2019 Nuclear Staffing Benchmarking Analysis

Final Report

ONTARIO POWER GENERATION

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GOODNIGHT CONSULTING

Final Report – January 21, 2020

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- Executive Summary

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Executive Summary: OPG Is Now Below The Benchmark, A Consistent Improvement Since 2011

- OPG asked Goodnight Consulting to compare OPG Nuclear staffing to other North American nuclear operators through an approach consistent with the one we used in 2011, 2013 and 2014.

- Our current analysis shows that OPG, as of August 2019, is 239 FTEs (4.5%) *below* the total North America nuclear operator benchmark of 5,255 FTEs. The North American benchmarks have increased slightly since 2014 due to aging plants and a less-experienced workforce which required additional staff.

- We benchmarked 5,016 OPG Nuclear staff and long-term contractors; 2,404 OPG Nuclear personnel were excluded from benchmarking consistent with the methodology applied in prior studies.

- OPG is above benchmark staffing in 14 job functions, and below benchmark staffing in 28 functions.

- 13 functions have been recommended to OPG for detailed review.

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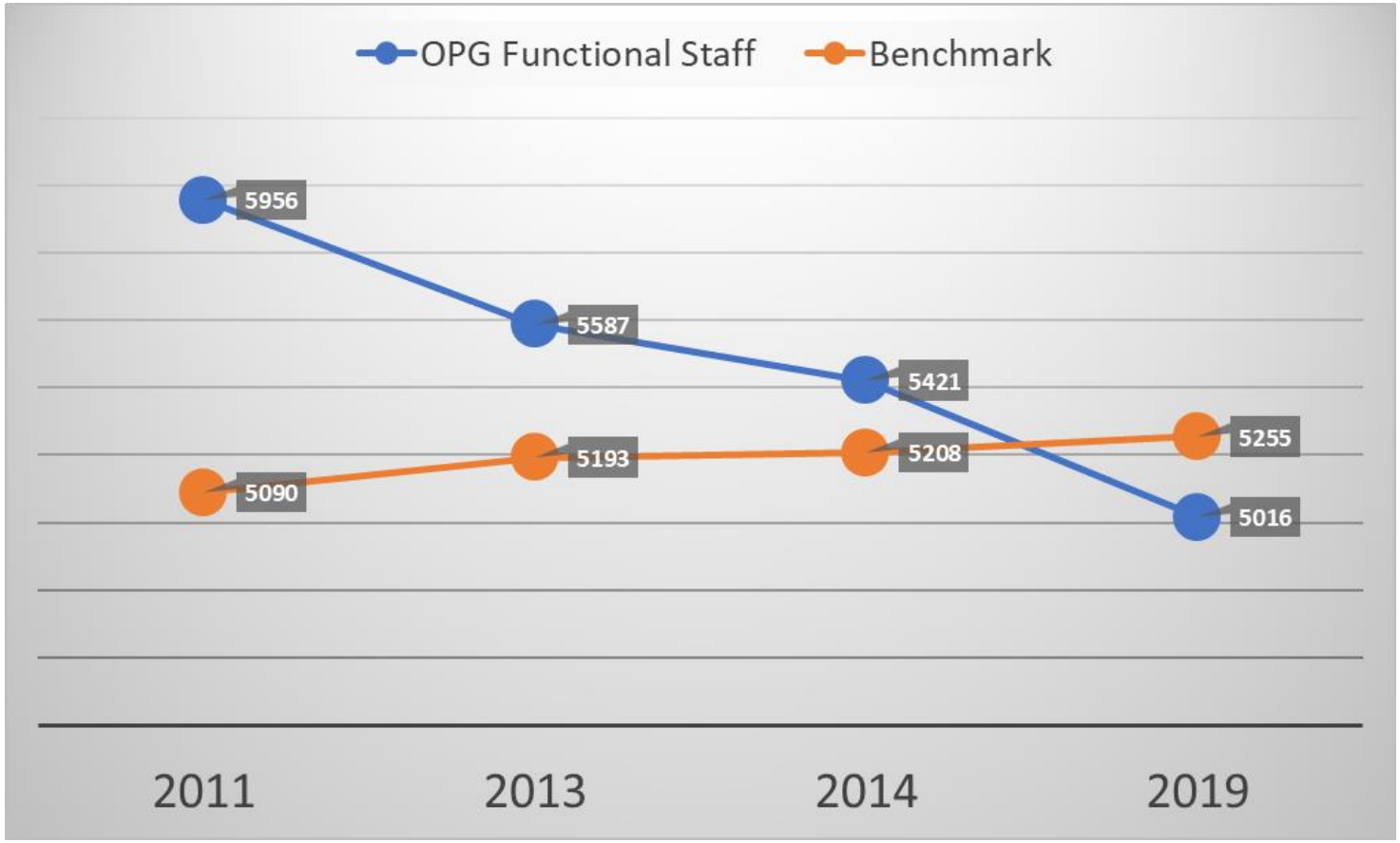
Attrition, OPG Staff Management, & Increases At Benchmark Plants Brought OPG Below The Benchmark



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We Identified 13 Functions That Have The Largest Functional Variances From The Benchmarks

Each of these functional areas should be further reviewed by OPG for workforce planning, process improvement, and / or organizational improvement opportunities

Facilities	208
Maintenance - Support	98
Operations Support	85
Fire Department	77
Human Resources	75
Project Management	71
Maintenance - Mechanical	59
Design/Drafting	-54
Maintenance Planning	-72
Engineering-Plant	-75
Engineering-Technical	-110
RP Applied	-114
Operations	-163

Note that these functions are not offsetting

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

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

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

Exclude personnel whom we are ***unable to benchmark per benchmarking methodology***

Identify ***contractors*** *and include those* who provide baseline support

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

*Full-Time Equivalents

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

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

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42 Unique Job Functions Were Used To Benchmark OPG Nuclear Staffing[1]

Function	Process Area
Budget/Accounting	Administrative Services
Communications	Administrative Services
Document Control/Records Mgmt.	Administrative Services
Fire Department	Below the Line
Management Support	Below the Line
Design/Drafting	Configuration Management
Engineering - Mods	Configuration Management
Nuclear Fuels	Configuration Management
Engineering - Computer	Equipment Reliability
Engineering - Plant	Equipment Reliability
Engineering - Reactor	Equipment Reliability
Engineering - Technical	Equipment Reliability
QC/NDE	Equipment Reliability
Emergency Preparedness	Loss Prevention
Licensing/Regulatory Affairs	Loss Prevention
QA	Loss Prevention
Safety Programs	Loss Prevention
Chemistry	Operate the Plant
Environmental	Operate the Plant
Operations	Operate the Plant
Operations Pipeline	Operate the Plant
Operations Support	Operate the Plant

