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Project Historical Databases for the Canadian Oilsands

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It has been reported that oil sand deposits in Alberta, Canada may total over 1.6 trillion barrels of bitumen, with potentially over 300 billion barrels of oil recoverable using existing technologies [1]. This makes the Canadian oil sands potentially the largest petroleum resource in the world, perhaps larger than Saudi Arabia. Announced investments to develop oil sands projects currently total over $80 billion. In the last several years, however, there have been significant cost and schedule overruns for major oil sands projects constructed in Alberta. In order to prevent future uncontrolled cost and schedule growth of projects located in this strategically important region of world energy supplies, it is imperative to understand the reasons for why this has occurred. If the owner companies cannot gain control of their runaway project costs, the huge capital inflows to the Alberta oil sands could be slowed. Domestic and international investors will evaluate and determine whether the risk is justified to continue this magnitude of capital investment to the region.

There have been many studies describing the reasons for the major cost and schedule overruns for Canadian oil sand projects. Several of the reasons and contributing issues for the poor project results are listed below:

- lack of experienced owner and contractor resources;
- overall quality of owner and contractor management capabilities;
- ineffective organizational and alliance structures for mega-projects;
- inappropriate delegation of owner responsibilities to contractors;
- lack of clear definition of lines of authority and management responsibilities;
- lack of discipline and ineffective control of project scope;
- complexities of major expansions to existing operating plants
- customization of owner specification requirements;
- level of project definition and complexity not well understood;
- lack of familiarity with the northern Alberta climate, safety requirements, environmental constraints, government regulations, construction practices;
- scarcity of qualified craft workers, high labor costs, inconsistent productivity;
- many competing mega-projects affecting resources and labour availability;
- ineffective contractual arrangements and lucrative contracting environment;
- ineffective material management plans and premature field mobilization;
- inappropriate management influence of cost estimates to meet economic hurdles and ignoring project reality;
- ineffective project control systems and project development practices;
- lack of discipline and consistent application of project code of accounts to allow effective control and collection of actual costs;
- lack of owner front-end estimating capability and project control personnel;
- lack of appropriate risk analysis expertise;
- lack of owner estimate review and validation expertise; and
- lack of owner historical project systems and databases which reflect northern Alberta conditions.

NEED FOR HISTORICAL DATA

In summary, this litany points to a lack of owner understanding and use of basic project management and control practices. It is the owner company's responsibility to respond to these issues, but first they must understand the costs involved in creating their own assets. Effective cost engineering practice depends on effective planning, which ultimately depends on historical data as a basis of understanding. You can't improve if you don't know where you've been and how you got there. In Alberta, owners must begin collecting actual project practices and results, and to maintain this information in a historical project database system. Unfortunately, this type of project historical database and system is not common, but is seriously needed for owner companies that execute capital projects in the Canadian oil sands industry.

"This issue is important enough to have triggered an industry conference in September 2004, dubbed 'Best Practices for EPC Mega-Project Management,' where participants [pondered] all these issues, particularly how to rein in cost overruns. The oil sands industry has also asked the Alberta government to help it develop a project management database accessible to all" [6]. We can debate the merits of this approach, but it is essential that each individual owner company understand the actual costs and schedules that result from the implementation of their specific project delivery processes and systems.

John Hollmann, of Independent Project Analysis Inc., reported in 2002 that the historical project cost database is where the owner "closes the loop on the project control process" [4]. To quantitatively and effectively validate an estimate, a cost specialist must have existing data against which the estimate can be compared. A historical project database provides a collection of such information, including estimated and actual costs for comparison projects, and a variety of key cost metrics and ratios on completed projects. Industry benchmark information should be obtained as well. A secondary benefit of developing a historical database is that the practice of asking for detailed cost proposals and detailed final project closeout data shows contractors that the owner understands project costs and is not likely to be fooled. However, the goal of validation is not to repeat history, but to improve upon it. Validation asks this question: "this is what happened in the past—what are we doing differently the next time to improve, and how much better can we do?"

Before you can collect and analyze cost information, a standard code of account structure must be in place and utilized by all company personnel involved with the execution of capital projects. The implementation of a mandatory code of account structure for charging to projects allows for consistent retrieval and analysis of all information that will be input into the company's project historical database system.

