# A Comparison of Canadian & U.S. Hydro Operations and Maintenance Practices

**TR-109484**

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# REPORT SUMMARY


Phase 1 of the *Comparison of Canadian & U.S. Hydro Operations & Maintenance Practices* project indicates that hydroelectric plants in Canada have significantly lower operations and maintenance (O&M) costs than those in the United States. Phase 2, focused on a more in-depth investigation, will begin as soon as permission is granted by the respective plant owners.

### Background

Deregulation in the electrical generation industry has prompted power utilities to become increasingly interested in benchmarking plant performance. Informal reviews of hydro plant O&M data have suggested that hydroelectric plants in Canada have lower O&M costs than those in the United States.

### Objectives

- To determine, in Phase 1, if the available data on Canadian and U.S. hydroelectric plant O&M performance indicates a significant difference.
- To validate and further document, in Phase 2, findings from Phase 1 that indicate an O&M performance difference.

### Approach

Project managers obtained permission from the Electric Utility Cost Group (EUCG) to use data from their Hydroelectric Productivity Database. Using this database, analysts based their work on summary data from 1994 and 1995, the years for which a full set of data is available. Their results are presented in a series of graphs. To aid in summarizing data and to keep the identity of individual plants confidential, project analysts grouped plants by capacity and moving averages. Performance of U.S. and Canadian plants are kept separate so that readers can easily compare differences between the two.

### Results

Initial analysis of data in the EUCG Hydroelectric Productivity Database does indicate that Canadian hydro plants have significantly lower costs than U.S. plants. It also shows that plant performance, in terms of unit availability, is almost equal for the two countries.

## EPRI Perspective

If the significant O&M cost differences can be validated based on reviewing actual plant information, then reasons for these differences can be determined. These reasons will then lead to improvements in how O&M is performed in the United States and to greater avoided costs and increased hydroelectric competitiveness.


## TR-109484

## Interest Categories

Hydroelectric

## Keywords

Operations
Maintenance
Hydroelectric
Performance
Benchmarking
Cost control

# ABSTRACT

De-regulation in the electrical generation industry has prompted power utilities to become increasingly interested in benchmarking the performance of their plants. Informal reviews of hydro plant operations and maintenance (O&M) data have suggested that hydroelectric plants in Canada have lower O&M costs than those in the United States. The *Comparison of Canadian & U.S. Hydro Operations & Maintenance Practices* project was initiated to conduct a comprehensive review of available O&M data. The objective for Phase 1 was to determine if the available data indicated a significant difference. An initial analysis of data in the Hydroelectric Productivity Database maintained by the Electric Utility Cost Group (EUCG) does indicate that Canadian hydro plants have lower costs than U.S. plants.

# ACKNOWLEDGMENTS

This project would not have been feasible without the cooperation of the Electric Utility Cost Group (EUCG) in allowing the analysis of data contained in the EUCG's Hydroelectric Productivity Database.

The project team also acknowledges the contributions of T. Bond, Chairman of the EUCG Hydroelectric Productivity Committee (HPC) and W.A. Burpee, B.C. Hydro's representative to the EUCG.

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# 1

# INTRODUCTION

## The Comparison of Canadian & U.S. Hydro O&M Practices Project

De-regulation in the electrical generation industry has prompted power utilities to become increasingly interested in benchmarking the performance of their plants. Informal reviews of hydro plant operations and maintenance (O&M) data have suggested that hydroelectric plants in Canada have lower O&M costs than those in the United States.

The EPRI Research Project *A Comparison of Canadian & U.S. Hydro Operations & Maintenance Practices* was initiated to study and compare the available data on Canadian and U.S. operations and maintenance (O&M) practices. The goal is to determine if a significant difference exists between hydroelectric plants in the two countries. This is being accomplished through analysis of the data contained in the Electric Utility Cost Group's (EUCG).Hydroelectric Productivity Database.

The project consists of two phases: The objective of Phase 1 is to determine if the data indicates a difference in cost, reliability and availability between hydro plants in the two countries. If the data indicates a significant difference, Phase 2 of the project will consist of an investigation to determine what the reasons for the apparent differences are.

### *Phase 1: Compare Canadian & U.S. O&M Data*

Phase 1 consisted of four main tasks:

- Obtain Permission to use the EUCG Hydroelectric Productivity Database
- Establish a suitable data analysis format.
- Analyze the information in the EUCG database, process the data and produce graphs
- Prepare a report on Phase 1 of the project

### *Phase 2: Investigate the Differences in O&M Data*

If a significant difference is found in Phase 1, a detailed investigation into the differences will be proposed for Phase 2. This will include interviews with staff at Canadian and U.S. plants in the EUCG group. The sources and methods used by Canadian and U.S. utilities to produce the statistical data submitted to the EUCG will be studied. The possibility that maintenance cycles or other factors may have impacted on the limited time period (two years) covered by the data will be considered. Variations in performance, O&M costs, capital costs and staffing will be assessed.

## EUCG Hydroelectric Productivity Database

The EUCG was formed in 1973 to provide a professional working forum for the electric utility industry and to share confidential information to help individual companies improve their operating, maintenance and construction performance. Productivity data was initially collected only from thermal and nuclear generation utilities. Data collection from hydro utilities began in 1993. The information in the EUCG Hydroelectric Productivity Database comes from a number of U.S. and Canadian utilities. These utilities make annual confidential submissions of hydroelectric operations, maintenance and performance data to the EUCG. The data is entered into the EUCG Hydroelectric Productivity Database by an independent database administrator. The processed data collected from all of the utilities is distributed to each contributing utility annually.

