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Developing Benchmarking Metrics for Pipeline Projects in Alberta

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Developing Benchmarking Metrics for Pipeline Projects in Alberta

by

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Abstract

The high level of construction activity in the Alberta pipeline projects leads to significant concerns about cost, schedule, safety, engineering productivity, and construction productivity in regards to pipeline operations and activities. Moreover, the growth of industry in Canada and specifically in Alberta means that more products are being processed today than ever before. Those products must be transmitted effectively to the desired area. However, pipeline projects, due to their characteristics and nature, are categorized differently than heavy industrial projects. These characteristics include the length of the pipes in addition to the vast area they cover and also different regulatory processes that pipeline projects follow in order to obtain necessary construction permits. These characteristics are different than other typical industrial projects. Comparatively, the time and work required through the front end-planning phase of pipeline projects sharply increase due to this fact that pipelines vary in lengths and the products they carried inside. Pipelines need a huge amount of study and design prior to the detailed engineering and construction phases. Moreover, the sensitivity of these projects requires special consideration. Several pipeline projects have been either delayed or stopped due to environmental impact concerns, hazardous risks, and public resistance. These specific characteristics, impact factors, and environmental risks create a pressing need for benchmarking of these projects.

Benchmarking is a reliable comparison tool used to compare one project's data against other companies' and operators' data in the industry. A benchmarking system has been developed over the past several years as a collaboration work between COAA (Construction Owners Association of Alberta) and CII (Construction Industry Institute) to assess the performance of Alberta pipeline projects. An analysis of a research's results indicated areas for enhancements.

The purpose of the current research project is to expand and extend the previous benchmarking system, focusing on activities and methods utilized by engineering, procurement, and construction (EPC) owners and contractors to design and build the pipeline projects. The results of previous Alberta pipeline projects report indicate that specific metrics for pipeline projects need to be better defined and developed in order to build a new, valuable performance assessment system. These new metrics and performance assessment techniques will span the project life cycle from front end planning and detailed engineering through construction, commissioning, and start-up. The current areas for heavy industrial metrics, such as cost, schedule, safety, rework, and productivity will be the focus in developing these new metrics for pipeline projects. This research project contains an extensive literature review of pipeline construction specifically in Alberta in addition to the history and current practices of benchmarking. The data collection phase of the research includes two sets of interview and survey conducted among pipeline industry experts. Finally, conclusions and recommendations achieved from the analyses of gathered information are presented.

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As a researcher you need a team of advisors, colleagues and people who encourage you through the whole journey. Going through the project of research would never be a single man journey. Through the first tough six months of commencing my masters' degree, I was lucky and blessed to have people who believed in me and helped me to pass the difficult days. I cannot mention everyone who helped me in the past two years; however I would thank several special people as my advisors, supervisors and friends who supported me through all hills and dales of this journey so I would be able to become a researcher.

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Dedication

I would like to dedicate my thesis to the members of my great family for their supports and sacrifices throughout the journey of life. I have no idea how a mom and dad could do so much for their son. I could remember how they sacrificed their youth and health in order to teach me the responsibilities and values of life and education.

Mom! I am not sure if I have ever been a good listener and learner but I definitely would remember every story you told me when I was a kid. I remember nights you stayed awake with me until morning to encourage me to finish what I had as work although you were sick and tired. You are the greatest and kindest woman I was blessed to know in my childhood. I don't know how to express my appreciations but please know that I listened to you and tried to pursue the kind of life you valued so much. Thank you for being my mom and please stay healthy as I need you so much in my life.

Dad! Please know you are my biggest role model in life. Your kind, generous and wise advices will be my biggest treasures to go through the life with. Thanks for being there for me through every first steps of my journey; first step to walk, first step to kick a soccer ball, first step to go to school and then university. You are such an amazing man which anyone wants to have as dad. I am working towards another university degree and this is how you taught me to be. Dad! I have never stopped dreaming to pursue my interests or to have a better life or to be a better man. Thank you for everything. Mom and dad! Thank you for giving me the desire to learn and the drive to remember I can achieve whatever I try hard for. Thanks for telling me always to not be disappointed in life and myself. You were my true guardians.

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I dedicate my thesis to you and my lovely family for helping me to achieve the goal of this long journey. I hope I would always have your supports in my life.

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AUT Automatic Ultrasonic Testing

BA Benchmarking Associate

CDN$ Canadian Dollar

CII Construction Industry Institute

CM Construction Management

COAA Construction Owners Association of Alberta

CP Cathodic Protection

EPC Engineering, Procurement and Construction

FEED Front End Engineering and Design

HS&E Health, Safety and Environment

KPIs Key Performance Indicators

NDT Non Destructive Tests

PAS Performance Assessment System

PDRI Project Definition Rating Index

QA Quality Assurance

QA/QC Quality Assurance/Quality Control

WH Work Hours

CHAPTER ONE: INTRODUCTION

Chapter one presents the thesis summary and describes the purpose and scope of the study. The research method selected in addition to the summary of findings in interviews and survey is discussed. The chapter also introduces the involved industry participants in the research.

1.1 Summary of the Research Study

1.1.1 Background

The construction activities in the Alberta oil and gas sector, including pipeline construction and operations, have strained the industry's ability to execute work effectively, leading to significant concerns about low productivity levels and cost and schedule overruns.

A benchmarking system has been developed by COAA (Construction Owners Association of Alberta) in collaboration with CII (Construction Industry Institute) over the past several years to assess the performance of these Alberta construction projects. In 2008, a benchmarking study completed and established a comprehensive benchmarking system comprised of a customized questionnaire and a dedicated database. An analysis of the results indicated areas for enhancements. A second benchmarking study is needed to determine what precise enhancements and modifications are required regarding this matter. An analysis of the results to this point shows that there is a need for new metrics as well as modifications to those currently in use in the pipeline industry. In addition, developing a new system to measure the performance of pipeline projects in Alberta and in Canada seems to be necessary.

According to the Inventory of Major Alberta Projects by Sector, $7341.9 M had been anticipated for total cost of pipelines in Alberta in 2012. Moreover, significant worldwide cost escalations and labor shortages have affected the pipeline industry of Alberta (Inventory of Major Alberta Projects by Sector, 2012). Loss of productivity and excessive indirect costs are other facts showing the needs for developing a benchmarking process for this industry (Jergeas and

Ruwanpura, 2010) Furthermore, there is limited public information on benchmarking of pipeline projects. Despite the fact that pipeline projects have an extended history in the industry, there is no clear or robust definition of pipeline project in industry, which causes confusions for industry participants involved in the construction of pipeline projects. Also, based on different diameter size of pipelines, which normally indicates the size of the pipeline project, there is no standard or framework of gathering data elements among different companies. It means each company uses its own data-gathering framework for each project.

1.1.2 Purpose

1.1.2.1 Better Understanding of a Pipeline Project: Definition and Lifecycle

As indicated before the study tries to conduct series of data collection techniques as such interviews and surveys to present a clear definition of a pipeline project and also have a better understanding of the differences between pipeline and piping. Research also tries to clear different phases and major activities in the lifecycle of a pipeline project cost-wise and schedule-wise.

1.1.2.2 Use of Benchmarking Metrics among Different Pipeline Companies

One purpose of the research study is to examine the use of applying benchmarking metrics through the project lifecycle of pipeline projects to determine if the existing metrics can provide professionals with the opportunity to compare project to other participants in the industry and improve project performances.

1.1.2.3 How to Benchmark the Pipeline Projects Efficiently

Another purpose of the research is to indicate how the pipeline companies behave in gathering data for benchmarking purposes. The research also tries to find the industry opinions in regards to different metrics priorities. These results help pipeline companies to benchmark their pipeline projects efficiently.

1.1.3 Scope

1.1.3.1 Pipeline Project Definition/Lifecycle and Use of Benchmarking Metrics

I will examine the understanding of professionals in pipeline industry in different organizations of owners or contractors to identify their perspective on pipeline definition and its lifecycle. Specifically the research study will:

1. Determine the clear definition of pipeline project among industry professionals
2. Determine the lifecycle and major activities of pipeline project and breakdown the phases of the project based on schedule and cost
3. Examine which metrics are currently used for pipeline performance assessment and determine what needs to be developed
4. Develop a framework of metrics for use in benchmarking of pipelines
5. Examine what risks are associated with pipeline projects

1.1.4 Objectives and Expected Outcomes

The goal is to develop a framework for benchmarking metrics and define a set of parameters specifically for pipeline projects that will assist other industry participants and also researchers in examining and comparing their projects in pipeline industry. In this study, I will develop the desired metrics in addition to this fact that I need to identify the environment, context, barriers, and boundaries in pipeline industry that can affect the results, and which techniques are effective in obtaining data that will lead to conclusions and recommendations.

The following deliverables are the expected outcomes of the research:

- Develop a definition for pipeline projects
- Develop a new categorization for pipeline projects
- Develop benchmarking metrics for pipeline projects
- Identify risks associated with pipeline construction

- Identify industry practice regarding data collection

1.1.5 Research Method

1.1.5.1 Exploratory Research

This research is categorized as exploratory since there is limited public knowledge available on the subject of benchmarking of pipeline projects. There is also no public access to the current use of benchmarking databases. Using the exploratory research method, we start with what we have and gather as much information as possible. Later, the important data will be selected and studied. Another important purpose of the research study is to identify and develop new metrics that should be used for benchmarking of pipelines. The goal is to develop a framework in regards to different elements and metrics that can assist the performance assessment of the projects.

1.1.5.2 Interviews

An interview was designed and used to develop a baseline for gathering information on benchmarking of pipeline projects. This questionnaire contained a series of open-ended questions to obtain qualitative information on the pipeline project definition and benchmarking metrics in regards to this type of project in Alberta. In addition, some other open-ended questions have been asked to obtain information on different phases in construction of pipeline projects and also risks associated to pipelines. After design of interview questions, a set of interviews has been conducted with senior pipeline professionals in Alberta. This sample of industry professionals included experts from both owner and contractor organizations. Senior industry professionals were chosen as a judgment sample since it was anticipated they had knowledge of and experience with benchmarking of pipelines.

The other characteristic of the chosen sample was this fact that the interviewed experts were chosen from organizations with big size pipeline projects and also smaller size pipeline projects. The qualitative data collect by these interviews was analyzed to develop benchmarking metrics specifically for pipeline projects. The gathered data was analyzed to determine if additional information was needed to identify the level of project data gathering in different companies. The number of interviews conducted was determined by analyzing the information from each interview to reach a point of saturation wherein no new information was obtained from the interviewees.

1.1.5.3 Survey

In anticipation that additional information was needed, an online survey instrument was developed and used to conduct a series of close-ended questions to find the best way of developing the gathered benchmarking metrics in phase I, into two different types of questionnaire. The survey also has been used for validation of the previously collected data. The author prepared a set of conclusions and recommendations based on the analysis and interpretation of the information collected throughout the different phases of the research study. This research study followed the procedures and protocols necessary to meet the ethical requirements of the University of Calgary.

1.1.6 Involved Companies in Interviews and Surveys

17 companies were involved through the phase II of COAA benchmarking project. The interviews and surveys have been conducted between these companies:

Bantrel, ConcoPhilips, Enbridge, JC Driver's, Laricina Energy, MEG Energy, Nexen, Shell, Statoil, Steeplejack, Suncor Energy, Syncrude, TransCanada, WorleyParsons, Devon, Pembina Pipeline, Fluor

Figure 1.1 Involved Companies in Interviews and Survey

1.1.7 Summary of Findings

1.1.7.1 Interviews Findings

Background of Pipeline Construction

According to most of participants there were not many well-written references on different phases or lifecycle of projects; however during interviews some useful resources recommended to the author.

Definition of a Pipeline Project

As literature never proposed a robust or clear definition of a pipeline project, the author tried to include this question in the interviews. As a result of discussion with pipeline experts, "a pipeline moves products or raw materials in pipe from point A to point B which is outside the battery limit (boundary of an industrial project) and needs right of way."

Pipeline vs. Piping

During the interviews, the important differences between pipeline and piping have been discussed with the experts. These differences are discussed in the interview section.

Lifecycle of a Pipeline Project

During interviews, participants have been asked about lifecycle of pipeline projects. They also determined the breakdown of the pipeline project phases (cost-wise and schedule-wise).

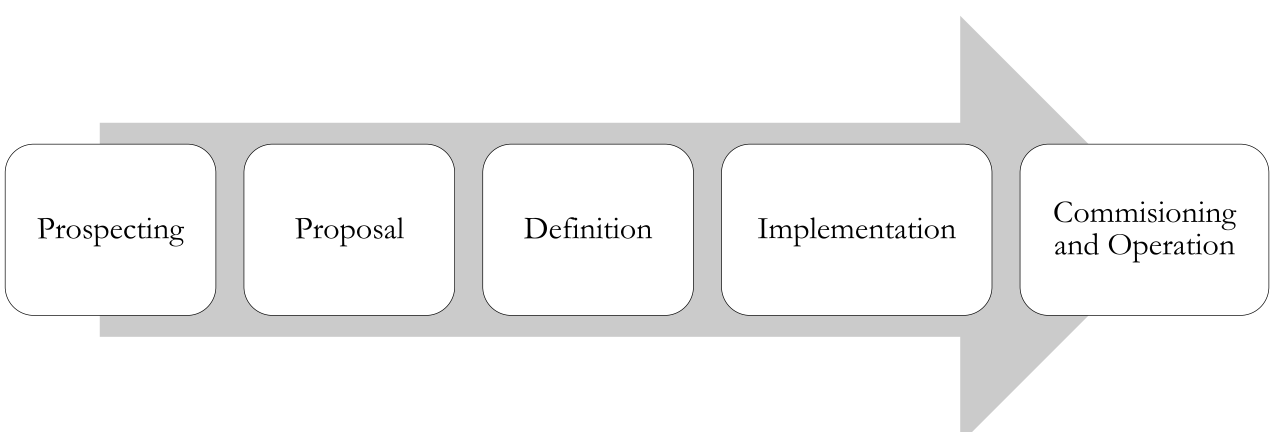


Figure 1.2 Lifecycle of a Pipeline Project

Moreover, some different activities and processes were identified for each of the phases mentioned in the interviews. The breakdowns of phases for cost and schedule are discussed later in the chapter of the interviews findings.

Categorization of Pipelines into One More Level of Details

It has been asked from the pipeline experts how they would categorize the pipeline projects into one more level of details and what parameters they would consider for this categorization.

Different parameters have been gathered and discussed in this section such as pipe size, location or region, type of the project, depth of burying the pipe, material of the pipe, pressure, different crossing, the product which pipe carries inside, insulation, and coating.

Minor Validation on Previous Conducted Study

According to another study conducted in 2009 for enhancement of COAA benchmarking database different categories have been developed in regards to pipeline projects. During interviews, it has been asked from the participants whether they agree or disagree with these categories

Metrics for Performance Assessment

The most important purpose of the interview was to develop metrics for benchmarking of pipeline projects. 53 Different metrics have been identified during interviews with participants. These metrics are used in performance assessment of pipeline projects.

Different Risks Associated with Pipeline Projects

During the interviews, participants were asked about different risks they identified with pipeline projects in different categories of operational risks, strategic risks, and contextual risks.

1.1.7.2 Survey Findings

Validation of Pipeline Definition:

One of the objectives of the survey was to validate the definition of a pipeline project. 93.55% of participants in survey agreed with the proposed definition: “A pipeline moves products or raw materials in pipe from point A to point B which is outside the battery limit and needs right of way."

New Categorizations for Pipeline Projects

Survey results indicate 53 previously developed metrics have been determined by the experts to be recognized as performance assessment tools of big size projects and 25 metrics have been determined for small size projects. The metrics for both categories are discussed in the survey findings chapter.

The Metrics and Their Priorities

According to pipeline experts, different developed metrics in the interviews have different priorities for the companies. Likert-scale method indicated the importance of the metrics individually. The metrics and their achieved scores are discussed in the survey findings chapter.

These results show the focus of the companies involved in pipeline industry, which can help different involved parties to collect only the most important data in case of labor shortage or unavailability of different data elements.

The Data Elements and the Data Collection

In the last question of the survey, author tried to review different data elements, the companies' behaviors in regards to the data collection, and how difficult these elements are to be gathered.

The results show how companies behave in the data gathering process. Mostly, high ranked data, which have been gathered by the companies, are easy to collect; however some of the elements are not being gathered even in this case where they are easy to collect. Moreover, the results of the survey also determine which metrics are most difficult to be collected.

1.2 Organization of the Thesis Document

The thesis has seven chapters divided into four sections: Introduction, Literature Review, Study, and Conclusions. Each section contains chapters describing a particular component of the research study.

1.2.1 Introduction Section

1.2.1.1 Chapter One – Introduction

Chapter one is a summary of the complete research study. This chapter describes the purpose and scope of the research. The research method selected in addition to the summary of findings in interviews and survey is discussed. The chapter also introduces the involved industry participants in the research.

1.2.2 Literature Review Section

1.2.2.1 Chapter Two – Background and Literature Review

Chapter two presents the review of background and literature. The chapter discusses pipeline project and its major activities specifically in Alberta, benchmarking, and background on benchmarking of pipeline projects. Finally, the chapter brings the discussion on safety, security, and environment.

1.2.2.2 Chapter Three – Research Method

Chapter three describes a number of research methods that may be selected to study a subject area. The choice of a research method is typically between quantitative and qualitative. A quantitative method is field-based experimental research leading to knowledge of actual practices which can be used to identify relevant research problems and provide a baseline for further study. A qualitative method is often simply defined as research that does not use numbers or statistical procedures.

1.2.3 Study Section

1.2.3.1 Chapter Four – Selected Research Method

Chapter four describes the research method selected from the available research methods described in previous chapter.

1.2.3.2 Chapter Five – Interviews Findings

Chapter five discusses the findings from the 12 interviews conducted with pipeline experts. Different tables and figures show the collected data and results.

1.2.3.3 Chapter Six – Surveys Findings

Chapter six presents and explains the findings on the 31 responses collected from pipeline experts via survey. This survey was conducted as an online web-based tool in the beginning of year 2013.

1.2.4 Conclusions Section

1.2.4.1 Chapter Seven - Research Analyses and Discussions

Chapter seven presents a series of analyses and conclusions regarding the development of benchmarking metrics for the pipeline industry.

1.2.4.2 Chapter Eight - Conclusions

Chapter eight presents and explains the conclusions in regards to findings and deliverables of the research study. This chapter also reviews the existing barriers to benchmarking for pipeline companies and finally, some recommendations for future studies are presented.

