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A Study of Project Owner's Costs in the Canadian Hydropower Industry

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Abstract–This paper presents a study of project owner's costs in the Canadian hydropower industry. The study sought to improve the owner company participants' understanding of these costs (including actual/estimate cost growth) and potential owner's cost drivers (e.g., variations by project type, size, complexity, year, and so on.) The study included data from 64 power generation, transmission and distribution projects by the five participating companies in five Canadian provinces. This paper may offer insights to those working in other regions and industries and will provide a reference for an AACE International recommended practice (RP) on owner's costs. As background, the paper proposes a definition of owner's costs and introduces an owner's costs account structure developed for use in the study. After the study, the team initiated draft AACE RP 137R-25 "Owner's Costs: Definition and Considerations for Estimating" [1] that is now a reference to this paper.

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1. Introduction

Most project cost estimates include items that the asset owner is responsible for performing or acquiring. These are often called *owner's costs*. Each company has its own way of estimating and accounting for these costs. The lack of estimating guidelines for these costs and a scarcity of industry owner's cost metrics makes benchmarking owner's cost estimates a challenge. In 2022 a group of five Canadian hydropower companies [part of the Canadian Utilities Cost Engineering [CUCE] joint industry practice group (i.e., "the group")] initiated a study to improve their understanding of these costs and its potential drivers[1]. An impetuous behind the study was a perception that owner's cost may be increasing over time; while time trends were not examined, the study established a baseline for study going forward. The study was facilitated by a consultant working under confidentiality; company specific information was not shared. The study was completed in 2024. This paper summarizes some of its learnings and findings. It shares selected cost metrics and includes a comparison of one key metric to another published metric source.

The group also initiated development of an AACE® International (AACE) recommended practice (RP) to define the term owner's cost and provide estimating guidelines including an industry-generic owner's cost account structure (RP 137R-25, "Owner's Costs: Definition and Considerations for Estimating" [1].) Some wording in this paper and the draft RP is similar because they were developed concurrently.

2. Definition of Owner's Cost and Related Terms

2.1. Owner's Cost Definition

This study required the collection of historical owner's project cost estimate and actual data as will be described later. At the start of the study, the group's first challenges were agreeing on what owner's costs are and to define a cost account structure to support data collection and analysis. There was no AACE definition of owner's costs in RP 10S-90, "Cost Engineering Terminology" [2] and surprisingly few publications were found on the topic. The following is a definition the group settled on (and proposed in the draft RP 137R-25 [1]):

OWNER'S COSTS – The costs of indirect project scope of work activities and items that a prudent owner is typically responsible for performing or acquiring. In project code of account development, it is an element of organizational breakdown (i.e., as opposed to contractor's costs).

The words *typically* and *indirect* would exclude self-performed detailed engineering and construction and owner-procured equipment and materials. The word *prudent* recognizes that some owners fail to take some responsibility for important roles (e.g., taking active part in construction management). The word *acquiring* recognizes that owner's may self-perform or outsource work to a consultant or contractor (e.g., costs of an owner agent for project management team (PMT) tasks would be an owner's cost).

2.2. Project Management Team (PMT) Definition

The PMT oversees the owner's interests and manages the owner's activities. Every major project has at least an owner project manager or equivalent, usually supported by a team of functional leads and specialists (e.g., project controls, construction management, permitting, and so on). Beyond that, owner's costs include indirect activities, deliverables and items typically managed or acquired by the owner such as permit negotiations, stakeholder management, special studies, insurance and so on. Also, owners may acquire some direct equipment and materials and self-perform some work (e.g., commissioning); the last sentence is where industry commonality diminishes as distinctions between owner and contractor roles blur.

[1] The CUCE and its consultant had previously done studies on hydropower generation and power transmission cost growth (accuracy) as reported in AACE International Transaction papers [8] [22] and supported development of AACE RPs on estimate classification for hydropower and power transmission project estimates.

The group recognized that a key focus or core of owner's costs is the PMT given that staffing a team is a central owner planning concern. Given the typical project focus on staffing, one of the metrics that was studied was full-time equivalent (FTE) staffing for the PMT. For a definition of PMT, the group was generally guided by the following definition of PMT activities found in an AACE paper by an upstream oil benchmarking consortium [3]:

- *The PMT staffing includes:*

  1. Senior management, supervision and surveillance, project controls, procurement activities and contracts,

  2. Project support, includes QA/QC, audits, legal,

  3. HSE support, and

  4. Administration, communications, documentation.

2.3. PMT Full-Time Equivalent (FTE) Staffing Definition

FTE is a metric that approximates the number of people in an organization such as a PMT assuming everyone worked full time (which is usually not the case). When the only information measured is the cost for an organizational element, FTE calculations typically use assumed hourly charge rates and hours worked per year by an individual to approximate the head count. For this study, to derive PMT FTEs, it was assumed the average annual cost of owner staffing (in Canadian dollars) was approximately \$100/hour for 2,000 hours/year or \$200,000 per FTE/year. The following FTE calculation was used:

FTE = (\$PMT cost/number of years)/(CAN\$200,000/year).

Equation 1

3. Owner's Cost and PMT Account Structure

3.1. Study of Account Structures

Each study group participating company had its own unique owner's cost account structure. At the start of the study in 2022, the group did not have the benefit of the draft RP 137R-25 [1]. Most owner companies have their own go-by account structures and rules, but perhaps due to perceived wide variability or confidentiality concerns, these structures and data have not been widely published. Before agreeing on the group's study structure, a search was done of published guidelines such as the International Cost Management Standards (ICMS, re: acquisition costs [3]). It was found that most guidelines focus on trade, discipline and/or functional breakdowns, not organizational breakdown which is perceived as unique to each project. Perhaps the best reference found was AACE RP 103R-19, "Project Code of Accounts – As Applied in the Mining and Mineral Processing Industries" [5]. The learnings of the literature search have since been captured in RP 137R-25 [1].

3.2. Code of Account Structures for the Study

The group agreed to the overall total project cost accounts shown in Table 1 to guide cost collection. The study examined metrics such as owner's cost as a percentage of total project costs, therefore Table 1 reflects all project costs at a suitable level of detail for the purposes of the study.

Owner's Office Costs	**Description**
Project Management/Administration	
Engineering	
Front-End Engineering & Design (i.e., FEL 3/Class 3)	Exclude FEL 1/2 (typically expensed). FEL 3 produces mainly diagrammatic deliverables, not take-off ready drawings. May or may not be by a contractor; this line is **only owner involvement in that work**.
Detailed Engineering & Design	Detailed engineering means detail. Usually by a contractor (in Contractor Engineering), so this line is only owner involvement in that work.
Procurement/Contracting/Supply Chain	Owner involvement in these functions. Contractor procurement is in Contractor Engineering
Special Studies	Environmental, geotechnical, and other studies, typically by or involving 3rd party consultants but supervised closely by owner
Owner's Field/Construction Costs	
Indirects	
General: CM/PM, Field Office/Admin, Field Engr, Misc	Owner support staff and expenses during construction; may be home office or field
Owner Furnished Services/Temp Facilities/Utilities	Usually all contracted services, other than camp/catering, by various vendors managed by owner
Owner Furnished Camps/Catering	Usually contracted services for camp/catering supply and operation
Owner Procured Equipment and Materials	Items that the owner procurement department RFPs/acquires.
Owner Performed Construction Labor	Usually limited on major projects, but may include owner operations personnel supporting certain capital efforts
Owner's Startup & Commissioning	Owner staff and operations support of this phase that is capitalized. May include some supplies. Excludes contractor work.
Other	
Mitigations/Compensations/Payments	Misc fees, charges, and so on to regulators, communities, etc.
Misc. Corporate Overheads and other charges	Catch all for costs not directly captured above
Contingency/Reserves on owner's cost (for estimates only)	Risk funds, other than escalation, including in capital funding
Interest	For capital funds during construction

Table 1–Overall Cost Accounts for the Study

Table 2 is a subset of Table 1 that includes the owner's costs as covered by the proposed owner's costs definition. Key exclusions from owner's costs are owner detailed engineering, owner-procured materials and owner-performed construction. It includes payments and corporate overheads. This structure is at a fit-for-use level of detail (as opposed to the detail in RPs 137R-25 and 103R-19 [1] [5]. The Table 1 structure sought to balance the desire for detailed metrics against the difficulty that each company would likely encounter in extracting data from records that used different structures. A lesson learned from prior benchmarking studies by this group was "the more you ask for, the less you get."