Much of the data requested by the EUCG corresponds to data submitted to the North American Electric Reliability Council (NERC). NERC was formed in 1968 in the aftermath of the 1965 blackout that affected the northeastern United States and Ontario, Canada. NERC's mission is to promote the reliability of the electric supply for North America. NERC maintains the Generating Availability Data System (GADS) database. GADS was created to record power plant operating and outage information for improving the performance of electric generating equipment. In Canada information on power plant operations is collected by the Canadian Electrical Association (CEA).

The EUCG Hydroelectric Productivity Database consists of eight component databases of annual information:

- Performance
- Operations & Maintenance
- Capital Cost
- Burdened Production Cost

- Central Staffing
- Region/Watershed Staffing
- Plant Staffing
- Forced Outage

## Confidentiality of EUCG Data

The contents of the EUCG Hydroelectric Productivity Database are kept confidential within the membership of the EUCG. Permission was received from the EUCG to allow use of the database in this study on the condition that the information published does not identify individual plants or utilities. This was accomplished by grouping plants by capacity and through the use averaged trend lines in the published graphs.

# 2

# CANADIAN-U.S. STATISTICAL DIFFERENCES

## Processing of EUCG Productivity Data

The processing and graphing of data was done using Microsoft Excel. The EUCG Hydroelectric Productivity Database consists of more than a dozen linked dBase tables. One of the tables generated by the database software is a summary of annual plant data. A full set of this summary data from the eight hydro utilities is available for 1994 and 1995. The data for these two years was averaged and used for the Phase 1 data analysis. To aid in summarizing the data and to keep the identity of individual plants confidential, grouping of plants by capacity and moving averages were used. U.S. and Canadian plants are separated so that differences between plants in the two countries can be easily compared. All costs are expressed in U.S. dollars.

## Results of EUCG Productivity Data Analysis

The results of the analysis of the EUCG 94 and 95 productivity data are summarized in the following graphs and table.

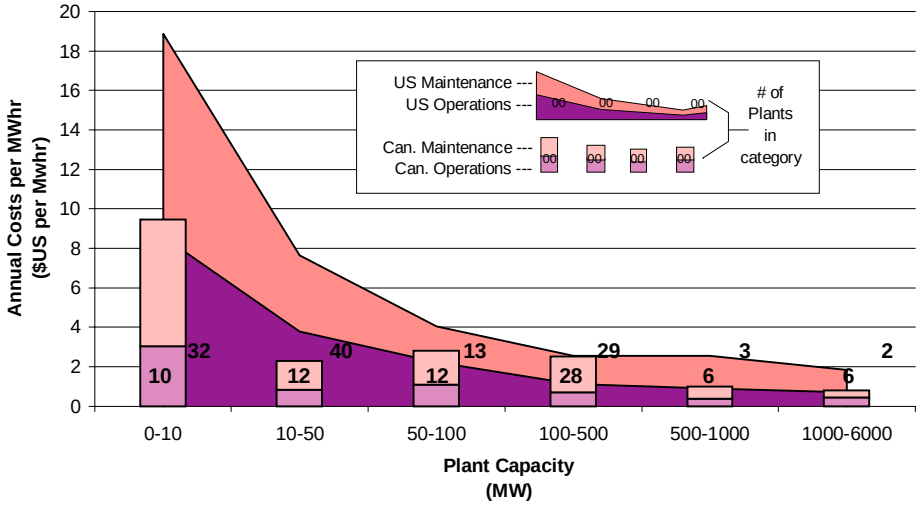


**Figure 2-1**
**Annual Production Costs per MWhr vs. Plant Capacity**

**Table 2-1**
**Annual Production Costs per MWhr**

| U.S. Hydro Plant Costs per MWhr ($US per MWHr) | | | | |
|---|---|---|---|---|
| **Plant Cap. (MW)** | No. of Plants | **PROD. TOTAL** | Maint. Cost. | **Oper. Cost.** |
| 0-10 | 32 | 18.9 | 10.3 | 8.6 |
| 10-50 | 40 | 7.7 | 3.9 | 3.8 |
| 50-100 | 13 | 4.0 | 1.8 | 2.2 |
| 100-500 | 29 | 2.5 | 1.4 | 1.1 |
| 500-1000 | 3 | 3.0 | 1.6 | 0.9 |
| 1000-6000 | 2 | 1.8 | 1.1 | 0.7 |
| **Canadian Hydro Plant Costs per MWhr ($US per MWHr)** | | | | |
| **Plant Cap. (MW)** | No. of Plants | **PROD. TOTAL** | Maint. Cost. | **Oper. Cost.** |
| 0-10 | 10 | 9.4 | 6.4 | 3.0 |
| 10-50 | 12 | 2.2 | 1.4 | 0.8 |
| 50-100 | 12 | 2.8 | 1.7 | 1.1 |
| 100-500 | 28 | 2.5 | 1.8 | 0.7 |
| 500-1000 | 6 | 1.0 | 0.6 | 0.4 |
| 1000-6000 | 6 | 0.8 | 0.4 | 0.4 |

