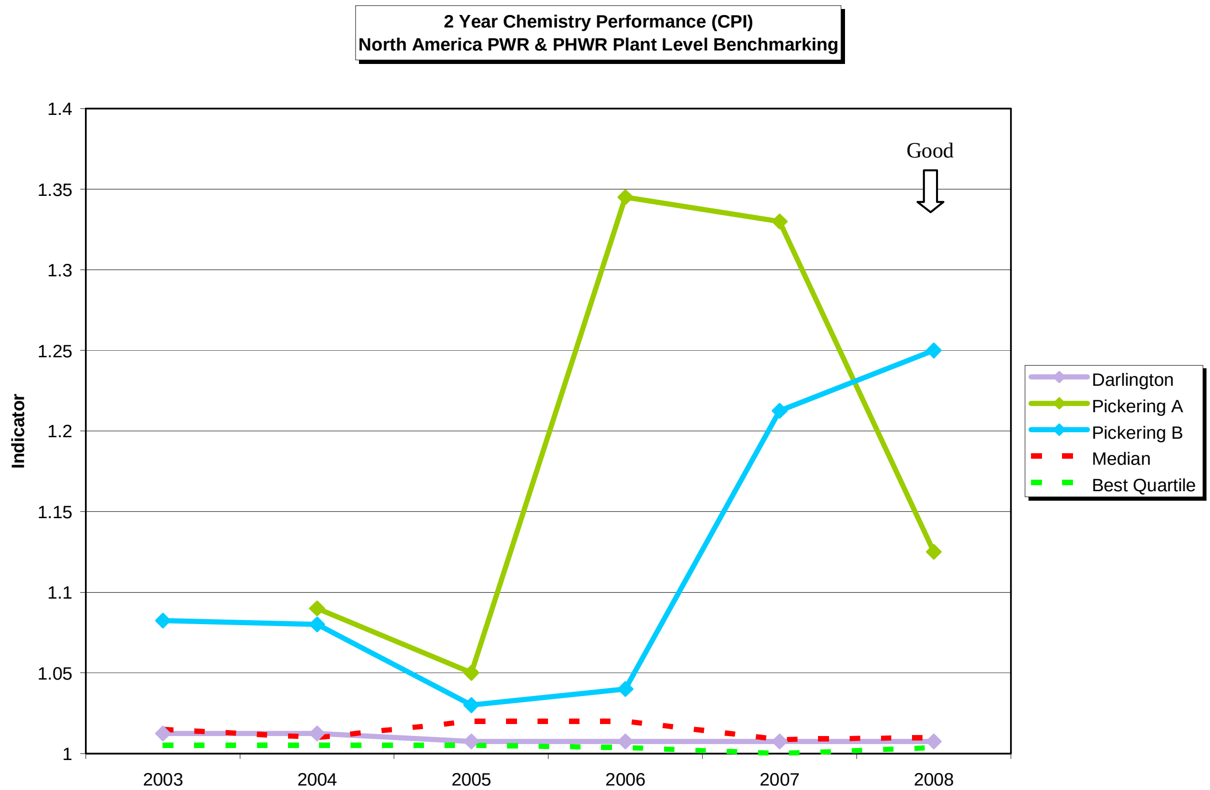
- Pickering A performance has been impacted by two major causes:
  - Unit re-start following a long period out of service negatively impacts the indicator. P4 was relatively stable during the reporting period, the return to service of P1 negatively impacted the overall Pickering A score
  - Pickering A units were affected by the December 2006 water treatment plant resin intrusion event. This indicator is a two-year rolling average, so the effects of this event remain in the calculation for 2008.

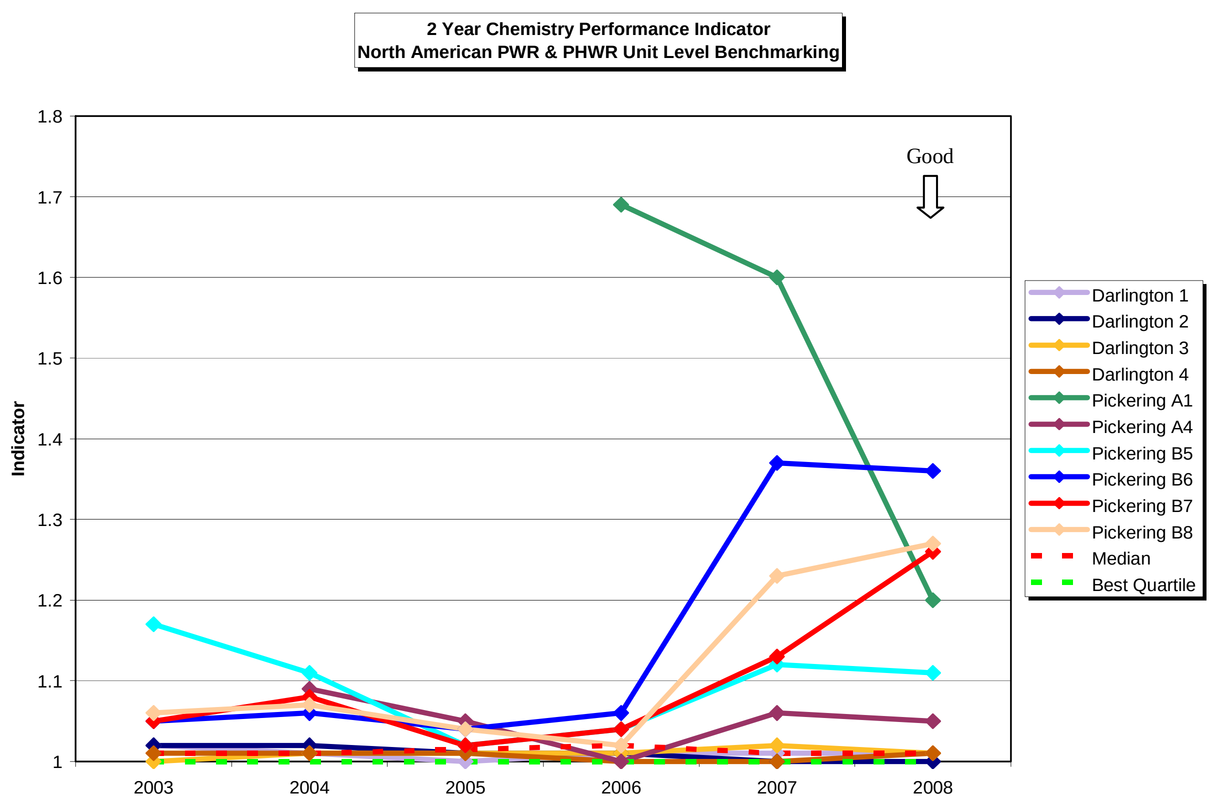
Pickering B

- Pickering B units were moving toward median and best quartile prior to 2006. In December 2006 significant quantities of cation form resin entered the feedwater and boilers from the water treatment plant, releasing sulphate (one of the chemical species that makes up the indicator). The worst affected units were P6 and P8 . Despite much improved performance recently, the effect is still reflected in the two-year rolling average period


2008 2 Year Chemistry Performance Indicator
North American PWR & PHWR Plant Level Benchmarking
Best Quartile 1.00
Darlington
Median 1.01
Max. NPI
Threshold = 1.01
Pickering A
Pickering B
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
Indicator


2008 2 Year Chemistry Performance (CPI)
North America PWR & PHWR Unit Level Benchmarking
Best Quartile 1.00
Darlington 2
Median 1.01
Darlington 4
Darlington 3
Darlington 1
Max. NPI Threshold = 1.01
Pickering A4
Bruce Nuclear B, Unit 6
Bruce Nuclear B, Unit 7
Bruce Nuclear B, Unit 5
Pickering B5
Pickering A1
Pickering B7
Pickering B8
Pickering B6
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
1.60
Indicator


2 Year Chemistry Performance (CPI)
North America PWR & PHWR Plant Level Benchmarking
Good
Indicator
1.4
1.35
1.3
1.25
1.2
1.15
1.1
1.05
1
2003
2004
2005
2006
2007
2008
Darlington
Pickering A
Pickering B
Median
Best Quartile


2 Year Chemistry Performance Indicator
North American PWR & PHWR Unit Level Benchmarking
Good
Indicator
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
2003
2004
2005
2006
2007
2008
Darlington 1
Darlington 2
Darlington 3
Darlington 4
Pickering A1
Pickering A4
Pickering B5
Pickering B6
Pickering B7
Pickering B8
Median
Best Quartile

Observations – 2-Year Chemistry Performance Indicator (North American PWR/PHWR)

- The performance of OPG's units has been shown relative to best quartile, median, and the threshold established by WANO to achieve full WANO NPI points. Since achievement of full WANO NPI points is recognized within the industry as a measure of desirable performance, performance gaps are assessed against full WANO NPI points in addition to median and best quartile. In the case of Chemistry Performance Indicator, there is essentially no mathematical difference between achieving best quartile and median performance

2008 (2-Year Rolling Average)

- Darlington unit performance is in top quartile or median of the North American PWR/PHWR panel
- Pickering A (units 1 and 4) is in the bottom quartile
- Pickering B units are all at the bottom of the performance chart

Trend

- Darlington performance has remained consistent during the review period
- Pickering A performance decreased from 2005-2006, but has started to improve
- Pickering B performance remained just under median until 2006 at which point performance began to drop
- Top-performing units have little differentiation, with top performance being maximum score (1.00) and median 1.01
- U.S. PWRs and BWRs have been reporting the INPO Chemistry Effectiveness Indicator (CEI), in addition to the WANO CPI for a year and one quarter
- The intent of the CEI is to allow more direct benchmarking of performance between different reactor designs (PWR and BWR), provide an indicator of performance for more than one system (i.e. not just the steam generators as is the case for the CPI) and to allow more meaningful differentiation among plants
- OPG and Bruce Power have done some preliminary internal reporting of a metric similar to CEI and are currently working to produce a CANDU CEI to present to the COG CANDU community as a possible replacement for CPI

Factors Contributing to Performance

In general, for all OPG units CPI performance is maximized by:

- Ensuring high-quality, make-up water is delivered at all times by the facility water treatment plant
- Ensuring condenser in-leakage is minimized, and in particular, reacting quickly to condenser tube leaks
- Ensuring steam generator blowdown is available at all times to remove accumulating impurities
- Minimizing the number of unit start-ups and reviewing start-up documentation to ensure best practices for chemistry control are in place. Items such as options for condensate/filtration should be evaluated

Factors Contributing to Performance (Cont'd)

