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A PROGRESS REVIEW OF ONTARIO HYDRO'S NUCLEAR GENERATION AND HEAVY WATER PRODUCTION PROGRAMS

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1.0 INTRODUCTION

At present, all of the 6 CANDU-PHW (Pressurized Heavy Water) nuclear-electric generating units that are in-service in Canada are operated by Ontario Hydro. In addition, Ontario Hydro owns and operates the Bruce Heavy Water Plant-A (Bruce HWP-A), the world's largest and most economical producer of heavy water, and is building two more nearly identical plants.

The year 1976 served to underscore the CANDU success story in dramatic fashion. Although the 6 nuclear units represented only about 12% of Ontario Hydro's total generating capacity they produced 16.2 terawatt-hours (TWh) of electricity and 0.7 TWh (electricity equivalent) of process steam. The 16.2 TWh was 17.4% of the total electricity supplied to our customers.

The nuclear-electric fraction of total generation will increase considerably during the next decade, as an additional 16 CANDU-PHW units, totalling about 11500 MW, come into commercial service.

This paper describes the operating experience, commissioning experience and construction status of each of Ontario's nuclear-electric generating stations and heavy water plants. The information presented covers mainly the period January 1, 1976 to April 30, 1977. In addition, for the In-Service projects, important lifetime performance factors are given.

Early experience with Canada's first Nuclear Training Simulator is also described.

The nuclear generating units now in service are:

1. The 22.5 MW Nuclear Power Demonstration (NPD), Canada's first nuclear-electric generating station that has been operating extremely well since 1962. NPD is jointly owned by Ontario Hydro and Atomic Energy of Canada Limited (AECL).

2. The 206 MW Douglas Point Nuclear Generating Station (NGS), which first produced electricity in 1967 and is now a unique dual-purpose facility, supplying electricity to the Ontario Hydro grid and steam to the Bruce HWP-A. Douglas Point is owned by AECL.

3. Pickering NGS-A, Canada's first commercial nuclear-electric generating station, located 32 kilometres from the centre of Toronto, has four identical 514 MW (net) units placed In-Service between July 1971 and June 1973. Pickering is owned by Ontario Hydro.

In addition, Ontario Hydro is:

1. Constructing the four-unit, 3000 MW Bruce NGS-A, where Units 1 and 2 have reached power levels of about 700 MW and 600 MW respectively. Bruce NGS-A will also supply steam to the existing and new heavy water plants.

2. Adding 4 more 500 MW units at Pickering (Pickering NGS-B) for operation in 1981 to 1983.

3. Building a second four-unit, 3000 MW station at Bruce (Bruce NGS-B) for operation in 1983 to 1986.

4. Planning to build a four-unit, 3400 MW station at Darlington, about 25 kilometres east of Pickering, to be placed In-Service between 1985 and 1988.

5. Carrying out conceptual and preliminary engineering studies for future nuclear stations with unit capacities up to 1200 MW.

2.0 OPERATING EXPERIENCE

2.1 Nuclear Power Demonstration (NPD)

NPD is used mainly to train people and to help develop new fuel designs, new hardware and new techniques. However, whenever it has been operated as a base-load station, NPD has been reliable and durable. This is shown by its 86% Net Capacity Factor (NCF) during the past 4 years and by its 88% NCF over the last 14 years during our winter peak load periods of December, January and February.

In 1976, NPD achieved an annual NCF of 92.4%, the highest in its 15 year history and an encouraging sign of durability.

2.2 Douglas Point NGS

In 1976, Douglas Point continued to demonstrate that it is overcoming many of the prototype hardware problems which in earlier years caused low production reliability and high Unit Energy Costs.

From January through August 1976, Douglas Point had a very respectable NCF of 89%.

At the end of August the unit was shut down for a lengthy planned outage to repair 2 moderator heavy water leaks in the calandria vault. The leaks, which began about 3 years ago and gradually increased, were repaired using remote-controlled tooling developed specifically for the purpose. Many valuable lessons were learned regarding the development and application of special tools, the importance of construction accuracy in inaccessible regions, and corrosion effects of such leaks.

Because of this outage, the 1976 NCF was 58.9%, compared with 57, 62.5 and 71% in 1973, 1974 and 1975.

Excluding capital charges, the Unit Energy Cost in 1976 was 11.9 m$/kWh, which is about equal to the Fuelling Cost alone of our most efficient fossil-fired station.

Douglas Point was restarted at the beginning of April 1977.

2.3 Pickering NGS-A

Performance of Pickering NGS-A will be described under the following headings:

Operating History
Production Reliability
Economics
Radioactivity Emissions

Pre-1976 experience has been reported extensively in earlier reports.(1),(2)

Operating History (see coloured chart)

At the beginning of 1976, Units 1, 2 and 3 were operating very well, while Unit 4 was nearing the end of a 10½-month outage, during which 52 faulty pressure tubes (among 390) were replaced.

Unit 4 was restarted at the end of March, 1976 but was shut down a few days later to repair:

(1) a generator hydrogen to stator cooling water leak

(2) several feeder pipes to end-fitting connection leaks (an aftermath of the pressure tube replacements).