CHAPTER TWO: BACKGROUND AND LITERATURE REVIEW

Chapter one reviews the literature and background on benchmarking, pipeline project and its major activities specifically in Alberta. The chapter also discusses current practices of pipeline benchmarking. Finally, the discussion on safety, security, and environment is presented.

2.1 Benchmarking

2.1.1 Introduction

Benchmarking is basically the process of identifying the best and highest standards for products, services, or processes and then comparing your products, services, or process in order to make progress and improvements necessary to reach those standards, commonly called best practices. John Reh, a project manager and a senior business executive, believes that "benchmarking is the process of gathering information about other companies in your industry to compare your performance against and to use to set goals." (Reh, 2012)

As a matter of fact, benchmarking is a new, growing technique which is becoming a major and reliable tool for comparing project data against common industry aggregate data. The reason for using benchmarking simply lies in this question: "Why re-invent the wheel if I can learn from someone who has already done it?" (Ross, 1995)

Benchmarking history goes back into the late 1970s with Xerox Corporation. During that time, Xerox was not in good shape and was losing market share to its competitors. In an attempt to get back into the game, the company decided to start comparing its operations and services to the competitors. After a while, they found the quality standards they needed to compare themselves to and Xerox became one of the pioneers in the business world today (McNair and Leibfried, 1992).

Recently, Benchmarking has been gaining popularity among different industries and between different competitors, especially in the last five years. The process of benchmarking is not only a tool for gathering data on how well a company operates in an industry; it can be used in a variety of industries for services and manufacturing. Moreover, benchmarking can be used as a method of identifying new ideas and new ways of improving processes. The ultimate purpose of benchmarking is process improvement which can help a provider to meet the customer expectations (Omachonu and Ross, 1994).

In late 1980 Robert C. Camp at Xerox replied: "The full definition of benchmarking is finding and implementing best practices in our business, practices that meet customer requirements. So the flywheel on finding the very best is this question which, does this meet customer requirements? The basic objective is satisfying the customer, so that is the limiter" (Linsenmeyer, 1991)

There were no significant benchmarking programs before 1993 in the construction industry in the public sector. The first benchmarking program in the construction industry that was publically accessible was started in the United States (US) by the Construction Industry Institute (CII) in 1993 (CII 2000). In the United Kingdom (UK), benchmarking programs were launched in 1998, following Latham and Egan "Constructing the team", "Rethinking Construction" and "Accelerating changes" reports. The Key Performance Indicators (KPIs) program was launched in 1998 by the UK Best Practice Program. A new body known as "Constructing Excellence" was formed by the amalgamation of Rethinking Construction and the Construction Best Practice Program (CBPP). The aim of the Constructing Excellence Program is to improve on a continuous basis the construction productivity and performance in the UK construction industry. The program is supported by government through national and regional offices. Independent Project Analysis (IPA) is a private international construction benchmarking and metrics corporation headquartered in the US and was founded in 1987. The IPA consults on project evaluation and project system benchmarking. This primarily includes large oil companies, chemical producers, pharmaceutical companies, minerals and mining companies, and consumer products manufacturers. IPA's data and methods are proprietary. As of the middle of 2009, the IPA database contains more than 11 000 projects of all sizes having a range from US$20 000 to US$25 billion located throughout the world (Haas et al., 2012).

2.1.2 Reasons and benefits of using benchmarking

In the benchmarking process, companies try to look at the "best" in the industry and try to follow their styles and processes. This can help companies to understand what they could be doing better. The benchmarking process can be valuable if the companies would be open to new ideas and approaches (Allan, 1997). Companies are benchmarking for a variety of reasons including:

Increasing Productivity and Individual Design

The reasons can be extensive such as increasing productivity or it can be more specific like improving an individual design. With benchmarking, a company can use different ways to shed light on new opportunities to use new process for increasing productivity (Muschter, 1997).

Strategic Tool

The competition between different companies can be another reason to use benchmarking as a strategic tool in a company. By benchmarking, a company can jump on its competitors by using new strategies. This can help identify room for growth that the company may not be aware of (Elmuti and Kathawala, 1997)

Enhance Learning

Enhancing learning is another reason to benchmark. Reviewing other companies' processes and seeing how they are operating can show employees another way to compete (Brookhart, 1997).

Growth Potential and Changes in Organizational Culture

Benchmarking can help change the culture of an organization. By looking outside the companies' walls for potential areas of growth, a company can become a more enhanced organization and increases its profits (Elmuti and Kathawala, 1997).

A Tool for Performance Assessment

Another definition by S. Allan in 1997 for benchmarking is "the process of identifying and learning from best practices anywhere in the world". Identifying the best practices can help an organization to know where they are standing in relation to other companies. Best practices can show and provide possible solutions for each area of concern in regards to identifying problem areas and possible solutions. When companies participate in benchmarking, they share information with each other and learn from each other. This process helps them to understand their own operations better and set goals for improvement (Allan, 1997).

A Continuous Improvement Tool

Recently, benchmarking is becoming a popular tool for improvements in different companies. Cost savings of 30 to 40 percent have been reported from different companies who are dedicated to using benchmarking strategies. Benchmarking helps in identifying different methods of measuring areas in regards to metrics and units of output. Moreover, benchmarking helps in budgeting, strategic planning, and capital planning (Lyonnais, 1997).

As an example, in 1980, Ford Company benchmarked some of its operations and costs against Mazda's operations. As a result, the company achieved 5 percent reduction in cost (Elmuti and Kathawala, 1997).

Performance Improvement

Besides all other benefits of benchmarking and why companies intend to use it, learning new and innovative approaches is another reason. This can help improve performance by setting achievable goals that have already been examined and proven to be successful (Fuller, 1997).

2.1.3 Different Types of Benchmarking

Reviewing the literature indicates that there are four distinct types of benchmarking. A company needs to understand which type is more suitable for them based on what they want to benchmark.

2.1.3.1 Internal Benchmarking

Internal benchmarking is the first type, and is the simplest form as most of the companies have similar functions among different units inside the company. The main objective of this type is to determine the overall internal performance standards of an organization. By understanding the best internal procedure and transferring it to other departments, an organization can improve its overall performance (Matters and Evans, 1997).

2.1.3.2 External Benchmarking

External benchmarking is competitive benchmarking. The goal in this type is to compare a company to its competitors in the same industry which have competing services, processes, or products. This strategy helps a company to see where it is standing in regards to performance. Normally, data collection is hard to achieve as, for some company, this data is quite valuable (Finch and Luebbe, 1995).

2.1.3.3 Functional or Industry Benchmarking

This type of benchmarking is an external type of benchmarking performed against industry leaders or the best companies based on their performances. "The benchmarking partners" is the term used for those organizations who share some common data in the same industry. Normally, these companies concentrate on specific functions or metrics. As this type of benchmarking has no direct competitors involved and the data can stay anonymous, the benchmarking partners are more willing to share the data. The cost and time taken for collecting data and contributing to the benchmarking are the disadvantages of this type of benchmarking (Matters and Evans, 1997).

2.1.3.4 Generic Benchmarking

This type of benchmarking focuses on the best work processes. It can be used across dissimilar and different organizations in different industries. Though it seems to be tremendously effective, it is costly and difficult to implement. Moreover, it needs a clear understanding of procedures and a broad conception of entire processes (Finch and Luebbe, 1995; Matters and Evans, 1997).

The best way for a company to find the suitable benchmarking type is to determine whether they want to focus on financial results or meet expectations of customers. By realizing the needs and goals of the organization, a benchmarking process can be chosen.

Benchmarking implementation is a project itself with all aspects of a project. The processes normally include the following steps according to Margaret Matters and Anne Evans:

1. Planning the Exercise
2. Forming the Benchmarking Team
3. Data Collection
4. Analyze Data for Possible Gaps
5. Take Actions (Matters and Evans, 1997).

No matter which method is used in benchmarking, most organizations have to begin with the step of measuring the performances of other leaders or best in class performance variables such as cost, productivity, and quality. Second, they have to identify how they can achieve this level of performance and third, they need to use the information to develop and implement a plan for action and improvement (Omachonu and Ross, 1994).

2.1.4 Advices from the Benchmarking Companies

In research by Michael J. Spendolini in 1992 on best practices in benchmarking, some recommendations have been developed. Many of these recommendations deserve consideration from benchmarking associates in companies:

1. Look for changes and be action-oriented. The benchmarking process is not a passive process and is not suited for those who only intend to fish for ideas.

2. Try to be open to new ideas

3. Know yourself before knowing other organization or attempting to get external data.

4. Concentrate on improvement of practices and processes. Don't only focus on measurements and numbers.

5. Introduce and maintain discipline.

6. Allocate sufficient and well-organized resources to get the job done right.

7. Get benchmarking specialists involved in the process.

8. Allocate sufficient time to the process of benchmarking.

9. Ensure that your company provides adequate communication in regards to benchmarking process and its purpose, benefits and findings (Spendolini, 1992).

2.1.5 Lessons Learned From Previous Benchmarking Metrics Development Studies

There is a difference in perspective between the senior managers and accountants or estimators regarding the purpose and benefits of the performance and productivity benchmarking program. The senior managers group which include vice presidents, divisional heads, senior project managers, etc., focus on macro level issues and see value in benchmarking their company's performance against other companies engaged in the same business and are also interested in productivity measurement and improvement. However, the estimators or accountants are more concerned with the day to day performance measurement such as time, cost, schedule, etc. Detailed, low level, productivity measures related to project environmental factors are of interest to them for their utility, while the project level performance and productivity metrics are relatively less important to them.

In a benchmarking study conducted by Carl T. Haas, It was observed that owners are typically more interested in participating in collaborative performance measurement and improvement programs than contractors (Nasir et al., 2008).

Moreover, it is found that it is difficult to obtain data from subcontractors. This could be due to many reasons; such as lack of communication with the subcontractors, confidentiality of data, or no control regarding provision of data from subcontractors (Haas et al. 2012).

2.2 Pipeline

This section describes the main activities and processes involved in construction of a pipeline project. As a summary, different steps in pipeline construction are briefly explained below:

- **Surveying and Clearing the Right of Way:** The right of way can be described as a narrow strip of land, which contains the pipeline. All construction activities are undertaken on right of way. The right of way has to be surveyed and also cleared of trees. Moreover, the site needs to be leveled to give easy access to workers and crew in order to move equipment and materials and to build, inspect, and maintain the pipeline (Esso Imperial Oil et al., 2004).

- **Right of Way Preparation:** The right of way needs to be graded and gravel pads have to be built to allow easy movement of ditchers, different equipment and materials.

- **Hauling and Stringing the Pipe:** A crew moves the pipes from the stockpile sites and lines them up along the right of way. These pipes will be ready for welding.

- **Bending the Pipe:** After stringing the house, a bending machine is used to bend pipes, which need to be bent to the shape of the land. The steel pipe keeps its characteristics and strength.

- **Welding:** The location where the pipes are joined together is stronger than the pipe itself. The welding process is repeated a number of times until the desired sections are joined to form a long pipeline. An x-ray test and quality control program are undertaken to ensure the strength and quality of the welds.

- **Digging the Trench:** A trench is needed to bury the pipeline. Type of soil determines what equipment needs to be used for digging the right of way (Shashi Menon, 2011).

- **Lowering the Pipe:** Side boom tractors are used to lower the pipe into the prepared trench.

- **Installing Valves and Special Fittings**: Valves, including shut-off valves, which can be used to separate some sections of the pipeline for maintenance, are installed while the pipeline construction is undertaken.

- **Crossing:** Along the pipeline right of way, rivers and streams, roads, and other pipelines are considered as crossing. Engineering plans are developed in advance of pipe construction. Water crossing can be undertaken with the open cut technique or by horizontal directional drilling (HDD). HDD is normally selected where the major river crossings happen and the local soil conditions permit.

- **Backfilling the Trench:** After completion of the crossings and prior to testing, the trench is backfilled. The excavated soil can be used to fill the trench and sometimes other selected backfill is used. Care is taken in order to protect the pipe coating.

- **Testing:** The final phase in pipe construction includes a variety of methods for testing the pipeline to ensure the integrity of the installed pipeline and if it complies with code.

- **Reclamation:** Reclamation of the pipeline right of way is undertaken and the temporary facilities such as camps are cleared from pipeline right of way (Esso Imperial Oil et al., 2004).

Major Group Activity	**Associated Activities**
Surveying/ Clearing the Right of Way	Brush and other vegetation will be generally cleared or mowed from the construction right-of-way and extra temporary workspace.
Grading / Right of Way Preparation	Following topsoil salvage, grading will be conducted on irregular ground surfaces to provide a safe work surface.
Hauling and Stringing	The pipes will be transported by truck from the stockpile sites to the right-of- way. The pipes will be lined-up before next activity.
Bending	A bending machine is used to bend pipes, which need to be bent to the shape of the land.

Major Group Activity	Associated Activities
Welding	The welding process is undertaken until sections are joined to form a long pipeline. An x-ray test and quality control program are done to ensure the quality of welds.
Digging the Trench	The trench will be excavated using tracked excavators to a depth sufficient to ensure the depth of cover is in accordance with or in excess of applicable codes.
Lowering the Pipe	The pipes will be lowered into the trench using side boom tractors.
Installing Valves and Special Fittings	Valves, including shut-off valves, which can be used to separate some sections of the pipeline for maintenance, are installed.
Crossing	Along the pipeline right of way, rivers and streams, roads, and other pipelines are considered as crossings. Water crossing can be undertaken with open cut technique or by horizontal directional drilling (HDD).
Backfilling the Trench	The trench will be backfilled using backhoes, graders, bulldozers, or specialized backfilling equipment. Backfill material will generally consist of native trench spoil material.
Testing	The final phase in pipe construction includes methods for testing the installed pipes.
Reclamation	Reclamation is undertaken and the temporary facilities, such as camps, are cleared from pipeline right of way.

Table 2.1 Different Major Activities in Pipeline Construction

The different forms of construction that can be used in a pipeline project depend on different categories such as:

I) Open cross-country areas: The spread technique is used.

II) Crossing: The specialist crews and civil engineering techniques are used.

III) Special sections such as built up urban areas, restricted working areas, difficult terrain sections and also environmentally sensitive areas (Shashi Menon, 2011).

2.2.1 Spread technique:

The basic method of constructing steel, welded oil and gas pipelines in open cross-country areas is known as the spread technique. In this system of constructing, the product (the pipeline) is static and the individual work force, (crews) move along the pipeline track (right-of-way). The implementation of the spread technique is conditional on the pipeline being welded above ground with the maximum possible continuous length between crossings. Then, multiple mobile lifting tractors install the welded pipe lengths into unsupported trenches in one continuous length (IFC Company, 2000)

The breaks in the continuous main spread method result from the location of existing services, roads, railways, tracks, ditches, streams, and river crossings, and are also dependent upon restricted working, time constraints, and physical obstructions. Dedicated specialist crews are responsible to undertake these breaks in the main pipeline spread activities. It generally happens after the main pipeline sections have been installed.

The installation of main pipeline spread uses crews who undertake one operation at a time starting at one end of the pipeline and travelling forward to the other end, accomplishing between 500m and 1500m per day depending on the diameter of the pipe, terrain, soils, etc. There are a total of some 40 separate operations carried out in 7 main activity groups. These activity groups will be discussed in the main pipeline construction activities section. The schedule of activities and the start-up of the crews are dependent on available resources and the risk of one activity group having impact on subsequent activities (Shashi Menon, 2011).

It is essential for the timing between working crews to be such that there would be no risk of one crew causing stoppage or disruption for the preceding or subsequent crew. If the float between crews is not managed on a continuous basis, with the emphasis placed on the daily moving, then it is possible for there to be substantial disruption and standby costs. Effectively, there can be up to a buffer between 4 week crews to ensure that delays do not occur (Interviews Conducted by Author). Another important note is the average time from start of ROW to commencement of land reinstatement, which is typically on the order of 10 to 15 weeks.

2.2.2 Pre-Construction Activities:

Pre-construction activities need to be carried out by the Installation Contractor before the start of the main pipeline installation activities. These activities include finalizing the pipeline route, detailed design finalization, mobilization, notification of entry to landowners, setting-up of pipe yards and base camps, establishing temporary works requirements, setting-up of geographic positioning stations, design of land drainage in agricultural areas and reinstatement works, construction of temporary access roads, pre-environmental mitigation works, and agreeing with landowners about any special requirements and permits prior to entry onto their properties.

2.2.3 Main Pipeline Construction Activities:

After completion of pre-construction activities, the main construction works can commence. Usually, operations are carried out in seven main activities groups:

Group 1: Preparing Work Area

Group 2: Layout Pipe and Weld above Ground

Group 3: Trench Excavation and Installation of Pipe

Group 4: Pipeline Crossing, Special Sections, and Tie-Ins

Group 5: Final Backfill and Reinstatement Works

Group 6: Facilities and Pipeline Control

Group 7: Testing and Commissioning (Mohitpour et al, 2007)

2.2.3.1 Group 1: Preparing Work Area

Setting-out

The Setting-out crews are the first set of crews from the contractor's workforce to enter the site to begin the main construction activities. The setting-out of the works should be scheduled to commence at least about four weeks prior to the remainder of the group 1 activities. This activity can be done with a small crew using GPS and surveying instruments. Setting-out pegs will be placed at all the boundaries, changes in direction, and intermediate sightings on the proposed center line and the borders of the working areas.

In areas of open country where level access is available along the pipeline route and where the ground is anticipated to have strength sufficient to potentially delay progress of the trench excavation, then initial ground investigations work will be carried out directly behind the setting-out crew. Another responsibility of the setting-out crew is to identify any existing services that cross or are in close proximity to the pipeline. They would also supervise the trial-hole crew. The trial-hole crew will hand excavate to identify the exact location of all existing services. Later, this data will be recorded and transferred to the engineers in the design team for incorporation into the final pipeline design (EOG Resources Canada Inc., 2011).

Advanced Archaeology Major Works

This activity applies to specific locations with substantial archaeological remains, which could involve extensive excavations. Provided access is available or requires minimal work along the ROW from an established entry point, a separate advanced ROW will be mobilized to enable the archaeology works to commence in advance of the mainline and be completed before front-end crews pass. This activity should be done at archaeology locations to avoid any disturbance to the stripped subsoil (IFC Company, 2000).

Right of Way/Easement Boundary Separation - Secondary Ground Investigation

These group activities commence after the setting-out. Crews and equipment are involved mainly in the removal of all hedging for disposal off-site, and bridge or flume pipe access. Also, the activities include protection of existing services and also the erection of goalpost and safety signs at overhead electric power lines and telecommunication cables. The other responsibilities are the placement of hard standings and removal and re-grading of rock areas to deliver a safe and easy access excavation line right beside the main pipeline route (Marshall and Ruban, 1982).