Pickering A

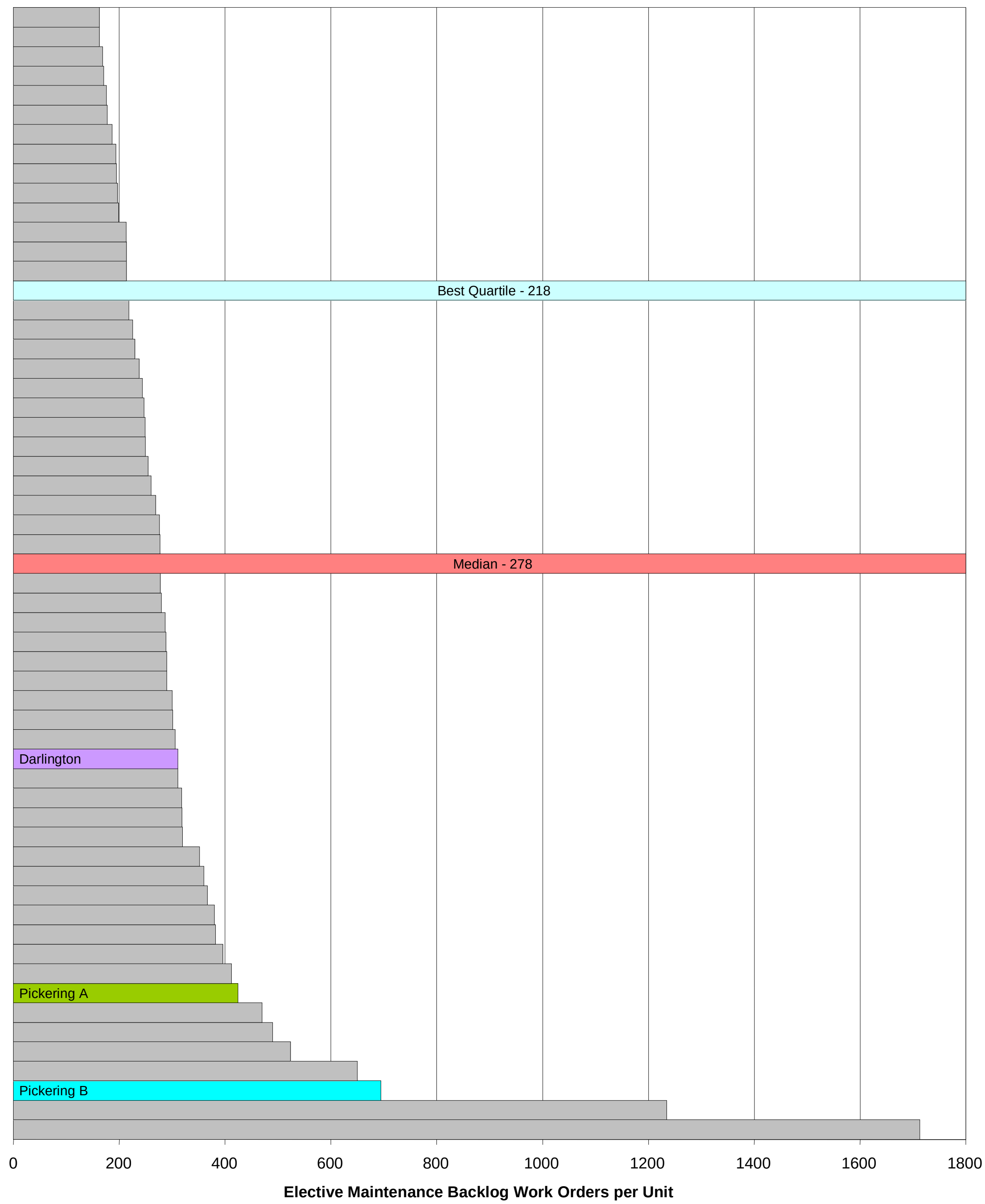
- Pickering A performance is difficult to assess due to the impact of the resin event of 2006 and the minimal differentiation in performance between top and bottom performing plants. Nevertheless, allowing for the impact of the resin event, performance would be expected in the 1.00 to 1.05 range, though performance at the bottom end of this very narrow range would still place the units well toward the bottom of the performance chart
- In any case, start-up transients would likely have impact the ability of these units to consistently produce top quartile performance

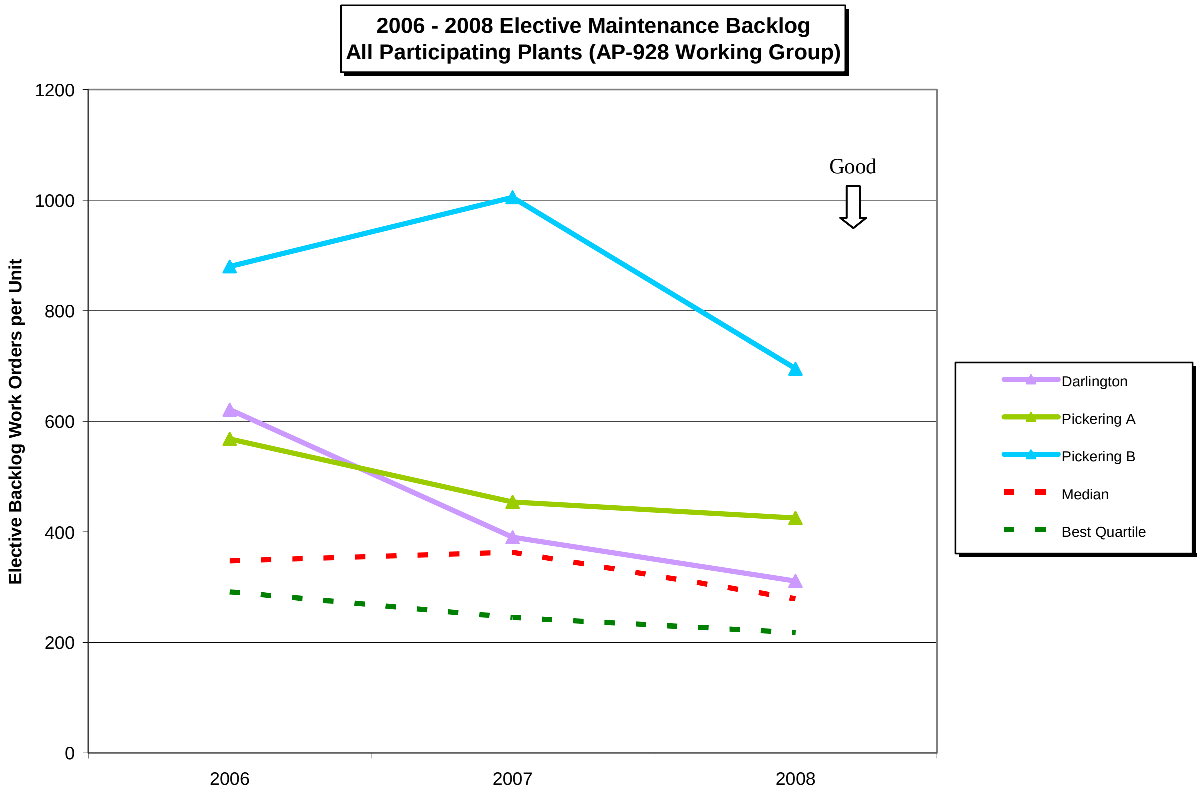
Pickering B

- Pickering B performance is difficult to assess due to the impact of the resin event of 2006 and the minimal differentiation in performance between top and bottom performing plants
- Allowing for the impact of the resin event, performance would be expected in the 1.00 to 1.05 range, though performance at the bottom end of this very narrow range would still place the units well toward the bottom of the performance chart
- It is expected that start-up would similarly impact the ability of these units to consistently produce top quartile performance

1-Year On-line Elective Maintenance Backlog

2008 Elective Maintenance Backlog
All Participating Plants (AP-928 Working Group)




2006 - 2008 Elective Maintenance Backlog
All Participating Plants (AP-928 Working Group)
Elective Backlog Work Orders per Unit
1200
1000
800
600
400
200
0
2006
2007
2008
Good
Darlington
Pickering A
Pickering B
Median
Best Quartile

Observations – Elective Maintenance Backlog (INPO AP-928 Workgroup)

- Although all common services backlogs at Pickering are ascribed to Pickering A for purposes of internal reporting, when reporting externally, such backlogs are divided up between Pickering A and B based on operating units. Therefore 33% of common services backlogs reside at Pickering A, the remaining with Pickering B. This adjustment is reflected in the Pickering A and B backlog numbers presented below

2008

- The data in this panel is gathered by an independent industry group of peers through an INPO AIP-928 group
- Best quartile for the panel is 218 elective work orders
- All three plants are currently performing worse than median

Trend

- The overall industry best quartile has improved steadily for the review period
- Darlington is the closest station in the OPG fleet to reach median performance as indicated in industry performance metrics. Darlington has been focused on its elective maintenance backlogs for some time, however, efforts made in 2006 allowed them to drive their backlogs down with an entire site focus. Considerable work still remains to reach top quartile, but the infrastructure is in place
- Pickering B was an outlier with the industry in 2004 and 2005, far above the nearest reporting utility. Significant gains have been made but they remain with the fourth quartile group, with a significant gap to top quartile remaining

Factors Contributing to Performance

- Key performance drivers for this metric include: parts obsolescence, bottle necks, and engineering holds

Darlington

- Darlington recently broke the 300 plane putting them within reach of median status. In order to bridge the gap in attaining top quartile, a 30% further reduction in backlogs is required. An additional challenge Darlington faces is related to the speed in which the industry is advancing in this area. It is projected that actual gap they are facing is closer to a 40% reduction. Issues challenging Darlington include timely engineering holds resolution and parts obsolescence

Pickering A

- Pickering A elective maintenance backlog has held in the 500 range (unadjusted, 475 adjusted) as they fight through a planned as well as two forced outages this year. A reduction of approximately 60% of their backlog is required to attain top quartile. Challenges affecting Pickering A include forced loss rate, work assessment, and parts obsolescence

Factors Contributing to Performance (Cont'd)