Function	Process Area
Admin	Personnel Services
Human Resources	Personnel Services
Management	Personnel Services
Training	Personnel Services
Facilities	Plant Maintenance
Maintenance - Construction	Plant Maintenance
Maintenance - Electrical/I&C	Plant Maintenance
Maintenance - Mechanical	Plant Maintenance
Maintenance - Support	Plant Maintenance
Decon/Radwaste	Radiation Protection
RP Applied	Radiation Protection
RP Support	Radiation Protection
Security Support	Security
Contracts/Purchasing	Supply Chain
Engineering - Procurement	Supply Chain
Warehouse	Supply Chain
Maintenance Planning	Work Management
Outage Planning/Scheduling	Work Management
Project Management	Work Management
Scheduling	Work Management

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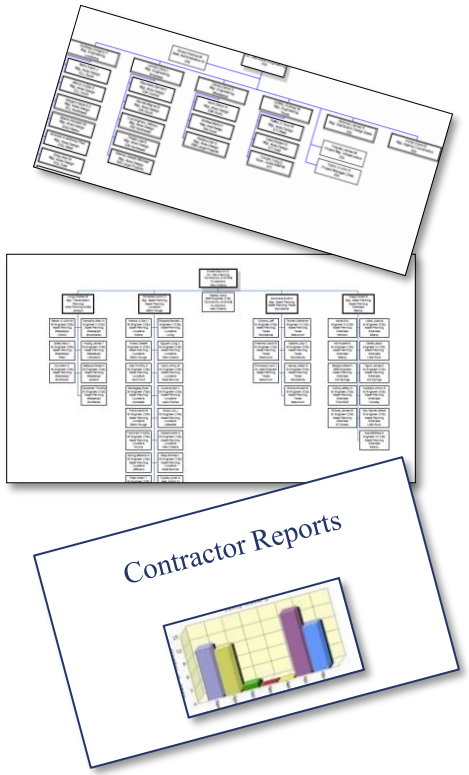
[1] *The Security Operations function was excluded to be consistent with OPG policy and Information Mgmt. was Benchmarked via a different method external to this study*

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

OPG Staffing & Contractor Data



Goodnight Staffing Functions

- Safety Programs
- Operations
- Maintenance - Mech
- Emergency Prep
- Rad Pro Applied
- Others . . .

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5,016 OPG Employees & Contractors Were Functionalized For Benchmarking

Process Area Summary	Regular	Term	Total Regular HC	Non-Regular	Augmented Staff	Oncore Hourly	Other Purchased Services	Total Contractor FTEs	Total OPG FTEs	2019 Goodnight Benchmark	Variance	%
Administrative Services	98		98	7				7	105	129	(24)	-19%
Configuration Management	182		182	2	4	4	13	23	205	337	(132)	-39%
Equipment Reliability	398	2	400	28	7		26	61	461	590	(129)	-22%
Loss Prevention	139		139	2	5	16	14	37	176	201	(25)	-12%
Operate The Plant	854	156	1,010	8	3		10	21	1,031	1,073	(42)	-4%
Personnel Services	580	27	607	40	24	11	3	78	685	600	85	14%
Plant Maintenance	928	149	1,077	260		114	19	393	1,470	1,225	245	20%
Radiation Protection	122	4	126	12			20	32	158	287	(129)	-45%
Security*	31		31	2	1		3	6	37	97	(60)	-62%
Supply Chain	177		177	6	1	1	1	9	186	235	(49)	-21%
Work Management	346	7	353	16	11	9	3	39	392	417	(25)	-6%
Below the Line	93	11	104	1	5			6	110	64	46	72%
Benchmarked Total	**3,948**	**356**	**4,304**	**384**	**61**	**155**	**112**	**712**	**5,016**	**5,255**	**(239)**	**-4.5%**

*Security Support is now benchmarked as subset of Security; Security Operations protected information continues to be excluded from the study

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

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

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

Data Provided

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

Spend Converted to FTEs

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

Hours Converted to FTEs

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

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

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Applicable OPG Baseline Contractors Equates To 712 FTEs In 37 Job Functions

37 job functions where OPG contractor FTEs were identified

Function	Total Contractor FTEs
Admin	30
Budget/Accounting	3
Chemistry	13
Communications	2
Contracts/Purchasing	5
Decon/Radwaste	25
Document Control/Records Mgmt.	2
Emergency Preparedness	5
Engineering-Computer	10
Engineering-Mods	22
Engineering-Plant	35
Engineering-Procurement	1
Engineering-Reactor	9
Engineering-Technical	4
Environmental	4
Facilities	137
Human Resources	8
Licensing/Regulatory Affairs	1
Maintenance - Construction	8
Maintenance-Electrical/I&C	51
Maintenance - Mechanical	77
Maintenance - Support	120
Maintenance Planning	6
Management	3
Management Support	6
Nuclear Fuels	1
Operations Support	4
Outage Management	3
Project Management	27
QA	4
QC/NDE	3
RP Support	7
Safety Programs	27
Security Support	6
Scheduling	3
Training	37
Warehouse	3
Total	**712**

Number of OPG contractor FTEs identified in each function (712 total)

Contractor FTEs have increased from 531 FTEs included in the previous study to offset Regular staff attrition and achieve OPG's strategic objectives, aligned with labour relations agreements.

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CANDU-Specific Activities Were Not Benchmarked As Part Of This Study To Facilitate Comparison with Peers

- We contacted all of the other operating CANDU NPPs around the world requesting CANDU-specific data for benchmarking:
  - Argentina: NA-SA/Embalse
  - Canada: Bruce Power/Bruce, NB Power/Point LePreau
  - China: CNNC/Quinshan
  - Romania: SNN/Cernavoda
  - South Korea: KHNP/Wolseong
- Staffing data from other non-OPG CANDU reactors was not sufficient to develop realistic benchmarks for OPG
- No CANDU-specific functions were benchmarked in this study (see the next page)
- This approach is consistent with the approach taken on prior studies

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2,404 OPG Nuclear Personnel Could Not Be Benchmarked

CANDU-Specific Exclusions*

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

*Unique to CANDU design with no comparable PWR activity

OPG-Specific Exclusions

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

Generic Exclusions**

- *Nuclear waste and used fuel*: Functions not performed by plants in the benchmark
- *Outage execution activities*: Excluded for consistency with counts at benchmark plants
- *Water treatment*: Functions not performed by plants in the benchmark

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

Other Exclusions

- *Information Management*: Benchmarked via a different method external to this study
- *Long Term Leave Personnel*: Excluded consistent with Goodnight Consulting benchmarking methodology

Out of Scope

- Consistent with previous methodology, areas such as Security Operations and Corporate Support not directly supporting the Nuclear program (e.g., treasury, tax) are out of scope and additional to the 2404 not benchmarked for the study.

