10FO # 14

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Q. Provide copies of all benchmarking studies performed since 1992 relating to electrical system or generating station performance.

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A. The only benchmarking study performed was performed by Haddon Jackson Associates, Inc. (HJA). Hydro engaged HJA in 2000 to do a benchmarking study of all of Hydro's hydroelectric generation (referred to Bay d'Espoir in the report). This study entailed collecting a large range of data and submitting it to HJA. This data was complied and analyzed by HJA along with the data from 244 other stations or groups participating in the study.

Hydro is unable to provide the full text of the study results summary due to confidentiality agreements with HJA and the other participants. However, HJA has authorized the release of the study summary in a modified format to exclude the confidential information. The report as modified is attached.



# HYDRO 2000 Hydroelectric Generation Benchmarking Program

Participant Summary

Newfoundland & Labrador Hydro Churchill Falls (Labrador) Corp.



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# Study Overview Introduction



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### **Panel Composition**

- HYDRO program includes 244 stations, comprised of over 950 units that represent over 75,000 MW of installed capacity.
- Participants are predominately from the United States and Canada, but represented companies from around the globe from Europe to New Zealand.
- The panel of stations is diverse in size, type of facility and age, and includes a mix or run of river, reservoir and pumped storage stations.
- The 244 stations are grouped into approximately 108 station groups. Study results are presented on a station group basis.

### **Functions Benchmarked**

• The hydro business is broken down into distinct functions.

-Operations	-Buildings& Grounds Maintenance	-Public Affairs & Regulatory
-Plant Maintenance	-Investment	-Engineering Services
-Waterways & Dams Maintenance	-Support	

### **Study Segmentation**

- The study results were segmented into various groupings that were flexible and changed based on the area being analyzed.
  - For the most part, segmentation is different for each function.
  - Drivers that determined segmentation were: unit sizes, number of units, age, station group capacity or head.
  - Segmentation was ultimately driven by the cost distribution curves for each function.

### **Expected Costs**

 HJA can now predict costs -- with a high degree of certainty using our data base -- for the Operations, Plant Maintenance and Waterways & Dams Maintenance functions, based on the specific characteristics of your station group.

### Study Overview HYDRO Program Station List



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# Study Overview How Segments Were Determined



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#### Function Cost Segments

First, We Separated Special Purpose Stations From the Others. Then the Remaining Stations Were Segmented Based on Average Unit Sizes and Average Station Group Capacities

#### <u>Special Purpose Stations Cost Performance Was Typically Quite Different Than The</u> <u>Other Stations In The Study.</u>



<u>Costs in General. Decreased. As the Unit Sizes Became Larger. This Relationship</u> <u>Helped Us Establish Appropriate Benchmarking Segments.</u>





All Costs Expressed In U.S. Dollars

- 4

# Study Overview Study Segmentation



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### Findings

- <u>Economies of scale are evident</u> overall, and in most of the functional areas. Cost comparisons recognize and address these structural differences.
- Where economies of scale were present, costs were very closely aligned with <u>the average size of the units in</u> <u>the station group and average station capacity</u>.
- Age of the stations had a significant impact on costs for some of the functions.
- The number of units in the station group was a significant cost driver.
- Costs for special purpose stations were incomparable to conventional hydro stations in some of the functions.

Group 1	Group 2	Group 3	Group 4
Small Hydro	<u>Medium Hydro</u>	Large Hydro Stations	<u>Special Purpose</u> <u>Stations</u>
Average Station Capacity less than 60 MW	Average Station Capacity equal to or greater than 60 MW but less than 700 MW	Average Station Capacity equal to or greater than 700MW	All Stations with Capacity Factors less than 23%

# Study Overview Function Cost/MWH



Average Function Cost/MWH (NO INVESTMENT) PA&R Cost PARTIAL Function Cost Performance Based on Long-**Term Production** Average Bay D'Espoir <u>张뵵웈쁙뎡卓꼆к곾묣ヰ</u>╂윾۶쯥류쥖**줴꺠**ろ읏**牲**옥쀼ᠫ<sup>粪</sup>쀠렮**먺**쏭슊슝큡Ҟ高꿕<del>휬</del> **┽**餐Ⴓ**ຌ**ႸႩჁႵ**ჽ**ႩႳႹჇჽຘຬ 338 PARTIAL Function Cost/MWH -The sum of the following function costs (Operations, Plant Maintenance, WW&D Maintenance, B&G Maintenance and Support), divided by the MWHs produced by the Station Group. No investment costs or PA&R costs included. Long-Term Production AVG -Long-Term Production Average was reported based upon average yearly energy (MWH) produced over an extended period of time (i.e., over the life of the facility or as long as records permitted).