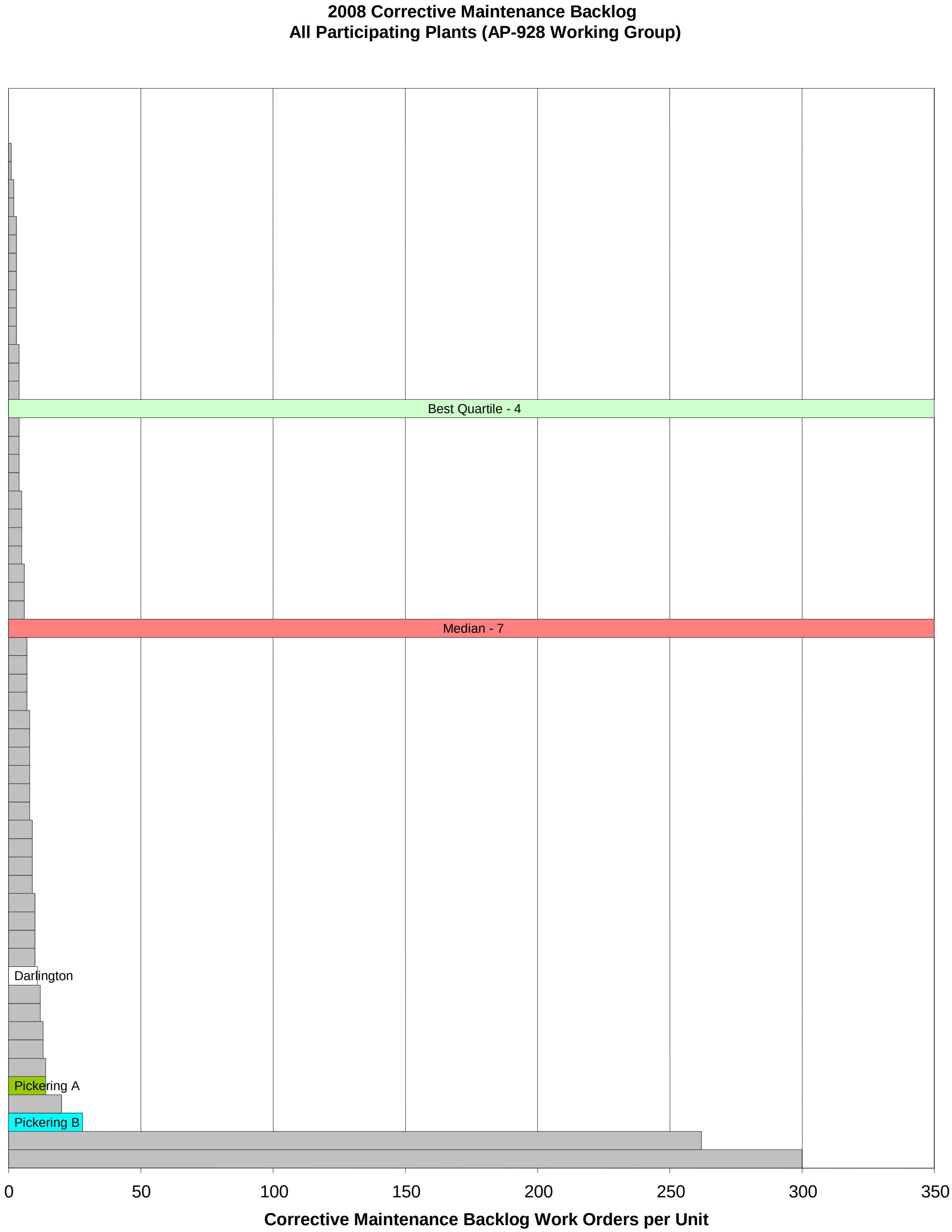
Pickering B

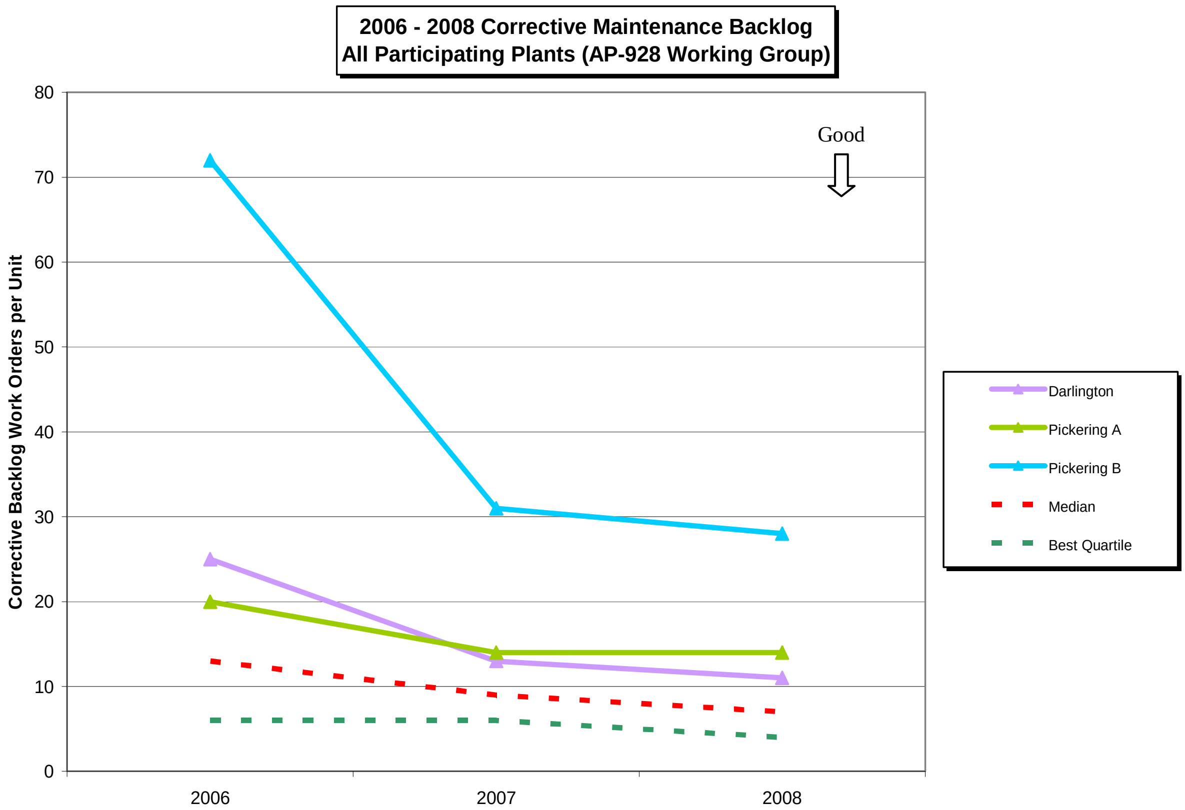
- Pickering B elective maintenance backlog is currently at 685 (unadjusted, 698 adjusted). They have to reduce their backlog by 70% to attain top quartile. Performance for the year has been flat with one unit in a planned outage. Challenges affecting Pickering B include extended planned outages resulting in resource availability issues for operating units backlogs; assessing work**,** engineering holds resolution, and parts obsolescence

General Comments

- Recognition should be given to the challenges a four-unit CANDU site has that is not present with PWR and BWR technology. On-line fueling, heavy water management and a common vacuum building that connects all units' containment structures raise the complexity of accomplishing scheduled work.
- Having four-unit stations increases impacts of plant perturbations on the other units. In terms of comparison, there are no four-unit PWR or BWR sites in existence. The closest comparison would be three-unit sites with only three in existence (the remaining sites are single- and dual-unit stations)
- While this additional complexity cannot be quantified into a factor when comparing backlog performance, it should be a consideration when understanding the effort required to maintain backlogs at a four-unit CANDU station

1-Year Corrective Maintenance Backlog




2006 - 2008 Corrective Maintenance Backlog
All Participating Plants (AP-928 Working Group)
Corrective Backlog Work Orders per Unit
0
10
20
30
40
50
60
70
80
2006
2007
2008
Good
Darlington
Pickering A
Pickering B
Median
Best Quartile

Observations – Corrective Maintenance Backlog (INPO AP928 Workgroup)

2008

- Best quartile for the panel is four work orders
- Currently all OPG sites are performing worse than median
- Darlington is at 11, Pickering A is at 14 and Pickering B is at 28. A 50% reduction by Pickering A corrective maintenance backlog and a 70% by Pickering B corrective maintenance backlog are required to bring them into alignment with top performance in the industry

Trend

- Best quartile has remained fairly constant and a low number for the review period, while median has improved, revealing an overall trend in the industry to single-digit corrective maintenance backlog results
- All OPG sites have shown consistent improvement over the review period but remain worse than median for the duration of the review period. All stations were in excess of single-digit corrective maintenance values over the review period

Factors Contributing to Performance

- Both best quartile and median are single-digit values. Achieving single-digit corrective maintenance backlog (i.e. nine or lower) is considered desirable indicator performance. Further reductions may not be prudent from a cost/benefit perspective, i.e. it is not apparent that there is additional value for OPG to seek performance levels at best quartile/median.

Darlington

- Darlington has maintained current performance level for the better part of the last year. Their program and process rigor are able to maintain corrective maintenance backlogs at this level

Pickering A

- Pickering A has remained flat with the same challenges mentioned in the elective maintenance analysis

Pickering B

- Pickering B has also remained flat with parts obsolescence and subsequent engineering issues with corrective maintenance backlogs

General Comments

- The general comments on elective maintenance backlog (previous section) are also applicable for this section

4.0 VALUE FOR MONEY

Methodology and Sources of Data

Costs indicators were retrieved from the EUCG website in April of 2008. Data was collected for three-year rolling averages for all financial metrics covering the review period from 2005-2008. Zero values for cost indicators are excluded from all calculations. For two-year averages where only one year of data is available, the most recent year's value is used. All data pulled from the EUCG website by OPG is automatically converted by EUCG to Canadian dollars. Therefore, all values included within this benchmarking report are in Canadian dollars.

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

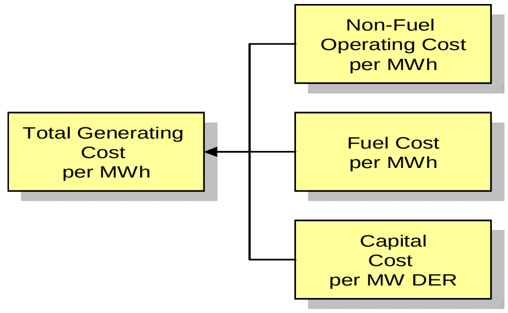
The benchmarking panel utilized for value for money metrics is made up of all North American plants reporting to EUCG. Within that panel, there is only one other CANDU technology plant reporting, Bruce Power. The remaining plants are BWRs or PWRs. For that reason, some of the gaps in performance are likely associated with technology differences rather than comparable performance. However, some of a plant's performance is not directly tied to technology differences and can be compared across technologies, allowing this panel to be used for benchmarking purposes.

All metrics include cost information normalized by some factor (MWh or MW DER) to allow for more accurate comparison across plants of different sizes and numbers of units.

Discussion

Four "value for money" metrics are benchmarked in this report. They are total generating costs per MWh, non-fuel operating costs per MWh, fuel cost per MWh and capital costs per MW DER. The metrics themselves roll up as shown in the illustration below. Total generating cost is the sum of non-fuel operating cost, fuel cost, and capital cost. Given differences between OPG and most North American plant with respect to both fuel costs and capital costs, the best overall financial comparison metric for OPG facilities is total generating cost per MWh.

Diagram of Summary Relationship of Value for Money Metrics



Capital cost is reported on a capital cost per MW DER basis individually; because that is the most appropriate benchmarking metric (output or MWh are not appropriate values to normalize for capital investment). When totaled to calculated total generating cost per MWh, the denominator for capital cost is changed to MWh to maintain consistency of units.

Capital costs per MW DER: The benchmark data indicates that OPG per unit capital spending is the lowest in North America with Darlington, Pickering A and Pickering B all performing within the best quartile for the panel. Lower capital costs could be in part due to the application of the capitalization policy at OPG for purposes of classifying projects as capital or OM&A or due to the use of higher capitalization threshold at OPG than at most other plants in the panel. When OPG OM&A projects are added to capital expenditures, the resulting total is more consistent with the per unit capital spending of other plants in the EUCG panel.

As a result, the benchmark data suggests that the lower capital costs results in higher non-fuel operating cost per MWh. In other words, the impact of low capital project costs offset by high OM&A projects costs results in OM&A expenses appearing slightly higher against benchmark plants and capital expenditures appearing lower against benchmark plants.

The best way to address this difference is to utilize total generating cost per MWh (i.e. the sum of non-fuel operating cost, fuel cost, and capital cost) as the primary financial benchmark to eliminate any unintended impact of the capitalization policy on total operating cost per MWh.

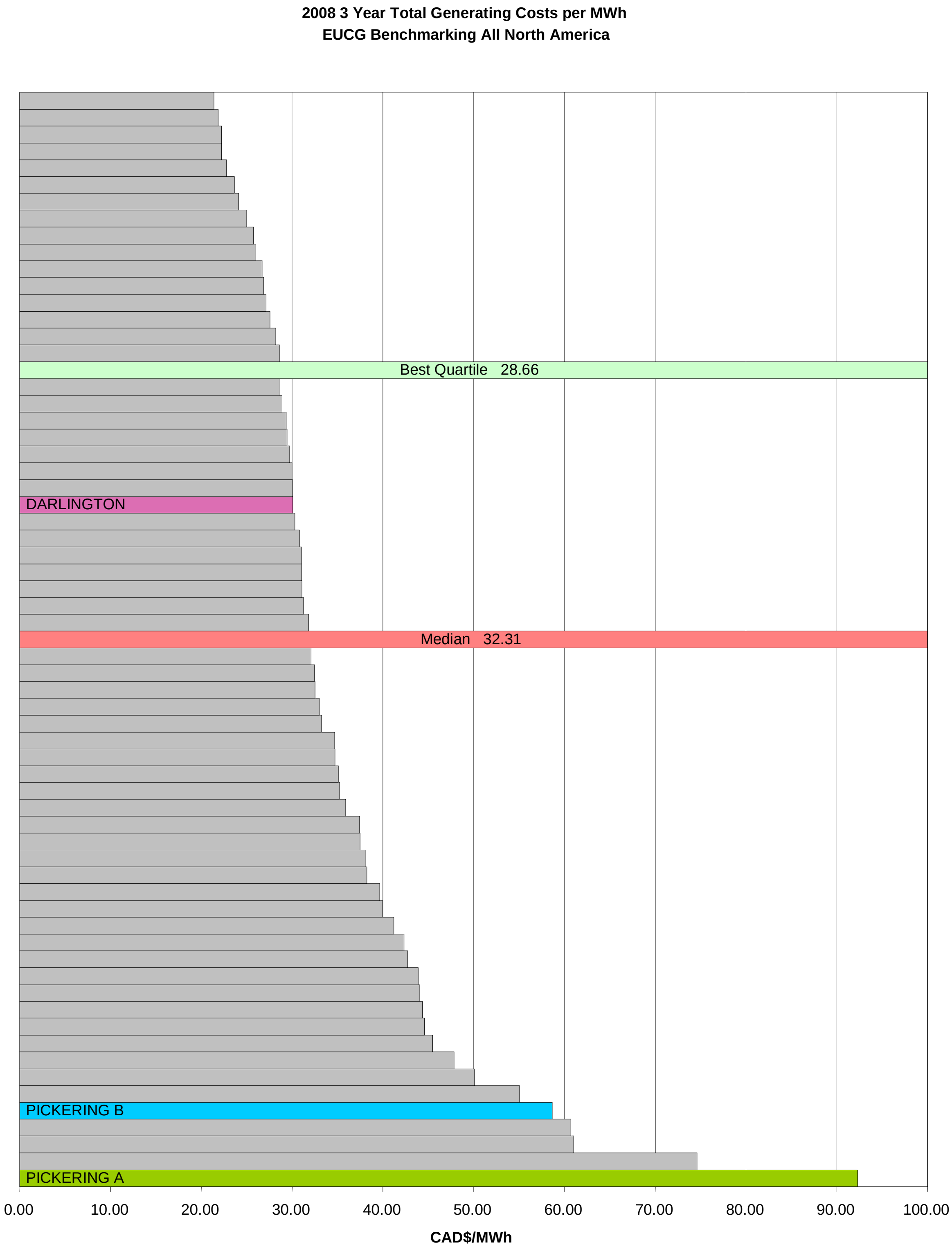
Fuel costs per MWh: Fuel cost, primarily driven by the technological differences in CANDU technology, are lower for OPG than for most North American PWR/BWR reactors. CANDUs do not require enriched uranium like BWRs and PWRs and, as a result, experience lower fuel costs. This provides a significant advantage for OPG in this cost category. Fuel cost per MWh for Darlington, Pickering A, and Pickering B are each approximately $2.30/MWh better than the best quartile value for this metric.