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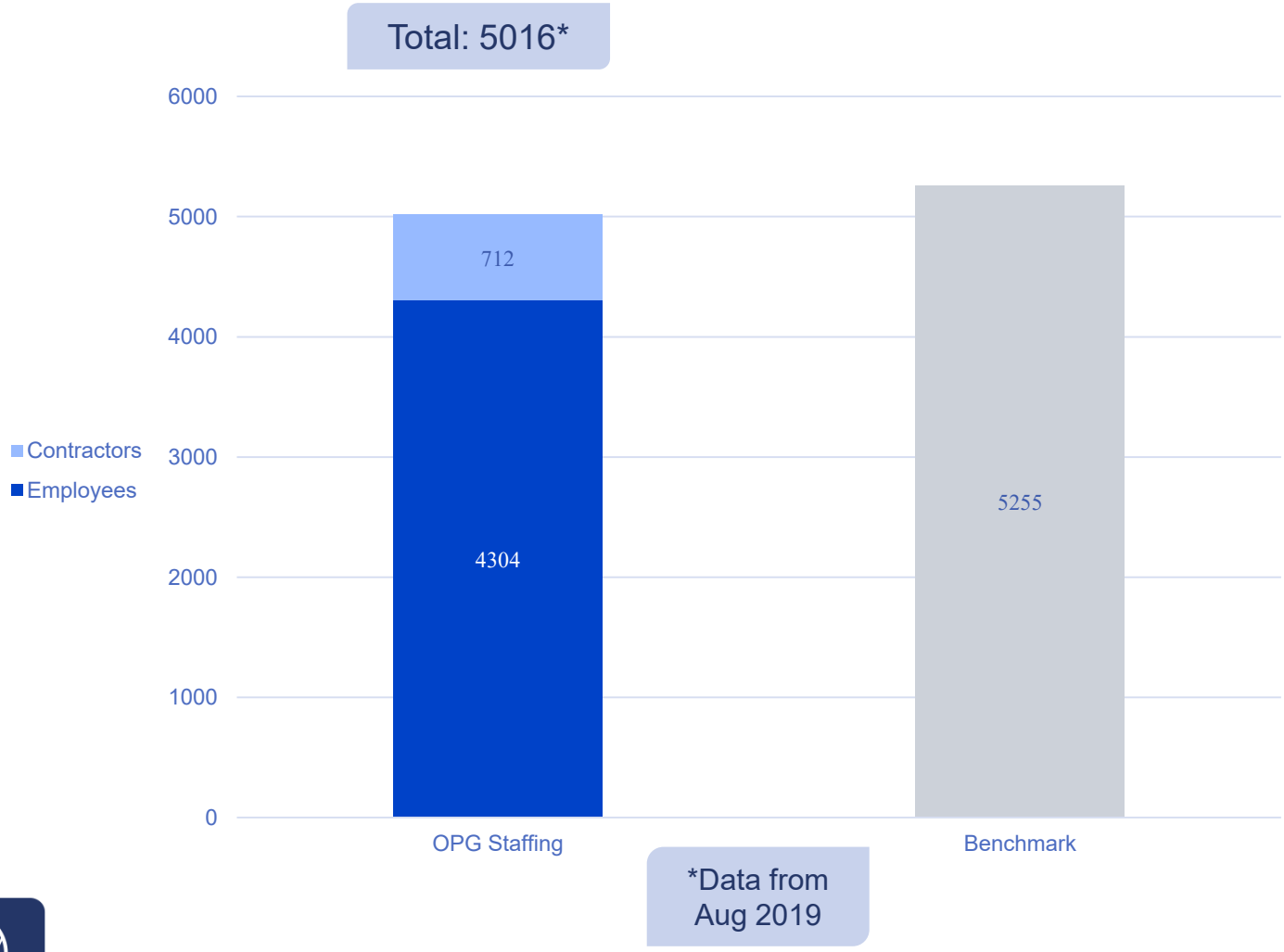
OPG Is 239 FTEs (-4.5%) Below The Benchmark of 5,255



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We Developed Functional Benchmarks Utilizing The Same Methodology Applied In Prior Studies

Function	Total Regular HC	Total Contractor FTEs	Total OPG FTEs	2019 Benchmarks	Variance
Facilities	181	137	318	110	208
Maintenance - Support	173	120	293	195	98
Operations Support	166	4	170	85	85
Fire Department	100		100	23	77
Human Resources	93	8	101	26	75
Project Management	126	27	153	82	71
Maintenance - Mechanical	294	77	371	312	59
Admin	147	30	177	137	40
QC/NDE	78	3	81	41	40
Operations Pipeline	172		172	135	37
Engineering-Computer	45	10	55	30	25
Safety Programs	61	27	88	63	25
Budget/Accounting	67	3	70	47	23
Chemistry	120	13	133	120	13
Contracts/Purchasing	76	5	81	82	-1
Outage Management	83	3	86	87	-1
QA	45	4	49	51	-2
Communications	7	2	9	13	-4
Decon/Radwaste	27	25	52	56	-4
Management	186	3	189	197	-8
Engineering-Reactor	42	9	51	60	-9
RP Support	56	7	63	74	-11
Emergency Preparedness	18	5	23	36	-13
Engineering-Procurement	36	1	37	51	-14
Environmental	15	4	19	33	-14
Training	181	37	218	240	-22
Scheduling	66	3	69	92	-23
Management Support	4	6	10	41	-31
Warehouse	65	3	68	102	-34
Licensing/Regulatory Affairs	15	1	16	51	-35
Nuclear Fuels	19	1	20	56	-36
Engineering-Mods	148	22	170	212	-42
Document Control/Records Mgmt.	24	2	26	69	-43
Design/Drafting	15		15	69	-54
Maintenance - Construction	15	8	23	79	-56
Security Support	31	6	37	97	-60
Maintenance-Electrical/I&C	414	51	465	529	-64
Maintenance Planning	78	6	84	156	-72
Engineering-Plant	188	35	223	298	-75
Engineering-Technical	47	4	51	161	-110
RP Applied	43		43	157	-114
Operations	537		537	700	-163
Total	**4304**	**712**	**5016**	**5255**	**-239**