Following these repairs, Unit 4 was restarted at the end of April and has now operated almost continuously at full power for over a year.

Despite being shut down for the first 4 months, Unit 4 ended up with a 68.4% NCF for 1976 because of near perfect performance for the balance of the year. Indeed, for the 12 months since restart (May 1, 1976 to May 1, 1977) Unit 4 achieved a remarkable 98.5%.

Our previous report to the CNA (June 1976) identified pressure tube defects in Units 3 and 4 and generator defects in all units as the main hardware problems causing lost production.

In 1976 and the first 4 months of 1977:

- There has been no re-occurrence of leaks in the Zirconium-Niobium pressure tubes of Units 3 and 4.

- An inspection of 72 of the Zircaloy-2 pressure tubes in Unit 2 confirmed them to be free of cracks.

- There has been no re-occurrence of generator conductor failures.

- No new hardware problems comparable to the pressure tube and generator problems were encountered.

Units 1, 2 and 3 have enjoyed remarkably high NCF's in 1976 and the first 4 months of 1977. The principal cause of lost production was a nominal 2½ week Planned Outage on each unit in 1976 and a 3-week Planned Outage on Unit 2 in April 1977. Since a 2½-week outage consumes 5% of a year, the maximum possible 1976 NCF for Units 1, 2 and 3 was about 95%. The actual 1976 NCF for units 1, 2 and 3 averaged 93.3% (as described later) corresponding to a very low forced incapability of about 1.7% --- in other words, extremely reliable performance.

Production Reliability

Our CANDU-PHW units, because of their unmatched low fuelling costs, are never shut down or derated for economic reasons. They are truly base-loaded units and Net Capacity Factor (NCF) is the best single indicator of production reliability.

Lifetime NCF

Excluding the 4-month strike shutdown in 1972, the average NCF to May 4, 1977, covering 18.9 unit-years, is 77.8%. The corresponding average Gross Capacity Factor (GCF) is 78.3%.

Unit 1	83.3%
Unit 2	83.3%
Unit 3	73.0%
Unit 4	69.2%
Weighted Average	77.8%

Winter Peak NCF

Nuclear unit reliability is particularly important during our winter peak load periods of December, January and February.

For the 1972/73 winter peak period, the 3 units then In-Service had an average NCF of 96%.

For 1973/74, with all 4 units In-Service, the average NCF was 95%.

For 1974/75, it dropped to 67% because Unit 3 was shut down to replace pressure tubes.

For 1975/76, the average NCF was 74% because Unit 4 was shut down to replace pressure tubes.

For 1976/77, the winter peak NCF was a near-perfect 98.9%.

	1972/73	73/74	74/75	75/76	76/77
Unit 1	99.4	89.2	72.4	98.0	99.9
Unit 2	90.2	94.0	100.0	98.0	99.3
Unit 3	97.6	99.5	-00.9	99.7	97.6
Unit 4	Not In Service	95.9	96.1	-0.9	98.7
Average	95.7	94.7	66.9	73.7	98.9

Annual NCF

In 1973, the four units had an average NCF of 83.4%.

In 1974, the average NCF was 74.3%. Unit 3 was low because of the pressure tube problem.

In 1975, the average NCF dropped to 61.9%. Units 3 and 4 were low because of pressure tube problems and generator problems.

In 1976, the station average NCF was 87.1% despite having Unit 4 shut down for the first 4 months. Units 1, 2 and 3 each achieved over 92% despite 2½-week planned outages for annual maintenance and inspection.

In 1977, to May 4, the NCF has been 92.5%.

	1973	1974	1975	1976	1977 (to May 4)
Unit 1	92.5%	72.0%	80.2%	92.8%	98.3
Unit 2	69.0	88.4	86.0	93.2	76.2
Unit 3	85.1	42.7	57.5	93.9	98.2
Unit 4	90.1*	93.9	23.8	68.4	97.4
Average	83.4	74.3	61.9	87.1	92.5

*(6½ months)

Economics

For base-loaded units, the valid economic criterion is Total Unit Energy Cost (TUEC - m$/kWh). The components of TUEC are:

- Capital UEC

- Operating & Maintenance (O&M) UEC

- Fuelling UEC

and, in the special case of heavy water reactors,

- Heavy Water Upkeep UEC

Heavy Water Upkeep UEC

Heavy Water is not consumed, but it can be lost or it can be down-graded by mixing with natural water.

Heavy water upkeep is the cost of:

(a) Replacing losses

(b) Upgrading downgraded heavy water to restore its isotopic purity to about 99.7 mass per cent.

The Lifetime Heavy Water Upkeep UEC has been 0.33 m$/kWh or only about 4% of Lifetime TUEC.

Fuelling UEC (FUEC)

The Fuelling UEC of large CANDU-PHW units is extremely low, and unmatched by any other reactor concept.