Table 3 is the subset of Table 2 that represents PMT costs. It excludes front-end engineering, studies, payments, and corporate overheads.

Owner's Cost Items
Project Management/Administration
Front-End Engineering & Design
Procurement/Contracting/Supply Chain
Special Studies
General: CM/PM, Field Office/Admin, Field Engr, Misc
Owner's Startup & Commissioning
Mitigations/Compensations/Payments
Misc. Corporate Overheads and other charges
Contingency on owner's costs (for estimates only)

Table 2–Cost Accounts for Owner's Costs (Subset of Table 1)

PMT Cost Items
Project Management/Administration
Procurement/Contracting/Supply Chain
General: CM/PM, Field Office/Admin, Field Engr, Misc
Owner's Startup & Commissioning

Table 3–Cost Accounts for Project Management Team (PMT) (subset of Table 2)

4. Analysis Background

4.1 Study Objectives and Data Collection

The study group spent much of 2022 agreeing on the cost account structure and a data collection form[2]. The data requirements were based on the study's objectives which were to 1) use descriptive statistics to get a picture of recent owner's cost metrics, including cost growth, on projects of various sizes and types (e.g., owner's costs as percent of total) and 2) use inferential statistics to better understand potential drivers of owner's cost (e.g., study potential correlation of owner's cost as a percent of total to parameters such as project type, size, complexity, year, and so on.)

To meet the objectives the data form entries included both the sanction estimate (typically Class 3 or 2/tender basis) and the final actual cost values of each account in Table 1. Table 1 includes the contractor costs as well as the owner's costs so that total project costs can be determined. To support normalization and metrics development, the form also captured the sanction year (assumed estimate basis year), asset in-service year, and percentage actual schedule duration slippage. The goal was set to obtain at least ten project records from each participating company with a mix of project sizes and types and completed within approximately the last 10 years (e.g., 2010 or later). Directions were given to the group to avoid selecting projects with all excellent or all poor performance. In the end, the number of projects from each company varied from 5 to 28. It is understood that the metrics may be biased towards the larger sample size companies; potential company bias was not studied or reported to respect confidentiality.

[2] The study, which took over 2 years, with the consultant on a voluntary basis, was done on a "time available" basis.

The study group companies spent much of 2023 and into 2024 completing data collection forms on a time available basis. While quality review was not rigorous, obvious errors were noted and clarification sought. While most of the forms provided entries for the PMT accounts per Table 3, some forms reported no cost in some of the other owner's costs fields in Table 2. It was assumed that given the challenges of deconstructing final accounting records, some costs were combined with other accounts, but some may have been missed. Therefore, some of the variance in the metric results reflects data quality issues, however, the central tendency should be reasonably dependable. In summary, the study metrics cannot be assumed to be representative of either the study group (e.g., differences in sample sizes) let alone industry. However, the results are indicative. The group's view was that this was a screening study that may lead to more focused studies by the group in the future. It is hoped this study and paper encourages others to conduct and report on similar studies.

4.2 Analysis Approach: Methods, Metrics and Variables

The study was done using basic descriptive and inferential statistical methods. *Analyse-it®* standard edition, an add-on for *Microsoft Excel®*, was used for the statistical analyses. Descriptive statistics were developed for the metrics listed in Table 4. These metrics were considered most useful for benchmarking and estimate validation (i.e., comparisons to means, medians, and ranges).

Owner's Costs / Project Costs (percentage)
Detailed Owner's Costs by Account / Total Owner's Costs (percentage)
PMT Costs / Owner's Cost (percentage)
PMT FTE / $10 million Canadian Project Costs
OC Cost Growth: Actual $OC / Normalized Estimated $OC
Total Project Cost Growth: Actual $Total / Normalized Estimated $Total

Table 4–Owner's Cost Metrics Studied

Estimated cost data was normalized to the mid-point year between sanction and in-service completion dates for the purpose of calculating the actual/normalized estimate cost growth metric. The price index used for normalization was the Statistics Canada Non-Residential Building Cost Index [4].

The study also applied basic inferential statistical analysis (e.g., multiple linear regression or MLR; not machine learning) to determine if the input variables were correlated with the metrics. This can improve benchmarking insight and provide predictive models. The independent variables studied (with owner's cost as a percentage of total cost being the primary dependent variable) are shown in Table 5. These are things that the group hypothesized may driver owner's cost. For example, regulatory challenges may place more demand on owner permitting staff resources. Variables were rated on three-point scales (e.g., low/medium/high or similar) or had specific selections (e.g., greenfield, expansion or revamp). Note that projects in progress after 2020 were impacted by significant escalation and other COVID-19 impacts in 2021/22. Therefore, a dummy variable was created for that.

Province (from east to west: QC, ON, SK, MB, BC)
Asset Type (hydropower, transmission, switching station, substation, or distribution)
Project Type (greenfield, expansion, or revamp)
Proximity (3-point scale)
Terrain/Site Conditions/Weather, etc. (3-point scale)
Cost or Schedule Driven?
Stakeholder Challenge; excluding Aboriginal and Regulatory (3-point scale)
Aboriginal Stakeholder Challenge (3-point scale)
Regulatory Challenge (govt, regulators or regulations) (3-point scale)
Environmental Challenge (3-point scale)
New Technology or Scale (3-point scale)
Execution Complexity (3-point scale)
Owner PM/Governance Maturity (3-point scale)
Primary Construction Contract Type (lump sum, unit price, cost reimbursable, turn-key)
Covid (=1 if project active during 2021-2022)

Table 5–Independent Variables Studied

4.3 Dataset Characteristics

The group of five companies located in five Canadian provinces collected estimated and actual owner's costs and total project capital cost data from 64 recent projects. Project size included a mix of small and large projects with actual costs ranging from approximately 200 thousand to 2.5 billion Canadian dollars (median CAN$48 million; mean CAN$100 million) completed from 2010 to 2024. The average duration from the full funding sanction to the in-service milestone was 4 years ranging from 1 to 9 years (the average project execution phase occurred from 2015 to 2019; i.e., pre-COVID-19). Table 4 outlines the number of projects by size and type. CAN$20 million was chosen as an approximate indication of small versus large or major projects[3].

Project Count	Generation	Transmission Lines	Switching Stations	Substation	Distribution	TOTALS
Total	*19*	*20*	*17*	*2*	*6*	*64*
<=$20M	*7*	*8*	*3*	*2*	*4*	*24*
>$20M	*12*	*12*	*14*	*0*	*2*	*40*

Table 6–Number of Projects by Size and Asset Type

The generation project asset types were all hydropower (no wind or solar data was provided although the companies are active in those technologies). Switching stations are higher transmission voltage and substations are lower distribution voltage. Because of small sample sizes, the distribution projects were later combined with transmission and substation projects with switching for studying asset types.