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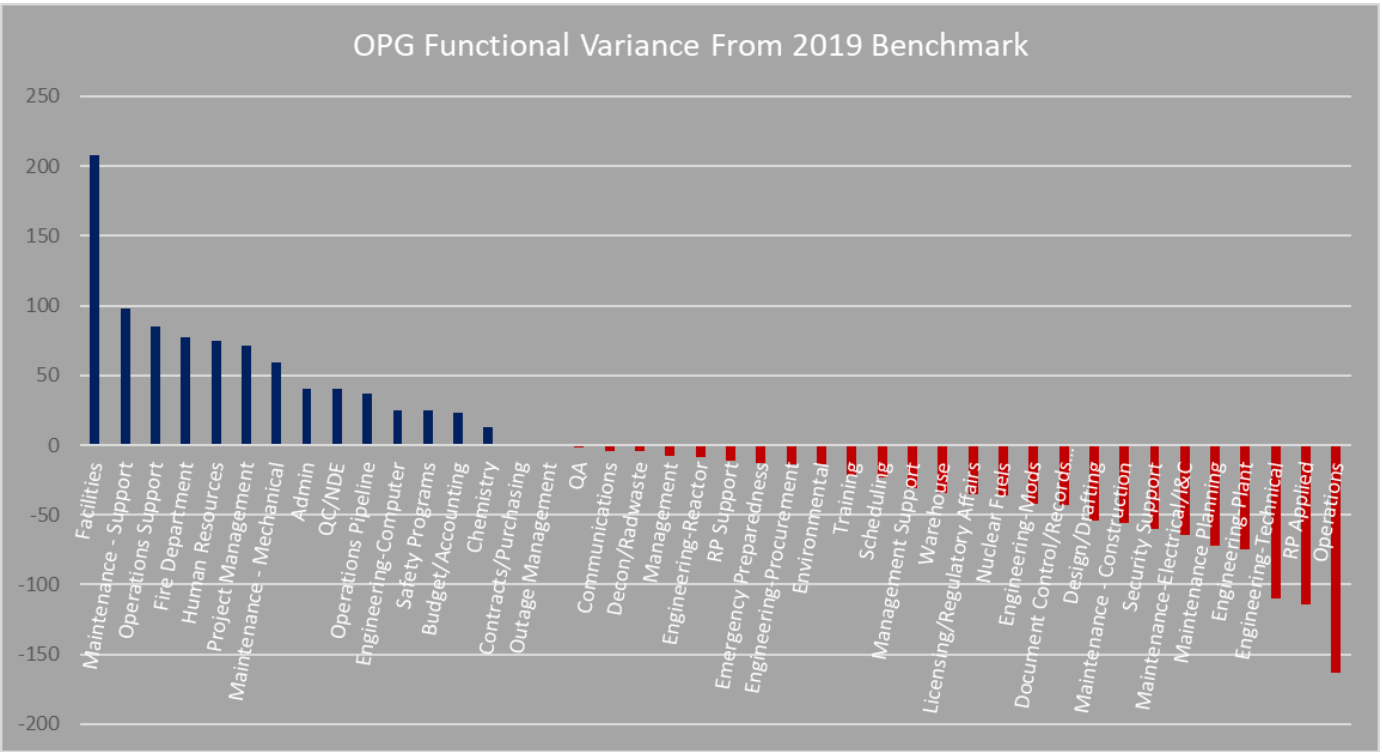
14 Functions Are Above The 2019 Benchmark; 28 Functions Are Below The 2019 Benchmark



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Admin	40
QC/NDE	40
Operations Pipeline	37
Engineering-Computer	25
Safety Programs	25
Budget/Accounting	23
Chemistry	13
Contracts/Purchasing	-1
Outage Management	-1
QA	-2
Communications	-4
Decon/Radwaste	-4
Management	-8
Engineering-Reactor	-9
RP Support	-11
Emergency Preparedness	-13
Engineering-Procurement	-14
Environmental	-14
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Scheduling	-23
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Security Support	-60
Maintenance-Electrical/I&C	-64
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Engineering-Plant	-75
Engineering-Technical	-110
RP Applied	-114
Operations	-163
Total	**-239**

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

Each of these functional areas should be further reviewed by OPG for workforce planning, process improvement, and / or organizational improvement opportunities

Facilities	208
Maintenance - Support	98
Operations Support	85
Fire Department	77
Human Resources	75
Project Management	71
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RP Applied	-114
Operations	-163

Note that these functions are not offsetting

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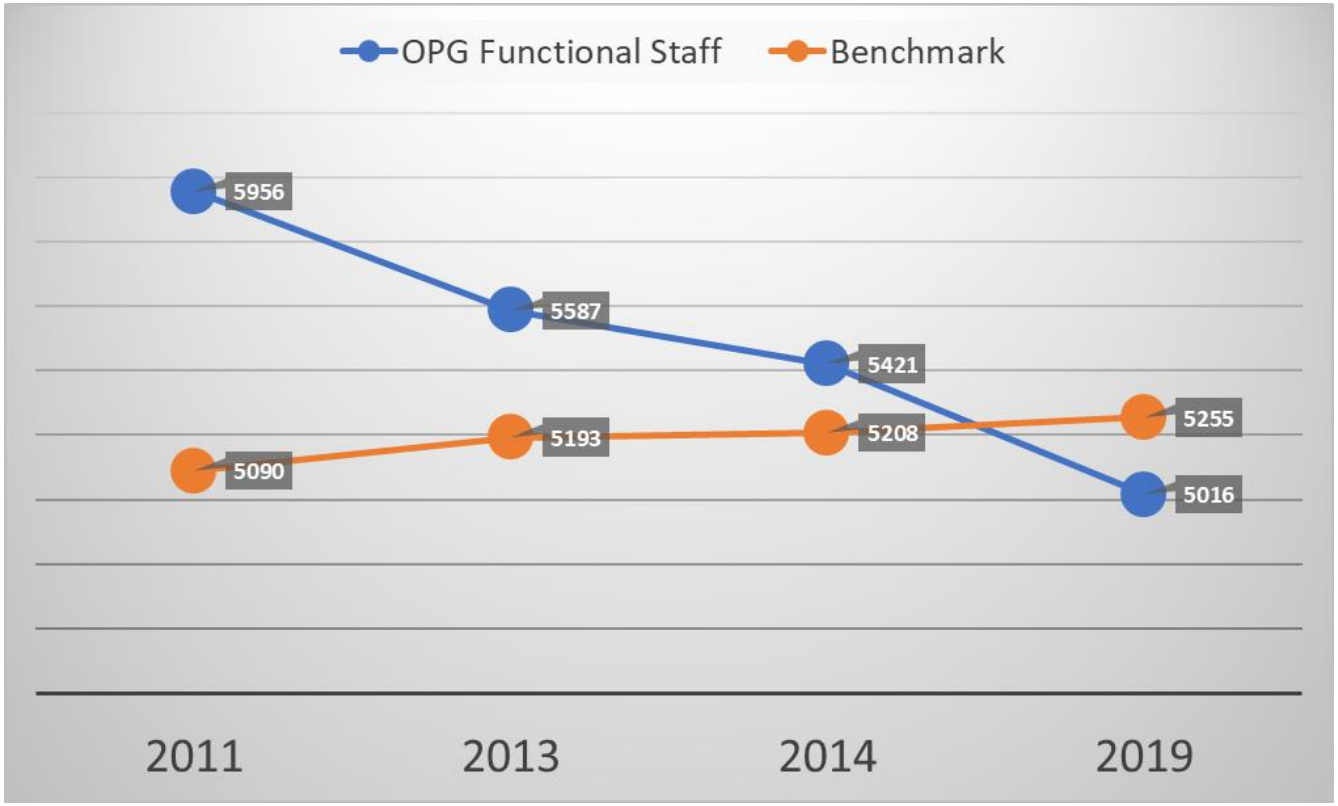
Attrition, OPG Staff Management, & Increases At Benchmark Plants Brought OPG Below The Benchmark