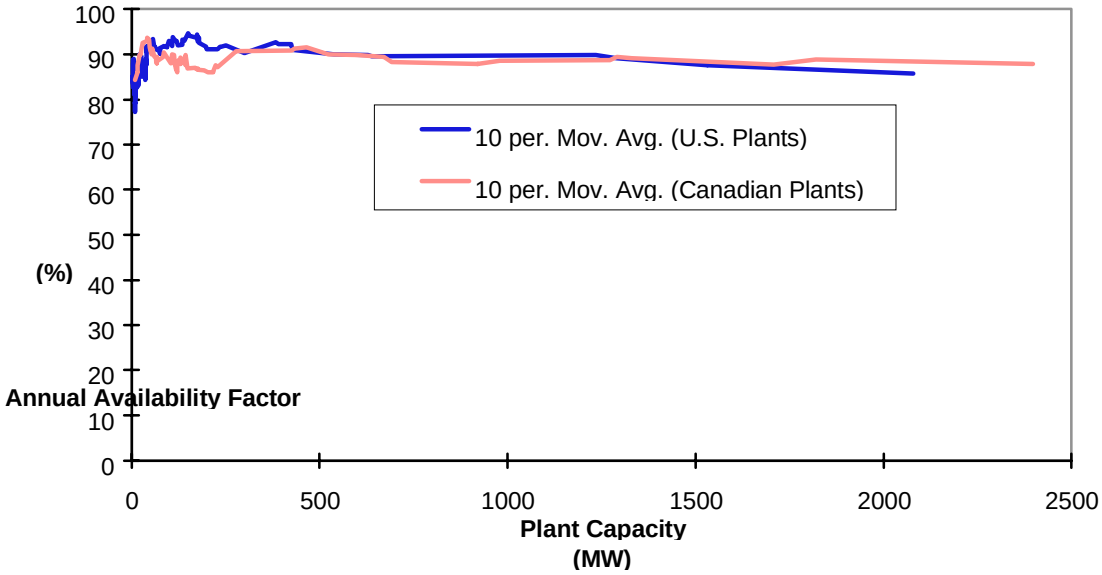


**Figure 2-2**
**Availability Factor vs. Plant Capacity**

In Figure 2-1 a combination bar chart (Canadian plants) and filled line (U.S. plants) format is used. Annual Production Cost is the sum of the annual operations and maintenance costs. The contribution of the two component factors is shown in this graph. Since the objective of this study is to compare the cost of operations and maintenance practices, the water license tax paid by some U.S. and most Canadian utilities has not been included. All costs are expressed in U.S. dollars. The data used to produce this graph is shown in Table 2-1. The second graph in Figure 2-2 compares Availability Factor as a function of Plant Capacity. While the availability of Canadian plants with capacities below 250 MW is slightly lower, the overall availability of U.S. and Canadian plants is very similar.

The full set of graphs used in the Canadian/ U.S. (O&M) analysis are in Appendix A:

- Annual Production Costs per MWh vs. Plant Capacity (MW)
- Annual Operations Costs per MWh vs. Plant Capacity (MW)
- Annual Maintenance Costs per MWh vs. Plant Capacity (MW)
- Annual Maintenance Cost per MW vs. Undepreciated Book Value per MW
- Forced Outage Rate vs Plant Capacity Factor (%)
- Availability Factor vs. Plant Capacity Factor (%)

Most of the graphs are plotted as line graphs using a 10 point moving average. Definitions for each of the graphed parameters are given in Appendix B. They are based on the Data Definitions in the EUCG Hydroelectric Productivity Database User Manual. Most of the graphed variables are defined in terms of other factors which are not graphed. Where plant level definitions are derived from unit level data, both unit level and plant level definitions are given.

# 3

# CONCLUSIONS AND RECOMMENDATIONS

## Conclusions

The graphs of data from the EUCG database show a consistent and significant difference between the Canadian and U.S. plants. They indicate that the operations and maintenance costs are lower for the Canadian plants as compared to the plants in the United States.

## Recommendations

The indicated differences between Canadian and U.S. plants should be further investigated to determine whether all the data has been collected on the same basis. The Phase 1 analysis of the EUCG database was limited to the information available in the Plant Summary data table. In Phase 2 a more in depth analysis of the information in the database should be done. Some anomalies have been found in the data analyzed to date. The source and extent of these inconsistencies should be process, each contributing utility could be offered the opportunity to see how the data from their own plants compares to the averaged values for the Canadian and U.S. plants examined in conjunction with discussions with the contributing utilities. To facilitate a study of the data collection presented in this report.

# 4

# BIBLIOGRAPHY

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*Definitions for Use in Reporting Electric Generating Unit Reliability, Availability, and Productivity*, Institute of Electrical and Electronic Engineers, New York, N.Y., 1986.