There was a good mix of project scope types and locations. There were 30 greenfield, 11 expansion and 23 revamp projects. Locations were 35 urban/suburban, 15 rural, and 14 remote spread across the five provinces.

[3] Project managers (PMs) tend to be assigned full-time on large projects. On small projects they tend to work part-time, supporting multiple projects. The CAN$20 million criteria was selected based on the consulting analyst's experience. Full or part time PM assignment was not a captured variable being difficult to determine retrospectively.

5. Analysis Findings: Descriptive Statistics

5.1 Account Item Actual Cost as Percent of Total Actual Project Costs

Table 5 reports the descriptive statistics for the component item “percent of total cost” metrics studied. Note that the actual total project costs used in these metrics include interest. The average interest for the dataset was approximately 5 percent of project total actual costs (range of approximately 1 to 15 percent).

As will be shown later, the distributions were typically significantly skewed so the focus of attention should be on the median (i.e., p50) values. Note that only the mean values are additive. Also, when interpreting, keep in mind the data quality issues previously discussed (e.g., a project with low PM costs may have high corporate overhead costs). The hypothesized causes of the low/high range values are discussed later.

Percent of Total Project Cost	P10	Median	Mean	P90
Project Management/Administration	0.4%	2.1%	2.7%	5.4%
Procurement/Contracting/Supply Chain	0.0%	0.3%	0.6%	1.8%
CM/PM, Field Office/Admin, Field Engr	0.0%	4.3%	7.4%	17.2%
Owner's Startup & Commissioning	0.0%	0.1%	1.5%	5.3%
PMT Costs			**12.2%**	
Special Studies	0.0%	0.0%	0.2%	0.6%
Owner Front-End Engineering & Design	0.0%	1.5%	1.8%	4.2%
Mitigations/Compensations/Payments	0.0%	0.0%	0.2%	0.8%
Misc. Corporate Overheads	0.3%	2.1%	2.6%	5.2%
Total Owner’s Cost (PMT + Above)			**17.0%**	
Owner-Performed Detailed Engineering	1.5%	6.6%	7.0%	13.0%
Owner-Provided Temporary Facilities	0.0%	0.0%	0.2%	0.8%
Owner-Provided Camp/Catering	0.0%	0.0%	1.0%	1.6%
Owner-Procured Materials	0.0%	24.0%	24.9%	55.7%
Owner-Performed Construction	0.0%	0.9%	6.5%	24.9%
Interest	0.0%	4.6%	5.1%	10.6%
Total ALL Items Above (OC + Other)			**61.7%**	

Table 7–Actual Owner’s, PMT and Other Owner Costs as Percent of Total Project Cost

Most of the owner’s cost is for PMT field project and construction management (PM and CM) and related costs. The costs for procurement support, special studies and payments in owner’s costs and owner provided temporary facilities and camp in other costs were minimal on average. Users of these metrics should be aware that these metric results may not apply to other industries; for example, many of the projects in this study had significant self-performed construction that may not be as common elsewhere.

On average, contractor costs comprise less than half of total project costs. Overall, the work performed by the owner and material procured by the owner, including interest, is 61.7 percent of project costs on average. Owner performed detailed engineering, materials and construction alone comprise 38.4 percent of project costs on average. As stated, it is likely that the degree of owner-performed work and procurement will vary between industries, and it is hoped that other studies will explore that topic.

5.1.1 Distribution of Actual Owner's Cost as Percentage of Total Actual Project Costs

This paper does not provide the group's statistical analyses at an account level. However, Figure 1 illustrates the distribution and quartiles of the key summary metric of actual owner's cost as a percentage of total actual project costs. This represents the "Total Owner's Cost (PMT + Above)" line in Table 5.

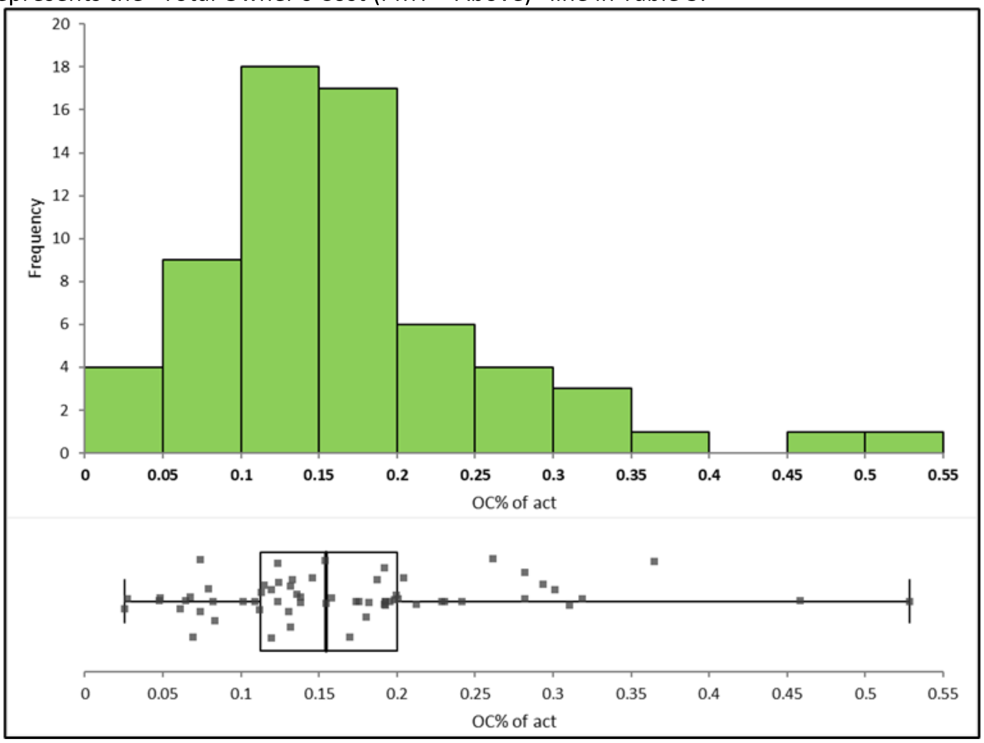

Figure 1–Actual Owner's Cost as Percent of Total Actual Project Cost (Analyse-it® Chart)

The distribution is skewed to the high side (the lognormal distribution is a good fit.) As per Table 5, the mean is approximately 17 percent and the median is approximately 15 percent. The first and third quartiles are bounded by 11 and 20 percent respectively.

The quartile greater than 20 percent is comprised mostly of projects with significant owner performed construction costs which while not included in owner's cost, drives up the cost of the owner construction management and field support role. The quartile under 11 percent was comprised of mostly simple, repetitive projects and/or those with cost dominated by large material purchases which places relatively low demand on owner resources.

5.2 PMT Full Time Equivalent (FTE) Metric Distribution

The PMT accounts in Table 5 are primarily for owner staffing costs. FTE staffing was calculated assuming the average annual cost of owner staffing with a mix of positions is approximately CAN$100 dollars/hour for 2,000 hours per year or CAN$200,000 dollars per FTE per year. The FTE value for a project is:

FTE = (PMT cost/number of years)/(CAN$200,000/year)

Equation 2

This value for each project was then multiplied by a ratio of that project's total actual cost divided by CAN$10 million dollars. The resulting metric is PMT FTEs per CAN$10 million. This metric gives a representation of staff head count for a project of modest size that the study participants can relate to.