PROJECT CODE OF ACCOUNTS

A project code of accounts is a "structured, coded index of project cost, resource, and activity categories" [8]. A complete project code of accounts includes definitions for the content of each account code; and is methodically structured to facilitate finding, sorting, compiling, summarizing, defining, and otherwise managing the project information linked to each code. A code of accounts is by its nature intended to reduce confusion. Consistent structure and format increases usability; while providing definitions of all elements in a reference dictionary or similar document improves clarity. Each cost code item requires a clear definition of what is included and what is excluded. Common understanding of the attributes of a project code of accounts is important because all projects are the result of team endeavors in which the timely and accurate flow of project cost, resource, progress, and other information is essential to project success.

The practice of benchmarking Alberta oil sands project costs, as well as those of other process industries, at a meaningful level of detail is often a difficult task because of the lack of cost coding commonality. A standard project code of accounts facilitates cost management activities such as internal and external benchmarking, estimating, bid or estimate evaluation, and general communication of cost information. A standard code of accounts provides many benefits for companies, including:

- uniform and consistent basis for all project information, thereby reducing team confusion;
- increased accuracy in actual cost charging and reporting;
- improved ability to integrate and roll-up multiple project cost and schedule level information;
- reduced costs from more accurate and quicker asset capitalization and expensing;
- reduced costs for training;
- improved project reporting credibility due to clarity and a stronger basis;
- improved cost & schedule control due to more accurate trending and forecasting;
- improved ability to audit cost and project progress;
- less effort is required to develop an appropriate code of accounts for each new project;
- improved quality of estimating databases through consistent cost feedback; and
- increased efficiency and accuracy in collection and analysis of historical project cost data.

"Before you can [effectively] collect and analyze cost data you must have a standard cost code of accounts. Fortunately, the elements that support good cost control practices also facilitate historical project analysis functions. A code that differentiates process types, broad activity types , such as engineering and construction, and resource types, such as labor and material, discipline and trades, directs and indirects, will permit useful ratios, factors, and benchmarks to be developed" [5].

After you implement a standard project code of accounts system at your company and begin to collect large volumes of actual project information, what are you going to do with all of this data?

PROJECT HISTORICAL DATABASE SYSTEMS

Implementation of a standard project code of accounts and collection process will allow oil sands project owners to start collecting meaningful project cost data in a consistent manner. With sufficient project cost and schedule information available, an automated system can be developed to house a project historical database. Think of this system as a library, or final repository that contains an electronic database of historical project cost, schedule, resource and technical data from completed projects. These types of systems will most likely have to be developed from the ground up because there are limited commercial applications available for these purposes. The goal of the project historical database system is to collect data and convert it into a strong knowledge base that can be used to drive improvements throughout the project process. It has also been reported that the use of project historical databases by owner companies is correlated with improved project performance [4]. And it is this improved project performance that owner companies in the oil sands industry need to pursue as a high priority initiative within their organizations.

The project historical database system should enable you to provide benchmarking data and metrics to monitor project cost and schedule performance, provide meaningful ratios and statistics to aid estimate reviews and validation, provide estimating database feedback and calibration, and can serve as a strategic cost estimating tool to generate estimates based on benchmark measures.

The associated database should collect summary level cost information, estimates and actual costs, as well as related scope and schedule information. Products flowing out of the historical data collection process are calculated benchmarks, ratios, factors, and other information required to measure and evaluate performance and quality of both individual projects, as well as the overall project system. The project historical database system contains information that fall into these categories [5,7]:

- Tools for Strategic and Conceptual Cost Estimation and Scheduling—information includes ratios, factors, benchmarks, parameters, cycle time, and other data calculated from project histories that are essential to estimating, budgeting, and project front end planning of future projects.
- Measures of estimating database quality—feedback on actual project costs help improve the detailed estimating cost database by calibrating labour productivity factors, and material pricing.
- Measures of project, function and organizational quality and performance—information can be collected to develop objective factors related to issues such as rework, unit productivity, process variance, and cost of quality compared to other projects. Subjective project factors influencing project costs can also be captured.
- Tools of organizational forecasting—historical data can be used to produce objective factors that can be applied to gross budget forecasts to yield organizational workload and resource forecasting based on technical and performance characteristics of the project backlog.
- Tools for planning—work breakdown structures, schedule logic, account coding, lessons learned from both successful and failed approaches, and other supporting information can be used to improve project front end planning for future projects.
- Tools for risk assessment—historical project data can be used to identify risk factors for evaluating project risk, such as considering the impact of technology selection, project delivery methods, execution strategies, etc.