Additional crews install offsite ROW accesses along the pipeline main route to help the ROW crew in gaining access to the working areas, where access from the public road is not available or has safety risks or environmental concerns. Agreements with the landowners involved in any offsite access must be finalized before the pipeline commencement.

Whenever temporary ROW fencing is required, additional crews are required to erect the fencing. During this phase of operation, it is possible to undertake ground investigation works to determine actual ground substrata, trench stability, ground water levels and seepage. These investigations, however can only take place at this time in open areas where there is no restrictions due to land use and environment (Shashi Menon, 2011).

Pre-construction Terrain and Ground Stability (Excluding Dewatering)

Wherever there is a risk of ground movement or safety risks to the construction activities then permanent stabilization of the affected terrain needs to be undertaken. This work can be separated into two different parts:

- Removal of loose materials that could move during the installation works
- Addition of material such as Bentonite, which is injected under pressure into gravels with high and fast water tablets to provide protection around the main pipe (Mohitpour et al, 2007)

Trench Excavation in Rock Areas

In any rocky area that is confirmed by the initial ground investigation works, the trench has to be excavated before any pipe operations. This sequence of works is important to ensure that the excavation of the trench cannot cause any damage to the pipe and will also provide a safe working area. After the data from the initial ripper and trial hole surveys is reviewed, the ground will be categorized into five different groups based on the method of removal:

1. Utilizing standard excavation

2. Large, more powerful excavation
3. Ripping/hydraulic hammer and excavation
4. Blasting/hydraulic hammer and excavation
5. Rock trenching (using saw and blade)

The finished trench should have the correct depth and width that suit the pipe diameter, plus any bedding and pipe cover. It also has to be in a straight line so that the pipe can lay in the center of trench without contacting the trench sides.

Finally, the excavation will start with dedicated crews following the ROW operation. The progress will depend on the strength of the ground, terrain, access, method of removal, number of crews, and available equipment (Shashi Menon, 2011).

Pre-construction Cut-Off Drains

After the right of way and fencing operations, all cut-off drainage works, which connect the existing drains to a new header pipe, will start immediately. The cut-off drainage works will be held at the locations with existing concentrated drainage schemes on agricultural land; however this happens after agreements are reached with landowners or occupiers. Usually the progress is desired to be 500 to 1500 meters per day along the pipeline route.

Topsoil Strip-Secondary Ground Investigation

The topsoil strip operations start after cut-off drainage operations, and must be scheduled properly in order to let the drainage works finish before this phase. The operation consists of 1 crew with usually about 8 excavators/bulldozers removing the topsoil to about 300 mm and storing in a single stack on the opposite side of the trench. In areas where topsoil removal is required, the ground investigation works would be held after the removal of the topsoil. These investigations include the same details as in the ROW section to determine the ground sub-strata, trench stability, ground water levels, and seepage (Marshall and Ruban, 1982).

2.2.3.2 Group 2: Layout Pipe and Weld above Ground

The second group of activities consists of:

Project Mechanical Procedures/Testing of Welders

Before the start of any mechanical works the contractor will ask the client to review and approve a full set of mechanical procedures for bending, welding, x-ray, and coating. These procedures will show how the contractor intends to commence and proceed, with the project specifications detailing equipment and also the specific mandatory requirements. These procedures will cover all various characteristic of the project including diameter, wall thickness, and technique.

After approval, all procedures start and will be fully inspected by the client. The welding includes non- and also full-destructive tests to ensure that welding complies with the contract requirements, minimum strength, hardness, and quality requirements. All the welders have to be tested based on the requirements of the procedure welds. The welders who have been employed will be issued registration with the various welding techniques they are approved to work on (Mohitpour et al, 2007).

Double-Jointing

Double jointing of the single 12 meter long pipes into 24 meter lengths will be carried out during this phase whenever it is considered economically viable by the project. This activity makes the welding process much faster with the same basic welding resources or allows the same production with a much smaller crew (Esso Imperial Oil, APG, ConcoPhilips, Shell, ExxonMobil, 2004).

Pipe Stringing

The pipes and preformed bends have to be delivered and stockpiled at the site 4 to 8 weeks in advance of stringing operations. After ROW, topsoil strip, and excavation in rock areas, the pipe stringing operations would start, including laying the pipe lengths along the easement length. A typical crew consisting of two cranes would be enough for this task. One of the cranes can be at the base camp loading the pipe trailer and the other one on the pipeline easement off-loading the pipes from the trailer.

In projects where ground conditions do not permit traveling down the easement with standard equipment or heavy-duty pipe trailers then tracked pipe carriers on the public roads can be used.

Forming Field Bends (Cold Bending)

After the stringing operations, once the pipes have been strung along the easement, engineers determine locations of all bends along the main pipe. These bends are required in order that the pipeline can follow drawings and the contours of the land. Normally, two types of bends are used in the pipeline industry. The first one is hot pre-formed bends, which are manufactured off-site in a factory. This type of bend is to a radius of 3 or 5 times the pipe diameter. The second type is the cold bend, which is to a radius of 50 times the pipe diameter and is typically performed in the field (Bilston and Murray, 1993).

Normally, a cold bending crew consists of a four-man team together with a bending machine and a side boom tractor. The side boom tows the bending machine along the main pipeline route and bends the pipe to the required radius and angle. The number of cold bends required depends on the route and contours of the pipeline. It varies from 1 pipe in 10 to 1 pipe in 50. Also, the cold bend angle can vary from angles of 12 degrees (42" pipe) to 40 degrees (12" pipe).

Welding of the Pipeline

The welding of the pipeline begins a few days after the cold bending activity. The welding crew welds the pipeline in continuous lengths between features such as roads, tracks, railways, services, and other underground obstacles, which can prevent the pipeline being installed in the trench.

Primarily, two methods of welding are available, manual and automatic. As the names imply manual welding is performed by welders and automatic welding involves a semi-automatic system. Normally, if experienced welders are available then there are not many differences in quality or production of these two types (Shashi Menon, 2011).

Automatic welding is used primarily for three main reasons:

1. Ensure welding quality
2. Increase/sustain a high daily production rate
3. Reduce the overall manpower requirements

The main reasons for manual welding are:

1. Experienced welders are available
2. Difficult terrain, weather, and site conditions exist
3. Special sections and areas with a high percentage of tie-ins are present
4. High production rates cannot be achieved

The crew can generally achieve the progress of one weld every 3 to 5 minutes. This number would yield 90 to 150 welds per day, which is equivalent to 1000 to 1500 meters of pipe, on 12-meter pipes. If the pipeline is made using double-jointed pipes the welding progress would be up to twice this (Shashi Menon, 2011).

Welding of Fabrication Pipe Work

Any reduction in the speed of the welding crew can increase cost and also cause delays to following operations. Fabrications, pipe works involving bends, and difficult setups are included in these potential delays. Welding of the fabrications should be done together and needs a small, dedicated crew who completes these welds prior to the field joint coating crew.

Not Destructive Test (NDT) Inspection:

All welds on the pipeline have to be inspected by radiography. This task is achieved on the main pipeline by an internal x-ray tube travelling along inside the pipe and taking x-rays at each weld for approximately 2 minutes per weld. After this phase the film is taken to a dark room and processed for inspection at the end of the day or early the next day. The welds which do not meet the requirements are repaired or cut out, in which case the pipe would be re-welded. Radiography should be undertaken by experienced and qualified x-ray specialists. Before the test, the pertinent sections of pipe are marked so that non-x-ray personnel will not enter the desired test sections. Also audio/flashing warning alarms are active at all times when the x-ray tube is energized.

Welds performed by semi-automatic welding processes are examined using automatic ultrasonic testing (AUT) techniques. This device checks the boundaries of each completed weld in order to detect any defects. The results of each ultrasonically inspected weld are recorded and used for inspection. The recorded data indicates if a weld repair is required (EOG Resources Canada Inc., 2011).

Weld Rectification (Repairs)

Immediately after the NDT inspection results, a weld rectification crew carries out repair or cut-out of any defective welds. After all repairs, another x-ray test is carried out on the repaired welds to ensure that the finished welds meet the requirements. This test is normally carried out from the outside of the weld by a two-man crew.

Field Joint Coating

The coating of the pipeline field joints to prevent corrosion normally starts a few days after the welding. These few days can allow for any extra repairs or cut-outs to be completed so that the coating operations may be performed without any delays.

2.2.3.3 Group 3: Trench Excavation and Installation of Pipe

The group 3 pipeline activities consist of:

Trench Excavation

In areas with no rocks, trench excavation activities start a few days after the field joint coating operation. A typical crew consists of 5 to 8 excavators working in line. The operation is only focused on excavating a length of open cut trench sufficient to install the main welded pipeline. The crews do not excavate any roads, ditches, services or obstacles. The project has to employ the excavators such that the amount of trench excavated in a single day matches the progress rate of the welding activity. The excavated soil is stored on the opposite side of the ROW. The finished trench has the correct dimensions to suit the pipe diameter, plus any bedding or pipe cover. It is important that the trench be excavated in a straight line as far as possible so that the pipe lays easily in the center of the trench without touching the sides. All loose outcrops, which could be to contact with the pipe during laying operations, will be removed (EOG Resources Canada Inc., 2011).

Trench Excavation Watching Brief

During the main trench excavation, normally an archaeologist would be present undertaking a watching brief of the material being excavated. He can stop the trenching works if he considers the excavation has encountered a major archeological find.

Finalize Drainage Design

In agricultural lands, the contractor has to record the existing drainage system on the land which is in contact with the pipeline. The information must be reviewed and taken into account in the planned proposals and any final amendments to the system. This stage has to include follow-up with the owners or occupiers.

Pipe Installation (Lower and Lay) – Above Ground Tie-In Sections

The pipe is positioned at about 5 meters from the trench centerline and is installed into the open, unobstructed trench using a number of side-boos. This operation usually commences immediately after the excavation crew finalizes the trench.

As the main pipe is being installed a coating crew will be present to detect any damage to the pipe coating just before the pipe enters the trench. Fast-setting repair coating will repair any detected damage.

If there is any above-ground break in the main line such as opening across the ROW, expansion breaks, or bends then the pipe will be welded above ground. X-ray detection and coating will be done during excavation. This will optimize the use of the side-booms within the lower and lay crew and reduce the number of below- ground tie-ins.

Cross Trench Drainage Connections

Passing the agricultural land, the permanent reinstatement of the existing land drains has to be replaced across the pipeline trench. This activity is carried out prior to the trench backfill operations. The replacement drains extend for a short distance out of agricultural land into undisturbed ground. By the inspection of the reinstatement works, the trench can be backfilled and compacted in layers to the underside of the drain.

Installation of Permanent Cathodic Protection System Test Posts

Either as part of the fabrication welding crew activities or as part of the pipe being installed, Cathodic Protection lugs are welded to the pipe. These lugs, which can be 50 mm square plates, are welded on the pipeline. The welding process is done by using low hydrogen welding rods. The test posts are installed to check the ground/pipe to soil potential. The distances between each post is about 1km along the pipeline. The posts are located at fixed boundaries such as roads, crossings, or other locations with relatively easy access. During the reinstatement activities, the Cathodic Protection test posts are installed with the cable running up through a duct in the test post and tied off. The test post is later concreted into the ground directly above the pipeline (E. Shashi Menon, 2011).

Temporary Cathodic Protection System

As the pipeline may be buried underground for the whole construction period, before the activation of the permanent Cathodic Protection (CP) System, some form of temporary system needs to be installed before the backfilling of the pipe. The temporary system typically includes a number of zinc anodes attached to the pipelines.

Backfill of the Pipeline Trench

Trench backfill is commenced immediately after the placement of the mainline pipe in the trench. It should also be confirmed by an engineer that the required pipe cover has been achieved. There is a requirement that the initial backfill around the pipe and to 300mm above the pipe crown should be done with loose and fine particles. Fine particles can be readily compacted and they do not damage the pipe coating.

In areas of rock, it is essential to place the pipe on a 150mm bed of similar material with fine particles. Providing this material can be achieved by importing sand or soft material from off-site, and filtering with the crushed excavated material. The crusher and sieve equipment are portable machines; therefore they can be transported along the pipeline ROW. During this activity, the entire length of pipe is backfilled except for about 30 meters at each end of the pipeline work sections. These sections are left free to facilitate the tie-in to the crossing pipe work.

2.2.3.4 Group 4: Pipeline Crossings, Special Sections, and Tie-Ins

This activity group consists of:

Crossings

The crossings are performed by a number of different and dedicated crews working simultaneously with the main trench excavation and final tie-in to the main pipe installation. The crossings consist of two different and distinct methods of construction:

- Open Cut

- No Dig Technique

There are different options available for the two methods and the actual method performed at any given location will be based on the ground conditions, pipe diameter, local environment, third party restrictions, and the type of obstruction which pipe has to cross.

The extent of a crossing is normally defined in design from fixed locations, which extend to either side of the crossing land or boundary fencing. The length of a crossing, however, includes the crossing plus any temporary works to facilitate the installation. Another key aspect in the determination of the needed method of construction at any crossing is the requirement of the regulatory authority that has jurisdiction over the crossing.

Part of the approval process for crossings involves the issue of detailed plans and calculations of the design, which also should be supported by fully-detailed construction method statements. In the following sections, details of different crossings are described in terms of ease of construction and cost (Marshall and Ruban, 1982).

Open Cut

Generally, the most cost effective way of crossing obstacles that cause breaks in the main line is open cut. This method of crossing is undertaken by means of an open excavation. The trench excavation at the obstruction is for the full length of the crossing prior to the installation of the pipe. In order to minimize the time for which the excavated trench is open, the welding, NDT inspection and field joint coating of the section required for the crossing is completed in advance before the excavation of the trench. The open cut crossing can be installed in one working day.

No-Dig Technique:

At some locations using the open cut methods are impractical or not permitted for different reasons and no-dig techniques have to be implemented. The selection of final method is dependent on the ground conditions, third party restrictions, length of crossing, diameter, and safety requirements. Below, the different options available for no-dig techniques are described briefly:

Auger Bore is a term for defining a method where the pipe is supported by crane or side booms in a pit and a cutting head removes the spoil at the face. Thrust Bore is another term used to define the installation of pipes by the manual excavation with the pipe being pushed forward from a thrust pit. This method is used mostly in stable/hard ground conditions where the risk of potential face collapse upon the miners is low.

As this method needs the laborers to work at the face, it normally needs a minimum pipe diameter of 36". Different options are available for the thrust bore method of working:

- Concrete Sleeve: This method needs a pre-installation of concrete sleeve pipes, which are about 2.5 meters in length. After installation of the concrete sleeves, pipe will be lowered into the thrust pit and pushed or pulled along the sleeve to a point where the next pipe can be lowered, welded, x-rayed, coated, and positioned (Shashi Menon, 2011).

- Bare Pipeline: This method needs a similar installation of equipment to the concrete sleeve method, except that the pipe is used for the thrust pipe rather than a concrete sleeve

- Tunnels: The tunnels need to be installed at the locations with low strength of soil. The performance of tunnels and pipelines relies on the used material and structural integrity and also the ability of the material to resist external forces. Aging pipelines are increasingly susceptible to failure.

- Horizontal Directional Drill (HDD): This term is used to define the method of installing a pipeline along sections without entering onto the land. This method includes the welding of the pipeline above ground on one side of the desired crossing. After the welding activity, the crew pulls the string through a pre-drilled hole to the other side of the crossing. Usually, the pipe would be welded, inspected, coated, and tested on-site prior to the drilling operation. First, the drilling machine is positioned on the other side the of welded pipe string. The accuracy of the drill is maintained with a tolerance of 0.1% of the proposed profile at any point during the drilling process. (Esso Imperial Oil, APG, ConcoPhilips, Shell, ExxonMobil, 2004). For a 42" pipe the drill machine is positioned at the entry point and at an angle of around 5 degrees.

After this phase, the drill starts with a 3 to 5 inch drill rod in 3 to 5 meter sections. The machine then drills a pilot hole along the proposed profile. An on-site computer system has to monitor the drill head continuously. Once the pilot hole is completed, a reamer head will increase the drilled hole size to about 1.5 times the pipe diameter so that the pipe can be installed. After completion of the reaming process, the weld string is connected to the drill rods and the process of pulling the pipe into the drilled hole begins. Normally, the pipe pulling process has to be carried out as one continuous task without any delays. After this phase, the pipe coating integrity is checked to ensure that it is in the required conditions. Later, the equipment has to be removed from the site.

Special Sections

The term "special section" is used to define any existing section of pipeline that: (I) cannot be undertaken by the normal spread technique, (II) is a break in the pipeline but is not recognized in the definition of a normal crossing as described before, (III) has time restrictions, (IV) is a sensitive area in regards to environmental issues where third-party specific constraints apply, (V) involves restricted working, (VI) contains difficult directional drills, or (VII) is in an urban area.

If a section of the pipeline is designated as a special section it means that the section of concern is more complicated than a normal spread in a pipeline. This section of concern will need unique methods of working, which normally involves low production and higher than average project costs. Four basic forms of construction methods are normally used in special sections:

- Pull/Push method, which is mainly performed in unstable ground areas where the ground cannot support the construction traffic. This method involves installing the pipeline across an obstacle by welding the pipe in a continuous length and pulling it with winches at one end, while on the other side of the pipe side booms/excavators push the weld string along the rollers.

- Main lay operation is the installation of the pipeline in the trench one pipe at a time. This method is normally used in locations with narrow ROW, unstable ground, or in urban areas. This method needs a single, complete crew, which carries out all operations including, excavations, installation, welding, inspections, coating, and backfilling.
- Horizontal Directional Drill
- Above Ground Pipe work (Shashi Menon, 2011)

Tie-Ins

"Tie-in" is the term generally used for the weld undertaken in the trench that connects two sections of pipeline together. After completion of main pipeline installation, crossings, and special section activities, tie-in crews start to tie the crossings and special sections to the main line. The tie-in crew normally includes excavators to prepare the trench for welders, side-booms to lift and prepare the pipe for welding process, welding crews, NDT inspectors, and coating crews (IFC Company, 2000).

2.2.3.5 Group 5: Final Backfill and Reinstatement Works

The group 5 activities include:

Special Backfill

This backfill is required for washout, stabilization, and geotechnical protection. These activities are needed to ensure long-term stability, or where additional stability is needed following trench excavation. The requirements for special backfill are controlling the effects of water on trench main line and also controlling natural hazards which could result in pipeline failure. In order to have a life-cycle, cost-effective pipeline system, due allowance must be made to ensure all risks which could result in extensive operational costs have been mitigated or avoided.