# A

# APPENDIX A: GRAPHS

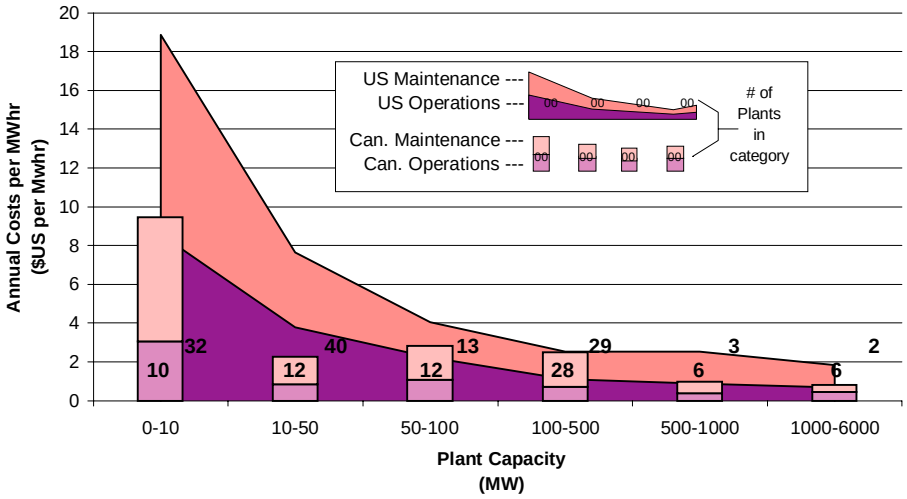


**Figure A-1**
**Annual Production Costs per MWhr vs. Plant Capacity**

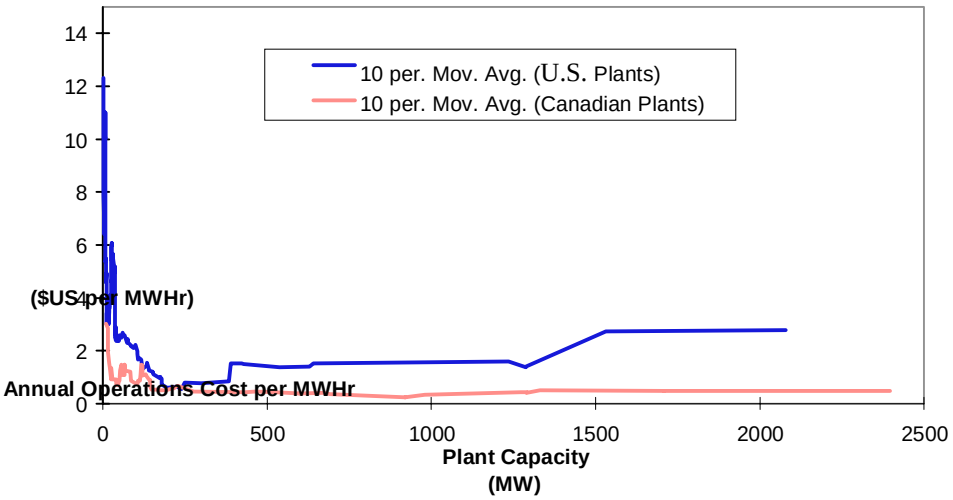


**Figure A-2**
**Annual Operations Costs per MWhr vs. Plant Capacity**

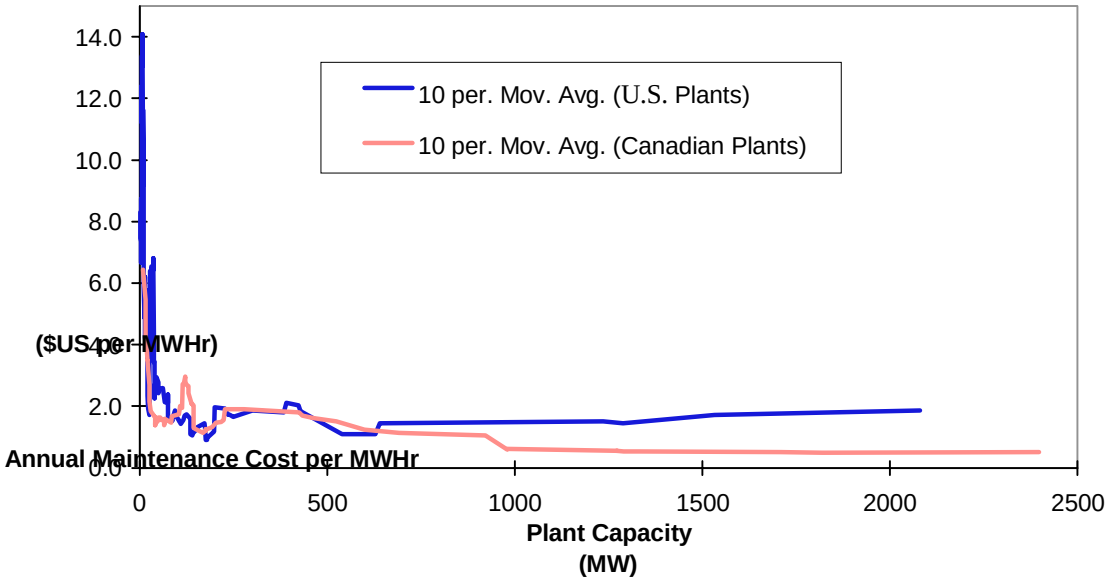


**Figure A-3**
**Annual Maintenance Costs per MWhr vs. Plant Capacity**

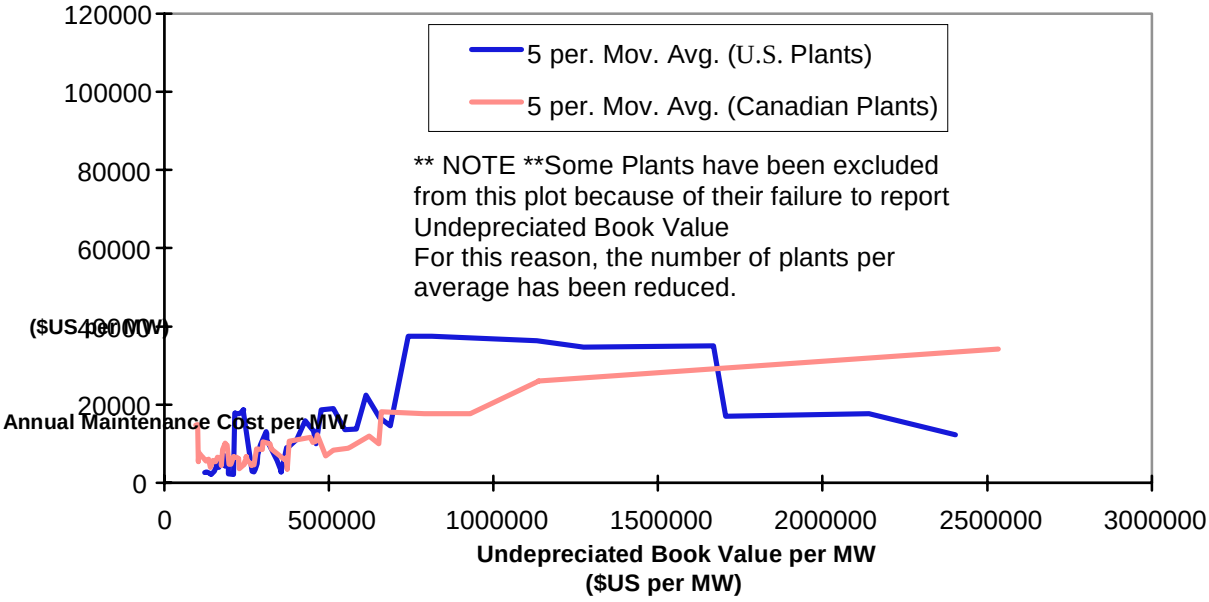


**Figure A-4**
**Annual Maintenance Costs per MW vs. Undepreciated Book Value per MW**

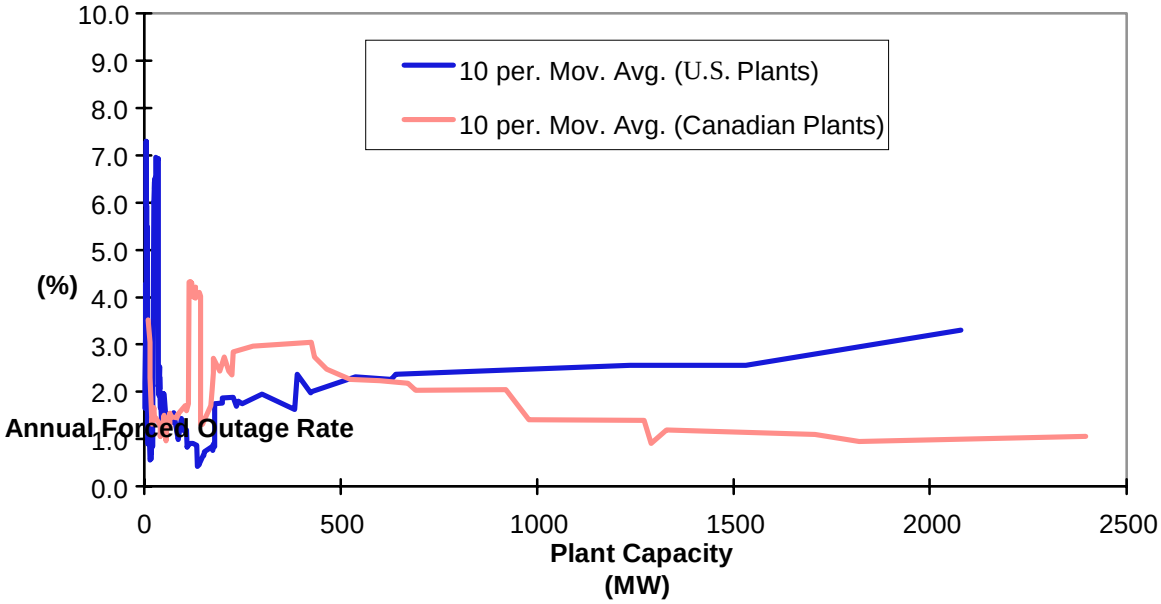


**Figure A-5**
**Forced Outage Rate vs. Plant Capacity**

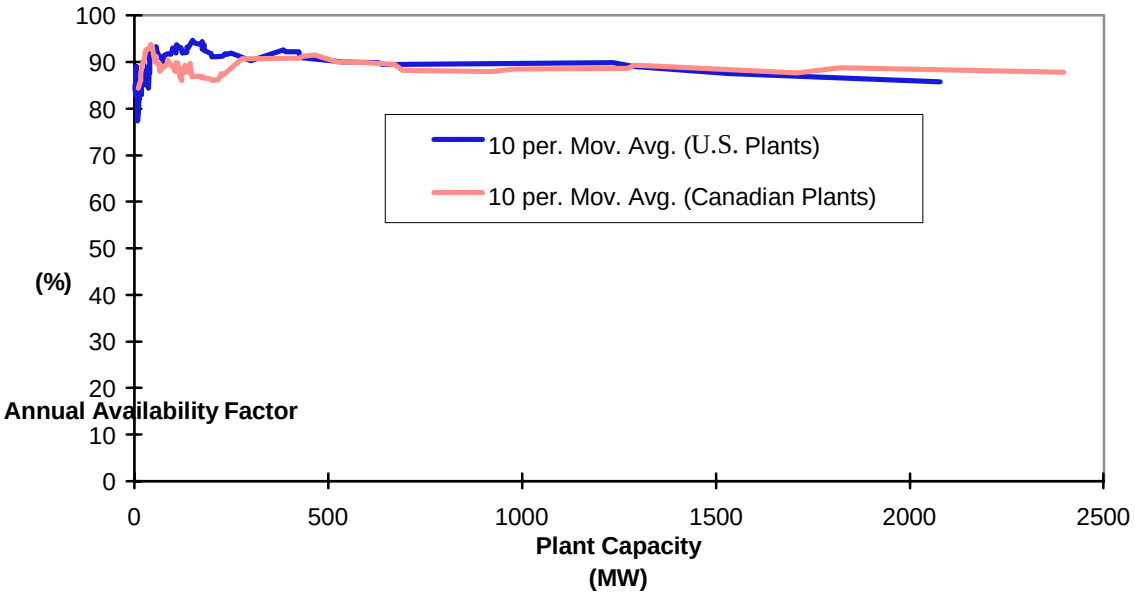


**Figure A-6**
**Availability Facto vs. Plant Capacity**

# *B*

# APPENDIX B: DEFINITIONS OF GRAPHED VARIABLES

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Definitions of the variables graphed in this report are based on the Data Definitions in Section IV of the EUCG Hydroelectric Productivity Database User Manual. Most of the graphed variables are defined in terms of other factors which not graphed. The names of the graphed variables are shown in bold type. Where plant level definitions are derived from unit level data, both unit level and plant level definitions are given. References are made to NERC-GADS or FERC data equivalents where applicable.

**Availability Factor:**

**(%)**

*Unit-level data:* The formula (refer to NERC GADS manual) is:

( AH / PH ) x 100 (%)

Where
AH == Available Hours
PH == Period Hours

*Plant-level data*: *Composite hours* are derived from unit hours as capacity-weighted averages, using the formulas below. This figure is reported as a percentage to two decimal places**.**