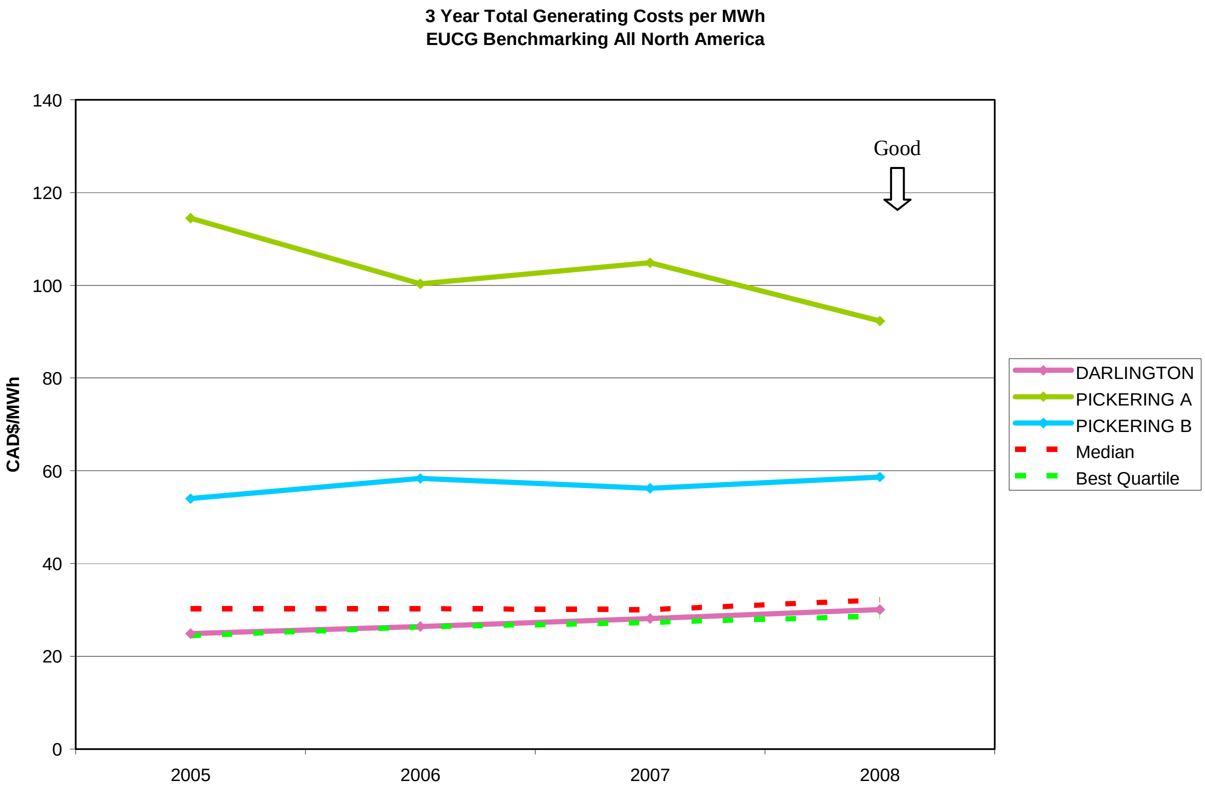
Non-fuel operating costs per MWh: Performance in non-fuel operating cost per MWh drives the majority of OPG financial performance. Removing OPG's advantages in fuel costs and capital costs reveals relatively poor financial performance at all three OPG facilities with respect to non-fuel operating cost per MWh. Specific drivers of performance vary from station to station and will be discussed in more detail later in the report, but overall the biggest drivers are; capability factor, station size, CANDU technology, corporate cost allocation and potential controllable costs. In more detail:

- The ‘capability factor’ driver is related specifically to generation performance of the station in relation to the overall potential for the station (results are discussed within the Reliability section within the 2-Year Unit Capability Factor metric).
- The ‘station size’ driver is the combined effect of number of units and size of units. The number of units and size of those units can have significant impacts on plant cost performance and review of the benchmarking data reveals a link between the two.

- The ‘CANDU technology’ driver relates specifically to the concept that CANDU technology results in some specific cost disadvantages related to the overall engineering and maintenance costs. In addition, this factor is influenced by the fact that CANDU plants have less well-developed user groups to share and adopt competitive advantage information, than do longer-established user groups for PWRs and BWRs. Quantification of CANDU technology impact to cost remains most difficult of all drivers.
- The ‘corporate cost allocations’ driver relates directly to the allocated corporate support costs charged to the nuclear group.
- The ‘potential controllable costs’ driver relate to the remaining costs which are not attributable to other specific cost drivers – and provide a potential improvement opportunity for further analysis.

3-Year Total Generating Costs per MWh




3 Year Total Generating Costs per MWh
EUCG Benchmarking All North America
Good
CAD$/MWh
140
120
100
80
60
40
20
0
2005
2006
2007
2008
DARLINGTON
PICKERING A
PICKERING B
Median
Best Quartile

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

2008 (3-Year Rolling Average)

- The best quartile level for total generating costs per MWh among North American EUCG participants was $28.66/MWh while the median level was $32.31/MWh
- Darlington achieve total costs better than the industry median but they did not achieve best quartile
- Pickering A's total generating cost was $92.27/MWh, well worse than the median of $32.31/MWh
- Pickering B's total generating cost was $58.68/MWh, also well worse than the median of $32.31/MWh

Trend

- Both best quartile and median total generating costs per MWh have increased slightly over the 2005 to 2008 period – in effect, lowering the bar. The best quartile costs rose by $4/MWh while the median cost rose by $1.8/MWh
- Darlington's costs trended upward over the review period. In 2005, they were at best quartile level but by 2008 they were between best quartile and median levels. The growth during this period was $1.4/MWh
- Pickering A's total generation cost per MWh was the highest cost of any station reporting and was $60/MWh above the 2008 median, although costs have decreased over the period by $22.2/MWh
- Pickering B's costs have consistently trended above the median

Factors Contributing to Performance

- Total generating cost per MWh is the sum of non-fuel operating cost per MWh, fuel cost per MWh and capital cost per MWh. The benchmark metric is capital cost per MW DER. To include capital cost impact in total generating cost, station capital costs are divided by net MWh produced – same as for fuel/ non-fuel operating costs
- For technological reasons, fuel per MWh is an advantage for all CANDUs and the OPG plants performed within the best quartile
- Non-fuel operating cost per MWh for all OPG plants yielded results of worse than median for the most recent data point compared to the North American EUCG panel

Factors Contributing to Performance – 3-Year Total Generating Cost per MWh (Cont'd)

Darlington

- As stated above, fuel cost per MWh and capital cost per MW DER performed within the best quartile for Darlington while the non-fuel operating cost per MWh performed worse than median
- The largest drivers of performance gap for Darlington are CANDU technology, corporate allocations and potential controllable costs
- Due to strong generation performance at Darlington, capability factor does not contribute negatively to performance.
- Station size actually provides an overall advantage for Darlington (due to 4 relatively large units), it does not contribute negatively to performance