Final Backfill and Clean-Up

After completion of tie-in activities on the main pipeline, final backfill and grade crew have to commence their work along the pipeline. They will inspect the coating again for the exposed pipe and all other sections in order to repair any coating defect. All temporary materials and trench supports including piles, surplus excavations, etc will be removed from the construction easement area. After these activities, the subsoil will be leveled to the original level, which is determined by operational requirements.

Post-Construction Lateral Drains

In areas with pre-construction drains or in areas where extra drainage must be installed after trench excavation, then lateral drains have to be installed to either side of the pipeline in order to collect and remove surface water.

Subsoil Cultivation

In agricultural land, subsoil cultivation activities involve the preparation of the final surface of subsoil by reforming of open cut ditch banks and other features. These features may have been affected by the ROW operations. When all the changed features are returned to their original condition and the surface leveling is done, marking shallow land drains will start and the subsoil carefully will be ripped parallel to these drains in order to avoid any damage to the shallow drainage installation (IFC Company, 2000).

Permanent Works for Post-Construction Terrain Stabilization

At locations with risk to safety, additional works need to be undertaken after ground final backfilling and cleaning up. Final ground and trench stabilization is handled by final grading and reshaping of side slopes and also by smoothing out any ground removal on the right of way operations in order to provide protection against run-off water in the trench.

Reinstate Off-Site Roads and Provide Operational Access

At the beginning of this phase crew has two options; they can either leave the temporary roads or remove them with a provision for sufficient temporary roads in order to provide access for a safe operation. The crew will remove, upgrade, or reinstate any temporary or existing roads that should be retained. However, this operation should permit access to the final reinstatement crews. Newly installed roads in ecologically sensitive areas need to be removed.

Topsoil Replacement and Final Reinstatement

The replacement of the pipeline easement area and the final reinstatement needs to be undertaken after the subsoil preparation and cultivation activities. This operation includes several activities, which have to be carefully monitored and supervised. These activities are:

- Removal of all equipment helping with temporary access
- Final formation of ditch banks
- Clean up of any damage to highways
- Replacement of topsoil
- Final level on open country
- Building of new permanent boundary fencing and hedging
- Building of cathodic protection posts wherever possible

After completion of final reinstatement activities, the easement land will be brought back to its original conditions:

- In open country: Any fencing is removed and the crews leave land for immediate occupation.
- In special sections/isolated areas: All fencing is removed, access roads are reinstated to the original level with safety security barriers, and the land is left for immediate occupation.
- In arable land: Fencing is removed and the land is prepared for planting.
- In grassland: The fencing will remain on the land and ground will be prepared for re-seeding in the

earliest growing season. After the re-seeding process, the temporary fencing will be removed (EOG Resources Canada Inc., 2011).

2.2.3.6 Group 6: Facilities and Pipeline Control

The main items in activity group 6 consist of:

- Block valve sites
- Pumping stations
- Off-take facilities
- Cathodic protection system
- SCADA and leak detection system: SCADA is a centralized monitoring system to optimize and automate the day-to-day operations from production and gathering to transmission and distribution.
- Electrical power supply
- Telecommunications system
- Control centers

During this phase of pipeline construction, separate contractors undertake the work associated with mentioned facilities and systems. All the work, however, must be coordinated with main construction activities to ensure that the overall schedule and cost for the project will be achieved. The required HSE standards also have to be maintained (IFC Company, 2000).

Construction Activity Group 7 – Testing and Commissioning

The final phase of pipeline construction includes different activities such as hydrostatic testing, pre-commissioning, and commissioning of the main pipeline.

Hydrostatic Testing

The purpose of Hydrostatic Testing operations is to ensure that the installed pipeline is in compliance with regulations. The testing is undertaken after completion of all construction work. First, the pipeline has to be cleaned and filled with fresh water with the use of internal pigs. This ensures that all air is removed from the pipe. The pipeline is then tested based upon the type of the pipeline and the raw material or product to be carried inside. The test will be carried out with 125% of the maximum operating pressure for a continuous period of 24 hours. If the pipeline passes the pressure test, the water will be removed by the use of the internal pigs propelled by air.

Before the testing activities start, the number of test sections should be established. This establishing is determined based on:

- Availability of the water suitable for the task and location of sources
- Location of a suitable place for disposal of testing water
- Variations in altitude, which affects the testing pressure
- Length of section. Test sections are mostly limited by 100- meter change in altitude and 100 km in length.

The water is transferred after being used in the first test section to the next one. It will be filtered and its chemical composition will be checked and modified as necessary. The test water also may be chemically treated to prevent biological growth in the water. The chemicals selected for this treatment should be evaluated strictly before the test. Moreover, environmental permits need to be obtained for all water usage and discharge in regards to hydrostatic tests.

The temporary equipment needed for the test includes large volume/low pressure filling pumps, a break or settling tank, low volume/high pressure testing pumps, chemical injection tanks and pumps, hard pipework, compressors, temperature and volumetric flow instrumentation, pig traps, testing cabins, power supply generators, and filters units. All the temporary equipment needs to be fully certified for the test pressure. When the pipe is filled with water, it will be left to allow the water temperature to equalize to the surrounding ground conditions. This phase takes typically 3 to 5 days. After the temperature is stable the test begins by raising the pressure in the pipe to ensure that the air content is less than that required by the code (normally 0.2%). Typically the test continues for 25 hours. During this ‘hold’ period, the pressure and temperature will be measured, monitored and recorded continuously.

After a successful test, the water is removed and sent to either an approved disposal site or to the next testing section (Shashi Menon, 2011).

2.3 Pipeline Projects in Alberta

In Alberta, pipeline sizes can vary from 5 to 122 cm (2 to 48 inches) in diameter. Pipeline right of way is also selected to accommodate pipe diameter and associated construction activities. In Alberta, right of way widths are typically 15 to 18 meters. Larger pipeline right of way or multiple pipes in one big trench can be up to 45 meters wide (Alberta Environment and Sustainable Resource Development, 2012).

In Alberta 85 percent of pipeline projects are for the oil and gas industry.

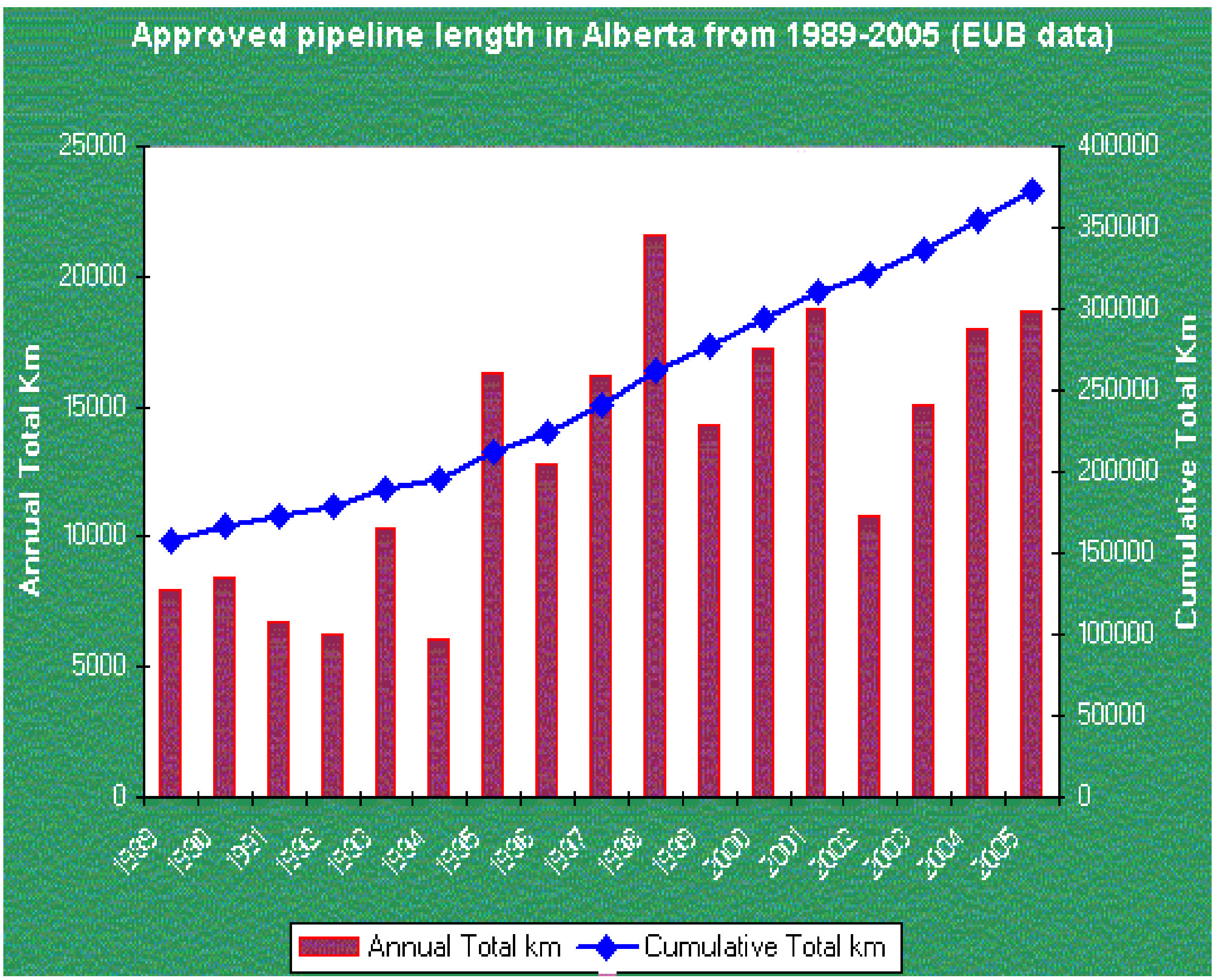


Figure 2.1 Approved Pipeline Lengths in Alberta (Alberta Environment and Sustainable Resource Development, 2012)

2.3.1 Alberta Regulatory Process

Alberta has two classes of pipeline:

2.3.1.1 Class 1 Pipelines

Class is determined by the project length in km multiplied by the outside pipe diameter in mm. This categorization is for projects for which this index value is greater than 2,690. These projects require a conservation and reclamation approval and permit under the *Environmental Protection and Enhancement Act*.

2.3.1.2 Class 2 Pipelines

Pipelines with an index value of less than 2690 do not require the above approval.

Environmental Protection Guidelines for pipelines address different phases of the project, including planning, construction, operations, maintenance, and reclamation. If the pipe is being constructed on public land, approval under *the Public Land Acts* is also required. Pipeline operators need to reclaim specified land in Alberta and obtain a *Reclamation Certificate* after the project is abandoned. The land needs to return to an equivalent land capability.

Major crossings in pipeline construction need to be undertaken by specialized crew. Pipelines that cross a river, creek, or body of water are subject to the *Code of Practice under the Water Act*. Depending on the situation, the project can also be subject to federal legislation under the *Navigable Water Protection Act* and also the *Fisheries Act*.

All issued permits under these Acts determine specific requirements, timing, and construction procedures. Moreover, the operators are required to contact *Alberta Fish and Wildlife Management* in regard to any timing constraints for related resources.

If pipeline construction and operations affect the proper use or management of the land, landowners or occupants are encouraged to contact *Alberta Environment* or *Alberta Sustainable*

Development. Then, department staff inspects the affected area and may ask the company to conduct an assessment and prepare a plan for improving the situation (Alberta Canada Government, 2012).

2.3.2 Pipeline Construction

Regarding pipeline construction in Alberta, before the commencement of construction, pipeline planners need to conduct all required surveys to identify best routes, soil conditions, wildlife habitat, archaeological resources, terrain stabilities, forest, and native vegetation resources. The pipes are normally located in the soil at depths of up to two meters depending on the diameter of the pipe. The pipes are also covered by a minimum of 80 cm of soil. They are also covered with a thin plastic coating in order to be protected from corrosion, water, and rocks (National Energy Board, 2011).

2.3.3 Environmental Considerations

In Alberta, there are various potential environmental issues in regards to pipeline construction and operations. These issues are:

- Land and water contamination from oil and gas, spills, or releases of salt water
- Loss and destruction of wildlife habitat
- Loss and destruction of natural vegetation, mountain, forest, wetland, parks, and rare species
- Loss of soils through trenching, mixing, and ditching
- Soil compaction
- Reduction in agricultural land and forested areas productivity
- Loss of historical resources and archaeological sites
- Increase in undesirable plants or weeds
- Greater access for public and off-road vehicles to natural and wildlife areas which increases exposure of wildlife to humans
- Stream sedimentation
- Destruction of fish habitat

In Alberta, provincial regulatory inspectors cannot carry out all inspections and surveillance for more than 370000 km of pipeline routes; therefore, industry operators are expected to monitor their own pipelines and report all environmental issues. Spill volumes greater than two cubic meters have to be reported. The public or the landowners affected by the pipeline constructions or operations can also alert related company or regulatory staff (Muhlbauer, 2005).

2.3.4 Best Management Practices

Best management practices, specifically in pipeline construction, can ensure that pipeline construction and operation will not destroy or adversely affect environmental resources. Some of the techniques for best practices include the use of:

- Frozen topsoil salvage (recover) equipment and procedures
- Full or partial plant or sod salvage equipment and procedures
- Pipe boring (especially for water crossings)
- Precision grading
- Pipe plough-in (The term is for the pipe with a tool in front to reduce the friction)

2.3.5 Scheduling

The construction period in Alberta, including clearing, grading, trenching, testing, and reclamation for a pipeline is assumed to commence upon receipt of approval. Consecutive phases of the pipeline construction process are expected to immediately follow the previous activity as construction progresses along the right-of-way. Some of final activities such as clean-up and reclamation may be delayed until suitable soil and weather conditions occur.

The exact duration of pipeline activities and operations varies from project to another project depends on the length, size, required permits, soil condition, and available crew.

In Alberta, a standard 10" size in diameter and 32 km in length may have approximately below durations for its different activities (Muhlbauer, 2005).

Pipeline Major Activities	Estimated Duration
Surveying/ Clearing the Right of Way	3 Months
Grading / Right of Way Preparation	2 Months
Hauling and Stringing	2 Months
Bending / Welding	2 Months
Digging the Trench	2 Months
Lowering the Pipe	2 Months
Backfilling the Trench	2 Months
Testing	1 Month
Reclamation	2 Months

Table 2.2 Approximate Duration for a 10" Size Pipeline in Alberta

2.3.6 Pipeline Construction Anticipation in 2012

According to the Inventory of Major Alberta Projects by Sector Report, $7341.9 M has been anticipated for total cost of pipelines in Alberta in 2012.

Due to this report, 15 different companies are involved in the construction of pipeline projects in Alberta, through the year 2012. This number had been calculated before the final approval of construction for the project Northern Gateway. This project had been initially estimated at about $1570 Million; however, due to the installation cost of new safety equipment, this number is anticipated to increase significantly.

Complete list of projects and involved companies in addition to the final cost and location of the projects is presented in the next table.

In the right column, additional information in regards to the each specific project has been given. Moreover, Projects have been marked with different status as such proposed, completed, or under construction.

Company Name	Project Description	Project Location	Cost in $ Millions	Construction Schedule	Remarks
Alberta East Central Water Corp.	REGIONAL WATER SYSTEM	Lloydminster to Vegreville	$150.0	2012-	Under construction (phase 2 of 5 phases). Contract 6 Nu Edge Construction.
Athabasca County	Athabasca Regional Water Pipeline	Athabasca County	$29.2	2011-2012	Under construction. Graham Design Builders A Joint Venture. From Boyle to Grassland / Wandering River.
Capital Region Northwest Water Services Commission	Water Pipeline	Edmonton area to Smoky Lake County	$22.2		Proposed
County of Newell	Rural Potable Water Supply	County of Newell	$51.0	2012	Under construction. Contract 2 Rosemary, Contract 3 Tilley, Contract 4 Rolling Hills.
County of St. Paul / Town of St. Paul / Town of Elk Point	Water Pipeline	Cty of St. Paul (St. Paul to Elk Point)	$7.3		Proposed
Enbridge Inc.	'Athabasca' Pipeline Capacity Expansion	between Cold Lake and Hardisty	$185.0	2012-2013	Under construction
Enbridge Inc.	'Waupisoo' Pipeline Expansion	Edmonton to Ft McMurray	$400.0	2011-2012	Under construction
Enbridge Inc.	'Norealis' Bitumen Pipeline, Husky Sunrise to Cheecham Terminal	RM of Wood Buffalo	$475.0	2011-2013	Under construction
Enbridge Inc.	'Wood Buffalo' Crude Oil Pipeline	RM of Wood Buffalo	$370.0	2011-2013	Under construction
Enbridge Inc.	'Woodland' Pipeline Extension	RM of Wood Buffalo (Cheecham) to Edmonton	$50.0		Proposed for 2012 - 2014. Public hearing starts June 18.
Enbridge Inc.	'Athabasca' Oil Pipeline Expansion	RM of Wood Buffalo to Hardisty	$1,200.0		Proposed for 2014 - 2015. ERCB application filed spring 2012.
Enbridge Pipelines Inc.	'Woodland' Bitumen Pipeline	RM of Wood Buffalo (Kearl to Cheecham Terminal)	$100.0	2011-2012	Under construction
Enbridge Pipelines Inc.	'Northern Gateway' Bitumen and Condensate Pipelines (Alberta portion)	RM of Wood Buffalo to Alberta / BC border	$1,579.0		Proposed for 2014 - 2015. Application filed May 2010. Construction cost entire pipeline (Alberta and BC) $5.5 billion.
Enhance Energy Inc.	CO2 Pipeline (Alberta Carbon Trunk Line)	near Edmonton to Camrose and Lacombe Counties	$600.0	2012-2014	Announced. Revised application submitted to ERCB November 2010.
Inter Pipeline Fund	'Polaris Pipeline' Expansion / Extension of Existing Diluent Pipeline	Edmonton area to Kearl Lake oilsands project	$135.0	2010-2012	Under construction
Kneehill County	Sunnyslope WSA Water Distribution System	Kneehill County	$8.7	2011-2012	Nearing completion. Chinook Pipeline.
MD of Acadia	REGIONAL WATER PIPELINE CONTRACT 1	Oyen to Acadia Valley	$7.5		Proposed for 2012. Planned construction start June.
MEG Energy Corp. / Devon NEC Corp.	'Access' PIPELINE EXPANSION	Edmonton to RM of Wood Buffalo (Conklin area)	$1,000.0		Proposed for 2013 - 2014. Final approvals expected by end of 2012.
Mountain View Regional Water Services Commission	Water Line Twinning	Innisfail to Olds	$26.0	2010-	Under construction (Phase 1 completed).
Northern Sunrise County	Regional Water System Phase 2A (Water Lines and Fill Stations)	Northern Sunrise County (St. Isadore and Nampa)	$9.0	2011-2012	Completed. Glen Armstrong Construction.
NOVA Gas Transmission Ltd.	Northwest Mainline Expansion	Mackenzie Cty (SW of Rainbow Lake)	$324.0		Proposed. Kyklo Creek, Timberwolf and Cranberry pipeline sections. NEB approval February 2012.
NOVA Gas Transmission Ltd.	Leismer to Kettle River Crossover Project	RM of Wood Buffalo	$157.0		Proposed for 2012 - 2013. Pending approvals. NEB public hearing starts May 8, 2012 at location to be determined.
Pembina Pipeline Corp.	Willesden Green Pipeline Expansion, Trunk Line Improvements and Debottlenecking	across Alberta	$40.0	2011-2012	Under construction
Pembina Pipeline Corp.	Pipeline Debottleneck and Construction of Truck Terminals	central Alberta	$11.0	2011-2012	Under construction
Pembina Pipeline Corp.	Crude Oil and Condensate Capacity Expansion, Peace Pipeline	northwestern Alberta	$30.0	2012-2013	Announced. Pending approvals.
Pembina Pipeline Corp.	Capacity Increase on Peace and Northern Pipelines	NW Alberta / BC	$100.0	2012-2013	Announced. Five new pump stations and upgrades to five others.
Plains Midstream Canada (Plains)	'Rainbow Pipeline II' Butane and Condensate Pipeline	Northern Sunrise County to Strathcona County	$200.0		Proposed for 2012 - 2013.
Rocky View County	Water Pipeline from Graham Reservoir to Conrich	Rocky View County	$25.0		Proposed
Swan Hills Synfuels	Synthetic Gas Pipeline	Swan Hills to Whitecourt	$50.0		Proposed for 2013 - 2015