Figure 2 illustrates the distribution of PMT FTEs per CAN$10 million for 59 projects excluding outliers[4]. Lognormal would be a good fit for this skewed distribution. The median is approximately 1.0 FTE with first and third quartile bounds of 0.6 and 1.7 respectively. The mean is approximately 1.3 FTEs. For the study's median project size of CAN$48 million, this suggests the PMT would have staffing of approximately 5 FTEs; this may for example reflect a full-time owner project manager supported by perhaps 6 or more people working part-time.

The dataset has 59 projects after excluding 5 projects that had 1 year (rounded) duration. It is believed some of these projects were revamps associated with shutdowns with compressed durations which distorts FTE calculations.

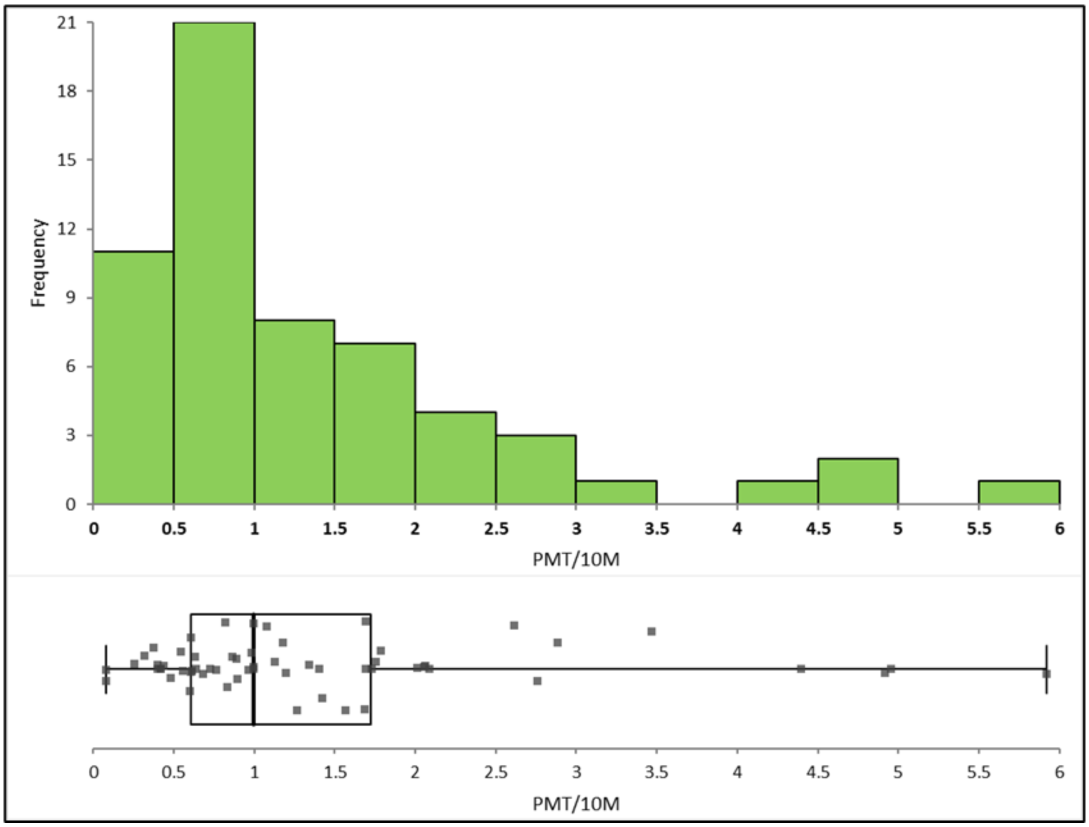

Figure 2–PMT FTE/CAN$10 Million Actual Project Costs (Analyse-it® Chart)

5.2.1 PMT FTE Comparison: Canadian Power Utilities versus Upstream Oil and Gas

The AACE virtual library includes a 2019 paper on PMT costs in the upstream oil and gas industry [3]. It included an equation relating PMT FTE (team size) for small projects which for those project types ranged in cost from USD$60 million to $300 million (CAN$80 million to $400 million.) That study provided a +/- root mean square error value as well. Figure 3 plots their equation converted from FTE per $USD 100 million to FTE per $CAN 10 million and with the root mean square error (RMSE) shown.

[4] Five projects were excluded that had approximately one year duration, likely revamps associated with shutdowns with compressed durations. Very short duration distorts FTE calculations.

For comparison purposes, Figure 3 shows the upstream paper's curve equation extrapolated from $CAN80 million down to CAN$40 million project size. Figure 3 also shows this study's mean, P75, P50 and P25 values for PMT FTE per $10 million for project costs of CAN$48 million (this study's median size). Allowing for the wide range of this Canadian power utility study and the understated RMSE range lines of the upstream oil and gas study, the results are quite comparable. [5]

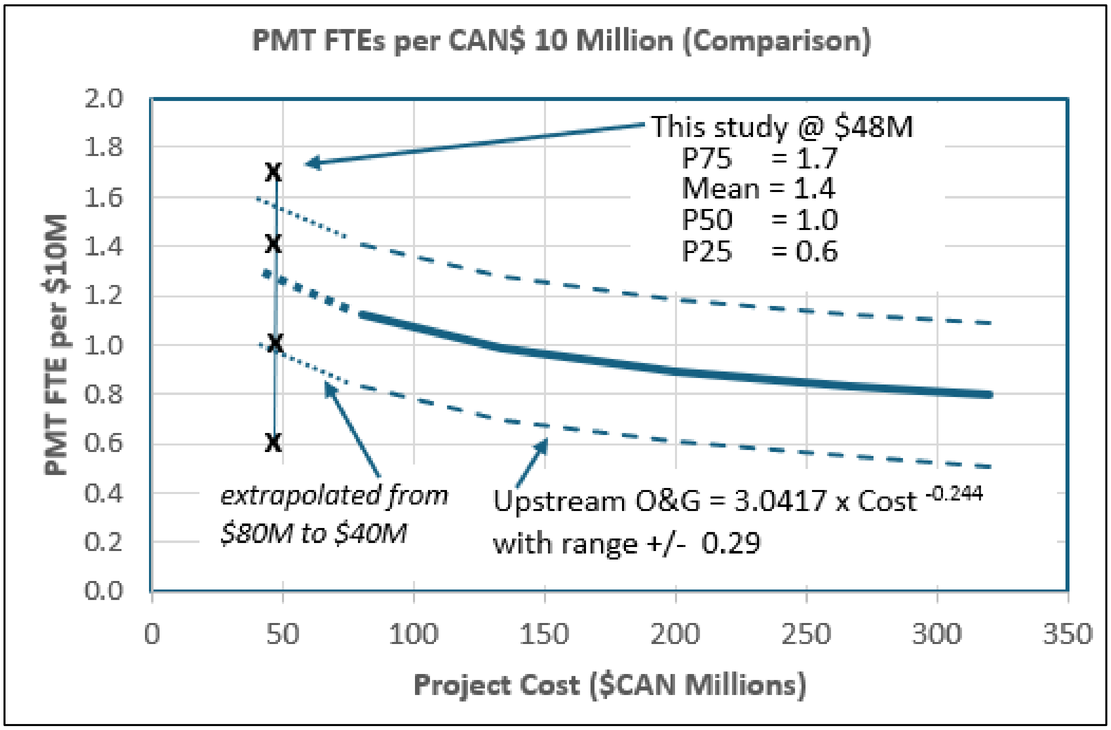

Figure 3–Offshore Oil & Gas [3] vs. Canadian Power PMT FTE per CAN$10 Million Project Cost

The offshore oil and gas study stated that the team size (per USD$100 million) "appears to be fairly consistent across a diverse group of operators and a variety of project sizes, types and locations" and that the "ranges could therefore be accepted as a "rule of thumb" for the offshore industry." The fact that the power utility study PMT FTE results are comparable may be coincidence, but it suggests that PMT FTE headcounts may be similar across multiple industrial project sectors. In that case, a rule of thumb of approximately 1 PMT FTE per CAN$10M is indicated. Later in this paper, some drivers of PMT costs are studied which help explain some of the wide range. The authors hope that other industry groups will study and report on this metric.