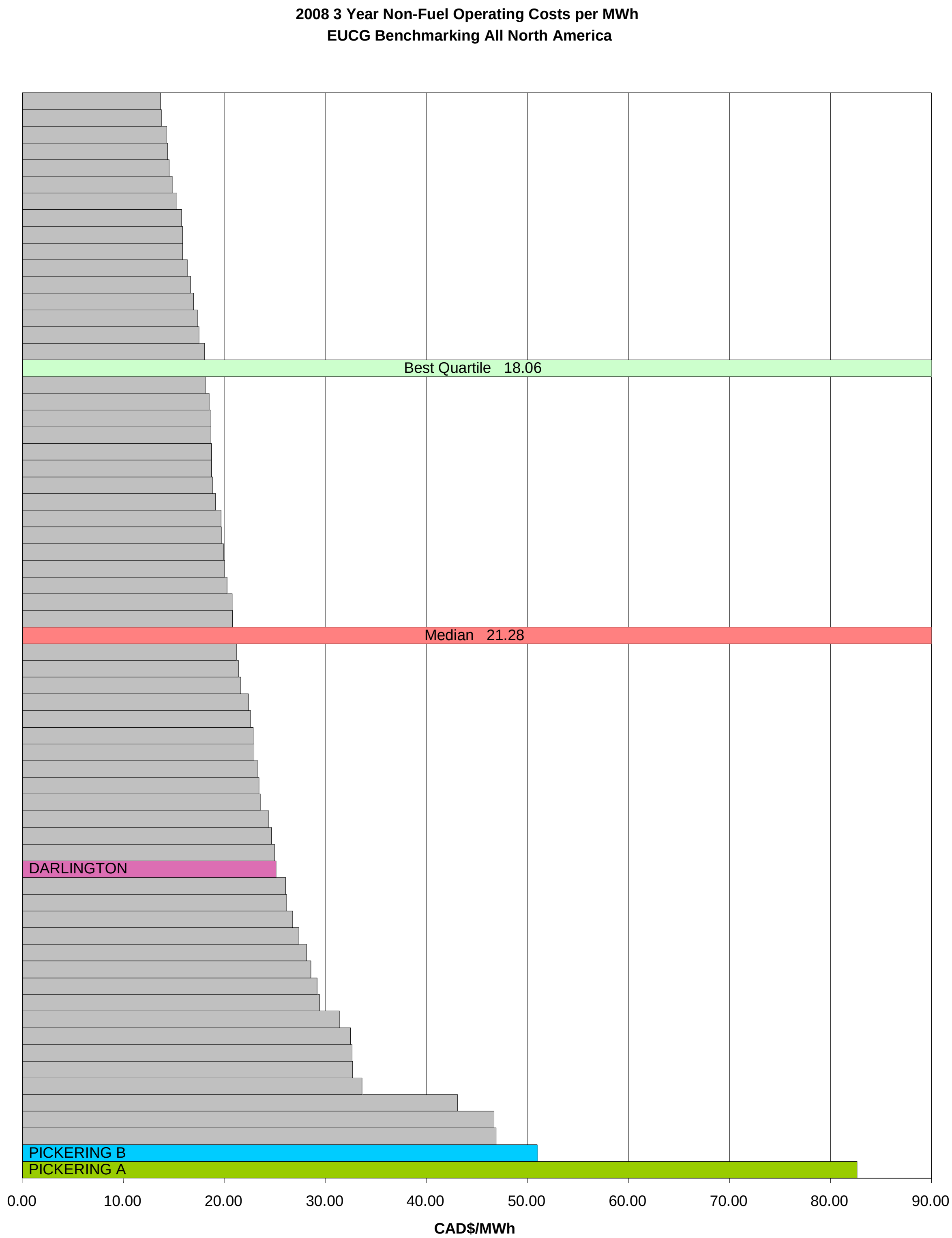
Pickering A

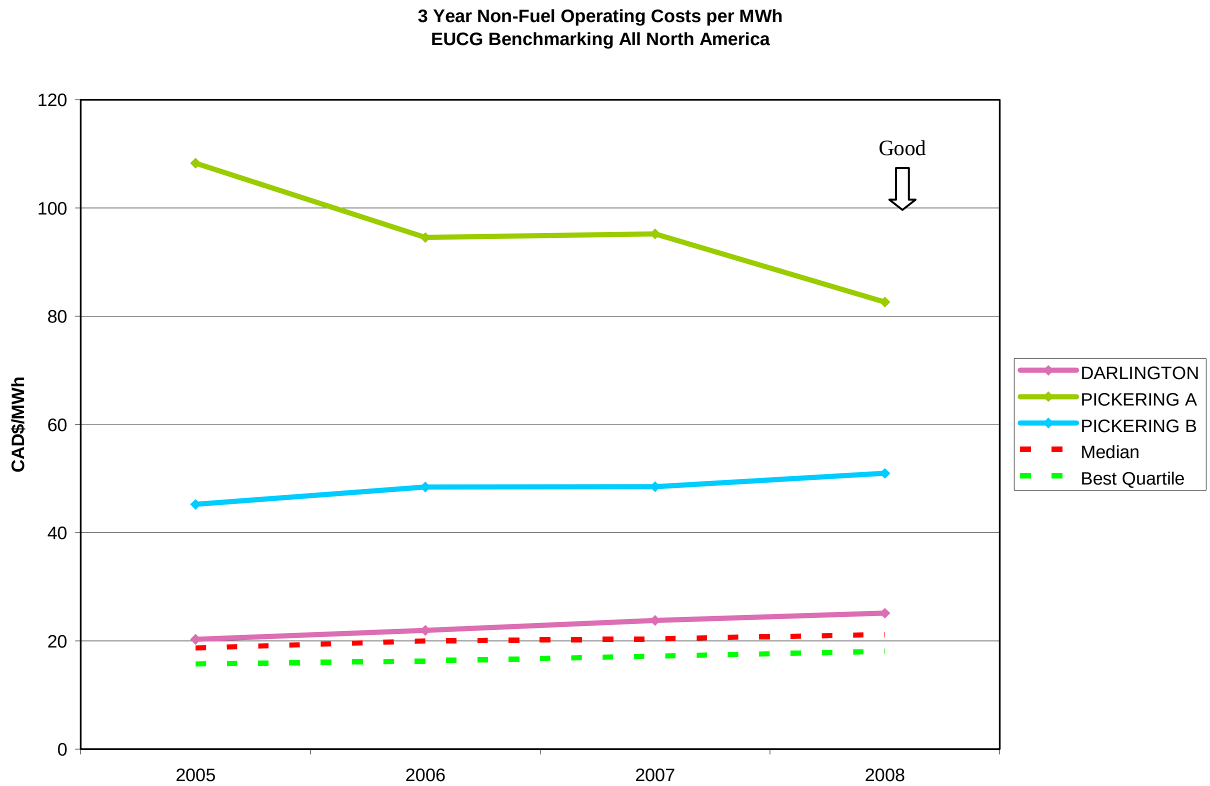
- As stated above, fuel cost per MWh and capital cost per MW DER performed within the best quartile for Pickering A while the non-fuel operating cost per MWh performed worse than median
- The overall largest driver of cost per MWh for Pickering A during the review period is capability factor
- Station size also negatively impacts cost per MWh for Pickering A (primarily driven by relatively small units)
- The remaining large drivers of cost performance at Pickering A include CANDU technology, corporate cost allocations, and potential controllable costs

Pickering B

- As stated above, fuel cost per MWh and capital cost per MW DER performed within the best quartile for Pickering B while the non-fuel operating cost per MWh performed worse than median
- Like Pickering A, the overall largest driver of cost per MWh for Pickering B over the review period is capability factor
- Station size also negatively impacts cost per MWh for Pickering (primarily driven by relatively small units)
- The remaining large drivers of cost performance at Pickering B include CANDU technology, corporate cost allocations, and potential controllable costs

3-Year Non-Fuel Operating Costs per MWh




3 Year Non-Fuel Operating Costs per MWh
EUCG Benchmarking All North America
CAD$/MWh
120
100
80
60
40
20
0
2005
2006
2007
2008
Good
DARLINGTON
PICKERING A
PICKERING B
Median
Best Quartile

Observations – 3-Year Non-Fuel Operating Costs per MWh (All North American)

2008 (3-Year Rolling Average)

- A total of 64 North American plants were included in this peer panel and four are CANDUs compared to 60 PWR or BWR plants
- Best quartile Plants had non-fuel operating costs of better than $18.06/MWh
- Median Plants were better than $21.28/MWh

- Darlington's costs, at $25.10/MWh, were $7.04/MWh higher than best quartile and $3.82/MWh higher than the median
- Pickering B, at $50.95/MWh, was $32.89/MWh higher than best quartile and $ 29.67/ MWh higher than median
- Pickering A, at $82.62/MWh, was $64.56/MWh above best quartile and $61.34/MWh higher than the median

Trend

- Both best quartile and median levels increased over the review period with annual percentages increases between 4% and 5% thus lowering the bar
- Darlington non-fuel operating costs per MWh trended upward at a rate of increase nearly double that of the industry as a whole thus lowering their overall standing on this metric
- Pickering A non-fuel operating costs per MWh showed a dramatic decrease since 2005 – a significant improvement
- Pickering B non-fuel operating costs per MWh rose slowly since 2005 and were approximately three times higher than best quartile for the North American EUCG panel

Factors Contributing to Performance

Darlington

- The major contributing factors for Darlington performance for non-fuel operating cost per MWh were reviewed within the total generating cost per MWh section
- The only additional contributing factor which appears within non-fuel operating cost is capitalization policy
- The impact of differing capitalization policies is removed when looking at total generating cost per MWh (i.e. the sum of non-fuel operating cost, fuel cost, and capital cost)

Pickering A

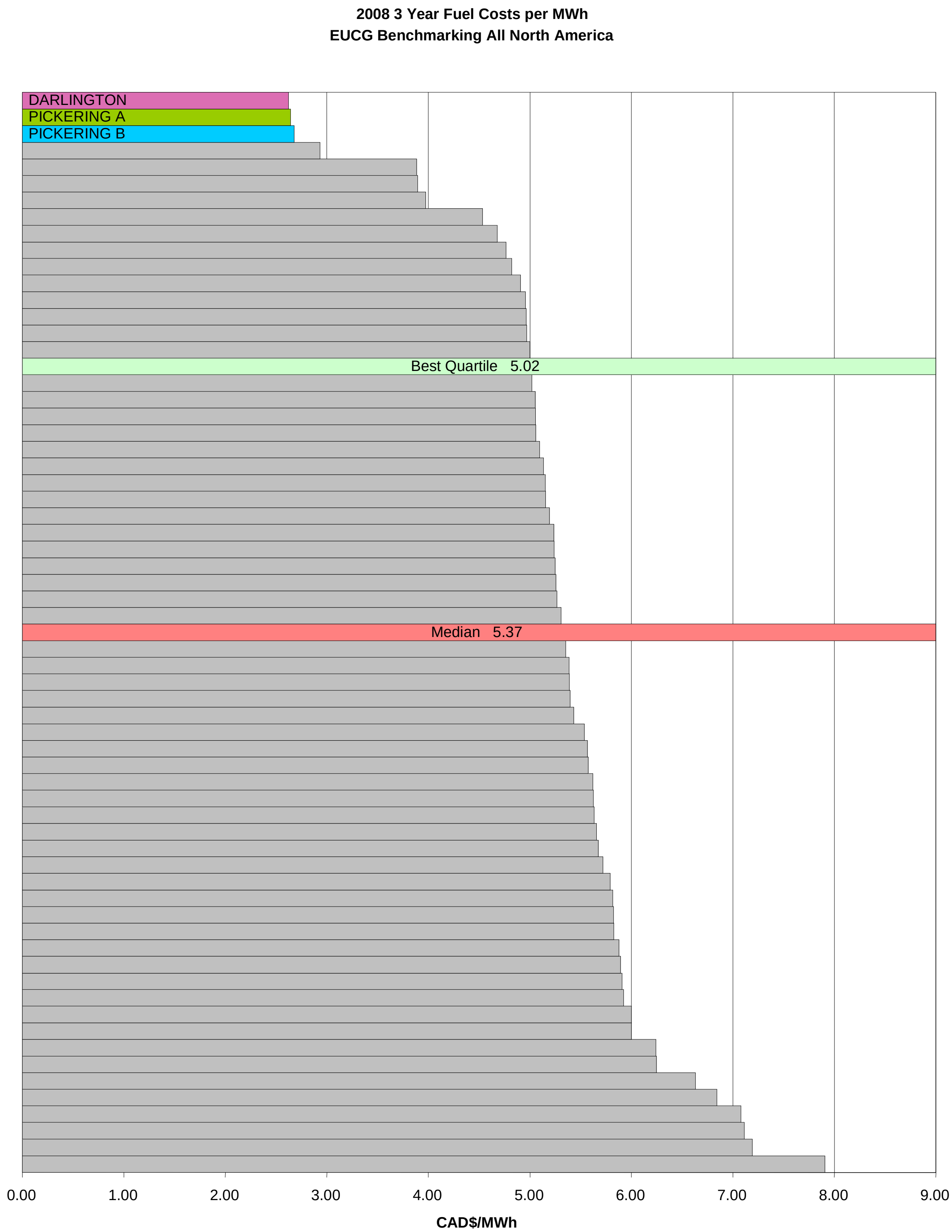
- The major contributing factors for Pickering A performance for non-fuel operating cost per MWh were reviewed within the total generating cost per MWh section
- The only additional contributing factor which appears within non-fuel operating cost is capitalization policy
- The impact of differing capitalization policies is removed when looking at total generating cost per MWh (i.e. the sum of non-fuel operating cost, fuel cost, and capital cost)

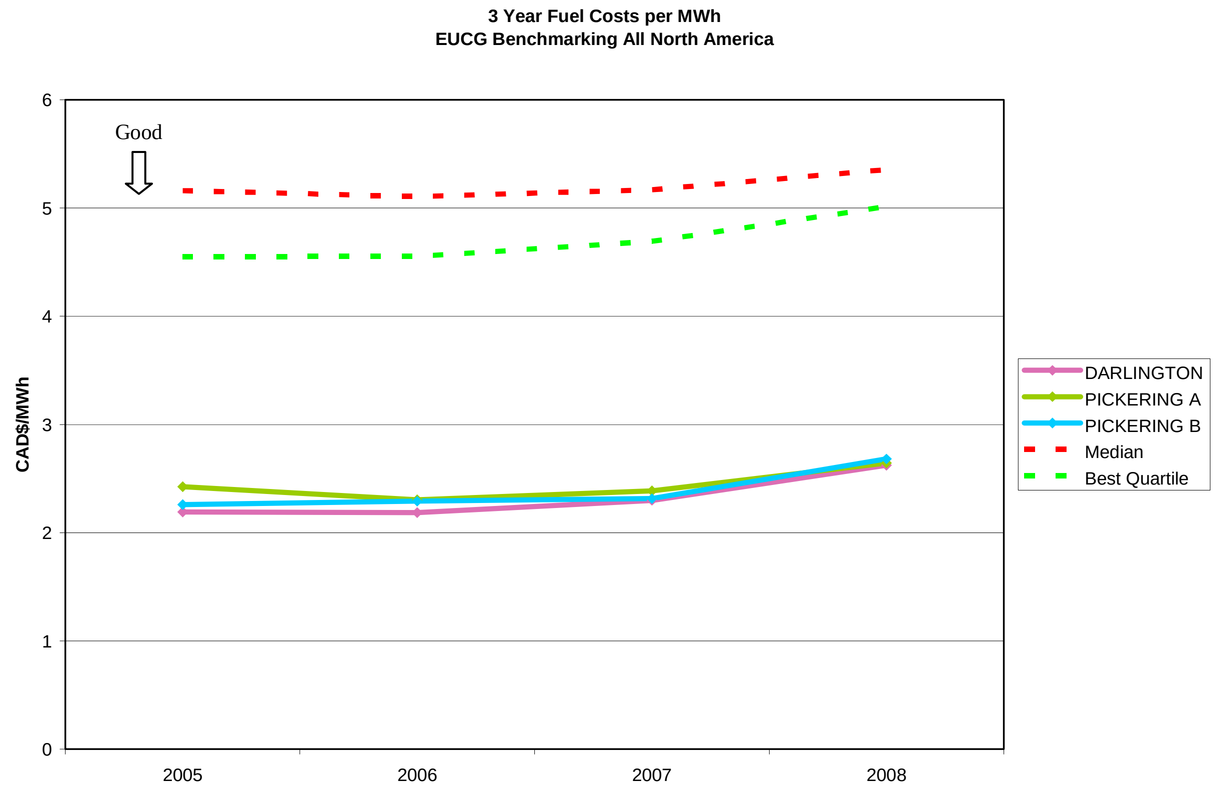
Factors Contributing to Performance – 3-Year Non-Fuel Operating Costs per MWh (Cont'd)

Pickering B

- The major contributing factors for Pickering B performance for non-fuel operating cost per MWh were reviewed within the total generating cost per MWh section
- The only additional contributing factor which appears within non-fuel operating cost is capitalization policy
- The impact of differing capitalization policies is removed when looking at total generating cost per MWh (i.e. the sum of non-fuel operating cost, fuel cost, and capital cost).