Available Hours:

*Unit-level data:* The sum of Service Hours, Reserve Shutdown Hours, Pumping Hours, and Condensing Hours (NERC-GADS Performance Report, Card 02, columns 30 - 33).

*Plant-level data: Composite hours* are calculated from unit Available Hours as a capacity-weighted average, using the formula

$$\frac{\Sigma(\text{Unit Available Hours} \times \text{Unit Gross Maximum Capacity})}{\Sigma\ \text{Unit Gross Maximum Capacity}}$$

Period Hours:

*Unit-level data:* The number of hours a unit was in the active state during the reporting year (NERC-GADS Performance Report, Card 02, columns 54–57).

*Plant-level data: Composite hours* are calculated from unit Period Hours as a capacity-weighted average, using the formula

$$\frac{\Sigma(\text{Unit PH} \times \text{Unit Gross Maximum Capacity})}{\Sigma\ \text{Unit Gross Maximum Capacity}}$$

**Forced Outage Rate:**

(%)

*Unit-level data:* The formula (refer to NERC-GADS manual) is:

[FOH/(FOH + SH)] * 100 (%)

Where
FOH == Forced Outage Hours
SH == Service Hours

*Plant-level data: Composite hours* are derived from unit hours as capacity-weighted averages, using the formulas below. This figure is reported as a percentage to two decimal places.

Forced Outage Hours:

*Unit-level data:* The sum of all hours a unit was off-line due to immediate, delayed, and postponed outages (NERC-GADS Cause Codes U1, U2, U3) during the reporting year.

*Plant-level data: Composite hours* are calculated from unit Forced Outage Hours as a capacity-weighted average, using the formula