The actual Fuelling UEC at Pickering, without taking any credit for potential recovery of plutonium, has been:

1973	0.91 m$/kWh
1974	0.88
1975	0.95
1976	1.17

Total Unit Energy Cost (TUEC)

The actual TUEC experience (including all corporate overheads and training costs) at Pickering has been as follows:

1973	7.1 m$/kWh
1974	8.2
1975	9.8
1976	7.7

For the year 1976 the TUEC component break-out was:

NCF	87.1%
Capital	4.46 m$/kWh
O&M	1.81
Heavy Water Upkeep	0.29
Fuelling	1.17
	7.73 m$/kWh

Even at the highest value in 1975, which was mainly due to the low NCF (61.9%), the TUEC is less than the current Fuelling Unit Energy Cost alone (12 to 19 m$/kWh) of any Ontario Hydro coal-fired generating station.

Customer Cost Implications

At the present time, the fuelling cost of new coal for our most efficient coal-fired station (Lambton) is about 12.7 m$/kWh. This is expected to rise to over 15 m$/kWh by 1978.

During 1973-1976 Pickering NGS-A produced 54,000,000 Megawatt-hours (54 Terawatt-hours), or about 16% of the total electricity consumed by our customers. In doing so, based on the current replacement cost of coal, Pickering has thereby saved the people of Ontario about $750 million dollars worth of coal which would otherwise have had to be imported from the United States (the original capital cost of Pickering A was about $750 million).

The value of reliability (high NCF) or the penalty of unreliability (low NCF) at our nuclear stations such as Pickering is evident from the fact that a 1% reduction in NCF at Pickering will cost, in 1977, at least 2.0 million dollars since replacement energy can only be obtained by burning fossil fuels.

Our motivation to quickly diagnose and correct problems and to minimize the frequency and durations of shutdowns should be obvious, and is paramount in our decision making, second only to safety of our staff and the public.

Radioactive Emissions

Our license limits for radioactivity emissions to air and to water, established by the Atomic Energy Control Board of Canada, conform to the recommendations of the International Committee on Radiological Protection.

Ontario Hydro and AECL have established design and operating targets of one per cent of these license limits for all new CANDU stations.

Although Pickering was designed before these targets were adopted, they have been comfortably met. The actual experience in 1974, 1975 and 1976 was:

Emissions to Air	% of Limit 1974	1975	1976
Tritium	0.24	0.20	0.23
Iodine - 131	0.02	0.0045	0.0072
Particulates	0.07	0.014	0.08
Noble Gases	0.20	0.22	0.12
Emissions to Water			
Tritium	0.09	0.064	0.036
Gross beta-gamma	0.29	0.10	0.09

2.4 Nuclear Training Simulator

We now have, adjacent to Pickering, a "generating station" that will never make a kilowatt-hour. It is Canada's first nuclear control room simulator, and will be used to improve the skills, knowledges and abilities of control room staff.

As stated earlier, our large nuclear units, because of their unmatched low fuelling costs are never shut down or derated for economic reasons. For the same economic reason, it is undesirable to shut them down or operate them at reduced output for training purposes.

The simulator looks exactly like the control panels of one Pickering generating unit, and its behaviour is, in all the essentials, indistinguishable from that of the actual Pickering units.

The operator (experienced or new) can start up, shut down and change the power level and many process conditions without economic penalty or hazard to plant and equipment.

In addition, he can be confronted with abnormal and emergency conditions which he may never see on an operating unit but for which he must be able to react skilfully and quickly if the condition does occur.

The simulator, supplied by CAE Electronics Ltd., was placed in service on November 29, 1976.

To date, several training courses have been conducted for staff from both Pickering NGS-A and Bruce NGS-A.

Both the training staff and the trainees have been very impressed.

2.5 Bruce HWP-A

Dependable supplies of heavy water at reasonable prices are vital to meet the needs of domestic and export CANDU reactors. In rough terms, the need is somewhat less than 1 megagram per megawatt.

The Bruce HWP-A, owned by Ontario Hydro is the largest heavy water plant now in operation, with a Design Capacity of 96.6 kilograms per hour (kg/h).

Two more identical plants are under construction (Bruce HWP-B and Bruce HWP-D).

Operation of Bruce HWP-A has been very gratifying since it was declared In-Service on June 28, 1973.

At first, the Demonstrated Capacity was limited to about 80% of the Design Capacity but it has now exceeded the Design Capacity by about 5%.

Accordingly in 1976 it was rerated officially to the Demonstrated Capacity of 100.6 kg/h. Further improvements are likely.

Capacity Factors and Annual Production have been:

	Capacity Factor - based on Design Capacity 96.6 kg/h	Capacity Factor - based on Demonstrated Capacity 100.6 kg/h	Production - Megagrams
1973 (6 months)	57		249
1974	75.6		640
1975	71.7*		605*
1976		91.0*	800*
1977 (4 months)		56.8*	174*
			2468

*Includes some heavy water enriched to 1ϵ-25% at Bruce HWP-A but "finished" to reactor grade elsewhere (Pt. Hawkesbury HWP, Glace Bay HWP and Pickering NGS-A upgrader)

The very high capacity factor in 1976 was achieved because of:

(1) Excellent equipment reliability

(2) Deferral of a planned 28-day outage into 1977.

Production will be lower in 1977 for 3 reasons:

(1) The planned outage deferred from 1976.