3-Year Fuel Costs per MWh




3 Year Fuel Costs per MWh
EUCG Benchmarking All North America
Good
CAD$/MWh
0
1
2
3
4
5
6
2005
2006
2007
2008
DARLINGTON
PICKERING A
PICKERING B
Median
Best Quartile

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

2008 (3-Year Rolling Average)

Trend

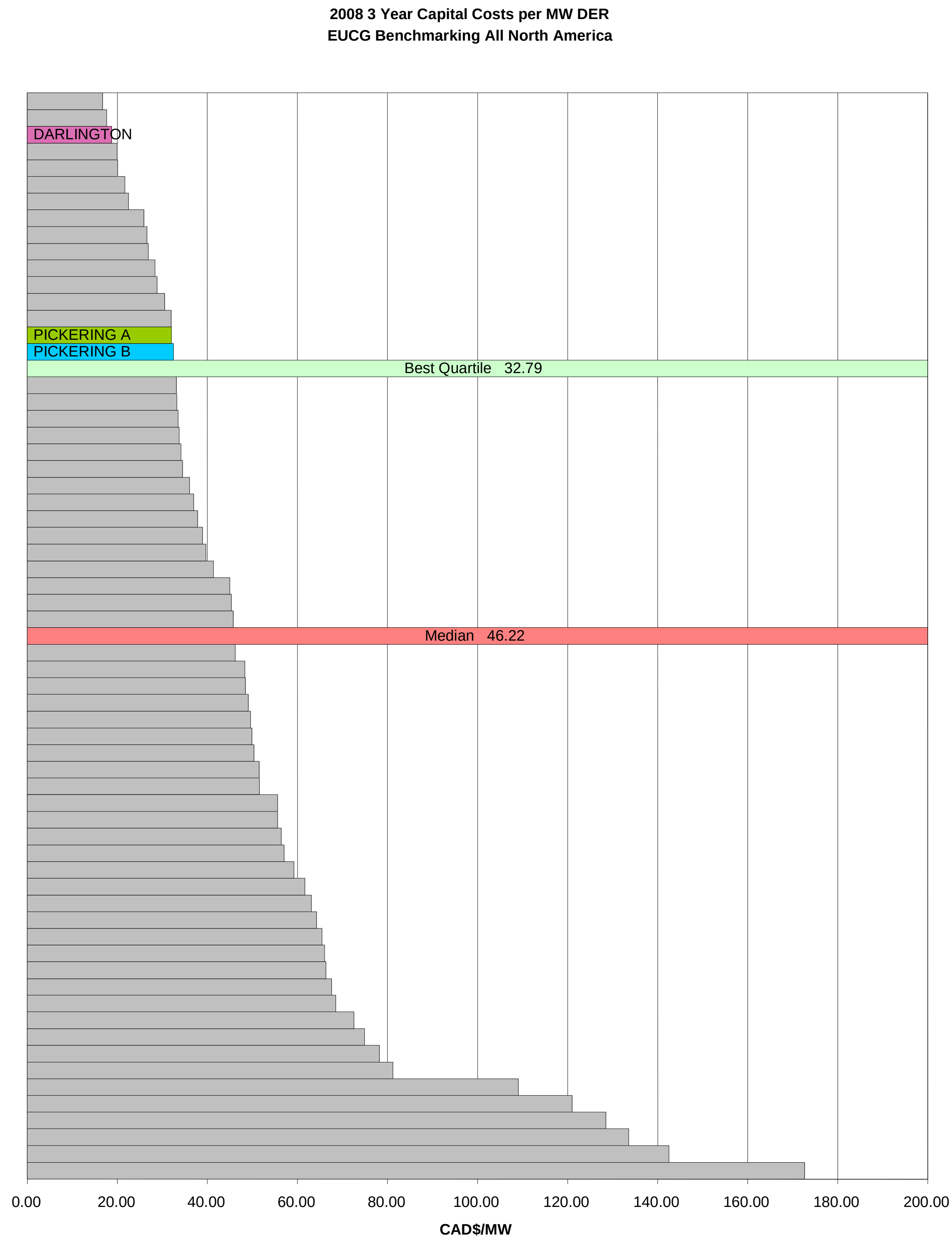
- The best quartile 3-year fuel costs per MWh have been slowing rising since 2005 with the greatest increase in 2008
- Since 2006 fuel costs per MWh for all three OPG plants have been rising with the greatest increase in 2008
- Fuel costs per MWh at the three OPG plants have been converging and currently are very similar to one another

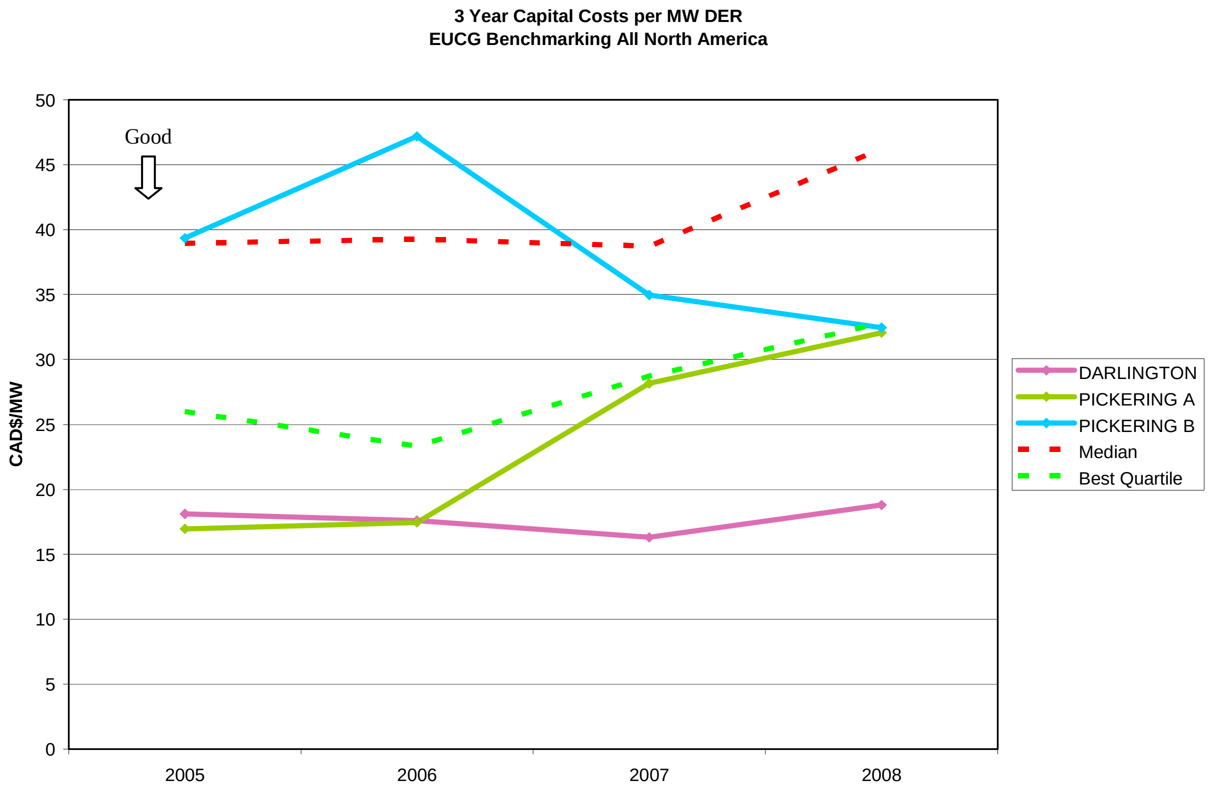
Factors Contributing to Performance

Best quartile fuel cost performance noted above is due to three significant factors:

- Uranium fuel costs: Raw uranium is processed directly into uranium dioxide to make fuel pellets, without the cost and process complexity of enriching the fuel as required in light water reactors. The advantage due to fuel costs also includes transportation, handling and shipping costs
- Reactor core efficiency: CANDU is the most efficient of all reactors in using uranium, requiring about 15% less uranium than a pressurized water reactor for each megawatt of electricity produced
- Fuel assembly manufacturing costs: Manufacturing costs for light water reactor fuel assemblies are significantly higher than CANDU fuel bundles, due to physical design complexity and increased amount of materials

3-Year Capital Costs per MW DER




3 Year Capital Costs per MW DER
EUCG Benchmarking All North America
Good
CAD$/MW
50
45
40
35
30
25
20
15
10
5
0
2005
2006
2007
2008
DARLINGTON
PICKERING A
PICKERING B
Median
Best Quartile

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

2008 (3-Year Rolling Average)

- Best quartile threshold for capital costs per MW DER across the North American EUCG peer panel plants was $32.79/MW DER
- Median cost for the panel was $46.22/MW DER
- Darlington had the third lowest capital costs/MW DER of any plant in the peer group
- Pickering A and B were both in the best quartile

Trend

- Best quartile capital costs per MW DER have increased since 2006
- Median levels for capital costs held steady from 2005 to 2007 and then escalated for 2008
- Darlington's capital cost per MW DER decreased moderately between 2005 and 2007 and escalated for 2008
- Pickering A's capital costs per MW DER rose from 2005 to 2008 but have maintained best quartile level
- Pickering B's capital costs per MW DER rose from 2005 to 2006 and have decreased through 2008

Factors Contributing to Performance

- Darlington, Pickering A, and Pickering B are all performing within the best quartile for the panel
- One contributing factor for OPG appears to be the capitalization threshold. The minimum expenditure threshold for capitalization at OPG for generating assets is $200k per unit whereas the majority of the companies in the industry have adopted minimum capitalization thresholds that are significantly lower
- A second contributing factor for OPG may be due in part to the application of the capitalization policy at OPG for purposes of classifying projects as capital or OM&A

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5.0 MAJOR OPERATOR SUMMARY

Purpose

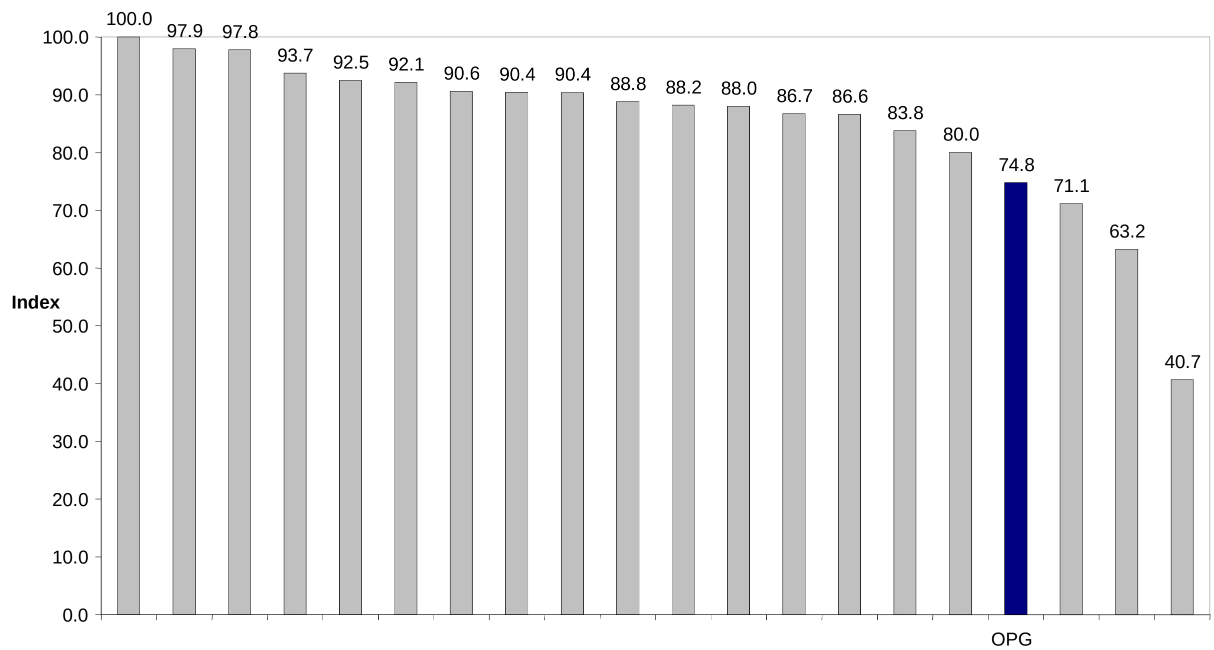
This section supplements the Executive Summary, providing more detailed comparison of the major operators of nuclear plants for three key metrics: WANO NPI, Unit Capacity Factor (UCF) and Total Generating Costs (TGC). Operator level summary results are the average (mean) of the results across all plants managed by the given operator. These comparisons provide additional context but all of the detail data in the previous sections provide the more complete picture of plant by plant performance. WANO NPI and UCF are calculated as the mean of all unit performance for a specific operator. TGC is the mean of plant level data because costs are not allocated to specific units within EUCG.