5.3 Owner's Cost Growth (Actual/Normalized Estimate)

The study examined owner's cost growth (i.e., contingency usage). The cost growth metric is actual owner's cost/normalized estimated owner's cost; paper Section 4.2 discussed how the estimated costs were normalized. The estimated costs exclude contingency, i.e., it reflects the "base" estimate. For this metric, a value of 1.0 means the actual cost equaled the normalized base estimate (i.e., cost growth of 0 percent.)

57 projects that included owner's cost estimate data were studied. The distribution of owner's cost growth was approximately symmetrical but with a wide range. The median owner's cost growth was approximately 6 percent with a p10/p90 range of approximately -43/+61 percent. Outliers pulled the mean cost growth up to 17 percent. This

[5] The upstream study plotting of a constant +/- RMSE difference from the mean line was a stylistic choice that is not statistically correct. Variance tends to increase as the project size gets further from the dataset mean project size.

wide range is more typical of Class 5 estimates than of the Class 3 or 2 (tender) estimates of this study, but it is not uncommon for estimate cost growth ranges to widen at an item level.

Note that participants also provided the actual percent schedule duration slip experienced. This was requested to see if schedule slip had any correlation to the owner's costs metrics. The average actual schedule slip was 9 percent.

5.4 Total Project Cost Growth (Actual/Normalized Estimate)

Project estimated cost accuracy was not a study focus. However, the overall total project cost growth was calculated to see whether it correlated with owner's cost metrics. 58 projects included total cost estimates. The estimated base costs exclude contingency. For this metric, a value of 1.0 (or cost growth of 0 percent) means the actual cost equaled the total normalized base estimate.

As with owner's cost growth, the total project cost growth distribution for this dataset was fairly symmetrical which is unusual for accuracy data (prior project cost accuracy studies by this group found lognormal distributions were typical [7] [8]). The median and mean cost growth for these Class 3/2 estimates were negative -3 and 0 percent respectively, i.e., on average, these projects did not need contingency. Even if the projects had been funded at a p70 confidence level, the contingency needed would only have been about 9 percent.

The distribution symmetry and the zero mean cost growth (that differed from prior accuracy studies by the group) suggest the possibility that the sample was not representative. One possibility is that participants selected projects that had easy-to-interpret, higher quality cost records, and these projects had less than average cost growth.

In any case, the p10/p90 range of the 58 projects was -20/+39 percent around the base estimate without contingency. Since the p50 cost growth (contingency needed) was near zero, this is also the range around the suggested funded amount at that confidence interval. This equates to the -20/+30% maximum low/high range at Class 3 reported in most AACE estimate classification RPs including for hydropower and transmission.

Note that the cost form requested participants to enter the contingency that was estimated. It averaged 9 percent of the base estimate with an absolute low/high range from 3 to 21 percent. Compare that to the zero percent that was needed on average.

6. Analysis Findings: Inferential Statistics

This section discusses analyses to identify correlations between selected independent variables or drivers (e.g., complexity) and the owner's costs and PMT percentages of total cost metrics. Note that all costs used in these metrics were actual.

6.1 Owner's Cost as Percent of Total Project Costs vs. Project Size

Table 6 examines the actual owner's costs as a percent of total project costs by project cost size range. Industry research indicates that there is a dichotomy between how small versus large projects are managed with project managers typically being assigned part-time for small projects and full time for large ones. While there is no standard, the study used CAN$20 million as the dividing point. The study did not find a statistically significant difference by project size. However, the small projects appear to have a somewhat wider range as might be expected[6].

[6] The Jamieson study for the upstream oil and gas industry graphed their PMT FTE/US$100 million versus project size, the R2 of their regression was only 0.1 which does not suggest a particularly strong correlation with size [3].

Project Size Range	n	P10	Median	Mean	P90
<C$20 Million (Small)	22	4.8%	13.4%	16.3%	30.1%
>=C$20 Million (Large)	40	7.4%	15.6%	15.7%	23.1%
Total	62			15.9%	

Table 8–Owner's Cost as Percent of Total Project Costs vs. Project Size

6.2 Owner's Cost as Percent of Total Project Costs vs. Asset Type

Table 7 examines the owner's costs as a percentage of total costs for hydropower generation, transmission and transmission station project types. Because of small sample sizes, the distribution projects were combined with transmission and substation projects with switching. The study did not find a statistically significant difference by asset type.

Asset Type	n	P10	Median	Mean	P90
Generation	19	6.5%	13.6%	16.8%	28.2%
Transmission (excl. 2 outliers)	24	8.3%	14.6%	16.3%	30.1%
Stations	19	6.7%	15.8%	14.1%	19.5%
Total	62			15.9%	

Table 9–Owner's Cost as Percent of Total Project Costs vs. Asset Type

6.3 Owner's Cost as Percent of Total Project Costs vs. Project Duration

Figure 4 is a graph of owner's costs as a percentage of total cost versus the project duration in years. There are 57 projects after excluding outliers which included one year duration projects. The t-score is 3.06 (>2 is statistically significant) with the trend line percentage almost doubling from the 2 to the 9-year duration extremes. Surprisingly, the average project sizes for the 2-to-3 year and the 7-to-9 year projects are approximately the same. On further examination, it was found that the longer duration projects had a higher percentage of owner-performed construction that takes more time and owner construction management involvement (see Section 6.5).