Table 2.3 Alberta Pipeline Construction Anticipation in 2012 (Alberta Canada Government, 2012)

2.4 Pipeline Benchmarking

Benchmarking has long been used to improve the manufacturing process (Kumar, 2001). It is the continuous and systematic process of measuring one's own performance against the results of recognized leaders for the purpose of finding best practices that lead to superior performance when implemented (Nasir et al, 2008). In the capital projects industry, benchmarking is primarily used at the project level to help participants identify gaps in their work processes which lead to compromised performance (Brunso, 2003). For a given company, benchmarking provides sets of external comparisons to its peer group that can be used to establish improvement goals and objectively understand what "best in class" performance means (Swan, 2004). The execution of pipeline projects in Alberta is truly unique. Through 2012, Inventory of Major Alberta Projects by Sector has anticipated $7341.9 M in total cost, just for pipeline projects in Alberta. This dramatic growth in projects and costs has also brought about some challenges. Significant worldwide cost escalations and labor shortages have created increasing pressures on project perceptions regarding potential loss of productivity and/or excessive indirect costs, and cost overruns. Additionally, pipeline projects, due to their length, area of covering, specific characteristics, different risks, impact factors, and unique nature, need special consideration to address the potential risks associated with delivering the projects on time and on budget with sufficient quality.

The Construction Industry Institute (CII) started its Benchmarking and Metrics (BM&M) program in 1995 with an initial purpose to validate the benefits of best practices and to support CII research (Lee et al 2004; Park et al 2005). In 2006, the Construction Owners Association of Alberta (COAA) joined CII to develop a benchmarking system for Alberta projects. Over the years, an online benchmarking system, known as Project Central has been developed to allow benchmarking participants, known as Benchmarking Associates (BAs) to enter project data (including heavy industrial sector and pipeline projects data) in order to get real-time feedback 24 hours per day.

In 2011, COAA and CII Benchmarking & Metrics has launched a new benchmarking system named Performance Assessment System (PAS) for General Large Project to allow for better and faster assessment on the available projects' data submitted to the database. The COAA database framework includes upstream, downstream, natural gas, pipelines and well-sites projects.

Level 1	Level 2	Level 3
Upstream (Oil Exploration/Production)	Oil Sands SAGD	Cogeneration
		Central Plant Processing Facilities
		Pad and Gathering
	Oil Sands Mining/ Extraction	Oil Sands Mining
		Central Plant Processing Facilities
Downstream	Oil Sands Upgrading	Naptha Hydrotreater Unit
		Hydrogen Plant
	Oil Refining	Utilities and Offsite
Natural Gas	Natural Gas Processing	
Pipelines		
Well-Sites		

Table 2.4 COAA Database Framework (Adapted from COAA & CII, 2009)

The Current questionnaire in the COAA database for upstream and downstream projects is detailed into 3 levels (Table 2.4). The current research, in line with the second phase of the COAA benchmarking study, is also trying to break down the pipeline projects into one more level of detail (COAA&CII, 2009).

In January 2013 COAA and CII had 28 complete submitted pipeline projects. This number shows lower than expected data inputs among different companies which are involved in construction of pipeline projects. However, this number has increased significantly since 2012, when there were less than 10 projects submitted into the database. Figure 2.2 shows the aggregate data for these 28 projects in the database in regards to the project cost growth metric. The figure also shows the minimum and maximum of the project cost growth metric in North America.

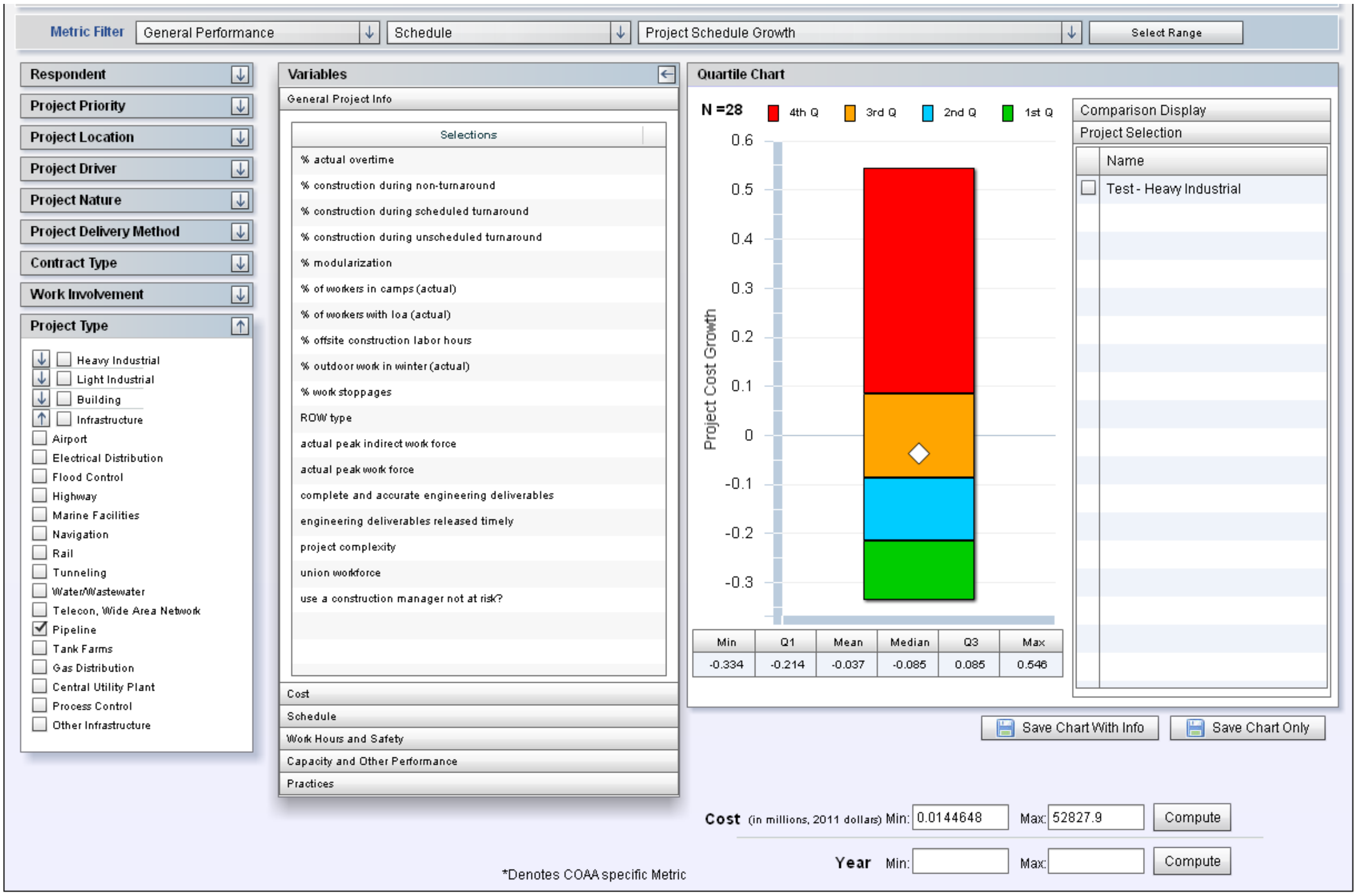


Figure 2.2 COAA Benchmarking Database Snapshot

Despite the fact that Alberta companies involved in pipeline construction have a benchmarking system, there is insufficient data contained in the current benchmarking database to allow for thorough data analysis. Although the number of pipeline companies participating in benchmarking has increased compared to previous years, only 4 pipeline companies currently participate in the COAA benchmarking system. A 2012 Alberta government report lists at least 15 pipeline companies that are currently active within Alberta. Some pipeline projects have reported cost growth of over 50%. Also, as figure 2.2 shows, about 25% of the projects have the cost overrun of more than 10%. These projects are placed in the 4th quartile (red section). The cost growth metric indicates a difference between the actual cost at project completion and the budget estimate at project sanction. A high cost growth metric can indicate a need for better performance. Although a large part of any variation between actual cost and budget estimate can result from poor performance by the project team during the construction phase, some of this variation can also be tracked to problems that may occur during the front end planning and detailed engineering phases. Since one purpose of benchmarking is performance improvement, increased participation in the COAA benchmarking system could result in more complete analysis that could lead to improved pipeline project performance.

2.5 Safety, Security and the Environment

2.5.1 Introduction

In 1959, the Canadian National Energy Board (NEB) was established as an independent federal regulator. This organization has the responsibility to promote safety and security. Canadian public interest, environmental protection, and economic efficiency are other responsibilities of NEB.

Annually, the Board must report to Parliament through the Minister of Natural Resources. In NEB report of 2011, the Board indicated that they regulated nearly 71000 km of pipeline across Canada with which was shipped approximately $103 billion worth of crude oil, petroleum products, and natural gas to the demanding market, Canadians and export customers. The shipping and transportation cost were estimated at about $6.1 billion. These numbers show the significance of the pipeline industry in Canada.

As a matter of fact, the protection of the environment and safety of the public are top priorities of Canada Energy Board. NEB also mandates the pipeline companies since 1959 to include the environment protection plans beside the protection of people who build and operate pipelines and pipeline facilities. The Board supervises companies' compliance in regards to safety and legal requirements based on the design, build, operation, maintenance, and abandonment of pipelines (National Energy Board, 2011).

As a brief summary of NEB activities, it can be mentioned that in 2010, NEB staff responded to three reported incidents in Canada regarding pipeline projects:

- Break in a gas pipeline near Beardmore, Ontario

- Oil pipeline leak in west of Edmonton

- Major oil release in Northwest Territories. The release was near Wrigley.

Also, in 2011, NEB conducted 224 regulatory inspections in regards to security, safety and environment which have been shown in Table 2.

Compliance Activity	Conducted
Inspections	
▪ Safety	46
▪ Pipeline Integrity	22
▪ Environmental	32
▪ Security	3
▪ Emergency Manual Reviews	5
▪ Post-construction Integrity and Environmental Report Reviews	23
Inspections Activity Subtotal	131
Emergency Exercises	11
Compliance Meetings	83
Technical Program Audits	19
Total	244

Table 2.5 NEB Compliance Activities in 2011 (National Energy Board, 2011)

2.5.2 Damage Prevention Program

All pipeline organizations or stakeholders who are living or working near pipelines or pipeline construction sites have an important responsibility to ensure that activities and operations have been performed and undertaken in a safe environment. Experience shows that excavation, construction, or any kind of ground disturbance near pipelines cause the majority of incidents and accidents in the pipeline industry. Construction practices and risky ditching or excavation can cause damage or fatal incidents in some cases. All companies and organizations involved in construction of pipelines have to try raising awareness about working safely around infrastructure on pipelines' right of ways.

Another cause of damages based on NEB 2011 reports, is unauthorized activities such as unauthorized crossings. Preventing these types of damages must be another role of companies and organizations. Organizations need to protect all stakeholders by reviewing the Board published documents such as *Excavation and Construction near Pipelines* and also by participating in sessions and workshops on compliance and enforcement for damage prevention (National Energy Board, 2011).

2.5.3 Risk Management Associated with Pipelines

Building a program for pipelines in regards to risk management can prevent failures, damages, unsafe operations, poor planning, and hazardous construction of pipelines.

This program has to be built as a company would build a new pipeline. It means all aspects of pipeline project lifecycle from pre-planning to the post-commissioning phase have to be considered in the risk program. Risk assessment during different phases of pipeline projects can help in measuring the risks and also in being prepared to re-act in probable incidents and potential hazards (Muhlbauer, 2005).

Conceptualization and preplanning

Activities: Determination of objectives, the required capacity, schedule

What to have in mind: Availability of data, availability of resources, value and reliability of data in regards to demands, the reliability of evaluation system in regards to different equipments and elements of pipeline such as valves, gathering systems, branch lines, etc.

Actions in regards to risk assessment: Estimate uses of the pipe and related unsafe probable incidents that can be anticipated. Develop a schedule and set progress measuring milestones.

ROW Selection

Activities: The team tries to determine the best routing and starts the process of acquisition of needed ROW.

Actions in regards to risk assessment: Identify the optimum locations for the pipes and field offices. Evaluate the cost of transportation for maintenance and the accessibility of pipes.

Design

Activities: The design crew undertakes detailed design and they specify required equipment, control systems, and needed material. They also perform design of hydraulic calculations.

Actions in regards to risk assessment: the raw information such as wall thickness, density, soil type, etc. need to be taken and turned into risk information. All contributing factors, elements, and equipment need to be entered in a list and the risks associated with failure of them have to be considered as risk variables. For the quantification or qualification of the risk the typical and popular formula can be used as: Event risk = event probability * event consequence

Material Procurement

Activities: The team identifies the long delivery equipment and material. They prepare the specifications and quality requirements as well. Actions in regards to risk assessment: Identify data for the longest delivery and begin the efforts immediately to ensure it can be obtained on time. The format of data and level of detail have to be determined to ensure consistency.

Construction

Activities: The team has to determine the number of normal and special spreads and sections, material staging and all protocols for inspections.

Actions in regards to risk assessment: Data collection team has to be formed. Roles and responsibilities have to be clearly defined. Special care needs to be undertaken in regards to scheduled milestones and steps to ensure quality assurance and control (Dey et al., 1996)

Commissioning

Activities: The crew tests all elements and components to ensure the completion of startup programs.

Actions in regards to risk assessment: Use risk model and statistical analysis on the results. Use "what-if" method to ensure the model is reliable. Ensure all failure situations are considered and have a mitigation action associated with them.

Project Completion/Post-Commissioning

Activities: The team has to confirm the finalizing of manuals. They also have to complete training and ensure that all maintenance codes and protocols have been determined and turned over to operation team.

Actions in regards to risk assessment: The most important element in this phase can be considered as documentation. Carefully document the process of risk assessment and all lessons learned for future reference. Document all:

- Assigned responsibilities
- Processes of measuring the progress and improvement
- Change management process (Muhlbauer, 2005).

2.6 Need to Benchmark the Pipeline Projects

As it has been mentioned through this chapter, despite the fact that Alberta companies involved in pipeline construction have a benchmarking system, there is insufficient data contained in the current benchmarking database. Although the number of pipeline companies participating in benchmarking has increased compared to previous years, only 4 pipeline companies out of 15 currently participate in the COAA benchmarking system. According to benchmarking inquiries from COAA database, some pipeline projects have reported cost growth of over 50. A high cost growth metric can indicate a need for better performance. Although a large part of any variation between actual cost and budget estimate can result from poor performance by the project team during the construction phase, some of this variation can also be tracked to problems that may occur during the front end planning and detailed engineering phases. Since one purpose of benchmarking is performance improvement, increased participation in benchmarking of pipeline projects could lead to improved pipeline project performance.

In next chapters, this study tries to acquire proper research methods to collect relevant data in order to define and develop necessary metrics for performance assessment of pipeline projects. Chapter three presents a number of research methods that may be selected to study a subject area.

CHAPTER THREE: RESEARCH METHOD

This chapter describes a number of research methods that may be selected to study a subject area. The choice of a research method is typically between quantitative and qualitative. A quantitative method is field-based experimental research leading to knowledge of actual practices which can be used to identify relevant research problems and provide a baseline for further study. A qualitative method is often simply defined as research that does not use numbers or statistical procedures.

3.1 Background

Research studies into capital industrial or pipeline projects can be difficult, particularly when they seek to address the different features and characteristics of the construction industry. Certain factors make the selection of a suitable research method extremely important in facilitating the well-organized collection of applicable, credible, and reliable data. These factors include the different organization environments and structures, the amount of available data, and the accessibility of desired data due to the consistency of documentation and formats of collected data. (Amaratunga et al., 2002)

By and large, the application of knowledge from the natural sciences forms the basis of large engineering projects, including pipelines; however, knowledge from the social sciences is applied to deal with the organization and execution components of these projects. The organizational structures, the strategies for planning and execution, and the management techniques among a large group of experts and professionals in a diverse social environment lead to many complex sets of objectives and barriers against the ultimate goal of successful project completion (Akinsola et al., 1997). Furthermore, much of the available data and information in the industry suffers from inconsistencies, with some data being only partially complete or even non-existent. These issues may be the result of a lack of an appropriate documentation process, lack of consistency in data collection, or even extensive changes in organizational responsibilities and large turnovers in the staff responsible for data collection (El-Diraby & O'Connor, 2004).

Another factor to be considered in the process of selecting a suitable research method is the amount of information available with respect to the development of benchmarking metrics for pipeline projects. There is not sufficient public information available regarding the understanding of these projects compared to other projects in the construction industry. Furthermore, the different nature and characteristics of pipelines make them unique in the industry with respect to understanding associated data including definitions, metrics, and related risks by professionals.