(2) Equipment problems aggravated by very severe weather in January and February.

(3) In the interests of longer term production and product cost, the production of "finished" reactor grade heavy water is being temporarily reduced in order to increase the amount of so-called "intermediate" product (16-25% purity). The intermediate product will be finished to reactor grade using other resources (such as the Finishing Unit of HWP-B) in the remainder of 1977.

3.0 COMMISSIONING EXPERIENCE

This includes:

- Units 1 and 2 of Bruce NGS-A

- Bruce HWP-B

3.1 Bruce NGS-A, Units 1 & 2

The 4 units are being built and commissioned in the sequence 2, 1, 3, 4.

The attached coloured chart shows the power history, key dates, and other information for Units 1 and 2.

The Unit 2 reactor achieved criticality on July 27, 1976, produced first electricity on September 4, 1976, and has been operated routinely and reliably at power levels up to 625 MW gross (about 575 MW net).

The Unit 1 reactor achieved criticality on December 17, 1976, produced first electricity on January 14, 1977, and has operated continuously at power levels up to 725 MW gross (about 675 MW net).

On-power refuelling was demonstrated successfully on February 10, 1977 and routine on-power fuelling is expected on both units by July 1, 1977.

As expected, and as previously demonstrated at Ontario Hydro's other multi-unit nuclear stations (Pickering-A) and fossil-fuelled stations (Lambton, Nanticoke, Lennox) the learning process resulted in shorter elapsed times and avoidance of problems for the second unit (Unit 1) than for the first unit.

During the power runup phase, hardware problems limited power output at various times:

(1) Unit 2 was limited to about 55 MW gross until December 6 because of vibration of the steam pipes at the inlet to the turbine.

    The cause was determined to be steam flow oscillations induced by the shape of the governor valves. After several tries, a successful modified valve plug design was developed and installed on all units.

(2) Unit 1, and to a lesser extent Unit 2, has suffered repetitive turbine-generator bearing failures during rundown.

    Improvements have been made to the bearings, their oil supplies and operating procedures. However, a final solution has not yet been applied.

(3) While authorized by the Atomic Energy Control Board to produce full electricity output (746 MW net) both units are currently power limited by main steam pipe vibrations, for which a solution is still being sought.

Major commissioning programs still to be completed before Units 1 and 2 are declared In-Service include:

- booster operation
- achievement of full electrical power
- pre-In-Service reliability demonstration.

In addition, but not necessarily before being declared In-Service for electricity production, the systems and equipment to supply process steam to the Bruce HWP's must be commissioned and placed In-Service.

Overall, the control characteristics and equipment reliability have been encouraging and promise favourable lifetime reliability.

Already, although not yet in commercial service, Bruce NGS-A has produced 2½ TWh. Last December and January when some power cutbacks were necessary in Ontario, Bruce contributed considerably to the avoidance of major power interruptions and to the continuation of profitable exports.

3.2 Bruce HWP-B

To date, the commissioning activities have been devoted to:

1. Completing the pre-commissioning planning and staffing.

2. Carrying out the field commissioning of enriching unit auxiliary and service systems as soon as they are turned over from Construction.

3. Commissioning and placing into service the Plant B Finishing Unit (F2). A dummy run using demineralized water was completed April 30, 1977. Finisher F2 was then connected to the BHWP-A enrichers which are now supplying 16% isotopic water to both the Plant A Finisher (F1) and F2. This mode of operation has 2 advantages:

   (a) Optimize total production of heavy water in 1977-78.

   (b) Ensure F2 will be a reliable unit when the Plant B enrichers are in service.

   F2 has been producing reactor grade heavy water since May 23, 1977.

4.0 STATIONS UNDER CONSTRUCTION AND PLANNING

This includes:

- Bruce NGS-A Units 3 and 4
- Pickering NGS-B Units 5-8
- Bruce NGS-B Units 5-8
- Bruce HWP's B and D
- Darlington NGS Units 1-4
- Future Nuclear Stations

4.1 Bruce NGS-A Units 3 and 4

The construction and commissioning activities on Units 3 and 4 are on schedule. Currently expectations are that Unit 3 reactor will achieve criticality in December 1977 with the unit going into service in mid-1978. Unit 4 is expected to achieve criticality in February 1979 and to go into service in mid-1979.

Unfortunately, until completion of the 500 kV transmission line from Bruce is completed, the maximum power that can be transmitted from the Bruce complex will be limited to about 1700 MW.

4.2 Pickering NGS-B Units 5-8

Expansion of the Pickering Generating Station to 8 units (i.e. the design and construction of Pickering NGS-B) was authorized in July 1974. The Manager of Engineering for the project, John McCredie, gave an excellent paper to the CNA's Sixteenth Annual International Conference.[3] He detailed the changes from the A station which were being undertaken in response to changes in Design and Regulatory Codes. Despite the changes, the B station will in all external physical aspects and in terms of electrical output per unit be virtually identical to the A station.