A table of plants and their operators for WANO NPI and for UCF is provided in Table 10 of the appendix and for TGC see Table 11 in the appendix.

WANO NPI Analysis

The WANO NPI results for the operators in 2008 are illustrated in the graph below. WANO method four was used for these calculations.

2008 WANO NPI for Major Operators*



*See Table 10 in the appendix for listing of operators and plants
**OPG unit values averaging to a WANO NPI of 74.8 in 2008 shown below:

Unit	2008 WANO NPI
Darlington 1	88.64
Darlington 2	98.90
Darlington 3	100.00
Darlington 4	95.13
Pickering A1	62.74
Pickering A4	58.95
Pickering B5	67.37
Pickering B6	64.31
Pickering B7	55.57
Pickering B8	56.45

In 2008, led all the operators in this data set with an NPI of 100. OPG ranked 17th, with an NPI of 74.8. Darlington performed significantly better overall than Pickering A and Pickering B, achieving best quartile for most of the review period. Refer to Section 3 for further information.

The NPI rankings of the major operators from 2006 to 2008 are listed in Table 5.

Table 5: Average WANO NPI Rankings

	2006	2007	2008
	9	8	1
	4	5	2
	2	1	3
	7	3	4
	19	17	5
	12	13	6
	5	9	7
	3	4	8
	6	10	9
	11	6	10
	8	11	11
	10	7	12
	1	2	13
	13	12	14
	14	14	15
	15	15	16
OPG	17	16	17
	20	19	18
	16	20	19
	18	18	20

Table 6 below provides a comparison of the ten sub-indicators that comprise the WANO NPI index.

Table 6: WANO Performance Indicator Results Summary (Operator Level)

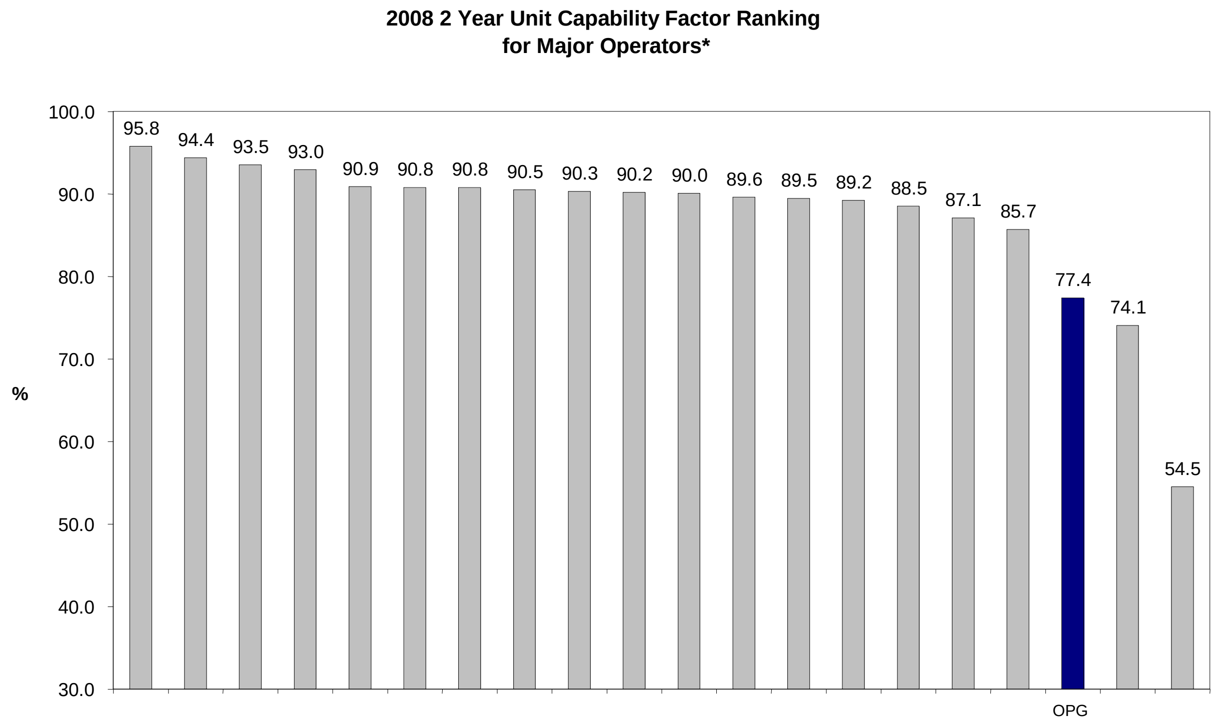
		All North American PWR and PHWRs (WANO)		All COG CANDUs (WANO)		
	OPG Average	Median	Best Quartile	Median	Best Quartile	Units
Safety						
2-Year Industrial Safety Accident Rate	0.07	0.12	0.07	-	-	# per 200,000 man-hours worked
Fuel Reliability	8.51E-04	5.63E-05	1.94E-05	5.63E-05	1.00E-06	Microcuries per gram
2-Year Reactor Trip Rate	0.38	0.32	0.18	0.38	0.21	# per 7,000 hours critical
3-Year Auxiliary Feedwater System Unavailability	0.0047	0.0044	0.0035	0.0020	0.0010	Unavailability/Required Availability
3-Year Emergency AC Power Unavailability	0.0061	0.0132	0.0105	0.0062	0.0040	Unavailability/Required Availability
3-Year High Pressure Safety Injection Unavailability	0.0003	0.0048	0.0027	0.0003	0.0000	Unavailability/Required Availability
2-Year Collective Radiation Exposure	76.30	71.97	57.64	76.30	51.78	man-rem per Unit
Reliability						
WANO NPI	74.81	88.50	92.20	71.12	86.28	Index
2-Year Forced Loss Rate	15.23	2.07	1.46	3.86	0.64	%
2-Year Unit Capability Factor	77.38	90.04	90.77	85.68	91.27	%
2-Year Chemistry Performance Indicator	1.13	1.01	1.01	1.01	1.00	Indicator

Note: This table contains the average of all unit results per operator

Unit Capability Factor (UCF) Analysis

Unit Capability Factor is the ratio of available energy generation over a give time period to the reference energy generation of the same time period. Reference energy generation is the energy that could be produced if the unit were operating continuously at full power under normal conditions. Since nuclear generation plants are large fixed assets, the extent to which these assets generate reliable power is the key to both their operating and financial performance. For this reason, we examine this NPI indicator more closely below.

A comparison of UCF values for major nuclear operators is presented in the graph below. UCF is expressed as a two-year average. OPG achieved a two-year average unit capacity factor of 77.4% and ranked 18 out of 20 major operators in the WANO data set. The range of values reported for these operators, however, varies greatly.



*OPG unit values averaging to a 2 Year UCF in 2008 of 77.4 shown below:

Unit	2008 2-Year UCF
Darlington 1	89.50
Darlington 2	91.12
Darlington 3	97.35
Darlington 4	89.97
Pickering A1	50.65
Pickering A4	62.55
Pickering B5	74.20
Pickering B6	83.73
Pickering B7	58.22
Pickering B8	76.54

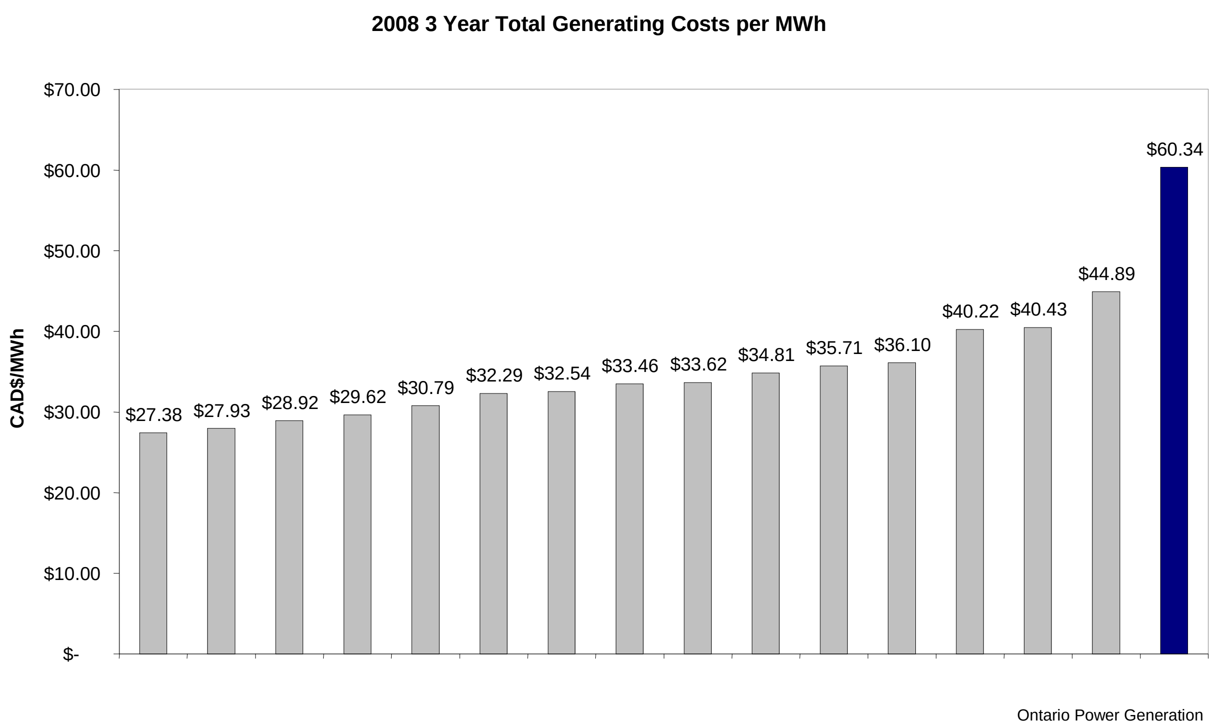
Based on reviewing individual unit results, Darlington performed the best overall, followed by Pickering A and then Pickering B. Rankings for the major operators for UCF over the past four years are provided in Table 7 below.

Table 7: Two-Year Unit Capability Factor Rankings

Operator	2005	2006	2007	2008
	1	2	4	1
	2	1	2	2
	6	10	9	3
	4	5	3	4
	13	19	19	5
	12	8	11	6
	10	9	6	7
	5	4	5	8
	3	20	17	9
	15	3	1	10
	8	12	12	11
	7	6	8	12
	9	7	10	13
	14	13	7	14
	17	14	13	15
	11	17	14	16
	19	16	15	17
OPG	20	18	20	18
	16	15	18	19
	18	11	16	20

Total Generating Costs/MWh Analysis

The 3-year total generating costs results for the major operators in 2008 are displayed in the graph below. Total generating costs are defined as total operating costs plus capital costs. This value is divided by the total net generation for the year and provided as a three-year average. The top performer for 2008 was OPG ranked 16th, with a 3-year total generation cost of $60.34 per MWh.



*OPG plant values averaging to 3 Year TGC of $60.34/MWh shown below:

Unit	2008 3 Year TGC
Darlington	$30.08/MWh
Pickering A	$92.27/MWh
Pickering B	$58.68/MWh

Table 8: Three-Year Total Generating Costs per MWh Rankings

	2005	2006	2007	2008
	1	1	1	1
	4	4	2	2
	6	5	3	3
	3	2	4	4
	2	3	5	5
	15	14	11	6
	13	7	6	7
	5	6	7	8
	8	8	8	9
	9	11	10	10
	10	10	9	11
	11	9	12	12
	7	12	13	13
	12	13	14	14
	14	15	15	15
Ontario Power Generation	16	16	16	16

Total Generating Cost is comprised of: (a) Non-Fuel Operating Costs, plus (b) Fuel Costs, plus (c) Capital Costs. Table 9 below shows the relative contribution of these cost components to Total Generating Cost and compares OPG's costs to those of all EUCG operators. As stated in Section 4, OPG's advantages in Fuel Costs and Capital Costs is offset by relatively poor financial performance at all three OPG facilities with respect to Non-Fuel Operating Cost. Low fuel costs are attributable to the use of CANDU technology while low capital costs may reflect OPG's policies regarding capitalization. Additionally, by reviewing individual plant results, Darlington performed by far the best overall, followed by Pickering B and then by Pickering A.