The past centre-led initiatives involved a major reorganization effort, decreasing staffing in several functions since 2011

The Pickering station amalgamation in the past has helped OPG achieve efficiencies and improve variances from the benchmark in several functions since 2011

As Pickering approaches shutdown, attrition occurs and some vacant positions go unfilled while management takes steps to continuously improve and find efficiencies.

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Operations Function Issues

- Operations/Operations – Pipeline – Ops Pipeline staffing above the benchmark (+37) indicates that OPG is aware of low on-shift Operations staffing (-163) and is executing a plan to help close the gap. However, even if most of the Ops Pipeline personnel successfully migrate to on-shift Ops, the gap will still be >100.

- Operations – Pipeline (Darlington) – Some of the personnel in the Operations – Pipeline count (operators in training) will be slated to go directly to the TRF or into Fuel Handling. This helps explain the size of the staffing level in this functional area.

- Operations Support (Pickering) - Additional staff are currently required to support life extension of the remaining operating units. There has also been additional focus on tritium management since the 2011 staffing benchmarking study. These activities are not required at benchmarked plants and helps explain higher staffing levels.

- Operations Support (Pickering) – Additional Operations Support staff are also required for support to outage planning as outages are now more focused on life extension.

- Operations Support – Some of the above-benchmark staffing in this function appears to be making up for lower on-shift Operations staffing levels

- Operations Support (Pickering) – Additional operations support staff are required for Units 5-8 due to specific licensing requirements.

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Chemistry, Environmental, and Radiation Protection Function Issues

- Chemistry (Darlington) – A few of the Operations/Chemistry & Environmental personnel were excluded from benchmarking due to support for the on-site Tritium Removal Facility (TRF). These exclusions included 1 for Heavy Water and 1 for Water Treatment.

- Environmental (Darlington) - A few of the Operations/Chemistry & Environmental personnel were excluded from benchmarking due to support for the on-site Tritium Removal Facility (TRF). These exclusions included 1 for Heavy Water and 1 for Water Treatment.

- RP Applied - Low staffing is offset by line personnel qualified to provide self monitoring and also, if certified, to monitor the activities of groups

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Maintenance Function Issues

- Maintenance – Mechanical, Electrical, I&C, Support, and Construction – Darlington maintenance staff currently perform both steady-state and outage(refurbishment) maintenance activities. Boundaries between the steady-state and refurbishment levels of effort have been established.

- Maintenance – Mechanical, Electrical/I&C, and Support - Additional Pickering staff are currently required to support life extension of the remaining operating units. There has also been additional focus on tritium management since the 2011 staffing benchmarking study.

- Maintenance Support – Some personnel may be being applied to make up for relatively low staffing in the Maintenance - Planning function.

- Facilities – The Civil Maintenance at Pickering organization has a contract management oversight department to oversee contract trades, as required by law. This is not required at benchmarked plants and helps explain part of the higher staffing levels. Overall Facilities functional staffing above the benchmark level continues to be driven by the large number of off-site facilities maintained by OPG, which are being consolidated in the future as part of their Campus Plan announcement.

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Engineering & Related Function Issues

- Engineering – Plant (Pickering) - Additional Pickering staff are currently required to support life extension of the remaining operating units. These conditions are exacerbated by below benchmark staffing. Benchmark plants have slightly higher than average Engineering – Plant staffing as an approach to provide a “first line of defense” for Operations and Maintenance.

- Engineering – Technical – It appears OPG Modifications/Design Engineers do more technical work than at benchmark plants, which is reflected in OPG staffing below the benchmark for this function.

- Design Drafting – Many benchmark plants still use draftspersons as support to design/modification engineering; it appears OPG does this less so, reflecting in staffing below the benchmark level.

- Project Management - Staffing above the benchmark reflects OPG’s current capital program and increased focus on strengthening their project management office as part of their strategic imperative.

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Training Function Issues

- Training – Staffing levels below the benchmark reflect lower than benchmark Operations staffing levels
- Training – A notable effort to reduce “nuclear” qualifications is underway in Training. Some longstanding “nuclear” specific qualifications are being systematically eliminated in favor of industry or provincial qualifications. For example, the Project Manager qualification is being eliminated in favor of experience (exemption) and non-nuclear professional development. Craft qualifications in fork-lift operation, fall protection, and other common industrial knowledge / experience areas will be handled similarly.
- Training – Use of technology is seen as a means to accommodate a planned “glide slope.” Both information technology (elimination of paper, lists, filing) and instructional technology (augmented reality) are being employed to reduce labor requirements.

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Other Functional Area Issues

- Management Support – These individuals have no direct reports and perform a variety or tasks for their direct supervisor that do no fit into one of the other nuclear work functions. The benchmark has significantly increased in the past few years due to aging workforce at benchmark plants that management has decided to retain due to their experience levels, and to apply them as direct support / advisors to younger managers.

- Fire Department – OPG has dedicated fire department staff, compared to most benchmark plants that rely on Operations and Security personnel for fire watch, and external fire departments for fire response. These differences in the approach to this function explain the large variance from the benchmark.

- Human Resources – OPG's approach to the HR function provides more support and services to the organization and to the employees compared to benchmark plants. Additionally, OPG has a significantly larger percentage of staff represented by labor unions, requiring more Labor Relations effort than at benchmark plants.

- Exclusions for Darlington Refurbishment – 629 individuals were excluded due to dedication to the Darlington Refurbishment project. At the completion of these individuals' Refurbishment assignments OPG will need to determine their roles in the organization relative to overall staffing and organizational goals.