Construction activities began on the site in 1974, however, the scheduled in-service dates for all units have been set back by one year as a result of the borrowing limits imposed upon Ontario Hydro by the Provincial Treasurer in early 1976. The original and revised planned in-service dates for all units are:

Unit In-Service Dates Pickering NGS-B

Unit	Original	Revised
5	Apr 1, 1980	Apr 1, 1981
6	Jan 1, 1981	Jan 1, 1982
7	Oct 1, 1981	Oct 1, 1982
8	Jul 1, 1982	Jul 1, 1983.

The engineering design schedule for the station was not changed and remains virtually on target on the original schedule. The total design staff in the Engineering Department stands at 119 with support by 170 draftsmen working in the various functional department drawing offices.

At site civil work on Reactor Building (R.B.) 5 is complete and concrete work on R.B. 6 internals is complete and dome construction is underway. Construction of R.B. 7 perimeter wall is in progress and pile-driving for R.B. 8 is 75% complete. The Reactor Auxiliary Bay (R.A.B.) 5 and 6 and control room areas have been turned over to Hydro by the steel erector, Newman Steel. Concrete work, lighting and cable pan installation are in progress. Roofing and cladding are proceeding well. Turbine Auxiliary Bay (T.A.B.) 5 structural steel is virtually complete with Unit #5 deaerator and storage tanks hoisted into position.

Unit #5 R.B. crane is being installed. The calandria for Unit #5 arrived on April 29 and was off-loaded on April 30.

4.3 Bruce NGS-B Units 5-8

Bruce NGS-B will be largely a repeat of the Bruce NGS-A design. Following hard on the heels of the design and construction of the A station as it does, it is unlikely that major changes will be dictated by changes in the Design and Regulatory Codes.

In at least three areas, there will be changes in the design. The Turbine-Generator will be supplied by General Electric. The turbine will be supported on a "tuned" turbine block design approved by Trombik-Stadelman. The steam generators will have integral drums similar to those employed at Pickering.

Construction of the B station, as in the case of Pickering B, has been deferred by a year owing to the reduced borrowing limits previously referred to. This is reflected in the Table below which sets out the original and revised in-service dates for each of the units.

Unit In-Service Dates Bruce NGS-B

Unit	Original 1/S	Revised 1/S
5	July 1, 1983	July 1, 1984
6	Oct 1, 1982	Oct 1, 1983
7	Apr 1, 1984	Apr 1, 1985
8	Jan 1, 1985	Jan 1, 1986

Although end dates for completion of the design part of the schedule have not changed, the civil design has been brought forward to allow for a more orderly progress in the mechanical and electrical aspects of the design.

Grading and excavation began on site during April 1977.

4.4 Bruce Heavy Water Plants -B and -D

BHWP-B

At the end of April 1977, construction of the Bruce HWP-B was 70% complete. In the last quarter of 1976, the instrument air compressor system and the utilities for Finishing Unit F2 were commissioned. The process systems for F2 were turned over to commissioning on January 6, 1977. Pre-startup commissioning checks were completed on schedule on February 18.

On March 31, the Standby Power Facility, comprising three 12 MW combustion turbine generators, was placed in-service.

First extraction of heavy water from the completed B plant is expected in December 1978 with an in-service date late in 1979.

BHWP-D

Plant D schedule was deferred for two years in early 1976 and the currently scheduled in-service date is mid-1981. As of the end of April 1977, construction of the plant was approximately 20% complete.

4.5 Darlington NGS Units 1-4

Darlington NGS will be built on the north shore of Lake Ontario about midway between Oshawa and Bowmanville. Each of the four initial units will have a nominal power output of 850 MW (net). In essence it will constitute an improved Bruce design in which the additional steam from the "stretched" nuclear steam supply used for heavy water production at Bruce, will be supplied to a larger turbine-generator.

The conceptual and preliminary engineering phase of the work has been completed. On announcement of the Environmental Planning Act, provision was made to allow for the exemption of Darlington by Order-In-Council from full environmental hearings. It was expected that the exemption would be granted in the event that little opposition developed following the release for comment of our environmental impact report. The exemption became the first casualty in the current Ontario election.

Unlike the Pickering and Bruce units which are designed primarily for base load operation, the Darlington units are required to have load following capability. Each unit must be capable of cycling 320 days of the year. Each cycle will consist of approximately 18 hours at 100% of full power followed by 6 hours at a lower power level to be specified by the grid control centre (Richview) but which will not be less than 50% of full power.

The table below sets out the scheduled unit in-service dates which have not been relaxed despite the delays being incurred in getting on site.

Unit In-Service Dates, Darlington NGS

Unit	In-Service
1	Nov 1, 1985
2	Aug 1, 1986
3	May 1, 1987
4	Feb 1, 1988

4.6 Future Nuclear Stations

In the table which follows, we have extracted from Ontario Hydro's Long Range Forecast 48A the nuclear stations whose in-service dates stretch out into the 21st Century and have given their currently scheduled unit size and in-service dates.