As a project nears completion, all relevant closeout information should be assembled for transmittal to the group that uses and maintains the project historical database system, most likely your estimating department. The collection of this project information should be mandatory and in accordance with the formal project process that each company has hopefully implemented. An example of the project historical deliverables and closeout information that needs to be collected would be as follows [7]:

- project summary information—basic project / area fact sheet identifying process unit capacities, etc. and written project narrative with findings and appraisals;
- scope documents—project requirements document, conceptual design proposal, basis of design document, project organization chart, approved preliminary and final funding documents, and final project acceptance notice;
- schedule—final statused master summary schedule, special control level or detail schedules and engineering and design progress reports;
- project coding structure—project work breakdown structure, project code of accounts and construction work package structure;
- project estimate—final project estimates, final basis of estimate document and key estimating backup information;
- cost and performance—cost reports by process area, final cost control report, final change order log, project cash flow curves and project performance curves;
- contracts—contract bid summaries, subcontract plan and unit price and other detail cost submittals; and
- technical—plot and site plans, block flow diagram and P&ID's, priced equipment and procurement lists and drawing list.

After implementing a project historical database system, it is surprising how many uses will materialize for this data. As the database of completed project histories grows, and the types of projects becomes diversified, many opportunities to analyze and manipulate the information will arise. Statistical analysis can generate strategic information such as investment curves, charts of project or equipment cost versus capacity, various estimating factors and ratios, indirects to direct field cost, engineering hours per piece of equipment, percent engineering by project type, etc. It can also be used to generate organizational planning metrics such as the number of engineering hours required per million dollars of capital project investment.

It is important to recognize that this data is sensitive and proprietary company property. Adequate security and access controls should be put in place to protect the information.

ESTIMATE VALIDATION

One of the main benefits of having a project historical database system is that it will provide the capability to assist in the effective review and validation of project cost estimates. A comprehensive estimate review process will include an estimate validation metrics report that compares several key benchmark ratios and factors versus historical values from similar projects. The historical database system should have the capability to provide metrics from both an owner's internal company projects in addition to any external or industry project metrics that may be available.

The goal is to ensure that key metrics from the estimate are in line with the same metrics from similar projects. If there is a large discrepancy, it must be explainable by the particular circumstances of the estimated project versus similar completed projects. Such comparison metrics may include values such as percent of administration (home office) costs, percent of engineering/design costs, equipment to total field cost ratios, equipment to total project cost ratios, cost per piece of equipment, labor hours per piece of equipment, and cost to plant capacity ratios ($/BBL, $/SF). Sometimes the metrics will be generated down to the discipline level where you may look at ratios such as cost per diameter inch of piping, cost per cubic yard of concrete, and cost per ton of steel [3]. There are literally hundreds of benchmark fac-