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- Benchmark development methodology

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To Identify Staffing Benchmarks, We Used The Same Methodology As Prior OPG Engagements

Identify Plants	Identify Benchmarks	Adjust For Technology	Adjust For Work Rules	Finalize Benchmarks
Identify applicable nuclear plants/nuclear organizations as the benchmarking sources	Identify staffing benchmarks reflecting steady-state operations from functional staffing data using selected nuclear plants	Adjust for technical/design differences (i.e., PWR vs. CANDU)	Adjust for regulatory and/or work rule differences (i.e., 35 vs. 40 hour work week)	Apply adjustments and identify final functional staffing benchmarks

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We Applied Several Key Assumptions In Our Staffing Benchmarking Methodology

Benchmarks Are From Steady State, On-Power Activities

Plants are considered to be in steady state operation:

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

Average Productivity Is Assumed

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

Current Vacancies Excluded

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

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

1. Apply Goodnight Consulting Nuclear Plant Staffing Database

2. Select The Most Similar Plants
   - Apply functional staffing data from large US (>800 MWe) Pressurized Water Reactors (see the following page)

3. Identify Benchmark Functional Staffing
   - Apply adjustments for PWR to CANDU design differences
   - Apply adjustments for OPG conditions

4. Develop Functional Staffing Comparison

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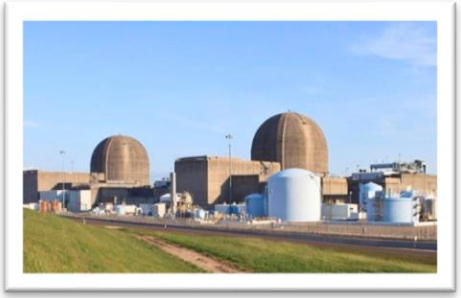
Large 2-Unit PWRs Provide The Closest Comparison to CANDUs For Benchmarking



Approach

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

Design Similarities

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

Later-Model PWRs

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

"Most Similar" to CANDU

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

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

Design & Operational Consideration Areas – PWR to CANDU Benchmark Conversion

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

Our technical team reviewed the differences between PWR and CANDU and accounted for those differences in a staffing model discussed later in this section of the report – This is the same methodology we applied in 2011, 2013, and 2014.

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2-Unit CANDU Staffing Benchmark Is 1,044* (Includes Corporate & Contractor FTEs)

Staffing Function	2019 2-UNIT US PWR Bmk	Raw Adjustments 2019	Total Bmk (2019
Admin	31	3	34
Budget/Accounting	11	1	12
Chemistry	26	0	26
Communications	3	0	3
Contracts/Purchasing	15	0	15
Decon/Radwaste	9	3	12
Design/Drafting	12	1	13
Document Control/Records Mgmt.	11	2	13
Emergency Preparedness	7	0	7
Engineering - Computer	5	0	5
Engineering - Mods	38	3	41
Engineering - Plant	48	8	56
Engineering - Procurement	8	2	10
Engineering - Reactor	6	5	11
Engineering - Technical	26	5	31
Environmental	4	2	6
Facilities	24	0	24
Fire Department	5	0	5
Human Resources	6	1	7
Licensing/Regulatory Affairs	9	1	10
Maintenance - Construction	14	2	16
Maintenance-Electrical/I&C	102	13	115
Maintenance - Mechanical	61	7	68
Maintenance - Support	39	3	42
Maintenance Planning	33	1	34
Management Support	8	0	8
Nuclear Fuels	11	-1	10
Operations	139	0	139
Operations Pipeline	27		27
Operations Support	17	0	17
Outage Planning/Scheduling	16	3	19
Project Management	15	1	16
QA	9	0	9
QC/NDE	8	1	9
RP Applied	31	3	34
RP Support	13	1	14
Safety Programs	15	0	15
Scheduling	18	2	20
Security Support	21		21
Training	49	3	52
Warehouse	17	2	19
Total	**966**	**78**	**1044**

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

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

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

Staffing Function	Raw Adjustments 2019	Total Bmk (2019	Rationale
Admin	3	34	Approximately 1 additional admin/clerical person is needed for each additional 25 staff
Budget/Accounting	1	12	1 FTE additional functional staff needed to support the added personnel due to CANDU technology differences
Chemistry	0	26	No basis for adjustment
Communications	0	3	No basis for adjustment
Contracts/Purchasing	0	15	No basis for adjustment
Decon/Radwaste	3	12	"Hotter shop" tritium, alpha radiation pervasive, more opportunities for deconning-more equipment, bigger source of radiation and more space. Larger volumes of I&LLW generated and packaged.
Design/Drafting	1	13	Greater number of systems
Document Control/Records Mgmt.	2	13	Higher number of systems, more control documents to manage
Emergency Preparedness	0	7	No basis for adjustment
Engineering - Computer	0	5	No basis for adjustment
Engineering - Mods	3	41	Greater number of systems
Engineering - Plant	8	56	Greater number of systems
Engineering - Procurement	2	10	Higher number of commercial parts dedications due to a smaller vendor market, lower availability of conforming parts
Engineering - Reactor	5	11	Adjusted to 2-unit equivalent of OPG CANDU stated requirements
Engineering - Technical	5	31	Higher number of systems, diversity instead of redundancy design philosophy
Environmental	2	6	Tritium monitoring, Canadian regulatory requirements
Facilities	0	24	No basis for adjustment
Fire Department	0	5	No basis for adjustment
Human Resources	1	7	1 FTE additional functional staff needed to support the added personnel due to CANDU technology differences
Licensing/Regulatory Affairs	1	10	Different regulatory scheme, greater number of safety systems, design philosophy of diversity over redundancy
Maintenance - Construction	2	16	Higher number of systems, diversity instead of redundancy design philosophy-track IMS impacts on numbers
Maintenance-Electrical/I&C	13	115	Higher number of systems, diversity instead of redundancy design philosophy-track IMS impacts on numbers
Maintenance - Mechanical	7	68	Higher number of systems, diversity instead of redundancy design philosophy-track IMS impacts on numbers
Maintenance - Support	3	42	Higher number of systems, diversity instead of redundancy design philosophy
Maintenance Planning	1	34	Higher number of systems, diversity instead of redundancy design philosophy
Management Support	0	8	No basis for adjustment
Nuclear Fuels	-1	10	Adjusted to 2-unit equivalent of OPG CANDU stated requirements
Operations	0	139	Additional systems to monitor= increases, common systems = decreases
Operations Pipeline		27	
Operations Support	0	17	Additional systems to monitor= increases, common systems = decreases
Outage Planning/Scheduling	3	19	Non fueling outages=decreases, more systems to deal with during an outage=increase
Project Management	1	16	Higher number of systems, diversity instead of redundancy design philosophy
QA	0	9	No basis for adjustment
QC/NDE	1	9	Due to additional maintenance work, additional QC/NDE work is required, "Innate" IMS counted here,
RP Applied	3	34	Additional radiation sources, differences in staffing are due to choices in program structures
RP Support	1	14	Additional radiation sources, differences in staffing are due to choices in program structures
Safety Programs	0	15	No basis for adjustment
Scheduling	2	20	Greater number of systems resulting in more scheduling work
Security Support		21	
Training	3	52	Additional trainers required to handle additional maintenance training requirements
Warehouse	2	19	Additional parts and components needed for more systems and to overcome more materials kept on hand due to a smaller vendor base
Total	**78**	**1044**	