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NUCLEAR STATIONS IN LRF-48A

Year	Bruce B 4 x 769	Darlington 4 x 850	E-15N 4 x 516	E-16N 4 x 850	E-19N 4 x 850	E-20N 4 x 1200	E-22N 4 x 1200	E-24N 4 x 1200	
1986	Jan	Aug							
87		May	Jul						
88		Feb	Apr	Jul					
89			Jan-Oct	Apr					
1990				Jan-Oct					
91					Jan-Oct				
92					Jul	Oct			
93					Apr	Jul			
94	E-26N 4 x 1200	E-28N 4 x 1200				Apr	Oct		
1995						Jan	Jul		
96			E-30N 4 x 1200	E-31N 4 x 2000			Apr	Jan-Oct	
97	Oct						Jan	Jul	
98	Jul	Oct			E-33N 4 x 1200	E-35N 4 x 2000		Apr	
99	Apr	Jul							
2000	Jan	Apr	Jul				E-37N 4 x 2000	E-39N 4 x 2000	E-41N 4 x 2000
01		Jan	Apr	Oct					
02			Jan-Oct	Jul	Oct				
03				Apr	Jul	Oct			
04				Jan	Apr	Jul			
2005					Jan	Apr	Oct		
06						Jan	Jul	Oct	
07							Apr	Jul	Jul
08							Jan	Apr	Apr

Bruce N.G.S. "A" Power History Units 1-4

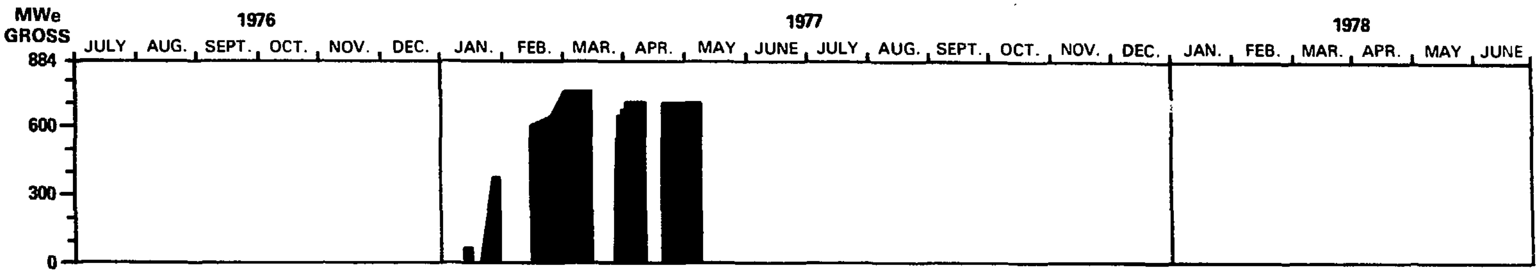
NOTE: Outages of less than three days are not indicated.

Maximum continuous rating gross = 791 MWe
Maximum continuous rating net = 746 MWe
Maximum process steam = 93 MWe (equivalent)

Color Designations
- production (process steam)
- production (electricity)
- planned and maintenance outages
- forced deratings and forced outages

Unit One

criticality date: 17 Dec. '76
first electricity: 14 Jan. '77
full electric power:
full reactor power:
in-service date:
1. electric:
2. electric & steam:

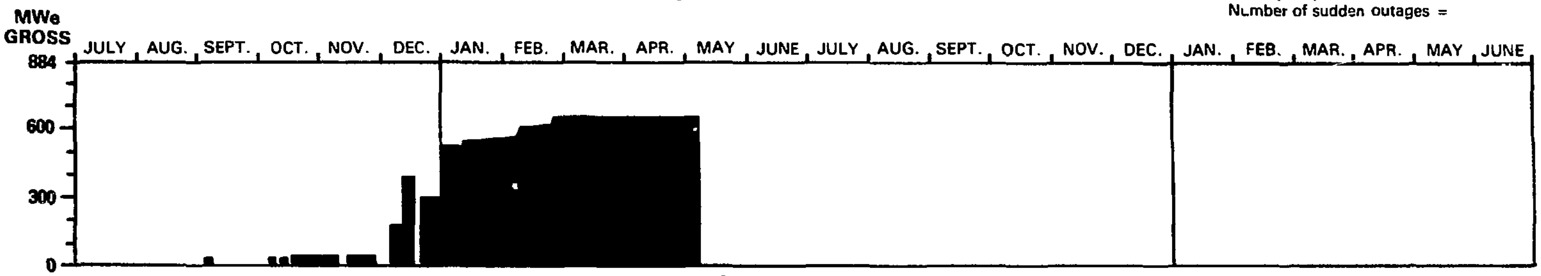


Net capacity factor - 1977 = 43.5 %
Number of sudden outages = 4

Net capacity factor - 1978 =
Net capacity factor since in-service =
Number of sudden outages =

Unit Two

criticality date: 27 Jul. '76
first electricity: 4 Sept. '76
full electric power:
full reactor power:
in-service date:
1. electric:
2. electric & steam:

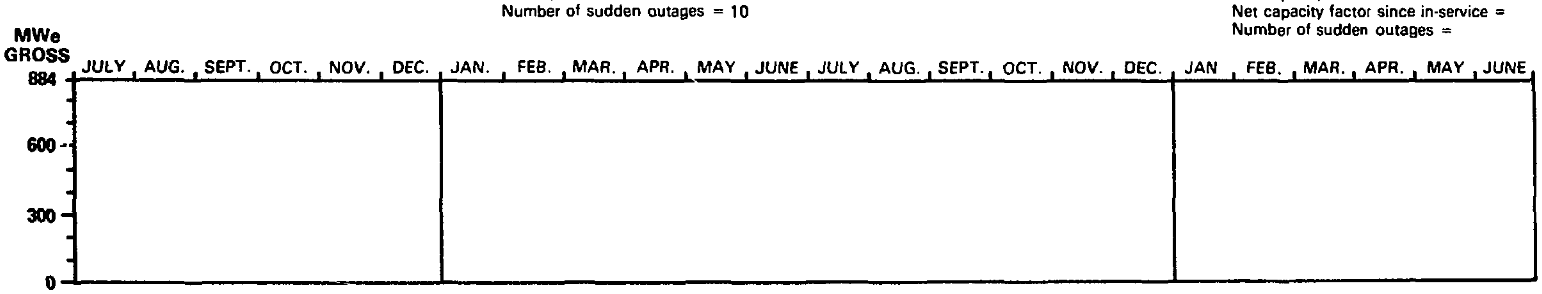


Net capacity factor - 1977 = 64.3 %
Number of sudden outages = 10

Net capacity factor - 1978 =
Net capacity factor since in-service =
Number of sudden outages =

Unit Three

criticality date:
first electricity:
full electric power:
full reactor power:
in-service date:
1. electric:
2. electric & steam:

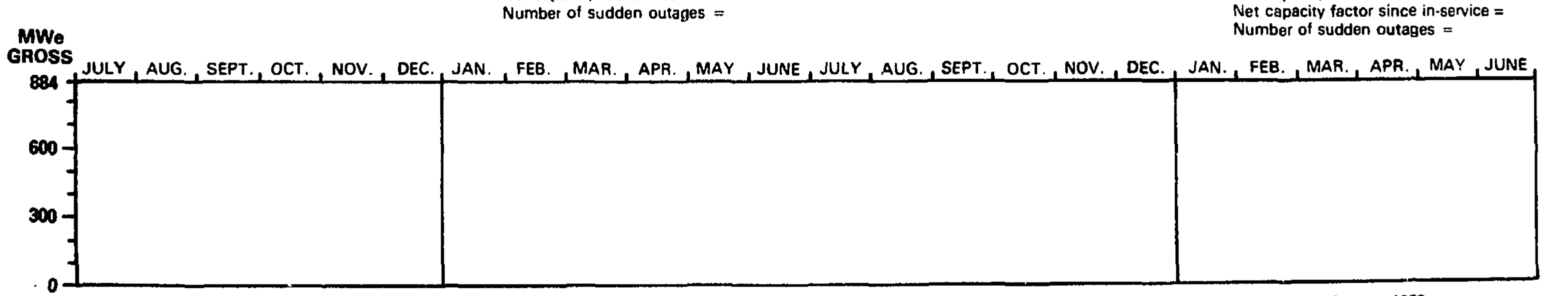


Net capacity factor - 1977 =
Number of sudden outages =

Net capacity factor - 1978 =
Net capacity factor since in-service =
Number of sudden outages =

Unit Four

criticality date:
first electricity:
full electric power:
full reactor power:
in-service date:
1. electric:
2. electric & steam:



Net capacity factor 1977 =
Number of sudden outages =

Net capacity factor - 1978 =
Net capacity factor since in-service =
Number of sudden outages =

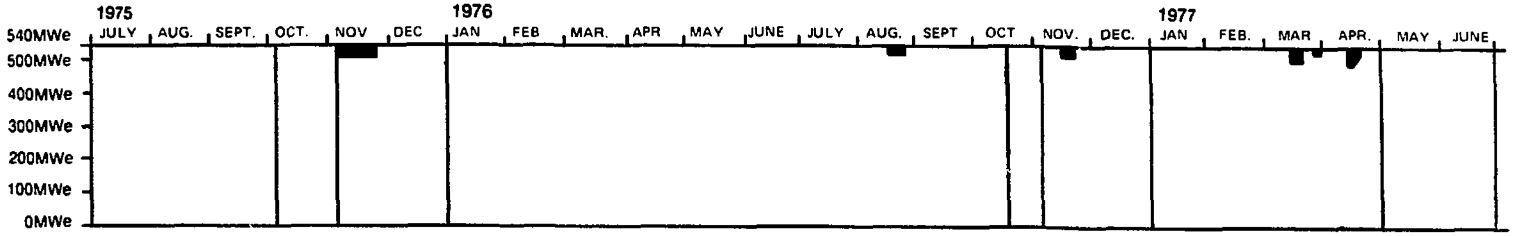
Pickering Nuclear Generating Station Power History Units 1-4

NOTE. Outages of less than three days are not indicated.