Table 9: EUCG Indicator Results Summary (Operator Level)

EUCG Indicator Results Summary	OPG Average	All EUCG Operators*		Units
		Median	Best Quartile	
Value for Money Performance				
3-Yr. Non-Fuel Operating Costs per MWh	$ 52.89	$ 21.09	$ 19.82	CAD$/MWh
3-Yr. Fuel Costs per MWh	$ 2.65	$ 5.40	$ 5.02	CAD$/MWh
3-Yr. Capital Costs per MW DER	$ 27.76	$ 49.63	$ 42.76	CAD$/MW
3-Yr. Total Generating Costs per MWh	$ 60.34	$ 33.54	$ 30.50	CAD$/MWh

*See Table 11 in the appendix for list of operators included
Note: This summary contains the average of all plant results per operator

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6.0 APPENDIX

Acronyms

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

Safety and Reliability Definitions

The following definitions are summaries extracted from the *November 2003 WANO PERFORMANCE INDICATOR PROGRAMME REFERENCE MANUAL.*

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

- PWRs with recirculating steam generators and VVERs
  - Steam generator blowdown chloride
  - Steam generator blowdown cation conductivity (only applicable to vver and pwrs with i-800 sg tubes)
  - Steam generator blowdown sulfate
  - Steam generator blowdown sodium
  - Final feedwater iron

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

- PWRs with once through steam generators
  - Final feedwater chloride
  - Final feedwater sulfate
  - Final feedwater sodium
  - Final feedwater iron
  - Final feedwater copper

- Pressurized heavy water reactors (PHWRs)
  - *Inconel-600 or Monel tubes
    - Steam generator blowdown chloride
    - Steam generator blowdown sulfate
    - Steam generator blowdown sodium
    - Final feedwater iron
    - Final feedwater copper
    - Final feedwater dissolved oxygen

  - Incoloy-800 tubes
    - Steam generator blowdown chloride
    - Steam generator blowdown sulfate
    - Steam generator blowdown sodium
    - Final feedwater iron
    - Final feedwater dissolved oxygen

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

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

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

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

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

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

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

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

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

Fuel reliability is inferred from fission product activities present in the reactor coolant. Due to design differences, this indicator is calculated differently for different reactor types. 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.

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

Plant capacity factor is defined as the ratio of the net electricity generated, for the time considered, to the energy that could have been generated at continuous full-power operation during the same period. (Note: this is a generic definition as no definition was provided by EUCG).

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

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

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

The safety systems monitored by this indicator are the following:

PHWRs

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

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

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

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

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

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

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

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

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

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

The following definitions are taken from the AP-928 Rev 2 issued November 2007.

Corrective maintenance is any work on a **power block** system, structure, or component (SSC) that has failed or is significantly degraded such that failure is imminent (within its operating cycle/preventive maintenance interval) and the SSC no longer conforms to or perform its design function. An SSC should be considered failed or significantly degraded if the deficiency is similar to any of the following:

- Is removed from service because of actual or incipient failure

- Significant component degradation that affects system operability – The SSC may be determined operable by engineering assessment, but the degradation is significant and requires immediate corrective action. This normally includes any deficiency that requires a basis for continued operation as defined in NRC Regulatory Issue Summary (RIS) 2005-20, *NRC Inspection Manual*, Part 9900, Technical Guidance.
- Creates the potential for rapidly increasing component degradation (for example, borated water leaks, steam leaks where cutting degradation is possible)
- Releases fluids that create significant exposure or contamination concerns (or has the potential to under postulated accident conditions) – Minor leaks that can be controlled and managed by simple drip catch containments would not be included here
- Adversely affects controls or process indications that impair operator ability to operate the plant or that reduce the redundancy of important equipment
- Significant component degradation identified from the conduct of predictive, periodic, or preventive maintenance which, if not resolved, could result in equipment failure or significant additional damage prior to its next scheduled preventive maintenance period

Elective maintenance is any work on **power block equipment** for which identified potential or actual degradation is minor and does not threaten the component's design function or performance criteria. This category of maintenance is intended to be performed in the future, but the nature of the degradation is such that scheduling flexibility exists. Examples are as follows:

- Minor leaks that are simply controlled and that do not justify immediate action to repair
- Minor degradation, identified by predictive, periodic, or planned preventive maintenance activities, that warrants attention to maintain the long-term reliability of the equipment but that is not expected to result in failure prior to its next scheduled preventive maintenance period
- Other minor plant equipment deficiencies that do not impede plant operation, nuclear or plant reliability, or operator ability to properly respond to normal, off-normal, or accident transients or conditions. Examples are as follows:
  - Damaged or broken local indication gauges that are informational only and that are not required for operator control of systems for normal or emergency response
  - Indications of internal valve leakage that do not hinder system operation or the ability to provide maintenance isolation

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

Power block equipment includes all SSCs required for the safe and reliable operation of the station. It will include all safety-related and balance-of-plant systems and components required for operation, including radioactive waste processing and storage and switchyard equipment maintained by the station. Systems, structures, or components required to maintain federal or state regulatory compliance should be included in this grouping. It will not include buildings or structures that support station staff, such as offices or storage structures, or the HVAC and support systems focused only on habitability of those structures. This distinction may vary among stations.

Value for Money Definitions

The following definition summaries are taken from the *January 2006 EUCG Nuclear Committee Nuclear Database Instructions*.

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

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

Generation (Gigawatt Hours)
Per NRC monthly operating report definition for net electrical energy: The gross electrical output of the unit measured at the output terminals of the turbine-generator minus the normal station service loads during the gross hours of the reporting period, expressed in Gigawatt hours (GWh). Negative quantities should not be used.

Design Electrical Rating (DER)
Per Energy Information Administration, the definition for design electrical rating: The nominal net electrical output of a unit, specified by the utility and used for plant design.

Operating Costs ($)
The data provided should reflect the full cost for operating and maintaining the nuclear plant. This should include all costs from the senior nuclear corporate officer down. These costs should reflect the share of payroll taxes & benefits and corporate administrative & general costs applicable to the nuclear plant. Costs that would be applicable if the plant were considered a business unit should be included.

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

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

Note: Capital costs, fuel costs, operating costs and total generating costs are divided by net generation as above to obtain per MWh results. Non-fuel operating costs and capital costs are also divided by MW DER to obtain MW results.

Table 10: WANO Panel

Operator	Plant	Operator	Plant
Bruce Power	BRUCE NUCLEAR A BRUCE NUCLEAR B	STARS	CALLAWAY COMANCHE PEAK DIABLO CANYON PALO VERDE SOUTH TEXAS
Constellation	CALVERT CLIFFS GINNA	TVA	WATTS BAR
Dominion	KEWAUNEE MILLSTONE NORTH ANNA SURRY	USA	COOK FORT CALHOUN
Duke Power	CATAWBA MCGUIRE OCONEE		
Entergy	ANO INDIAN POINT WATERFORD		
Exelon	BRAIDWOOD BYRON THREE MILE ISLAND		
FirstEnergy	BEAVER VALLEY DAVIS-BESSE		
FPL	POINT BEACH SEABROOK ST. LUCIE TURKEY POINT		
Hydro Quebec	GENTILLY		
Independents	SAN ONOFRE SEQUOYAH SUMMER WOLF CREEK		
Int'l CANDU	CERNAVODA EMBALSE QINSHAN 3 WOLSONG A WOLSONG B		
NB Power	POINT LEPREAU		
NMC	PALISADES PRAIRIE ISLAND		
OPG	DARLINGTON PICKERING A PICKERING B		
Progress Energy	CRYSTAL RIVER HARRIS ROBINSON		
PSEG	SALEM UNIT		
Southern Energy	FARLEY VOGTLE		

Table 11: EUCG Panel

Operator	Plant	Operator	Plant
Bruce	BRUCE	STARS	CALLAWAY
Constellation	CALVERT CLIFFS		COMANCHE PEAK
	NINE MILE		DIABLO CANYON
	R.E. GINNA		PALO VERDE
Dominion Resources	KEWAUNEE		SOUTH TEXAS
	MILLSTONE	TVA	BROWNS FERRY
	NORTH ANNA		SEQUOYAH
	SURRY		WATTS BAR
Duke	CATAWBA	USA	COLUMBIA
	MCGUIRE		COOK
	OCONEE		COOPER
Entergy	ARKANSAS ONE		FERMI
	FITZPATRICK		FORT CALHOUN
	GRAND GULF		SAN ONOFRE
	PALISADES		SUSQUEHANNA
	PILGRIM		WOLF CREEK
	RIVER BEND	Xcel	MONTICELLO
	VERMONT YANK		PRAIRIE ISLAND
	WATERFORD		
Exelon	BRAIDWOOD		
	BYRON		
	CLINTON		
	DRESDEN		
	LASALLE		
	LIMERICK		
	OYSTER CREEK		
	PEACH BOTTOM		
	QUAD CITIES		
	THREE MILE ISLAND		
First Energy	BEAVER VALLEY		
	DAVIS-BESSE		
	PERRY		
OPG	DARLINGTON		
	PICKERING A		
	PICKERING B		
Progress Energy	BRUNSWICK		
	CRYSTAL RIVER		
	HARRIS		
	ROBINSON		
PSEG	HOPE CREEK		
	SALEM		
SC Power and Gas	SUMMER		
Southern	FARLEY		
	HATCH		
	VOGTLE		

Table 12: COG CANDUs

Operator	Plant
Bruce Power	BRUCE NUCLEAR A BRUCE NUCLEAR B
China	QINSHAN 3
CNEA	EMBALSE
Hydro Quebec	GENTILLY
Korea	WOLSONG A WOLSONG B
NB Power	POINT LEPREAU
OPG	DARLINGTON PICKERING A PICKERING B
Romania	CERNAVODA

Table 13: CEA Members

Companies
AltaLink
ATCO Electric
ATCO Power
BC Hydro
Brookfield Renewable Power
ENMAX
EPCOR
FortisAlberta
FortisBC
Horizon Utilities Corp
Hydro One
Hydro Ottawa
HydroQuebec Distribution
Hydro Quebec TransEnergie
Manitoba Hydro
New Brunswick Power
Newfoundland Power
Nova Scotia Power
OPG
SaskPower
The Hydro Group (Newfoundland)
Toronto Hydro
TransAlta

WANO NPI Calculations

In the benchmarking report, the NPI index is calculated using the method four based on WANO data according to the following guidelines published by WANO. The "new" method is also referred to as "method four."

Table 14. WANO NPI Calculations

Indicator	Previous Ranges and Weights			**New Ranges and Weights**			Time Period (Months)
	Range Minimum	Range Maximum	Weight	**Range Minimum**	**Range Maximum**	**Weight**	
Unit Capability Factor	80	92	15	**80**	**92**	**15**	18 or 24*
Forced Loss Rate	8	1	15	**8**	**1**	**15**	18 or 24*
Unplanned Automatic Scrams	1.5	0.5	10	**1.5**	**0.5**	**10**	24
Safety System Unavailability (%)							
BWR High Pressure Injection	3	2	10	**3**	**2**	**10**	36
BWR Residual Heat Removal	3	2	10	**3**	**2**	**10**	36
PWR High Pressure Injection	3	2	10	**3**	**2**	**10**	36
PWR Auxiliary Feedwater	3	2	10	**3**	**2**	**10**	36
Emergency AC Power	3.5	2.5	10	**3.5**	**2.5**	**10**	36
Fuel Reliability (BWR)	3000	300	10	**3000**	**300**	**10**	3
Fuel Reliability (PWR)	5×10^{-3}	5×10^{-4}	10	$\mathbf{5 \times 10^{-3}}$	$\mathbf{5 \times 10^{-4}}$	**10**	3
Chemistry Performance	1.2	1.01	5	**1.2**	**1.01**	**5**	18 or 24*
Collective Radiation Exposure (BWR)	220	120	10	**220**	**120**	**10**	18 or 24*
Collective Radiation Exposure (PHWR)	120	60	10	**140**	**80**	**10**	18 or 24*
Collective Radiation Exposure (PWR)	120	60	10	**120**	**60**	**10**	18 or 24*
Industrial Safety Accident Rate	1.0	0.2	5	**1.0**	**0.2**	**5**	18 or 24*
	Total		100	**Total**		**100**	

*PHWR units will use 24 month time period

Note: Beginning in 2009, Darlington will use a 3-year NPI cycle.