EXAMPLE ONLY

COST RELATIONSHIP	COMPANY HISTORY LOW	COMPANY HISTORY AVG	COMPANY HISTORY HIGH	EST	VAR	INDUSTRY DATA AVG	INDUSTRY DATA VAR
TOTAL PROJECT $ / EQUIPMENT $	2.38	4.97	6.98	**4.77**	-4%	4.86	-2%
TFC $ / EQUIPMENT $	1.65	3.45	4.79	**3.20**	-7%	3.59	-11%
TOC $ / EQUIPMENT $	0.51	1.21	1.72	**1.15**	-5%	1.18	-3%
TFL $ / EQUIPMENT $	1.09	1.99	2.41	**1.80**	-10%	1.89	-5%
PROJ MGMT $ / TOTAL PROJ $	0.022	0.043	0.065	**0.037**	-14%	0.046	-20%
PROJ MGMT $ / TFC $	0.009	0.063	0.099	**0.054**	-14%	0.064	-16%
PROJ MGMT $ / TOC $	0.152	0.233	0.320	**0.210**	-10%	0.212	-1%
PROJ MGMT $ / EQUIPMENT $	0.190	0.295	0.452	**0.260**	-12%	0.241	8%
ENGR+DESIGN $ / TOTAL PROJ $	0.122	0.168	0.272	**0.198**	18%	0.189	5%
ENGR+DESIGN $ / TFC $	0.141	0.243	0.342	**0.291**	22%	0.262	11%
ENGR+DESIGN $ / TOC $	0.420	0.690	0.880	**0.872**	26%	0.779	12%
ENGR+DESIGN $ / EQUIPMENT $	0.810	1.020	2.000	**1.173**	15%	1.020	15%
TOC $ / TOTAL PROJ $	0.162	0.231	0.292	**0.245**	6%	0.229	7%
TOC $ / TFC $	0.190	0.310	0.550	**0.341**	10%	0.319	7%
TFC $ / TOTAL PROJ $	0.560	0.710	0.888	**0.682**	-4%	0.783	-13%
TFL $ / TOTAL PROJ $	0.272	0.362	0.523	**0.341**	-6%	0.362	-6%
TFM $ / TOTAL PROJ $	0.302	0.481	0.691	**0.419**	-13%	0.419	0%
TFL $ / TFC $	0.282	0.485	0.590	**0.457**	-6%	0.466	-2%
TFM $ / TFC $	0.291	0.550	0.817	**0.598**	9%	0.534	12%
TFL $ / TFM $	0.510	1.125	1.721	**0.902**	-20%	0.980	-8%
EQUIPMENT $ / TOTAL PROJ $	0.096	0.223	0.572	**0.241**	8%	0.251	-4%
EQUIPMENT $ / TFC $	0.125	0.304	0.632	**0.334**	10%	0.304	10%
START-UP $ / TOTAL PROJ $	0.000	0.034	0.158	**0.041**	21%	0.033	24%
START-UP $ / TFC $	0.000	0.051	0.111	**0.066**	29%	0.047	40%
START-UP $ / EQUIPMENT $	0.000	0.171	0.362	**0.235**	37%	0.169	39%
CONSTR IFC $ / TOTAL PROJ $	0.059	0.085	0.110	**0.079**	-7%	0.088	-10%
OWNER COST $ / TOTAL PROJ $	0.105	0.175	0.219	**0.155**	-11%	0.186	-17%
ENGR+DESIGN HRS / EQUIP COUNT	841	990	1287	**1120**	13%	1039	8%
TOT FIELD HRS / EQUIP COUNT	3087	4117	4734	**3884**	-6%	4089	-5%
CONCRETE CY / EQUIP COUNT	16	20	33	**16**	-20%	22	-27%
PIPING LF / EQUIP COUNT	392	474	687	**484**	2%	470	3%
CONCRETE HRS / CY CONCRETE	12.1	13.4	19.2	**12.4**	-7%	13.8	-10%
PIPING HRS / LF PIPE	2.7	3.2	3.4	**3.3**	3%	3.2	3%
CONCRETE MATL $ / CY CONCRETE	219	243	306	**224**	-8%	255	-12%
PIPING MATL $ / LF PIPE	88	103	113	**104**	1%	102	2%

Figure 1—Estimate Validation Metrics Report Eample.

tors, ratios and percentages you can analyze when trying to review and validate the completeness of a project cost estimate. Due to the certain uniqueness of Canadian oil sands projects, industry benchmarking data should be collected and calibrated by the owner companies to ensure that appropriate project factors and metrics are utilized during the estimate review and validation process. Refer to figure 1 for an example of an estimate validation metrics report.

Estimate validation is a very important activity during the project review cycle, and the proper tools need to be in place to allow this to occur. Benchmarking key estimate ratios and metrics depends upon having a project history database in place to collect, analyze and present the required information. Similarly, the capability to provide quick check estimates depends on having the correct strategic and conceptual estimating information and tools ready for use [3].