Maximum continuous rating gross = 540 MWe
Maximum continuous rating net = 514 MWe

Color Designations
- production
- planned and maintenance outages
- forced deratings and forced outages

Unit One

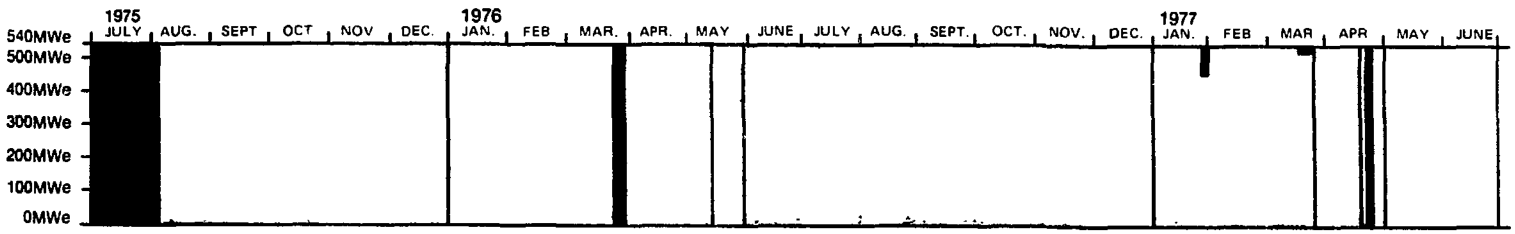


Net capacity factor—1975: 80.2%
In-service date: 29 July 1971
Number of sudden outages in 1975: 2

Net capacity factor — 1976. 92.8%
Number of sudden outages in 1976: 2

Net capacity factor — 1977: 98.3%
Net capacity factor since in service: 78.1% (83.3% Excluding Strike)
Number of sudden outages in 1977: 1

Unit Two

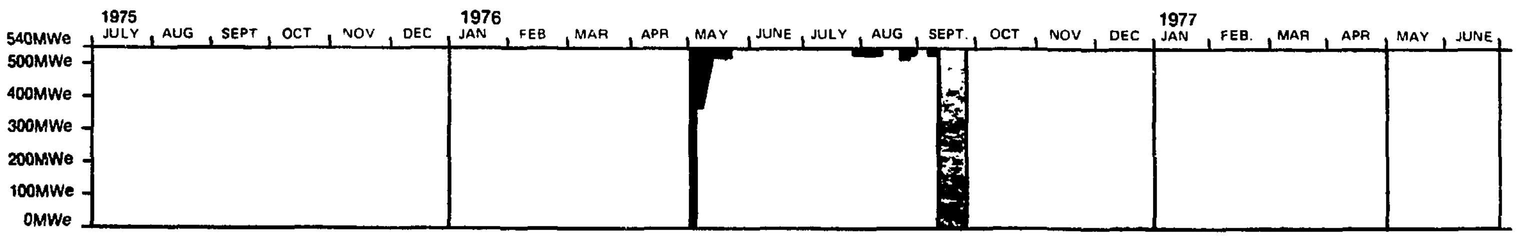


Net capacity factor—1975: 86.0%
In-service date: 30 December 1971
Number of sudden outages in 1975:3

Net capacity factor — 1976: 93.2%
Number of sudden outages in 1976: 1

Net capacity factor — 1977: 76 2%
Net capacity factor since in service: 78.1% (83.3% Excluding Strike)
Number of sudden outages in 1977: 1

Unit Three

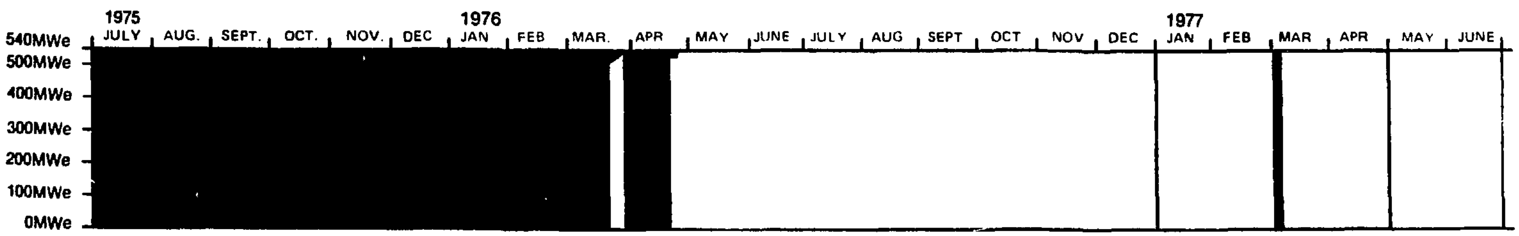


Net capacity factor—1975: 57.5%
In-service date: 1 June 1972
Number of sudden outages in 1975: 3

Net capacity factor — 1976: 93.9%
Number of sudden outages in 1976: 4

Net capacity factor — 1977: 98.2%
Net capacity factor since in service: 67.7% (73.0% Excluding Strike)
Number of sudden outages in 1977. 0

Unit Four



Net capacity factor—1975 23 8%
In-service date: 17 June 1973
Number of sudden outages in 1975 2

Net capacity factor — 1976: 68.4%
Number of sudden outages in 1976 2

Net capacity factor — 1977: 97.4%
Net capacity factor since in service: 69 2%
Number of sudden outages in 1977 1