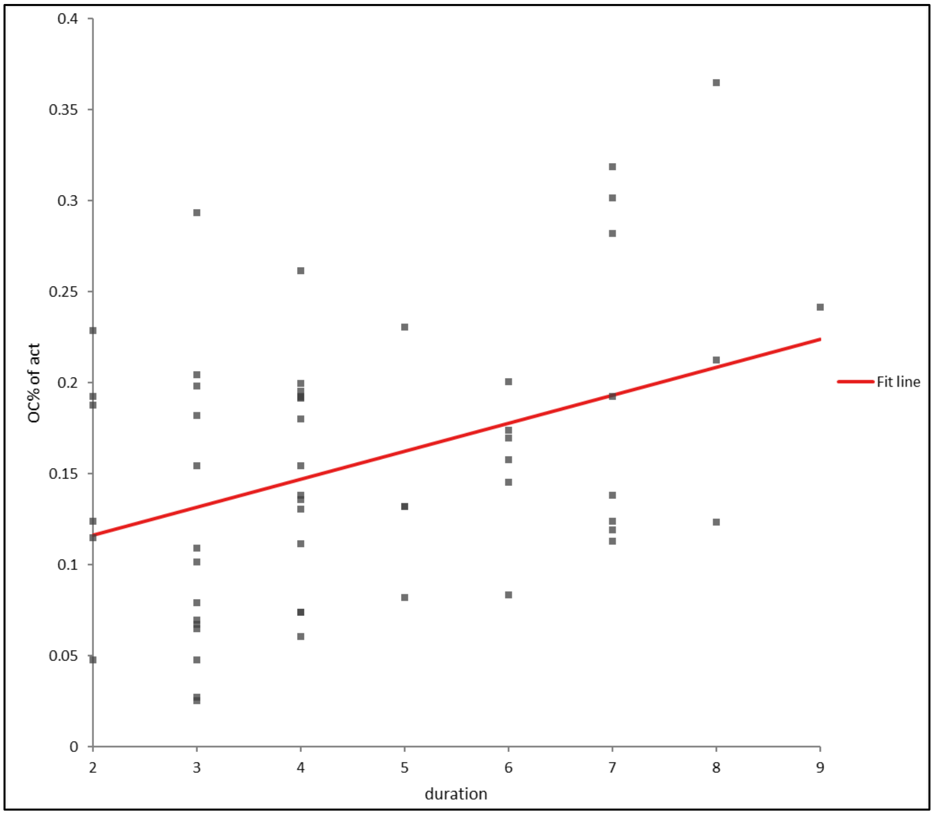

Figure 4–Owner's Cost as Percent of Total Project Costs vs. Project Duration

6.4 Owner's Cost as Percent of Total Project Costs vs. Owner-Procured Material Cost as Percent of Total

[Note: Use caution in interpreting this metric finding and that for owner-performed construction in Section 6.5. owner's cost as a percent of total project will decrease as the percentage of non-owners cost (which includes owner-procured material and owner-performed construction) increases. It is still a useful analysis because these non-owner's costs drive the amount of PMT resources needed, particularly to manage construction.]

As seen previously in Table 5, the average owner-procured material as a percent of total project cost was about 25 percent. Most of this material is major equipment for which these companies often have standing relationships with suppliers. The relationship between owner's cost as percent of total versus owner-procured material cost as a percent of total was not statistically significant. However, the regression trend line slope was negative; i.e., projects with more owner-procured material cost had less proportional owner's cost. Given the lead-in cautionary note, this may not mean much. However, this finding is shared as a lead into the next section, i.e., it appears to take relatively fewer PMT resources to procure equipment than to manage construction.

6.5 Owner's Cost as Percent of Total Project Costs vs. Owner-Performed Construction Cost as Percent of Total

Figure 5 is a graph of owners cost as a percent of total cost versus owner-performed construction cost as a percent of total cost. There are 61 projects after excluding outliers. The average percent owner performed construction costs for this dataset is 6.9 percent.

The relationship is strong with an R2 of 0.17 and a t-score of 3.5 (>2 is statistically significant). The likely cause is that owner construction management (CM) and related costs must increase along with the amount of self-performed construction work. That hypothesis was confirmed by examining CM-related cost item as a percent of total costs versus the owner-performed construction cost as a percent of total. Looking at the CM account only (when charted, it has a similar appearance to Figure 5) has a stronger R2 of 0.22 and a t-score of 4.1. In sum, owner-procured material is less demanding on owner resources and owner-performed construction is more demanding.

As will be shown later, the percentage of owner-performed construction is one of only two variables that are significant in an overall multiple linear regression model (MLR).

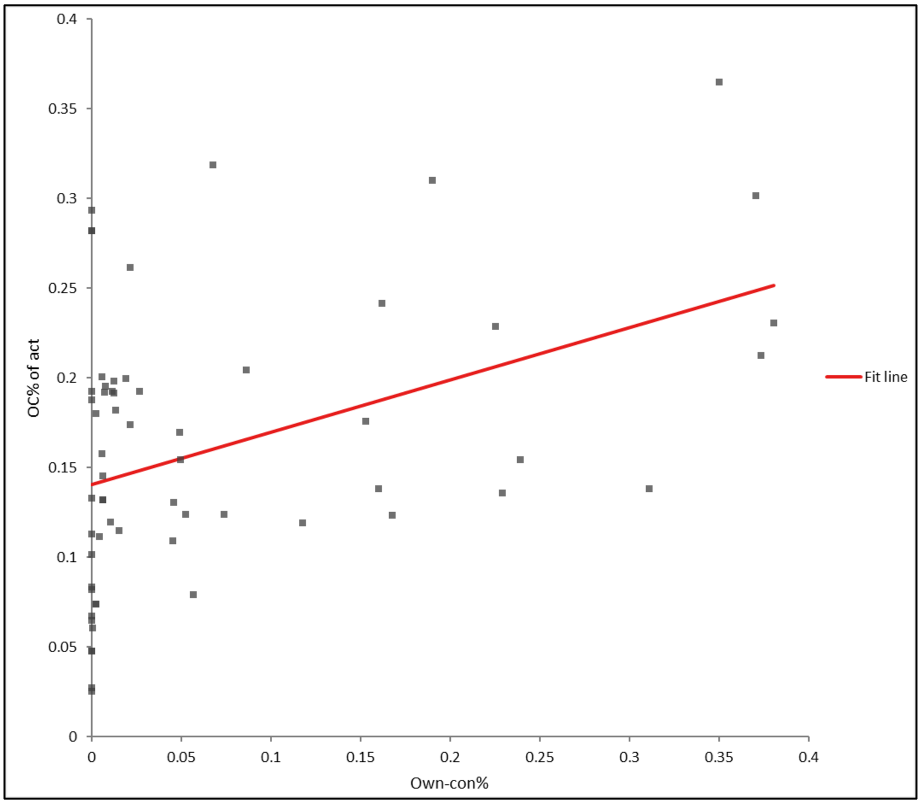

Figure 5–Owner's Cost as Percent of Total Project Costs vs. Owner-Performed Construction Cost as a Percent of Total Costs

6.6 Owner's Cost as Percent of Total Project Costs vs. Construction Contract Type

Table 8 examines the owner's costs as a percent of total by primary construction contract type. There were 62 projects analyzed (excluding two outliers). Given small datasets for reimbursable and turnkey types, they are combined with unit price and lump sum respectively.

Primary Construction Contract Type	n	P10	Median	Mean	P90
Lump Sum or Turnkey	47	6.5%	13.6%	15.2%	26.1%
Unit Price or Reimbursable	15	8.3%	18.0%	18.2%	28.2%
Total	62			15.9%	

Table 10–Owner's Cost as Percent of Total Project Costs vs. Contract Type

While lump sum or turnkey has a lower percent of total, the difference by contract type is not statistically significant. However, examining the owner CM-related cost alone as a percent of total, as was done in Section 6.5, discovered better statistical significance with a t-score of 1.6 (>2 is statistically significant). A likely cause is that unit price and reimbursable work requires more, and lump sum less, CM-related resources to manage. Note that the contract type was not significantly correlated with the project type (e.g., revamp) which is examined later.

6.7 Owner's Cost as Percent of Total Project Costs vs. Various Execution Challenges

For project execution challenge topics were rated as potential drivers of owner's cost. Prior study of US and Canadian power industry project estimate accuracy had found a relationship with project cost growth, so it seemed logical that these challenges may also drive owner's cost. [9] The challenge areas included stakeholder, aboriginal, regulatory, and environmental challenges, collectively abbreviated here as SARE. A hypothesis was that projects facing these challenges would experience greater owner's costs to pay for specialist support, special studies, and/or compensation payments.

For each of the four challenge categories were rated as being low, moderate or high (1, 2, or 3) with the possible total SARE sum range from 4 to 12 (only two projects had a SARE rating >8). Very few projects reported "high" challenges in any category. 57 percent of projects were rated as low in all categories.