3.2 Choice of Research Method

Typically, the choice of research method comes down to quantitative versus qualitative approaches. A commonly utilized quantitative method is field-based experimental studies to identify relevant research problems and a baseline for future investigations (Verma & Goodale, 1995). Conversely, a qualitative method is simply a research approach without statistical procedures or the use of numbers (Cassel et al., 2006). Nonetheless, qualitative research is much more than this. In fact, this method defines the research based on multiple meanings of individual experiences. Qualitative researchers attempt to develop a comprehensive and in-depth understanding of human behavior, looking to the reasons that direct behavior and actions (Creswell, 2003).

An alternative option for a research method is a combination of the discussed approaches in which both quantitative and qualitative methods are used in order to take advantage of the strengths and compensate for the weaknesses of each. This method has been used successfully in several disciplines (Mangan et al., 2004) and there are a considerable number of researchers who believe that these two methods should be integrated (Gummesson, 2003; Howe, 1988; Hyde, 2000). On the other hand, the combination of quantitative and qualitative methods has not been without debate among researchers. These scholars speak to the incompatibility of these two methods while admitting that their integration has some potential benefits (Huberman, 1987; Schrag, 1992).

Triangulation is one of the more important methods that combine quantitative and qualitative methods in construction research. This approach can be useful because construction projects are difficult to understand with an exclusively scientific quantitative method due to the element of human behavior, which cannot properly be ignored in this industry. Furthermore, triangulation, by using multiple research methods, tries to overcome bias and validity issues (Amaratunga et al., 2002; Greene *et al.*, 1989).

There is also another type of study referred to as 'exploratory research' that can be used to collect as much information and data about a subject as possible. This method is typically used in situations where there is limited information available. The method helps the researcher to gather information prior to a critical analysis of the data to gain a better understanding of the subject area. The method usually follows the goal of developing a system and method of study. The system helps in defining a set of parameters that will support other researchers in examining this subject in the future. The method is most suitable for determining how to study a relatively unknown area of research (Love *et al.*, 2002).

3.3 Quantitative Research Method

A quantitative research method is a designed experimental approach used to test or validate a specific observation and/or theory regarding a particular incident or phenomenon (Amaratunga et al., 2002)

The results of the research can be generalized as a comprehensive conclusion if:

1) They are the results of random experiments and the samples are of a sufficient size.

2) They have been generated in different populations.

3) The results are independent of the researcher.

In this method, results are presented in precise numerical data. Different data collection approaches include: surveys with closed-ended questions, structured interviews, participant observation, and retrieval of archived data.

Comparatively, quantitative data has been more popular and has been accorded higher credibility than qualitative information among those individuals with decision-making power over the financial support provided for research projects, as the results can be generalized and directly applied to a large population. The focus of such data is on 'what has been,' 'how much,' and 'how often' rather than 'what should be.' That is why this method can be defined as a snapshot in time and may not address the needs of different research projects such as an in-depth observation of human behavior.

3.4 Qualitative Research Method

Qualitative research methods have been designed and developed to understand phenomena in different and specific circumstances so as to be able to clarify human experiences (Amaratunga et al., 2002). Data collection in qualitative inquiry varies from survey instruments with open-ended questions to different longitudinal studies over time. Data can also be collected in unstructured or semi-structured interviews, observation, or case studies.

The abilities to observe changes over time and become adjusted to new issues and new thoughts as they emerge during the data collection process, make the qualitative method suitable for studies aiming for an in-depth understanding of problems involving human behavior. However, qualitative study is generally accorded lower credibility than quantitative study by those individuals responsible for allocating funding for research projects. The reason is that the results produced cannot always be assigned to a larger population. In addition, quantitative calculations cannot be generated by the results of a qualitative research study. Qualitative methods have several disadvantages when compared to quantitative research:

(1) Data collection requires more resources.

(2) Analysis and explanation of results is more complicated than with the quantitative method.

(3) It is also difficult to control the start and end point of the research. Furthermore, it can be challenging to manage the pace and progress of the report (Johnson & Onwuegbuzie, 2004).

3.5 Mixed Method Research

Simply, mixed method research is a combination of quantitative and qualitative methods, however it is much more complicated than that. Mixed method research is the combination of research techniques, methods, approaches, concepts, and language in a specific study (Johnson & Onwuegbuzie, 2004)

Data collection techniques in a mixed method research can be the same as either the quantitative or qualitative method; however, it depends on how the technique is applied to a single study.

For instance, 'hard' quantitative data can be collected by structured interviews with closed-ended questions while unstructured interviews with open-ended questions can collect 'soft' qualitative data (Amaratunga et al., 2002). Triangulation, which normally has been used for validating or testing the final data, can be applied in different ways of collecting data from different sources by different researchers acting independent of each other (Love et al., 2002).

Compared to either quantitative or qualitative research methods, the mixed method has its own advantages and disadvantages (Johnson & Onwuegbuzie, 2004). Some of the advantages include:

1) Pictures, comments, and narratives can add meaning to digits and numbers.

2) Digits can add accuracy and precision to words, pictures, and narratives.

3) The strengths and weaknesses of qualitative or quantitative methods can be addressed.

4) A wider range of questions can be addressed when researchers use several different approaches.

Conversely, mixed method research has some disadvantages including:

1) Additional resources may be required when researchers use several approaches.

2) Researchers must have a broader knowledge of research methods and understand different approaches to mix them effectively.

3) The mixed method can be more expensive and time consuming.

3.6 Exploratory Research

Exploratory research is suitable for a situation where there is not sufficient information available for a specific subject. Exploratory research helps scholars to become familiar with a topic and to have better insights. Moreover, this type of research is helpful for formulating more specific questions or hypotheses (Thia et al., 2005).

During an exploratory study, the researcher tries to recognize and categorize new variables that are not clear enough in the current understanding of the topic. After the determination of variables it may be possible to apply quantitative methods in order to validate the data. The initial process of data collection is done using a qualitative method in order to obtain sufficient data for better understanding the area of study; these variables will become part of subsequent investigations. The results of an exploratory approach are normally reliable enough for generalization in other populations rather than merely being representative of the population being observed and examined (Weischedel et al., 2005).

Interviews, case studies and open-ended questionnaires are typical data collection processes in an exploratory approach in order to gain as much rich data as possible to develop theories and concepts in new perspectives. This method is normally characterized as an inductive rather than a deductive approach. A deductive approach can limit the development of new theories; however, an inductive method uses experimental information to build and develop explanations and theories for what was observed. Despite these facts, the appropriate interpretation of the data is a balanced approach between inductive and deductive methods (Benavent et al., 2005).

The qualitative method in an exploratory approach helps researchers to avoid unnecessary complexity in the validation phase of the research by identifying the most important variables and relationships that require investigation.

Caution is also advised regarding the issue of self-assessment, which typically occurs during the qualitative method phase. The problem of self-assessment derives from the experience of the contributors, which they normally use as a reference point for their answers. Therefore the collected data must be examined closely in the appropriate context for the research study.

Because of their characteristics, open-ended questions typically provide richer answers than direct, closed questions, and it is the researcher's obligation to search for a better in-depth understanding of the collected data.

In short, exploratory research begins with a qualitative method investigating what is available and collecting as much information as possible in preparation for the subsequent phase. A later study will be conducted to determine what data is important and what data is irrelevant or can be discarded.

3.7 Data Collection Techniques

Several data collection techniques have been mentioned before for quantitative, qualitative, and mixed method research. This section will present various data collection techniques in greater detail.

3.7.1 Survey Instrument

Survey instruments, also known as questionnaires, ask questions on a certain topic or issue in order to determine what is occurring in a specific situation, what people are doing or thinking, or how various things are changing (Janes, 1999).

Poorly worded questions in a survey instrument are one of the primary reasons why many questionnaires are unsuccessful and ineffective. Questions should be:

1) Related directly to the issue being studied as people have to answer only the questions you ask.

2) In a correct type or format: Multiple choice, yes/no, open-ended.

3) Clear, accurate, and precise with no slang or complicated terminology.

4) Not deceptive - they should be designed without leading anyone to particular answers.

5) Able to be understood and answered by the participants without asking too much detail.

6) Short and not double – avoid the word 'and'.

7) Not negative – avoid the word 'not' as it can be misinterpreted.

8) Unbiased - they should have no influence on the participants to give desired answers.

Other important factors that can make the survey instrument a success include the order of the questions, the design and layout of the survey form, and the instructions for answering different types of the questions.

If the questionnaire contains some questions asking for sensitive or personal information from the participants it can influence the survey results negatively. It is better to start the questionnaire with non-threatening questions, which may serve to develop a trusting connection with the person. Furthermore, complicated instructions can cause the participant to give inaccurate or false information or refuse to complete the survey. An organized questionnaire with enough space for answers can encourage people to complete the questions. Pre-testing of the survey with a small group of people is one way to identify problems prior to the distribution of the main survey (Collins, 2003).

The overall research design may affect whether the chosen sample of people can be considered suitable representatives of the population being studied and also indicate if the results of data are valid and reliable (Collins & Gordon, 1997; Forza, 2002; Janes, 2001).

Caution is advised that if a question is not important to the problem being observed it should not be included in the survey. The issue of distributing and completing the surveys will affect the cost and time of survey administration. Self-administered surveys can be quick and inexpensive but face-to-face or telephone surveys may provide better quality responses. These types of surveys are more suitable for complex questions which require more detailed instructions. Generally, questionnaires are excellent tools for identifying the attitudes and feelings of participants. They can show what people think rather than what they have done or what they would do.

3.7.2 Interview

An interview can be an efficient and cost-effective way of gathering information on people's behaviors and attitudes (Jarratt, 1996; McClelland, 2005; Ratcliffe, 2002; Wright, 1996). Depending on how the researcher interacts with participants, interviews may be structured, unstructured, or semi-structured.

3.7.2.1 The Structured Interview

The structured interview involves the researcher working through a series of standardized questions, an interview schedule, and a questionnaire. This type of interview is usually composed of closed questions and fixed choice responses (McNeil and Chapman, 2005). These types of interviews are mainly used to result in quantitative data. Structured interviews pose the same set of questions to each respondent in order to gather information that specifically addresses the topic under observation. The questionnaire may contain closed- or open-ended questions as suits the purpose of the research.

3.7.2.2 The Unstructured Interview

Unstructured interviews usually involve the researcher having a list of topic areas that need to be covered but there are no specific defined questions that have to be used. These types of interview are characterized by open-ended conversations that allow the participant to discuss the desired topic in any manner he likes with some minimal direction from the researcher. Unstructured interviews often give this opportunity to the respondents to 'speak for themselves'. These interviews often use smaller samples than those found in large scale surveys (McNeil and Chapman, 2005).

3.7.2.3 The Semi-Structured Interview

Semi-structured interviews fall somewhere in between the structured and unstructured varieties. They include a specific set of questions that can allow the researcher the flexibility to investigate other topics that may arise from the answers given by the respondents. Semi-structured interviews tend to be made up of a combination of closed and open questions aimed at collecting data.

Interviews can be conducted face-to-face, by telephone, or by other communication media. Two specific types of interviews can provide comprehensive detailed information on the areas under observation. These two types are: the in-depth interview (Ratcliffe, 2002; Wright, 1996) and the convergent interview (Rao & Perry, 2003).

In-depth interviews would be conducted face-to-face in order to allow the researcher to assess verbal and visual clues from the participants so they can move the interview into other related areas of concern. The face-to-face approach also allows the researcher to address any concerns the respondents have about the confidentiality of the provided information. In-depth interviews also allow the researcher to direct the discussion into areas of interest that are identified in the responses.

Convergent interviews are in-depth interviews with a structured data analysis process (Rao & Perry, 2003). This method of interview uses a series of in-depth interviews that allow the researcher to refine the questions following each interview to converge on the issues under observation.

Issues which have been raised in one interview can be followed-up on in subsequent interviews in order to uncover agreement or disagreement among the participants. Supporters of the convergent interview technique believe that it is a quick way to converge on the main issue in an emerging area. It also has an efficient mechanism for analyzing data and it includes a way of determining when to stop the process of data collection.

3.7.3 Case Study

Another research technique is the case study, which can provide both quantitative and qualitative data in order to develop theory (Amaratunga & Baldry, 2001; E. Patton & Appelbaum, 2003; Woodside & Wilson, 2003). Some researchers believe that the case study is the best method to answer 'how' and 'why' questions when the research is exploratory, descriptive, or explanatory (Rowley, 2002). Case studies can involve single or multiple cases. They also can follow up with numerous levels of analysis. Case studies combine different data collection methods including archive retrieval, interviews, surveys, and observations. The following steps identify a framework for executing a case study:

1. Define the research question.
2. Select desired cases to study.
3. Prepare data collection instruments (quantitative, qualitative, or both)
4. Start collecting data in the field. The researchers' impressions can be included in field notes.
5. Analyze collected data.
6. Search the different cases for cross-case patterns. Look at the data in different ways in order to reduce bias.
7. Form hypotheses.
8. Compare the emerging hypotheses with existing literature.
9. Reach closure.

Case studies can support an in depth investigations on 'how' and 'why' questions about a current emerging event over which the researcher has little or no control (Rowley, 2002). Comparatively, the number of examined units in a case study is less than that examined when using a survey instrument/questionnaire, but the extent of detail is more comprehensive in the case study.

The unit can be a person, an event, or an organization (Grunbaum, 2007).

Case selection depends on the purpose of the research, the questions and theories in the literature, the availability of the participants, and the time available for collecting and analyzing the data. A single case is most often used when the case offers something unique and valuable for contributing to a theory. It can also be a preliminary or pilot case to multiple case studies.

Multiple cases would be used in a situation that can provide more clear research outcomes. The number of cases is calculated by how many cases are needed to produce similar results or produce different results with predictable reasons. It also depends on the nature of the problem under observation.

3.7.4 Participant Observation

Participant observation is another data collection tool for gathering evidence that needs skill, knowledge, and understanding on the part of the researcher (Vinten, 1994). The researcher is usually absorbed in the event looking for more information and greater depth of knowledge. Normally, it is easier to obtain the information by being on the inside rather being on the outside looking in. Observation provides the researcher with more channels of communication and allows him/her to be more selective about the data received.

Mere observation means that the researcher can capture 'moments in time' data rather than a study over an extended period. The researcher who simply observes a situation may only obtain limited data, which would not be sufficient for the purpose of the study; however, if the researcher is immersed in the event, he/she would be able to gain more useful information due to the fact that the participants who interact with the researcher would be more open to providing information.

An experienced observer can address the issues of researcher bias and unreliable data. This observer does not rely on observation as the only means of gathering data and information (Vinten, 1994). In addition to participant observation, other approaches and methods can be used for collecting data including quantitative methods such as the retrieval of archived data. A big objection to participant observation is how the presence of the observer may change the actions of participants under observation. One way to address this issue is to involve the observer with the individuals for an extended period of time in order to gain the acceptance of the group so his presence would come to seem natural. An alternative solution is for the observer to conceal his true identity or play another role not related to the study. In this case, the observer should take a secondary or 'back seat' position. However, the observer must consider the consequences of the degree of their own participation regarding the collection and loss of information that is critical to the success of the research study.

The other area of concern is the difference between data gathered by the observations from: 1) the individuals or 2) the group that has been assigned to solve the issue and make decisions. In this case, the information gathered by an observer watching the actions of individuals may not reflect the true reality of how the issues are addressed and managed in the organization (Vallaster & Koll, 2002). How the individuals interact with each other in the group, how the responsibilities are assigned to the individuals, what communication techniques are used to collect and gather data are some examples of factors that affect group decisions. Therefore, the observer should first collect information on how the group operates, communicates, analyzes, and makes decisions prior to gathering data related to the research study.

3.7.5 Focus Groups

A focus group is a form of interview that occurs in a group. An advantage of a focus group is that it encourages communication among participants which may generate information for a research study (Kitzinger, 1995). During a focus group, discussions can identify the attitudes and beliefs of the participants that may not be uncovered in one-on-one interviews (Threlfall, 1999).

The dynamics of a group usually lead the conversation into unexpected territory because individuals who may not be comfortable enough to express their true feelings under normal circumstances may gain a sense of empowerment within a group and become more open. On the other hand, individuals may also be affected by the group environment and follow the direction of the group rather than offering their own views. Another issue which may arise in some focus groups is that they may contain individuals who intimidate others in the group with aggressive behavior. In these groups, it is the role of the facilitator to restrict these unacceptable actions so that everyone may have an equal opportunity to express their thoughts.

Two important factors, which can affect the results of focus groups, are the size and composition of the groups (Calderon et al., 2000; Kitzinger, 1995). The ideal size is four to eight people. Most researchers recommend homogeneity within a group because it can make the most of shared experiences. However, other researchers suggest that diversity among the participants can bring different perspectives into the group. If individuals are at different levels inside the organization or work with each other, the group hierarchy will be an issue in focus groups. In this case, an experienced facilitator is required to manage the issues. The number of focus group participants may range from between two to five and up to fifty based on the purpose of the study and the resources available to the researchers. Focus group techniques can be combined with other data collection methods.

Although focus groups seem to be time and cost efficient, they can be more time consuming than individual interviews since the time saved in interviewing may be lost to recruitment, logistics, and analysis of a large amount of complex and messy data (Kidd & Parshall, 2000).

3.7.6 Action Research

Action research is a specific application of the participant observation approach discussed earlier (Vinten, 1994). Action research engages groups of people who use cycles of activities to plan, act, observe, and reflect on what happened. The purpose is to improve work processes to address complex problems when there is very little information available (Altrichter et al., 2002).

Simply, the process can be described as 'let's see what happens and then decide how to make it better' that follows a 'look, think, and act' process. Action research is typically used to find results that offer practical solutions to real life issues (Vinten, 1994). Some scholars have expressed a concern that action research has its own limitations and it is just consultancy, which may be affected by the biases of the researcher to the point that the reliability and validity of the research would be questioned (McKay & Marshall, 2001).

3.7.7 Longitudinal Study

A longitudinal study is defined as a study that involves repeated observations of the same problems over and over during long periods of time. The purpose of this study is to identify and clarify how a specific item, event, person, or organization works and changes over time. Regarding data collection, any technique can be applied to execute the longitudinal study. However, it is important that the observations are repeated in the same way so that the results are comparable across different time periods.

3.8 Research Quality

The main purpose of research is to have a contribution to the body of knowledge by study and analysis in order to develop or test a theory about a specific knowledge area (Dixon-Woods et al., 2004). There should be confidence in the quality of study results before they are included into the body of knowledge; however, it is important to know if it is suitable to apply a set of quality measures to all types of research methods or if there should be different measures applied to each type of research method.

3.9 Validity

The process of measuring quality is known as validity, and continues to be a topic of great discussion (Winter, 2000); there are different definitions for validity among researchers including:

1. It is the process of evaluating and measuring of the same thing with different techniques.
2. It is whether a tool measures what it is supposed to.
3. The degree of approximation of reality.
4. Accuracy.