All Costs Expressed In U.S. Dollars



### Study Overview Average Costs By Function And Segment



### Study Overview AVG HYDRO Total Cost Distribution







Study Overview
Bay D'Espoir



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### **Total Cost Distribution**



# Study Overview AVG HYDRO "O&M" Cost Distribution



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Study Overview
Bay D'Espoir



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### **"O&M" Cost Distribution**



## Study Overview **Expected Costs**



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With the Consolidated Data Base, We Can Now Predict Costs For Your Specific Stations, For Operations, Plant Maintenance And WW&D Maintenance Functions

#### **Plant Maintenance**



Regression Analysis Allows Us To Combine The Effects Of The Primary Cost Drivers Into Equations That Predict Expected Maintenance Costs With A High Degree Of Certainty.





<u>Calculating The Expected Cost For Your Station</u> <u>Group Establishes A Reasonable Target That</u> <u>Reflects Your Physical Parameters And</u> <u>Operating Realities. Moreover. We Can Identify</u> <u>The Gap Above Or Below The Expected Cost.</u>

All Costs Expressed In U.S. Dollars

### Study Overview Lessons Learned



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# Study Overview Learned



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# Study Overview Lessons Learned



# Study Overview Lessons Learned



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### Performance / Improvement Opportunities Assessment Framework



### **Cost Performance By Station Group**

- For each station group in the study, a summary spider chart compares the cost per unit of output for each function to the expected costs or the average of the low-cost segment leaders and the segment averages.
- For each axis on the spider the expected costs, or the cost performance of the leading quartile stations for that segment and the segment averages, as well as the actual costs for the Station Group in question are displayed.
  - Participant station group values are identified by an "X" on each axis.
  - Expected costs are identified by a "hollow box" on the appropriate axes.
  - Segment averages are identified with a "solid box."
  - Averages of the low-cost quartiles are identified by a "hollow triangle" on each axis.
- Shaded areas identify where the function cost per unit of output exceeded the expected cost or segment average.

### **Performance / Improvement Opportunities**

- An overview of performance at the function level for key functions is presented.
- Opportunities for performance improvement are also presented for these key functions. Discussions are at the Station Group or company level, as necessary.
- Key functions that are singled-out in this overview for performance and improvement opportunities include:
  - Operations
  - Plant Maintenance
  - Other Maintenance
  - Investment
  - Support
  - Public Affairs & Regulatory
  - Engineering Services

# Performance By Function



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### Bay D'Espoir

Function Cost as Compared to Leading Quartiles / Expected Costs / Averages



### Performance / Improvement Opportunities Performance By Function



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# Performance / Improvement Opportunities **Operations**



Leader **Better Than** Expected Expected Poorer Than Expected Deficient Bay D'Espoir

**Performance Score** 

#### **Performance**

• Operations cost for the Bay D'Espoir station group was poorer than expected, exceeding expected costs by about 50%.

There are special circumstances for both the Bay D'Espoir

stations and , however:
Not all the stations in the Bay D'Espoir station group are fully automated. It is recognized that the Bay D'Espoir station itself has operators in the control room.

• HJA's regression models for operations predict costs based on four primary drivers: automated operations vs. fully staffed on-site control room, number of units, average unit size and MWHs generated.

#### **Improvement Opportunities**

- The Bay D'Espoir station group appears to have opportunities for improvement. Other leaders have shown that:
  - Elimination of routine technical operator staffing at automated remote facilities will take full advantage of station automation and reduce costs.
  - If operators must be present at automated facilities for risk or other reasons, then performance can be significantly improved by broadening the operator's role to perform other functions, especially routine maintenance work. At these leading companies, multi-skilled and multi-functional workers perform both operations and plant maintenance functions.