$$\frac{\Sigma(\text{Unit FOH x Unit Gross Maximum Capacity})}{\Sigma \text{ Unit Gross Maximum Capacity}}$$

Service Hours:

*Unit-level data*: The number of hours a unit was electrically connected to the transmission system during the reporting year (NERC-GADS Performance Report, Card 02, columns 14 - 17).

*Plant-level data*: Calculate composite hours from unit service hours as a capacity-weighted average, using the formula

$$\frac{\Sigma(\text{Unit SH x Unit Gross Maximum Capacity})}{\Sigma \text{ Unit Gross Maximum Capacity}}$$

**Production Cost:** The formula is as follows:

Operations + Maintenance + Water Rental + Pumped Storage

This figure is calculated using data from the O&M Cost Database and is reported in thousands of dollars.

Total Operations: The total cost of labor, materials used, and expenses incurred in the operation of a hydraulic power generation plant. This figure is the sum of the individual areas defined below and includes the cost of:

Operation Supervision & Engineering Labor
Hydraulic Expense
Electric Expense
Miscellaneous Operations Expense
Rents

This value corresponds to the sum of FERC Accounts 535 through 540, plus pumped storage expenses, plus miscellaneous pumped storage generation expenses.

Operation Supervision & Engineering: The cost of labor and expenses incurred in the general and direction of the operation of hydraulic power generating stations. Direct supervision of specific activities, such as hydraulic operation, generator operation, etc., should be included in the appropriate operations area. This value corresponds to FERC Account 535.