Some researchers believe validity in qualitative research methods can easily be achieved if the researchers use unstructured interviews in order to help well-informed participants speak freely based on their own knowledge structures (Stenbacka, 2001). Moreover, the concept of triangulation, which will be discussed later, has been proposed as a means of addressing the validity discussion (Golafshani, 2003).

3.10 Reliability

In quantitative research, reliability refers to the consistency of the results over time. It means that the study results are an accurate representation of the observed population. In three ways, researchers measure the repeatability of the results:

1. The degree to which a repeated measurement remains the same.
2. The stability of a measurement over time.
3. The similarity of measurements (Golafshani, 2003).

Caution has been advised regarding use of these measures when a test-retest technique is used as they may make respondents sensitized to the matter under study and it can influence their responses. Similar to validity, the concept of reliability in qualitative research should be addressed as a measure of the quality of the research (M. Q. Patton, 2002). Also the measures of quality should be redefined from quantitative research in order to fit the nature of qualitative research. Some researchers have developed a new definition for reliability, which is called dependability (Riege, 2003). Dependability is a test for measuring the consistency and stability of the process of research. The questions that should be addressed in this measurement include:

1. Are the questions clear and congruent with the characteristics of the study?
2. Has the process of research been done with reasonable care?

Like validity, it has been discussed among some researchers that reliability has no place in qualitative research, while others argue that reliability is a consequential activity of validity such that if qualitative research is valid it would also be reliable without any further measurements (Patton, 2002).

3.11 Triangulation

Triangulation is a combined method which includes two or more different methods (quantitative and qualitative), data sources, and data analysis techniques in order to balance the strengths and weaknesses of any one method and also to increase the ability of interpreting of research findings; however, if a study is poorly designed, triangulation will not compensate for the research (Barbour, 1998).

Different types of triangulation include:

1. Data source triangulation
2. Investigator triangulation
3. Methodological triangulation
4. Theoretical triangulation
5. Data analysis triangulation
6. Multiple triangulation which combines multiple investigators, data sources, or data analysis in one study (Jack & Raturi, 2006).

Data source triangulation addresses the collection of data based on time, place, or setting and the person, who provided the information (Thurmond, 2001). Data source triangulation has several benefits such as:

1. Increases confidence in the research findings

2. Helps to find innovative ways of understanding a phenomenon
3. Uncovers unique findings and theories
4. Provides a clear understanding of the problem

Disadvantages are:

1. Very large amount of data have to be processed which can lead to false interpretation
2. Difficulties in combining qualitative and quantitative data (Blaikie, 1991; Thurmond, 2001)

Investigator triangulation uses one or more observer, interviewer, coder, or data analyst in one study (Thurmond, 2001). The credibility of a study is increased when gathered data and information is confirmed by different researchers without collaboration or discussion among themselves.

By using multiple investigators the potential of bias in gathering, reporting, coding, or analyzing data can be decreased. Benefits of investigator triangulation include:

1. Increasing credibility by keeping the team honest.
2. Multiple analyses strengthen the reliability of the findings.
3. More cross-checking and verifying of the data can increase the value of the findings.
4. The research can take advantage of different special skills each investigator brings to the study.

Disadvantages of investigator triangulation include:

1. Measuring and validating bias is difficult.
2. Researchers may use their own method and technique for the study instead of one designed technique.
3. Different investigators can interpret participant responses differently.

Methodological triangulation involves mixing data collection techniques as well as combining quantitative and qualitative methods in one study (Thurmond, 2001).

The use of different method can decrease the biases and mistakes that may occur when researcher uses only one method. Methodological triangulation can be applied within a method using two or more data collection techniques or it can be applied as use of both quantitative and qualitative data collection techniques in one study. Examples are combining interviews with questionnaires or observation with Likert-scale surveys (Blaikie, 1991; Thurmond, 2001).

Benefits of methodological triangulation include:

1. Combining multiple views of the same phenomenon, which is under study.
2. Exposing unique differences or information that may remain undiscovered if only one method was used.

The disadvantages of this type of triangulation (Blaikie, 1991; Thurmond, 2001) include:

1. It is difficult to design the study and include both quantitative and qualitative methods
2. Increased expense of the combined study
3. Researcher's lack of skill in either quantitative or qualitative method

Theoretical triangulation combines use of multiple theories or hypotheses in the process of examining an event (Thurmond, 2001). The purpose of the study is to test various theories and hypotheses by analyzing information from the same data set. Benefits of theoretical triangulation are:

1. Decreases alternative explanations for the phenomenon.
2. Provides an expanded and deeper analysis of the results.
3. Gives the researchers a different chance to look beyond the obvious explanations.
4. Increases the researcher's confidence to develop concepts and new theories

However, the disadvantages (Blaikie, 1991; Thurmond, 2001) include:

1. Incomplete theoretical framework can make confusion.
2. Use of different theories in order to support the same research may not be right.
3. Interpretation of data from different theories may be difficult.

Data analysis triangulation is the combination of two or more data analysis techniques (Thurmond, 201). This technique can include different statistical testing and techniques to determine similarities.

Finally, multiple triangulation is a situation in which researchers combine multiple observer, theoretical perspectives, more than one data sources, and different research methods.

3.12 Sampling

3.12.1 Sample Size in Quantitative Research

One important factor in quality of the findings during a quantitative research is sample size (Devane et al., 2004). If the sample size is too small the study might be unethical, not reliable, and can be a waste of resources. This study is not able to detect true differences between two situations. On the other hand a study with too large sample size also can be a waste of resources and time because more participants were involved than needed in the research (Devane et al., 2004).

Sampling in any study needs good planning and it is a key factor for a successful data collection. The process of defining a problem and designing reliable instruments should be followed carefully so that a randomized sample of the correct number of participants can be selected from an appropriate population (Lenth, 2001). A randomized trial is one of the best techniques for finding the suitable population. Participants who meet the criteria for the population under study are selected randomly in the numbers, and that should meet the quality requirements (Devane et al., 2004).

The first step is to establish one or more hypothesis to be examined. A hypothesis is a prediction of the relationship between two or more variables. Moreover, a null hypothesis which predicts no existing relationship is established even if we expect a relationship to exist. The test of the difference between two variables may not have sufficient resources to test every possibility. If the null hypothesis is rejected, we can conclude that there is a difference between the two variables; however it is not able to identify the degree of difference.

There are many different ways to determine an appropriate sample size. For in-depth qualitative studies, Abbie Griffin and John Hauser found that 20 to 30 in-depth surveys or interviews are necessary to uncover 90-95% of all customer needs. Thus, the authors determined that a sample size of 30 respondents would provide a reasonable starting point. This number is corroborated by some researchers, who state a "sample size larger than 30 and less than 500 are appropriate for most research," adding that at least 30 observations is an optimal sample size when applicable (Hoque, 2011)

To determine a suitable sample size, the magnitude of the difference between the two important variables should be specified. This is known as the effect size which is typically between 5% and 10%. The next step in determining the sample size is to select a significance level below which rejects the null hypothesis. The significant level is the probability (typically 1% to 5%) that we incorrectly reject the null hypothesis. This test which correctly identifies that there is a difference between two variables is called the power of the test. In other words, this is the ability of the test to reject the null hypothesis when it should be rejected. The power of a test is typically between 80% and 95% which means that there is either a 20% or 25% chance that we will accept the null hypothesis (Devane et al., 2004). Sample size can change by modifying or adjusting the values of the effect size, the significance level and the power of the test. If the research has insufficient resources to obtain a large sample size, the values of the quality criteria should be adjusted to reduce the size of the sample that fits within the available budget; however the reduction in sample size may reduce the quality level of a study.

3.12.2 Sampling in Qualitative Research

Having a random sample can help a researcher with generalizing the results in a quantitative study, but it is not effective in understanding complex issues relating to human behavior (Marshall, 1996). Researchers don't use random samples in qualitative research because the population's characteristics are unknown; moreover these characteristics are not distributed normally within the study population. Besides all these, biases are inevitable. A suitable sample size for qualitative research has to be large enough in order to answer the research question. In most situations this sample is very small. This sample is known as purposeful sampling (Sandelowski, 1995).

Three approaches exist in order to select an appropriate sample for a qualitative study (Marshall, 1996; Sandelowski, 1995):

1. Convenience Sample
2. Judgment Sample
3. Theoretical Sample

Convenience sample is the least costly method in terms of money and time but may result in poor quality and non-reliable data. It involves in just selecting available participants at the time of the study. Judgment sample is the most common method and technique, which within the researcher actively searches, finds, and selects the most productive population sample that can answer the study question. The participants answer the research question based on the developed framework, which identifies the variables that might influence the population sample in the study. This framework includes the researcher's practical knowledge and information extracted from literature concerning the area under study.

Theoretical sample is normally developed in the process of recruiting additional participants to the sample as the collected data is analyzed and interpreted. The whole process includes recruiting participants, collecting and analyzing data, and then recruiting additional participants. This process continues until no additional new information is gained from the respondents (Marshall, 1996).

3.13 Researcher Involvement

Normally, the quantitative study is looking for observable facts while the qualitative research tries to understand and analyze human experiences and behavior. An important difference between these two different types of study is the role of the researcher (Amaratunga et al., 2002; Johnson & Onwuegbuzie, 2004).

Independency is an important factor which a qualitative study observer needs to carry all through the research so as not to affect or bias the research findings. During a qualitative study the researcher is expected to be fully involved in all aspects of data collection and analysis processes.

Despite the fact that being independent in quantitative research gives the researcher the ability to objectively collect and identify cause and effect relationships, without bias he may miss other characteristics that can only be recognized by interacting with the participants. On the other hand, a researcher involved in qualitative research can be more flexible to changes that occur during the study, and can shift the focus of the study accordingly, but the credibility of the result may be questioned because of the potential bias of the researcher influencing the participants and the results.

A researcher who uses mixed method research needs to follow all the requirements of being independent and fully involved so to insure that the credibility of the findings is acceptable. The researcher also needs to know about all the multiple methods, approaches, and tools, and how to mix them appropriately. Next chapter, chapter four, explains the selected research method for the current study.

CHAPTER FOUR: SELECTED RESEARCH METHOD

Chapter four describes the research method selected from the available research methods described in previous chapter.

4.1 Study Scope

Large oil and gas engineering and construction projects have experienced cost and time overruns. It is critical for owners, contractors, and project managers to deliver the projects faster and meet imposed deadlines; this allows them to get products delivered to market sooner, industry professionals continue to search for techniques that will provide them the opportunity to meet cost and schedule targets. One technique to meet these requirements is the application of benchmarking during lifecycle of the project. Benchmarking also gives the opportunity of project performance analysis after completion.

John Reh as a senior project manager says "Benchmarking is the process of gathering information about other companies in your industry to compare your performance against and to use to set goals." Currently, there is limited public information on benchmarking and preliminary discussions with industry professionals indicate there may be a low level of awareness of benchmarking among pipeline projects.

The purpose of the current research project is to expand and extend the benchmarking metrics and system, focusing on activities and methods to design and fabricate pipeline projects, used by engineering, procurement and construction (EPC) owners and contractors.

Specifically this research study will:

1. Determine the level of applied benchmarking on pipeline projects among industry professionals.
2. Find out which assessment metrics are in used and also how important they are (the priority of use in the industry).
3. Clarify the definition of a pipeline project and differences versus piping projects.

4. Determine what risks are associated with pipeline projects.

5. Determine the lifecycle of a pipeline project and cost and schedule breakdowns in different phases.

6. Develop new level of details based on important parameters (size, length, products, etc.) associated with pipelines in order to categorize pipeline projects.

As we start this research study, we have the following level of knowledge about benchmarking in pipeline projects:

1. Oil industry professionals are experiencing confusion in understanding the applications of benchmarking, how benchmarking metrics should be chosen and measured, which metrics have to be measured, at what phase of the pipeline projects, benchmarking should be done, and how to interpret the results of benchmarking process.

2. Existing processes, tools, and metrics concerning benchmarking of pipeline projects have not been developed sufficiently and can cause confusion.

3. Limited public information on the benchmarking of pipelines is available.

4. No definite framework exists in order to show what metrics have to be measured and how to interpret them.

During the process of reviewing the literature, I studied the information available on the current level of knowledge of benchmarking in pipeline projects and I realized that this research study should be classified as exploratory since there is limited knowledge available on the subject. As discussed in the previous section, in exploratory research, we begin with what we have and collect and take a general view of the subject, gathering as much information as possible before deciding which data is important and which data can be discarded concerning the subject being studied.

In this research study, I will examine the current attempts by professionals in different big oil and gas companies to better understand the subject area and to determine the criteria and limitations within the pipeline industry that should be used for such studies. The goal is to develop a method of study and define a set of parameters that will assist to develop a framework of metrics.

4.2 Ethical Considerations

This research study will follow prescribed procedures and protocols necessary to meet the ethical requirements of the University of Calgary. The research approach and methodology have been submitted to the Conjoint Faculties Research Ethics Board of the University of Calgary for review and approval. After the review process by the committee, the application (File #7239) received ethics certification for the above-named project. The prescribed procedures will be discussed with all study participants who must voluntarily agree to participate in this research study. A copy of this procedure will be handed to participants in the study

4.3 Research Study Method

A one hour interview was designed and held to develop a baseline for the use of benchmarking metrics in pipeline project life cycle. This questionnaire contained a series of open-ended questions to obtain qualitative information on the definition of a pipeline project, what differences exists in a pipeline project lifecycle versus an industrial project, and also what metrics industry uses as performance assessment tools in this matter. The questions also obtained information on different phases, major activities, and risks associated with pipelines. The questions were designed to be open-ended so as not to influence the responses of the participants. It also gave the opportunity to gather as much information available.

The second round of questions as a survey instrument was designed as a closed questionnaire for validation of what was found in the first round. The study used a convenience sample in the first and second round from professionals working in the oil and gas industry to determine the efficiency of the interview and survey instrument in providing the necessary data to reach valid conclusions on the use and development of benchmarking metrics for pipeline projects. Following the successful conclusion of the first round interviews, the survey instrument was used with the same and new participants among industry professionals. I distributed the survey instrument to a random industry professionals from owners, engineers, and contractor organizations in industrial sectors and pipeline companies. Additional information on the existing metrics and use of benchmarking in the industry was captured from documents from individuals and organizations. Also, some portions of the information on existing pipeline projects and metrics were gathered from the Construction Owners Association of Alberta (COAA) benchmarking database managed by Construction Industry Institute (CII) located at the University of Texas.

The qualitative data collected by the interview was analyzed to determine the level of awareness and understanding of benchmarking in pipeline industry among industry professionals. The interview has been used to gather as much information as possible regarding existing pipeline projects. The information on the benchmarking methods conducted by different companies has been achieved. The quantitative data collected by the survey instrument (the second round) was analyzed using Likert-Scale to develop a framework of the most needed and the most efficient benchmarking metrics in the process of pipeline performance assessment.

The interviews and survey have been conducted by the author with senior industry professionals. This sample was chosen as a judgment sample as it was anticipated that they had the necessary knowledge of and experience with benchmarking metrics and pipeline projects. The number of interviews conducted was determined by analyzing the information to reach a point of saturation wherein no new data was obtained from the interviews. A set of conclusions and recommendations based on the analysis and interpretation of the information collected throughout the research study has been prepared by the author. The survey conducted among the industry professionals helped to validate and verify the conclusions from the first round of interviews and information gathering process.

4.4 Researcher Involvement

The author is the primary researcher in the proposed research study. A researcher or observer must be fully involved when collecting, observing, and interpreting qualitative data and he should be independent when collecting and analyzing quantitative data. The author tried to be diligent in being either independent or fully involved during collecting data.

The author is a graduate student of project management program degree at University of Calgary, civil engineering department. He has a bachelor degree of architecture and a master degree in construction management minoring in architecture. He has over 7 years industry experience in the design, planning, and construction sectors in architecture, project management, and project control and improvement. As the author feels the lack of experience in pipeline projects and construction fields, he has assigned large portions of the literature review to gathering information on pipeline projects and the process of planning and constructing them. Also, regulatory and technical problems aligned with risks associated with pipeline projects have been reviewed specifically. Moreover, a specific course "Fundamentals of Pipelines Economic" from the Mechanical Department has been taken as the author's last course of study at University of Calgary, and has been successfully passed with an A grade.

Under supervision of Dr. George Jergeas and Dr. Jim Lozon, the author was able to discuss the details of pipeline projects and benchmarking process with the study participants and understand the information and comments provided by these professionals.

4.5 Research Interview Instrument

Prior to the interviews with professionals, they were provided with the consent form which they read and signed to indicate that they voluntarily agreed to complete the interviews and gave permission that their voices could be recorded. They signed that all information would be used without identifying any individual or organization. The interview began by asking the participant for demographic information to be sure that he met the criteria and the gathered information would be valid. Before the interview, I indicated that my background knowledge on pipelines is not that rich, so any documents or sources which can give me some insights to this infrastructure sector would be much appreciated. The interview continued by asking about the participant's opinion on a pipeline project and how they or their organizations define a pipeline project. The participants were further questioned about how they distinguish a pipeline project from a piping portion of an industrial project. Then, the lifecycle of a pipeline project and phase breakdown from viewpoints of schedule and cost were discussed. Furthermore, the participants were asked about the importance of different parameters for breaking down the pipeline projects into one more level of details (size, length, product carried inside, etc.).

The discussion continued with questions on different metrics that different organizations measure as the performance assessment tools. Finally, the interview concluded by asking the participants about the risks associated with pipeline projects.

At the end of the interview, participants were asked whether any other persons in their organization could help in such interview or not, and also if they would give permission to go back and validate the gathered data by participating in the survey. A copy of the survey instrument used in this study is shown in the Appendix I.

The sample was recruited using a theoretical sampling technique in which data from the interview was collected and analyzed, then additional professionals were recruited until a sufficient saturation was reached that no new information could be added from the respondents.

4.6 Research Survey Instrument

Prior to being asked to do the survey, each professional was provided with the consent form which he read and signed to indicated that he voluntarily agreed to participate in the survey and that all information would be used without identifying any individual or organization. The professionals were selected for their level of experience in managing or evaluating pipeline projects. All professionals that participated in the survey and also the interview met these criteria.

The sample mostly included the same professionals who agreed to participate again in the survey so they could help in validation of what was gathered in the first round. Some other professionals have been added to this round of survey to have accurate results in validation process.

The survey began by asking some demographic information to verify that the participants met the selection criteria for this portion of the study. Then, the survey used likert-scale techniques for gathering quantitative data regarding the participant's opinions on different gathered information in the first round, specifically metrics and their importance for pipeline performance assessment. A copy of the survey instrument used in this study is shown in Appendix II.