Before studying SARE challenges versus owner's costs, the correlation of overall project cost growth (i.e., actual/normalized estimate costs) versus the overall SARE rating was examined to confirm alignment with the prior utility accuracy study findings. Indeed, there was a statistically significant correlation (t=2.2; >2 is significant). This is important to understand because if the non-owner's costs increase with SARE challenges, but absolute owner's costs stay about the same, then owner's costs as a percentage of total costs may decrease with increasing SARE. This was in fact the case. As shown in Figure 6, the owner's cost as percentage of total cost decreases as SARE challenges increase. While the t-score is only 1.6 (t>2 is statistically significant), a relationship seems evident.

In short, SARE challenges drive cost growth for non-owner's costs, but the absolute owner's costs are more nearly constant. One possible reason may be that typical PMT staffing has the capacity for addressing nominal challenges, but this study's dataset did not include the most challenging projects. This is an area for further potential study including such projects.

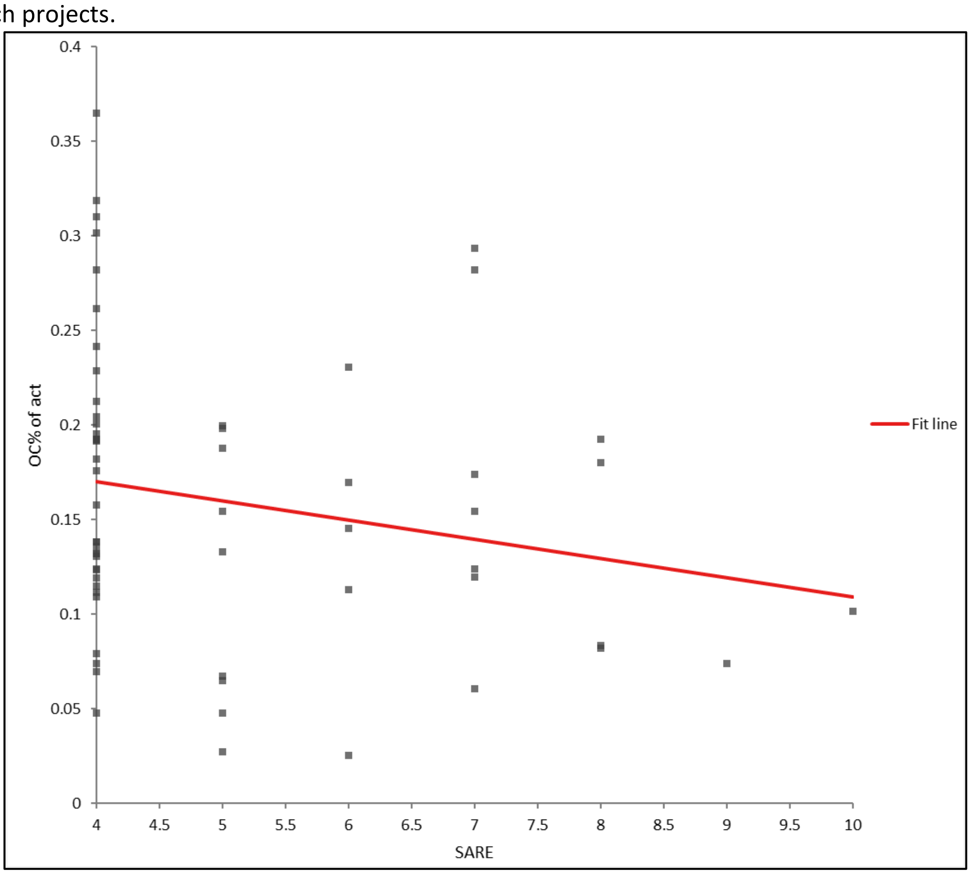

Figure 6–Owner's Cost as Percent of Total Project Costs vs. SARE Rating

6.8 Owner's Cost as Percent of Total Project Costs vs. Project Execution Complexity

Like SARE challenges, it was hypothesized that increasing complexity would drive higher owner's costs. However, the same thing was found as for SARE; the owner's costs as a percentage of total costs decreased with greater execution complexity. As with the SARE case, non-owner's cost growth increased with complexity. However, only two of the 62 projects were rated as high complexity; the rest were roughly split between low and medium. As with SARE, the t-score was 1.6 (t>2 is statistically significant). This is an area for further potential study including more complex projects.

6.9 Owner's Cost as Percent of Total Project Costs vs. Project Type (Revamp)

For this study, projects were identified as being of one of three types: greenfield, expansion/add-on, or revamp. Of the 62 projects analyzed, there were 27, 11 and 24 projects respectively (one co-located project was included in greenfield). Initial examination showed that greenfield and expansion projects had similar owner's cost percents of total, and with expansions being a relatively small sample, they were combined with greenfield. This left two types: greenfield/expansion/add-on or revamp.

Figure 7 shows the relationship between project type and owner's cost as a percent of total cost. Revamp projects, on the right of the Figure, have about 4 percent greater owner's cost percent on average. The t-score is 2.0 (t>2 is statistically significant). The hypothesis as to cause is that revamp project construction within existing assets require more CM coordination with operations. This is an area for further potential study of types of revamp projects.

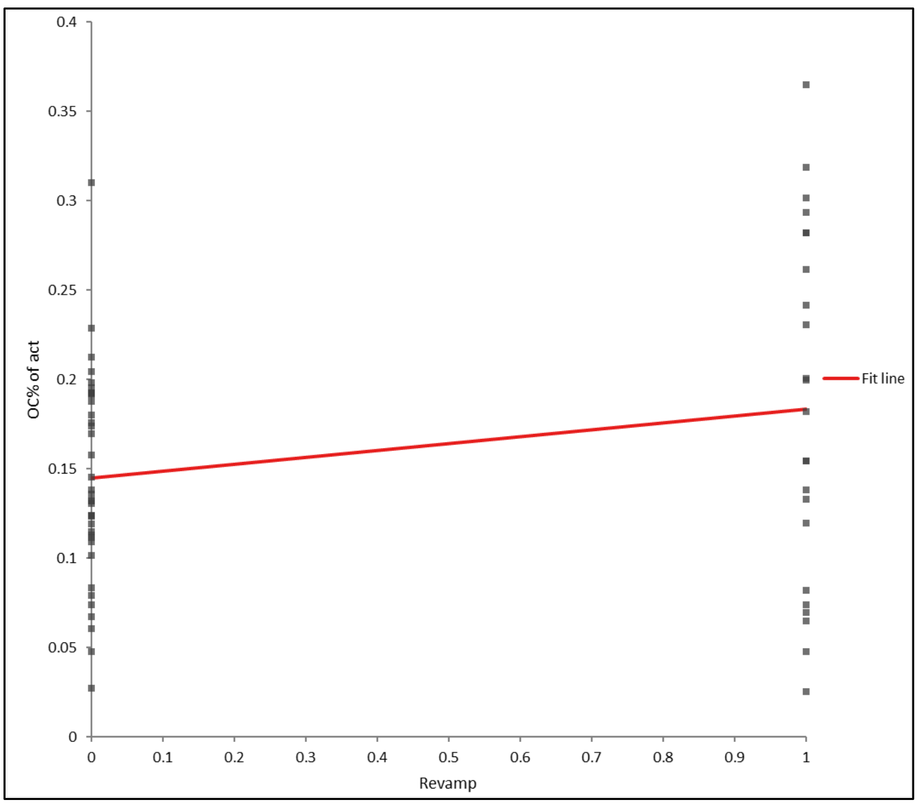

Figure 7–Owner's Cost as Percent of Total Project Costs vs. Project Type (Revamp = 1)

6.10 Variables Without Significant Correlation with Owner's Cost as Percent of Total Project Costs

The following potential driver variables had no statistically significant correlation with owner's cost as a percent of total costs (i.e., t<1 where t>2 is statistically significant).