Implementation of a project historical database system that contains a robust collection of historical project data records will enable the owner company to provide the following:

- cost estimate validation for formal estimate reviews,
- generation of key benchmark metrics for estimate reviews,
- cost estimate database calibration information,
- front-end or strategic level cost estimates, and
- strategic level scheduling information.

CANADIAN OILS SANDS

The Canadian oil sands industry is driven by the demand for oil worldwide [2]. Global political issues and petroleum industry economics will continue to remain important factors in the sourcing and development of oil and other energy supplies, especially for non-traditional sources such as Canadian oil sands. Oil sands production is increasingly becoming a major source of worldwide oil production, especially as a source for the US, which utilizes approximately 25 percent of the world's petroleum production. In 2005, oil sands are expected to yield over 50 percent of Canada's crude oil output, and potentially reaching over 75 percent by 2012. This is what is driving the approximately $80 Billion worth of investment in the Canadian oils sands industry.

Oil sands projects are rather unique. Oils sands are a combination of bitumen, sand, clays and water. Bitumen is a heavy, black viscous oil—almost like asphalt—that must be treated and converted into an upgraded crude oil before it can be used by traditional refineries to produce gasoline, diesel, and other petroleum products.

Where the oils sands deposits are relatively close to the surface, they are recovered by open-pit mining techniques. Approximately two tons of oil sands are mined to produce each barrel of oil. Initially using traditional open-pit mining techniques such as draglines and bucketwheel reclaimers, oil sand mines have now converted to primarily using hydraulic and electric shovel trucks and haul trucks. The mining equipment used is some of the largest in the world. Once mined, the oil sand is typically slurried using steam and hot water, and sent to an extraction plant that extracts the bitumen from the oil sands. The processed sand is then returned to the mine pit, and the site is reclaimed. The extracted bitumen is then converted in an upgrading plant to produce a low-sulphur, synthetic crude oil to be used as traditional refinery feedstocks. The upgrading plants themselves are also distinctive, using some of the largest cokers in the world.

Where the oil sands deposits are too deep below the surface to support traditional mining techniques, in-situ ("in-place") recovery is used to produce the bitumen. Typically these techniques use some form of steam-injection, or other means of thermal energy, to heat the bitumen in-place and then extract it through wells. The extracted bitumen is then upgraded similar to bitumen extracted using mining techniques.

Using either technique to extract the bitumen, oil sands projects are much different than traditional crude oil production methods; and there are only a small number of commercial facilities in operation. Commercial oil sands production facilities are only about 30 years old, and the technology for both extracting the bitumen and upgrading it to a synthetic crude oil is advancing rapidly. On top of this, the Alberta sources of oil sand deposits are located in the remote, northern areas of Alberta. A harsh winter climate contributes to the challenges of both constructing and operating oil sands production facilities.

Sizable oil sands projects are considered mega-projects. Whether developing a new facility, or making a significant expansion to an existing facility to increase production, projects can run into the billions of dollars. Skilled labour availability, equipment usage, construction logistics, infrastructure support, and diseconomies of scale are just a few of the many problems inherent in mega-projects. "Constructing very large and complex multi-billion dollar oil sands projects has turned out to be a considerable challenge" [2]. Recently, there have been several large projects that have missed cost and schedule targets, sometimes overrunning by billions of dollars.

So even with the tremendous potential existing in oil sands projects, investment capital is a scarce resource. Many of the oil sands developers are large, multinational companies with significant opportunities to invest elsewhere in the world. Therefore, oil sands owners must get control of the costs of their projects. Developing historical project databases is a first step for these owners. It is critical to understand the costs of oil sands facilities - costs that are calibrated to the unique technologies employed, the remote and harsh location, and the mega-size of the projects that in itself brings complexity and other factors into play.

The existence of an owner company project historical database system will NOT on it's own prevent the major cost overruns that are being experienced on Canadian oil sands projects. However, armed with significant historical cost information, data, metrics, ratios and factors, the cost estimator or project cost specialist should be much better equipped to review, validate, explain and defend the proposed project funding requests.

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