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

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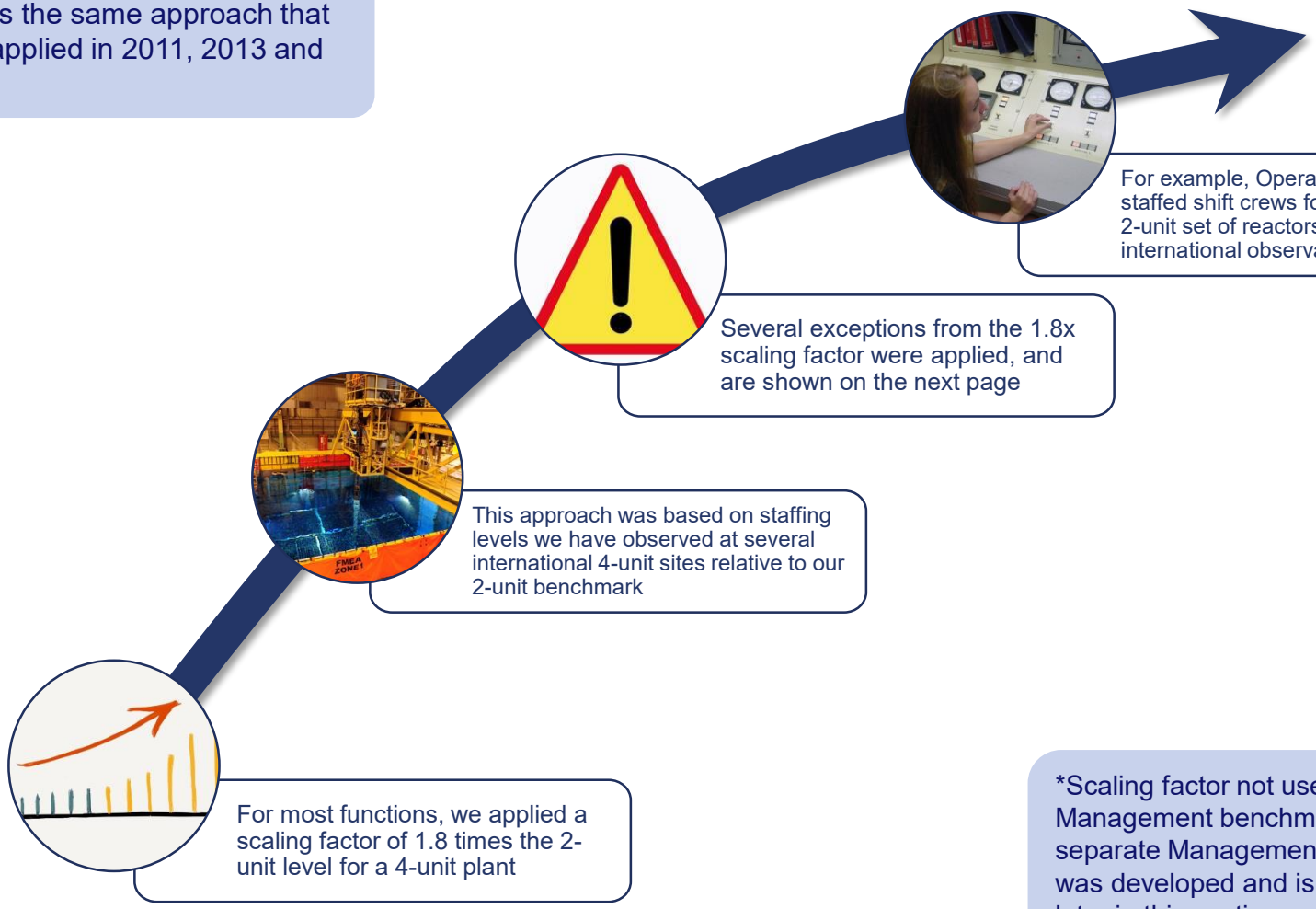
We Developed Functional Scaling Factors* Based On Our Experience & Best Estimates

This is the same approach that was applied in 2011, 2013 and 2014



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

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

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

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

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

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2-Unit OPG CANDU Benchmark Is 1,044*
Adjusted 4-Unit OPG CANDU Benchmark Is 1,973*

- Where applicable, adjustments were made for OPG's 35 Hour work week vs. 40 hours at U.S. plants
- The net increase in the 2-Unit benchmarks from the work week adjustment is 52 FTEs
- CANDU 2-Unit then scaled up to a 4-Unit model

Staffing Functions	2-Unit CANDU Benchmark	35 hour week	Adjustment for 35 hour work week	Scaling Factor from 2 to 4 Units	4 Unit CANDU Benchmark
Admin	34	1	39	Ratio	49
Budget/Accounting	12	1	13	Ratio	17
Chemistry	26		26	1.8	47
Communications	3		3	1.8	5
Contracts/Purchasing	15	1	18	1.8	32
Decon/Radwaste	12		12	1.8	22
Design/Drafting	13	1	15	1.8	27
Document Control/Records Mgmt.	13	1	15	1.8	27
Emergency Preparedness	7	1	8	1.8	14
Engineering - Computer	5	1	6	2	12
Engineering - Mods	41	1	46	1.8	83
Engineering - Plant	56	1	64	1.8	115
Engineering - Procurement	10	1	11	1.8	20
Engineering - Reactor	11	1	12	2	24
Engineering - Technical	31	1	35	1.8	63
Environmental	6	1	7	1.8	13
Facilities	24		24	1.8	43
Fire Department	5		5	1.8	9
Human Resources	7	1	8	Ratio	9
Licensing/Regulatory Affairs	10	1	11	1.8	20
Maintenance - Construction	16		16	1.8	29
Maintenance-Electrical/I&C	115		115	1.8	207
Maintenance - Mechanical	68		68	1.8	122
Maintenance - Support	42		42	1.8	76
Maintenance Planning	34		34	1.8	61
Management Support	8	1	9	1.8	16
Nuclear Fuels	10	1	12	1.8	22
Operations	139		139	2	278
Operations Pipeline	27		27	2	54
Operations Support	17		17	2	34
Outage Planning/Scheduling	19		19	1.8	34
Project Management	16	1	18	1.8	32
QA	9	1	11	1.8	20
QC/NDE	9		9	1.8	16
RP Applied	34		34	1.8	61
RP Support	14	1	16	1.8	29
Safety Programs	15	1	17	Ratio	23
Scheduling	20		20	1.8	36
Security Support	21		21	1.8	38
Training	52		52	1.8	94
Warehouse	19	1	22	1.8	40
Total	**1044**		**1096**		**1973**