# Performance / Improvement Opportunities



Leader Better Than Expected Expected Poorer Than Expected Deficient Bay D'Espoir

#### **Performance Score**

#### Performance

Bay D'Espoir station group cost performance in the Small/Medium <45 Yrs. Old segment was poorer than expected, with costs about 28% above that predicted by the models. The service level measure [combination of equivalent forced outage rate, equivalent availability and forced outage rate trend] was about average and placed just about in the middle of the group when ordered from high to low. This results in an overall performance score that was poorer than expected.

 HJA's regression model for plant maintenance predict costs based on four primary drivers: age, average unit size, MWHs generated and number of units.

#### Improvement Opportunities

- For Bay D'Espoir, overall plant maintenance staffing levels are higher than the leaders, resulting in higher overall costs. Leaders have reduced maintenance costs with the following strategies:
  - Reducing layers of management (flatter organization) and increasing workforce flexibility is key to good cost performance. Leaders have learned that traditional discipline oriented work groups (i.e., operators, electrical, mechanical, protection & controls, general maintenance, etc.) with rigid craft boundaries increases costs.
  - Other Leaders have purposely established plant maintenance strategies that minimize dayto-day maintenance staffing levels, and subsequent costs, in favor or periodic infusions of capital for station maintenance. In certain areas, there may be opportunities for considering this approach.
  - Maintenance appears to be performed primarily based upon time-based cycles. Leaders are generally moving toward condition-based assessments or triggers.

### Performance / Improvement Opportunities Other Maintenance



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د	<b>Performance</b>					
	• WW&D maintenance costs for both	the Bay D'Espoir station group and were				
Leader	higher than average. Bay D'Espoir o	costs were about 55% higher than expected by our				
	regressions models,					
	- Bay D'Espoir station group,	, however, had three times the dam surface area than the				
Better Than	next highest station in its se	egment.				
Average						
	HJA's regression model for waterwaterwaterwaterwaterwaterwaterwater	ays & dams maintenance predicts costs based on four				
	primary drivers: single or multiple	stations, number of units, weighted average head and dam				
Average	surface area.	north surger a near then arraying for both stations in the				
	Buildings & Grounds Maintenance	r in the highest cost quartile				
	program, with both stations placing	OUARTHE COST/Sa M				
		AVG Cost of Data Base \$30.70				
Poorer Than D'Espoir D'Espoir		Lower-Mid Quartile \$16.46				
Average		Highest Cost Quartile \$52.78				
	Improvement Opportunities					
	For both Bay D'Espoir and	in WW&D maintenance, configurational issues (high				
	number of large dams) appears to b	number of large dams) appears to be driving the costs higher than data base averages.				
Deficient Deficient	•					
	For the Bay D'Espoir	For the Bay D'Espoir station group, the same issues identified in plant				
WW&D B&G Maintenance	maintenance (flatter organization, f	lexible workforce, reduced maintenance strategies in favor				
Performance Sco	of periodic investment may offer op re	oportunities here as well).				

# Performance / Improvement Opportunities



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#### Performance

- The average investment spending per MW capacity over the last five years for the Bay D'Espoir station group was significantly below data base averages for stations of similar age (about 65% below average).
- The profile for the expenditures, concerning where the money was spent, was similar to the segment averages for the Bay D'Espoir group, but significantly lower.

Gen Equip \$/MW Cont/Monit \$/MW WW&D \$/MW B&G \$/MW P/F&Wild \$/MW TOTAL

	AVG	Bay D'Espoir	·
V.	3,193	1,617	
íW.	272	87	
	713	91	
	967	166	,
N	518	0	
	5,663	1,961	

#### **Improvement Opportunities**

Since both N&LH and are spending, on average, significantly less than other participants, especially in the generating equipment area, needed investments on station equipment may be going unmet. Continued low investment spending on these stations could jeopardize the status in the other functions (impacting O&M costs), as needed plant investments are overlooked or delayed.