Hydraulic Expense: The cost of labor, materials used, and expenses incurred in operating hydraulic works including reservoirs, dams, and waterways, and in activities directly relating to the hydroelectric development outside the generating station. *Also include* the cost of labor, materials used, and other expenses incurred in connection with the operation of fish and wildlife facilities and/or recreation facilities. A list of items included is in Appendix B of the EUCG Hydroelectric Productivity Database User Manual. This value corresponds to FERC Account 537.

Electric Expense: The cost of labor, materials used, and expenses incurred in operating prime movers, generators, and their auxiliary apparatus, switchgear, and other electric equipment, to the point where electricity leaves for conversion for transmission and distribution. A list of items included is in Appendix B of the EUCG Hydroelectric Productivity Database User Manual. This value corresponds to FERC Account 538.

Miscellaneous Operations The cost of labor, materials used, and expenses incurred which are not specifically provided for or are not readily assignable to other expense: hydraulic generation operation expense accounts. A list of items included is in Appendix B of the EUCG Hydroelectric Productivity Database User Manual. This value corresponds to FERC Account 539.

Rents: All rents of property of others used, occupied, or operated in connection

with hydraulic power generation, including amounts payable for the occupancy of public lands and reservations for reservoirs, dams, flumes, forebays, penstocks, power houses, etc. *It does not include* transmission rights of way. This value corresponds to FERC Account 540.

Total Maintenance: The total cost of labor, materials used, and expenses incurred in the maintenance of a hydraulic power generation plant, and in the maintenance of fish and wildlife facilities and recreation facilities. This figure is the sum of the individual areas defined below and includes the cost of:

Maintenance Supervision & Engineering
Maintenance of Structures
Maintenance of Reservoirs, Dams, and Waterways
Maintenance of Electric Plant
Maintenance of Miscellaneous Hydraulic Plant

This value corresponds to the sum of FERC Accounts 541 through 545.

Maintenance Supervision & Engineering: The cost of labor and expenses incurred in the general supervision and direction of the maintenance of hydraulic power generating stations. Direct field supervision of specific jobs is included in the appropriate maintenance area. This value corresponds to FERC Account 541.

Maintenance of Structures: The cost of labor, materials used, and expenses incurred in maintenance of hydraulic structures.

*Note:* The cost of labor, materials used, and expenses incurred in the maintenance of structures and improvements used in connection with the conservation of fish and wildlife and/or recreation is included in Account 545 (Maintenance of Miscellaneous Hydraulic Plant, below).

This value corresponds to FERC Account 542.

Maintenance of Reservoirs, Dams, and Waterways: The cost of labor, materials used, and expenses incurred in maintenance of reservoirs, dams, and waterways.

*Note:* The cost of labor, materials used, and expenses incurred the maintenance of facilities used in connection with the conservation of fish and wildlife and/or recreation is included in Account 545 (Maintenance of Miscellaneous Hydraulic Plant, below). This value corresponds to FERC Account 543.

Maintenance of Electric Plant: The cost of labor, materials used, and expenses incurred in maintenance of electric plant, including water wheels, turbines and generators, and accessory electric equipment. This value corresponds to FERC Account 544.

Maintenance of The cost of labor, materials used, and expenses incurred in the

| | |
|---|---|
| Miscellaneous Hydraulic Plant: | maintenance of miscellaneous power plant equipment, roads, and bridges. *Also include* the cost of labor, materials used, and other expenses incurred in the maintenance of fish and wildlife facilities and/or recreation facilities. This value corresponds to FERC Account 545 |

**Full-time Equivalents (FTEs):**

The Hydroelectric Productivity Database calculates this figure using the formula

$$\frac{\text{Hours}}{\text{Hours per FTE}}$$

Hours:

For Central & Regional Employees: The total number of productive and non-productive regular hours worked by employees in the specified discipline.

For Plant employees: The sum of regular hours (as described above) plus overtime hours.

The employees included in these figures are those assigned to hydroelectric production in the following areas:

Central & Region/Watershed Staffing

Management
Engineering / Construction Management
O&M Support
Administrative / Financial / Human Resources / Legal.
Regulatory / Environmental Compliance
Other

Plant Staffing

Operations: Plant Oper. staff from first-line supervision down.
Operations Contractors: (as described above)
Maintenance: Plant-based Maint. staff from first-line sup. down.
Maintenance Contractors: (as described above)
Engineering Support: (O&M from first-line supervision down.)

Additional staff not identified below are included in A&G costs or explained in the Notes to Annual Submittal.

Hours per FTE:

The number of hours worked by permanent employees working regular paid hours only.

**Gross Capacity Factor: (%)**

*Unit-level data:* The formula (refer to NERC-GADS manual) is

[GAG / (PH x GMC)] x 100 (%)

Where
GAG == Gross Actual Generation, MWH
PH == Period Hours
GMC == Gross Maximum Capacity, MW

*Plant-level data*:
Plant-level GAG is the sum of GAG for each unit.
Plant-level GMC is the sum of GMC for each unit.
Plant-level PH is the *composite hours* from unit period hours as a capacity-weighted average.
This figure is reported as a percentage to two decimal places**.**

Gross Actual Generation: (MWH)

*Unit-level data:* The actual number of gross electrical megawatt-hours (MWH) generated during the reporting year (NERC-GADS Performance Report, columns 22 - 28).