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

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Final Report – January 21, 2020

Adjustments For Pickering Units 1-4 Increase The OPG 2-Unit CANDU Benchmark To 1,096*

- Some cross-tied systems remain active at Pickering Units 2 & 3: We adjusted the benchmark to include personnel required to support those systems (16)
- FTEs assigned to SAFESTORE activities at Pickering Units 2 & 3 were **not** included in the benchmark

Staffing Functions	Unit CANDU Bench	35 hour week	Adjustment for 35 hour work wee	Adjustments for Units 2 & 3	Pickering A Benchmark	Rationale
Admin	34	1	39		39	
Budget/Accounting	12	1	13		13	
Chemistry	26		26		26	
Communications	3		3		3	
Contracts/Purchasing	15	1	18		18	
Decon/Radwaste	12		12		12	
Design/Drafting	13	1	15		15	
Document Control/Records Mgmt.	13	1	15		15	
Emergency Preparedness	7	1	8		8	
Engineering - Computer	5	1	6		6	
Engineering - Mods	41	1	46		46	
Engineering - Plant	56	1	64	4	68	**One additional System Engineer per discipine (M, E, I&C, Civil)**
Engineering - Procurement	10	1	11		11	
Engineering - Reactor	11	1	12		12	
Engineering - Technical	31	1	35		35	
Environmental	6	1	7		7	
Facilities	24		24		24	
Fire Department	5		5		5	
Human Resources	7	1	8		8	
Licensing/Regulatory Affairs	10	1	11		11	
Maintenance - Construction	16		16	5	21	**Estimated Additional staff (FIN-like)**
Maintenance-Electrical/I&C	115		115		115	
Maintenance - Mechanical	68		68		68	
Maintenance - Support	42		42	1	43	**Ratio of support to additional Maintenance/Construction**
Maintenance Planning	34		34		34	
Management Support	8	1	9		9	
Nuclear Fuels	10	1	12		12	
Operations	139		139	5	144	
Operations Pipeline	27		27		27	
Operations Support	17		17		17	
Outage Planning/Scheduling	19		19		19	
Project Management	16	1	18		18	
QA	9	1	11		11	
QC/NDE	9		9		9	
RP Applied	34		34	1	35	**One additional Rad Pro technican to conduct surveillances**
RP Support	14	1	16		16	
Safety Programs	15	1	17		17	
Scheduling	20		20		20	
Security Support	21		21		21	
Training	52		52		52	
Warehouse	19	1	22		22	
Total	**1044**		**1096**	**16**	**1112**	

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

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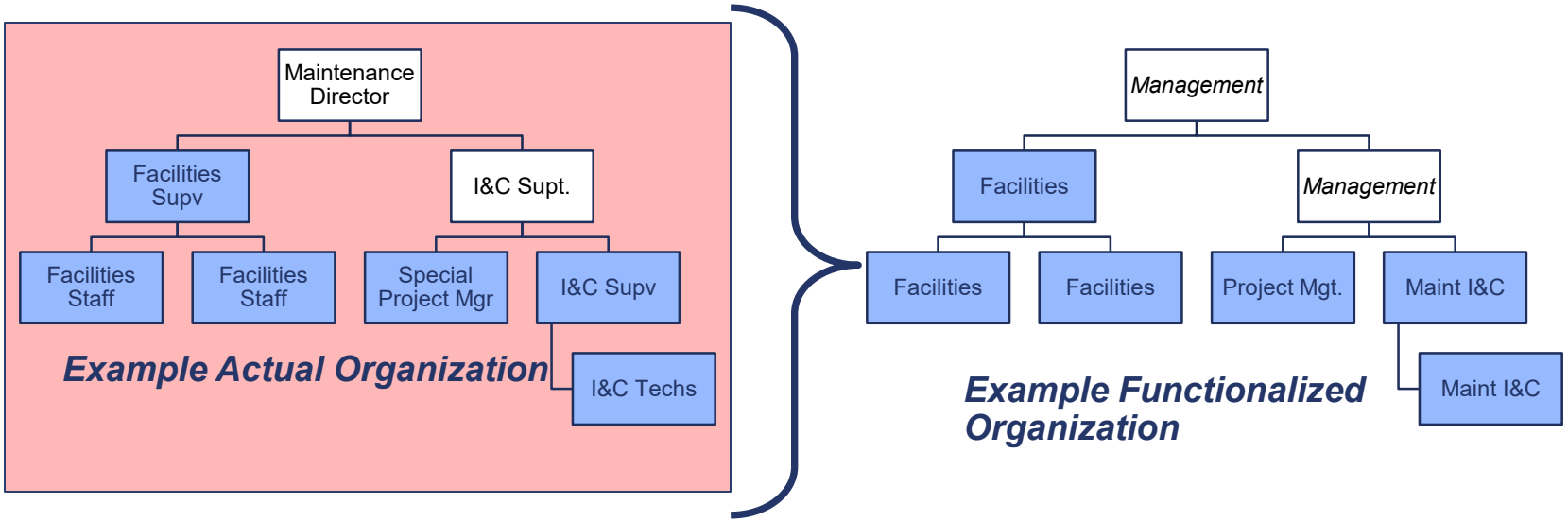
Management Is A Function, Not A Title, In Our Model: It Includes All Personnel Above 1st Line Supervisors

Management Function

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

All Other Functions

- First Line Supervisors
- Individual Contributors



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

OPG *Management* Function Benchmark = 197

- These account for distributed Management Function staff from benchmark Corporate Nuclear organizations
- These 197 FTEs are calculated from a ratio of 3.9% of total benchmarked staff

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

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

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

Final Benchmark Nuclear Organizational Chart has 197 Management Function personnel (excluding managers for not-benchmarked activities such as Info Management, Security, Refueling Ops, Etc.)

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Benchmarking *Summary*: Total 2019 OPG Nuclear Benchmark Is 5,255

	Pickering 1-4	Pickering 5-8	Darlington	Total
Large 2-Unit PWR Benchmark	966	966	966	
CANDU Technology Adjustment	78	78	78	
35 Hour Work Week Adjustment	52	52	52	
Scale From 2 to 4 Units		877	877	
Adjust for Pickering Units 2 & 3	16			
Add Management Benchmarks	43	77	77	
Total	1155	2050	2050	5255

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