<sup>5</sup> Yr. Spending Pattern

# Performance / Improvement Opportunities Support



		<u>Perfo</u>	ormance				
Leader		•	Support costs for the Ba an overall average of \$3	ay D'Espoir station group 32,795 for the data base a	o was \$26,183 nd results in a	per station FTE. This bove average perform	compares to nance.
		•	Expressed as a per cent	t of "O&M" costs (minus)	PA&R), Bay D	)'Espoir support costs	averaged
,			about 25%,			The data base avera	ge of for all
Above			stations was 32%.	<u>Cost Per Station FTE</u> Fleet Services	Data Base Average	Bay D'Espoir	
Average				Purchasing Materials/Warehouse Acctg./Budgeting	1,116 2,614 5,530	1,182 2,363 2,954	
				Legal Human Resources	843 3,035	2,554	· ·
Average				Train & Safety Security	3,329 1,514 965	295 2,363	· · · · ·
				Corp. Mgt/Staff/Facil. Telecommunication Other (Not Identified) TOTAL	6,250 573 4,579 32,795	0 0 16,731 26,183	
		<u>Impr</u>	ovement Opport	<u>unities</u>			
Below		•	Given the current level	s of support costs for bol	th the Bay D'E	spoir station group	
Average			there does not ap	pear to be any significan	it opportunitie	es for improvement. I	However, other
			leaders have shown the	at the following practices	s can reduce o	verall support costs:	•
			- Leaders have s	shown that improved vis	ibility and cor	ntrol over support cos	ts that are
			passed on to th	ne hydro projects is the fi	rst step in get	ting a handle on costs	
Deficient	t offer		- Flattened man eliminated bur	agement structures for so eaucracy and reduced co	upport service osts for some u	es provider organizati atilities.	ons have
	Bay D'Espoir		<ul> <li>Sharing of sup</li> <li>Decentralizing</li> </ul>	port services with other and moving certain sup	organizations port services t	can reduce overall su to the line organizatio	pport costs. ns (i.e.,
	Performance Scor	e	purchasing, wa	arehousing, human resou	urces) decreas	ed overall costs and in	ncreased the

level of user satisfaction and control of the service at other utilities.

### Performance / Improvement Opportunities Public Affairs & Regulatory



Leader Above Average Average Below Average Deficient

#### <u>Performance</u>

- PA&R costs for both the Bay D'Espoir station group were among the lowest of any stations in our hydro data base and both placed in the lowest cost quartile.
- Environmental compliance related costs appear to be the only major PA&R issue impacting both Bay D'Espoir and

	Bay D'Espoir	
	%	\$/MW
Visitor Cntr, Parks, Rec	0.0%	0
Fish/Wildlife Ops	0.0%	0
Fish/Wildlife Study/Analy	0.0%	0
Relicensing	0.0%	0
Real Estate Management	0.0%	0
Environmental Compliance	97.2%	97
FERC & Reg Fees	0.0%	0
Taxes	0.0%	0
Water Usage Fees	0.0%	0
Other	2.8%	3
TOTAL	100%	100

#### **Improvement Opportunities**

- Given the low level of expenditures, there does not appear to be any significant potential for improvement.
- For the future, however, others have shown that proactive and aggressive management of PA&R activities, limiting future commitments is essential -- especially in the fish and wildlife areas. Companies with the highest PA&R costs are those that pay water rental/usage fees, followed not far behind by those that are impacted by fish and wildlife issues. Both N&LH and should attempt to limit future commitments in the fish and wildlife areas.

Performance Score

Bay D'Espoir

# Performance / Improvement Opportunities Engineering Services





#### **Performance**

- Bay D'Espoir station group engineering expenditures were somewhat below average in their segment (\$75,055 per unit vs. a segment average of \$84,282),
- The profile of Bay D'Espoir engineering expenditures were similar to data base averages, with the exception of plant maintenance and investment. More engineering dollars went into plant maintenance than investment. These results are consistent with the low investment spending illustrated on page 24.

Per Cent of Engineering	<u>Data Base</u>	<u>Bay</u>
Costs (by function)	Average	<u>D'Espoir</u>
% Operations	5%	0%
% Plant Maint	17%	33%
% WW&D	22%	27%
% B&G	3%	7%
% Investment	34%	14%
% Support	5%	15%
% PA&R	13%	5%
TOTAL	100%	100%

#### **Improvement Opportunities**

- Engineering services expenditures appear to parallel the low level of investment. No significant opportunities identified.
- 1 Yr. Spending Pattern