*Plant-level data:* The sum of gross actual generation for each unit.

Period Hours:

*Unit-level data:* The number of hours a unit was in the active state during the reporting year (NERC-GADS Performance Report, Card02, columns 54–57).

*Plant-level data:* Calculate *composite hours* from unit period hours as a capacity-weighted average, using the formula

$$\frac{\Sigma(\text{Unit PH x Unit Gross Maximum capacity})}{\Sigma\ \text{Unit Gross Maximum Capacity}}$$

Gross Maximum Capacity: (MW)

The total obtained by summing the gross maximum capacity of each hydroelectric unit on the plant site. *Report this figure in MW* to two decimal places.

Gross Maximum Capacity: the maximum capacity a unit can sustain over a specified period of time when not restricted by ambient conditions or deratings (NERC-GADS Performance Report, Card 01, columns 14 - 17).

**Net Actual Generation: (MWH**)

*Unit-level data*: The gross actual generation less any generation (in MWH) utilized for station service or auxiliary loads during the reporting year (NERC-GADS Performance Report, columns 37–43).

*Plant-level data*: The sum of net actual generation for each unit.

**Net Maximum Capacity: (MW)**

The total obtained by summing the net maximum capacity of each hydroelectric unit on site*, reported in MW to two decimal places*.

Net Maximum Capacity: a unit's gross maximum capacity less any capacity utilized for that unit's station service or auxiliary load(NERC-GADS Performance Report, Card 01, columns 29 - 32).

**Undepreciated Book Value:**

The *undepreciated book value* of each area of the generating plant (this is a cumulative figure).

Annual Capital Expenditures:

Annual capital expenditures associated with each area of the generating plant.

Land & Land Rights:

Cumulative data: The cost of land and land rights used in connection with hydraulic power generation. *Also included are* the cost of land and land rights used in connection with the conservation of fish and wildlife and with recreation. *Not included are* costs incurred in connection with first clearing and grading of land and rights-of-way, or any damage costs associated with the construction and installation of plant. This value corresponds to FERC Account 330.

*Annual data:* The cost of all capital expenditures made during the reporting year associated with land and land rights as defined above.

Structures & Improvements:

*Cumulative data:* The cost in place of structures and improvements used in connection with hydraulic power generation. Also included is the cost in place of structures and improvements used in connection with the conservation of fish and wildlife and with recreation. *Also included are* costs incurred in connection with first clearing and grading of land and rights-of-way, or any damage costs associated with the construction and installation of plant. This value corresponds to FERC Account 331.

*Annual data:* The cost of all capital expenditures made during the reporting year associated with structures and improvements as defined above.

Reservoirs, Dams, and Waterways:

*Cumulative data:* The cost in place of facilities used for impounding, collecting, storage, diversion, regulation, and delivery of water used primarily for generating electricity*. Also included is* the cost in place of facilities used in connection with the conservation of fish and wildlife and with recreation. A list of items included is in Appendix C of the EUCG Hydroelectric Productivity Database User Manual. This value corresponds to FERC Account 332.

*Annual data:* The cost of all capital expenditures made during the reporting year associated with reservoirs, dams, and waterways as defined above.

Water wheels, Turbines, and Generators:

*Cumulative data*: The cost installed of water wheels and hydraulic turbines (from connection with penstock or flume to tailrace) and generators driven thereby devoted to the production of electricity by water power or for the production of power for industrial or other purposes, if the equipment used for such purposes is a part of the hydraulic power plant works A list of items included is in Appendix C of the EUCG Hydroelectric Productivity Database User Manual. This value corresponds to FERC Account 333.

*Annual data*: The cost of all capital expenditures made during the reporting year associated with waterwheels, turbines, and generators as defined above.

Accessory Electrical Equipment:

*Cumulative data*: The cost installed of auxiliary generating apparatus, conversion equipment, and equipment used primarily in connection with the control and switching of electric energy produced by hydraulic power and the protection of electric circuits and equipment. *Not included are* electric motors used to drive equipment included in other areas; those motors are included in the area in which the equipment with which they are associated is included. A list of items included is in Appendix C of the EUCG Hydroelectric Productivity Database User Manual. This value corresponds to FERC Account 334.

*Annual data*: The cost of all capital expenditures made during the reporting year associated with accessory electrical equipment as defined above.

Miscellaneous Power Plant Equipment:

*Cumulative data:* The cost installed of miscellaneous equipment in and about the hydroelectric generating plant which is devoted to general station use and is not properly included in other hydraulic production accounts. *Also included* is the cost of equipment used in connection with the conservation of fish and wildlife and with recreation. A list of items included is in Appendix C of the EUCG Hydroelectric Productivity Database User Manual. This value corresponds to FERC Account 335.

*Annual data*: The cost of all capital expenditures made during the reporting year associated with miscellaneous power plant equipment as defined above.

Road, Railways, Bridges:

*Cumulative data*: The cost of roads, railroads, trails, bridges, and trestles used primarily as production facilities*. Also included are* those roads, etc., necessary to connect the plant with highway transportation systems, except when such roads are dedicated to public use and maintained by public authorities. A list of items included is in Appendix C of the EUCG Hydroelectric Productivity Database User Manual. This value corresponds to FERC Account 336.

*Annual data*: The cost of all capital expenditures made during the reporting year associated with roads, railways, and bridges as defined above.