- Proximity
- Terrain/Site Conditions/Weather, etc.
- Cost or Schedule Driven?
- COVID-19 (=1 if project active during 2021-2022)

The following variables did not have enough range of values to study:

- New Technology or Scale (only two projects rated > 1)
- Owner PM/Governance Maturity (almost all ratings were 2)

The proximity and terrain ratings combined (P+T) did have a close to significant relationship (t=1.7) with total project cost growth. This was similar to the SARE correlation with cost growth. However, the SARE and P+T ratings were strongly colinear, i.e., a regression with them both included as variables did not produce unique results from each of them alone. In any case, non-owners costs cost growth obfuscates results looking at owner's cost as a percent of total versus these variables. This is an area for further potential study of projects incorporating more new technology or at larger scales.

7. Models of Owner's and PMT Costs as Percents of Total Project Cost

After studying the potential driver variables in isolation, effort was made to create multi-variable predictive models of owner's cost and PMT costs as percentages of total actual project cost. A predictive model is one that only uses variables with values that are knowable at the time of doing the estimate. Multiple linear regression (MLR) was used.

Two types of models were developed. One type is for benchmarking or comparison to an already completed total project cost estimate. It may show that the estimated owner's cost as a percent of total is more or less than the model suggests. The other model type is to support preparing a base owner's cost estimate based on a completed base estimate of non-owner's cost accounts. Non-owner's costs in the base include contractor execution, owner-performed construction, owner-procured materials, detailed engineering, owner-provided temporary facilities and camp costs. Interest is excluded from non-owner's costs because it is usually estimated last after total costs are estimated.

Note that SARE challenges and complexity are correlated with project cost growth and hence negatively correlated with owner's cost and PMT cost as percents of final actual total costs. These and actual duration cannot be used in a predictive or benchmark model because the cost growth and ultimate duration won't be known at the time of the estimate.

As described below, the resulting models include only two variables that had statistical significance. While the one-by-one variable analysis identified other variables of interest (e.g., contract type), in MLR, not all will survive as significant (e.g., there may be collinearity between some variables).

7.1 Benchmarking Models

The model variables that had t>2 significance are:

- Owner-Performed Construction percent of total costs, and
- Revamp (greenfield/expansion entered as 0 or revamp entered as 1).

As was discussed earlier in the report, the owner-performed construction as percent of total is not fully independent of the percentage of owner's and PMT costs. More of former reduces the latter. However, they are needed to produce representative metrics, and they do represent drivers of owner and PMT cost resources.

Two models were created: one for owner's cost and another for PMT cost as percents of total cost. All percents are of total project costs and are entered as decimal fractions. The following models have R2 values of 0.23 and 0.25 respectively.

OC% of Total = 0.135 + 0.253 * Owner-Performed Construction % + 0.053 * Revamp

Equation 3

PMT% of Total = 0.084 + 0.309 * Owner-Performed Construction % + 0.042 * Revamp

Equation 4

Back testing the models shows they have a very wide accuracy range of approximately +100/-40 percent at best. This is reasonably consistent with a Class 5 estimate.

As an example application, assume a bottoms-up total cost estimate was prepared for a greenfield project that has 10 percent owner-performed construction. The benchmark for owner's cost as a percent of total using Equation 3 would be as follows:

Example OC% = 0.135 + (0.253 * 0.1) + (0.059 * 0) = 0.16 or 16% of total project cost

(which is close to the overall study dataset mean of 0.17).

7.2 Estimating Models

These models are intended to support preparing a base owner's or PMT cost estimate based on a completed base estimate of non-owner's cost accounts. The models above were run with owner-performed construction variable as a percentage of *non-owner's cost excluding interest*. Note that the t-scores for the revamp variable remained high for these versions, however, the t-score dropped <2 for the owner-performed construction variable. However, the model R2 are still 0.17 and 0.18 for the owner's cost and PMT models respectively.

When using these, it is assumed the non-owner's cost base estimate has been prepared and the percentages of owner-performed construction of non-owner's costs calculated for input.

OC% of Non-Owner = 0.180 + 0.166 * Owner-Performed Construction % of Non-Owner + 0.090 * Revamp

Equation 5

PMT% of Non-Owner = 0.117 + 0.221 * Owner-Performed Construction % of Non-Owner + 0.066 * Revamp

Equation 6

Back testing the models shows they have a very wide accuracy range of approximately +150/-50 percent at best. It is best to do detailed owner's and PMT cost estimates, but the models can be used to challenge the assumptions made.

8. Conclusions

This paper is intended to provide insight into owner's and PMT costs. The study team also initiated an AACE RP to provide a guideline owner's cost account structure [1]. This paper provides owner's cost metric statistics for the Canadian electric power utility industry. A comparison to an upstream oil and gas industry PMT study indicates that the metrics may be useful in multiple industry sectors. This was a preliminary screening study; topics for potential further study are highlighted.

Besides for the metric descriptive statistics, the study provides simple (two-variable) MLR-based models to support benchmarking of owner's and PMT cost in already completed estimates and to support estimating of owner's and PMT base cost to add to non-owner's base cost estimates.

The inferential statistical analysis found that as owner-performed construction as a percent of total cost increases, owner's and PMT cost as a percent of total cost do as well. The study suggests that owner-procured material is less demanding on owner resources and owner-performed construction is more demanding of PMT construction management (CM) related resources. In a similar vein, being a revamp project is correlated with higher owner's and PMT cost as a percentage of total cost, likely because coordinating with operations creates a greater demand on PMT CM.

In fact, the study metrics found that the CM/field supervision/field engineering account dominated the owner's and PMT costs, i.e., it accounted for approximately 43 percent of the total owner's costs and 61 percent of the PMT costs on average for this dataset. This dominance of owner CM related costs likely explains why the only two variables that made it into the MLR models were percent of owner-performed construction and being revamp; these drive the need for CM staff and costs. It is not known if the extent of owner-performed construction is unique to this industry; it is a potential topic for future study.

This study also confirmed the findings of other studies that showed that project challenges from addressing stakeholder, aboriginal, regulatory, and environmental (SARE) issues, as well as project distance from population centers and harsh terrain, are correlated with increased project cost growth. However, contrary to expectations, the owner's and PMT costs in absolute dollars were not significantly driven by these challenges for this group of projects. A possible reason may be that typical PMT staffing levels have the capacity for addressing nominal challenges, but this study's dataset did not include the most challenging projects. A study of more challenging projects would confirm this.

The study also found that the PMT FTE per CAN$10 million metric for these power utility projects was comparable to that of a published study of upstream gas and oil projects.

For those seeking rules-of-thumb for benchmarking purposes, the paper reports mean owner's cost and PMT costs as percents of total cost of approximately 17 and 12 percent respectively. To get a sense of the range, the MLR models predict the values for non-revamp projects with no owner-performed construction are approximately 13 and 8 percent respectively (the constants of the MLR models) and the values for revamp projects with 25 percent owner-performed construction are approximately 26 and 20 percent respectively. The study also suggests a rule-of-thumb of approximately 1 PMT FTE per $10 million Canadian dollars. Caution is advised in using the paper's metrics recognizing the wide ranges observed.

Potential topics for future study include adding electric power projects with more extreme characteristic ratings of size, SARE challenges, execution complexity, and new technology. An update of this study in the future study may identify time trends. It is hoped that other researchers will study and report on projects in other industries and regions (leveraging the owner's cost account structure in the draft RP 137R-25 [1]). In any case, this study demonstrates the value of historical project data collection and analysis.

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