Next two chapters explain the study findings from conducted interviews and survey.

CHAPTER FIVE: INTERVIEWS FINDINGS

Chapter five discusses the findings from the 12 interviews conducted with pipeline experts. Different tables and figures show the collected data and results.

5.1 The Interviews

Interviews have been conducted with senior pipeline experts industry. Each interview was approximately about one and half an hour. All interviews have been recorded and data extracted later on the question papers from each individual. Twelve individuals from industry have been interviewed. After the 8^{th} interview the saturation on the gathered information has been reached and for safety 4 more interviews conducted later. This chapter presents gathered information and data from my interviews with pipeline experts from different companies. The companies have been selected from the group of companies involved in COAA benchmarking project, which were encouraged to participate in the interviews. Supporting COAA study was one of their responsibilities as benchmarking group members. Interview questions can be retrieved from Appendix I. Each section in this chapter describes each question in the interviews and also the collected information. Moreover, some results are presented.

5.1.1 Interview Purpose and Participant's Consent

Before start of the interview, brief history of the benchmarking project and the purpose of the interview were given to the participant. Moreover, the ethical considerations in regards to the interview explained to each participant. Also consents for the interviews and recording of the minutes were achieved. All twelve participants gave the consents and their voices were recorded.

5.1.2 General Information

After the consent of the pipeline expert, general information have been asked in the next section; including name, company, role, years the participant was involved in industry and also the contact information. Name, company and contact information were optional. Table 5.1 shows the general information gathered from the participants.

General Information	
Role	**Experience in Industry (Years)**
Benchmarking Coordinator	32
Project analyst	6
Estimating Lead	25
Benchmarking Coordinator	14
Estimating Lead	17
Senior Engineer	20
Benchmarking Coordinator	32
Project Engineer	5
Project Engineer	9
Estimating Lead	32
Project Engineer	12
Project Engineer	15
Average	18.25

Table 5.1 Interview Participants' General Information

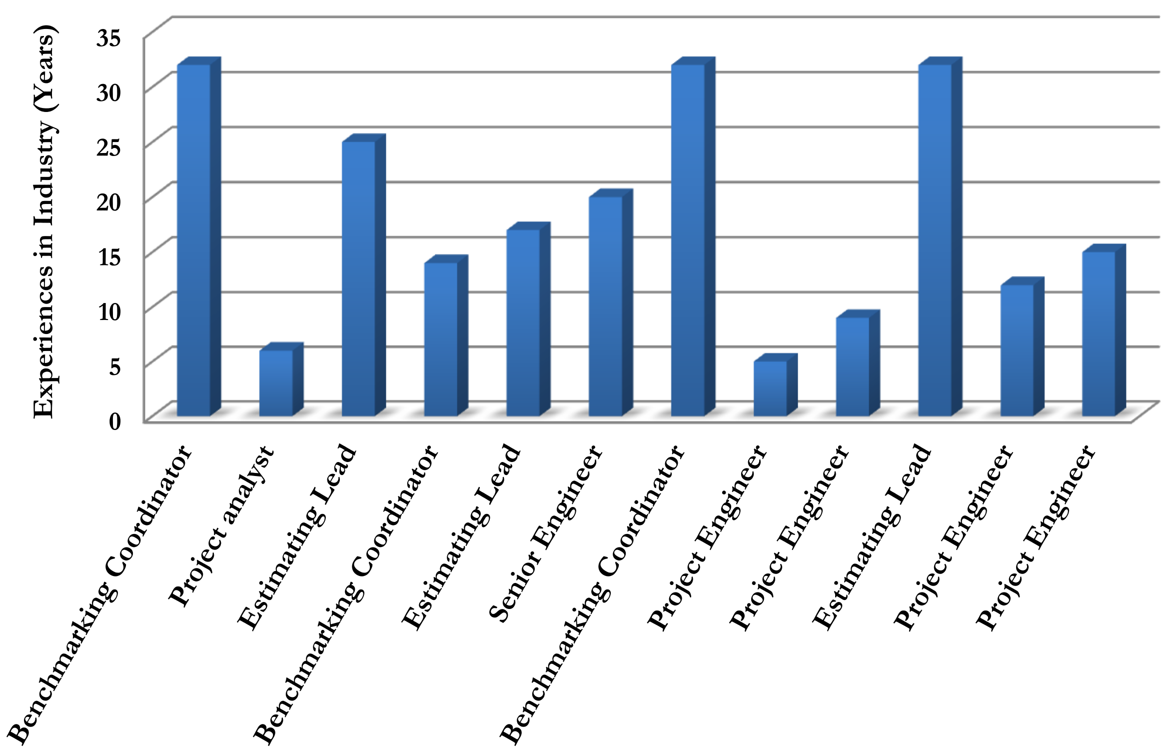


Figure 5.1 Interview Participants' Roles and Experiences in Industry

5.1.3 Interviews Findings

5.1.3.1 Literature and Background on Pipeline Construction

As author's background to a certain extent was different from pipeline industry, one of the questions from the participants was in regards to recommendations on some references and materials for a better understanding of pipeline construction.

According to most of participants there are not many well-written references on different phases or lifecycle of projects; however during the interviews some useful resources recommended to author as such: Pipeline Planning and Construction Field Manual by E. Shashi Menon, Mo, USA: Gulf Publishing Company, 2011

Another beneficial resource was an online resource from INGAA (Interstate Natural Gas Pipeline Companies) available via: http://www.ingaa.org/cms/65.aspx

5.1.3.2 Definition of a Pipeline Project

As literature never proposed a robust or clear definition of a pipeline project, author tried to include this question in the interviews. During the interviews, some participants mentioned that they have problems distinguishing pipeline projects from piping projects. Two questions during interviews have tried to find a clear definition and also identify the differences between pipeline projects and piping in industrial projects.

After the interviews, author came to this conclusion that "a pipeline moves products or raw materials in pipe from point A to point B which is outside the battery limit (boundary of an industrial project) and needs right of way."

5.1.3.3 Pipeline vs. Piping

During the interviews, the important differences between pipeline and piping have been discussed with the experts.

- Pipelines normally transfer products or raw materials from point A to B in longer distances than piping projects. Pipelines usually cover bigger geographical area.

- Pipeline projects are outside the battery limit (boundary of the industrial project) however the piping activities are inside the battery limit.

- Pipelines need right of way and piping activities don't need it.

- Land acquisition is mandatory in pipeline project and not in piping except the land used for industrial project.

- Pipeline activities have bigger environmental impact and public safety is an important issue.

- Piping is usually over ground however pipelines are normally underground and in some rare cases above ground.

- Engineering part of piping can be complicated in comparison to pipelines.

- Interface management, change orders and disputes play big roles in pipelines compare to piping.

5.1.3.4 Lifecycle of a pipeline project

Participants have been asked about their opinions on lifecycle of pipeline project and if it is different from industrial project. They also have been asked to determine the breakdown of the pipeline project phases cost-wise and schedule-wise.

Most of the participants mentioned that the lifecycle is to some extent similar to an industrial project; however, the engineering part is easier and faster to develop.

Some experts also mentioned the length of engineering phase depends on the length of the pipe. According to experts, pipeline projects which are more than 40 km in length need to get an additional permit normally called section “52” permit. This permit simply takes at least two years to be achieved. Pipelines less than 40 km in length, need to obtain permit from section “58”, which is faster and easier to receive.

Next figure shows the different phases mentioned by the experts.

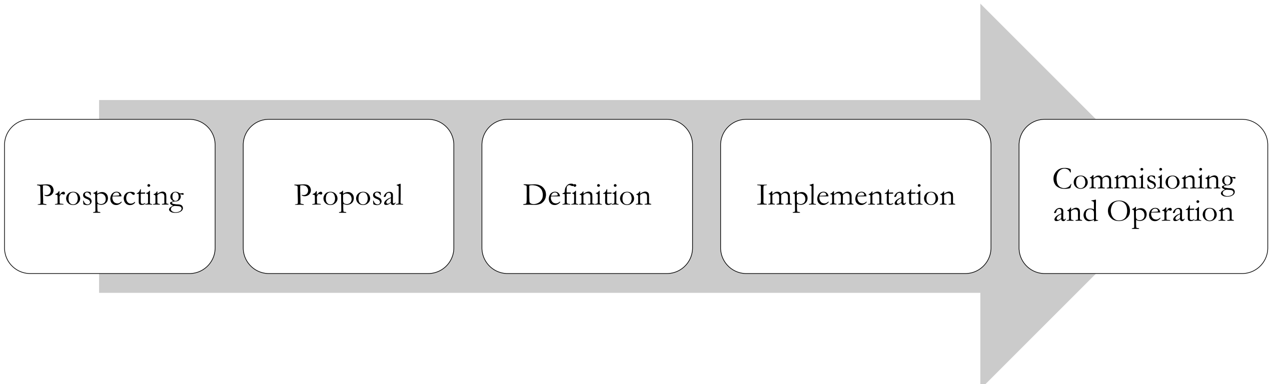


Figure 5.2 Different Phases in Pipeline Construction

Some different activities and processes for each phases mentioned in the interviews, which are:

Some of these activities have overlaps with the others based on the type and size of the project.

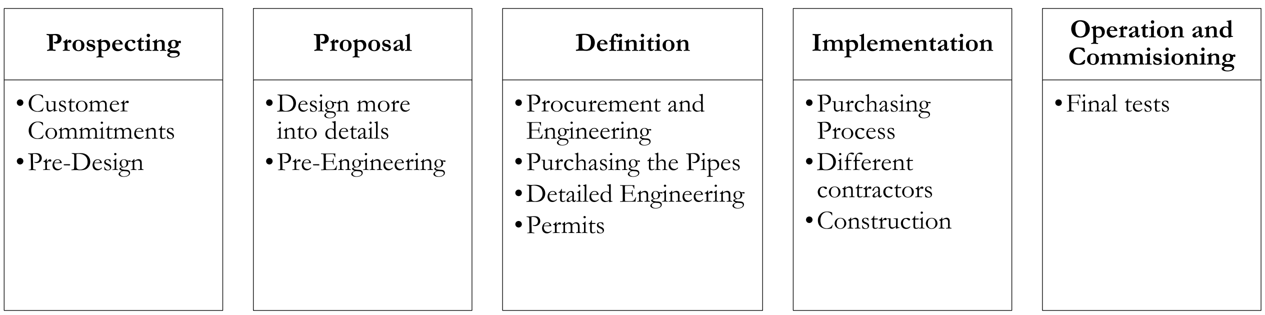


Figure 5.3 Different Pipeline Activities Mentioned in the Interviews

Regarding the breakdown of phases cost-wise and schedule-wise, information have been received from the experts. It is necessary to mention, these numbers are considered as standards but can be changed significantly based on the length and difficulty of the projects.

Phase	**Cost Breakdown**	**Schedule Breakdown**
Prospecting	2%	2%
Proposal	3%	5%
Definition	10%	60%
Implementation	80%	30%
Operation and Commissioning	5%	3%

Table 5.2 Pipeline Phases Breakdown

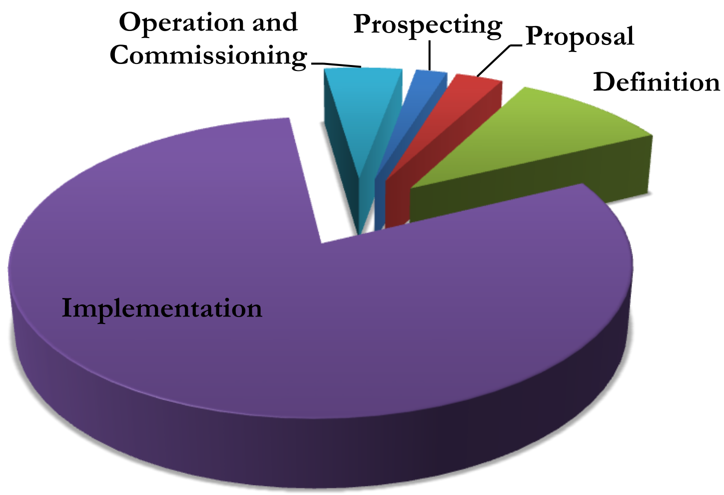


Figure 5.4 Pipeline Construction Cost Breakdown

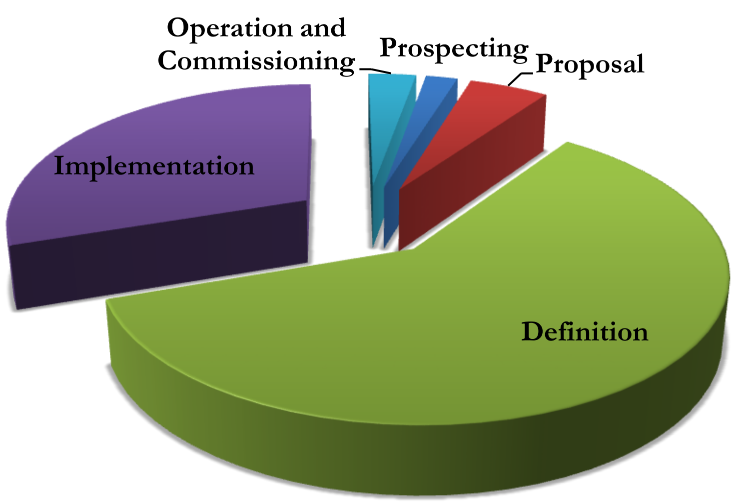


Figure 5.5 Pipeline Construction Schedule Breakdown

As the table shows, big percentage of the overall cost is assigned to implementation and construction of the pipeline project; however in comparison, schedule, detailed engineering, procurement and also receiving the permits need 60% of the overall time. An important reason for this point is "Spring Break-up". Each year, before April everything turns into mud especially in northern Alberta and that is the reason why implementation phase needs to be finished earlier.

5.1.3.5 Categorization of Pipelines into One More Level of Details

It has been asked from the pipeline experts how they would categorize the pipeline projects into one more level of details and what parameters they would consider for this categorization; moreover, which parameter is more important for this categorization.

The collected parameters mentioned in the interviews are:

- Pipe Size
- Location or region: Is the pipeline project local or it is transferring products between provinces or countries?
- Type: Green Field/ Brown Field
- Type and depth of burying the pipe: Above Ground, Buried, Mixed, the project with multi pipes with single trench
- Material of the Pipe: Steel, Plastic, etc.
- Pressure
- Different Crossing
- Product Pipe Carries inside
- Insulation and Coating

All participants agreed on pipe size as the most important factor for categorization of the pipelines. They were asked to indicate what range in size is more suitable for this categorization. Some mentioned 3 ranges of under 12", 12" to 24", and over 24". Other participants agreed on two ranges in size as less than 20" and more than 20".

5.1.3.6 Minor Validation on Previous Conducted Study

According to another study conducted in 2009 for enhancement of COAA benchmarking database, different categories have been developed in regards to pipeline projects. During the interviews, it has been asked from the participants whether they agree or disagree with these categories; if they didn't agree or had another note they have been requested to mention it.

Project Type: Green Field/ No Existing ROW, Expansion/ Looping Utilizing Existing ROW, Parallel Foreign Pipeline ROW

Pipe Predominant Diameter: Under 16" Diameter, 16"-24" Diameter, 24"-36" Diameter, Over 36" Diameter

Type of Pipeline: Above Ground, Buried, Mixed

All participants agreed with the proposed categories; however, they mentioned multi pipe system in one trench could be added to the project type.

5.1.3.7 Metrics for Performance Assessment

The most important purpose of the interview was to identify and develop metrics for benchmarking of pipeline projects. Involved companies in pipeline industry use these metrics as performance assessment tools.

The author has identified the following 53 metrics:

1. Project Cost / Number (#) of Spreads (CDN$/each)
2. Actual Length of Pipe / Estimated Length of Pipe
3. Pipe Cost / Actual Project Cost (%)
4. Pipe Cost / Actual Length of Pipe (CDN$/Km)
5. Actual Project Cost / Average Diameter / Actual Statute Length of Pipe (CDN$/inch-Km)
6. Construction Cost / Average Diameter / Actual Statute Length of Pipe (CDN$/inch-Km)
7. Design Capacity / Actual Capacity (%)
8. Owner Costs for Project Management (PM) / Actual Project Cost (%)
9. Owner Costs for Project Management (PM) / Construction Cost (%)
10. Engineering Cost /Actual Length of Pipe (CDN$/Km)

11. Permit Fees / Actual Project Cost (%)
12. Land Cost / Actual Length of ROW (CDN$/Km)
13. Environmental Studies & Monitoring / Actual Project Cost (%)
14. Environmental Studies & Monitoring / Actual Length of Pipe (CDN$/Km)
15. Construction Equipment Cost / Total Project Cost (%)
16. Number of Major Crossings / Actual Length of Pipe (#/KM)
17. Construction Cost / Actual Length of Pipe (CDN$/Km)
18. Contractors' Indirect / Actual Length of Pipe (CDN$/Km)
19. Site Preparation / Actual Project Cost (%)
20. Percent of Project with Heavy Wall Pipe (By Length of Pipe) (%)
21. Pipe / Short Ton (CDN$/ton)
22. Weight / Actual Length of Pipe (ton/Km)
23. Factory Pipe Coating / Actual Length of Pipe (CDN$/Km)
24. Coated Pipe Freight Cost / Actual Length of Pipe (CDN$/Km)
25. Freight Cost (bare pipe to coater)/Actual Length of Pipe (CDN$/Km)
26. Mainline Construction Cost / Total Site Work hours (CDN$/hour)
27. Crossing Construction Cost (all crossings) / Actual Project Cost (%)
28. Crossing Construction Cost (all crossings) / Actual Length of Pipe (CDN$/Km)
29. Health, Safety, and Environment (HSE) Costs / Actual Project Cost (%)
30. Surveying Costs / Actual Length of Pipe (CDN$/Km)
31. Construction Management / Actual Length of Pipe (CDN$/Km)
32. NDT Costs / Actual Length of Pipe (CDN$/Km)
33. ROW Initial Restoration / Actual Length of Pipe (CDN$/Km)
34. Actual Length of Pipe / Construction Phase Duration (Km/day)

35. Total Site Work hours / Actual Length of Pipe (work hours/Km)
36. Total Number of Welds / Welding Phase Duration (welds/day)
37. Total Indirect Work hours / Total Direct Work hours (WH) (%)
38. Clearing Cost / Actual Project Cost (%)
39. Ditching Cost / Actual Project Cost (%)
40. Grading Cost / Actual Project Cost (%)
41. Bending Cost / Actual Project Cost (%)
42. Welding Cost / Actual Project Cost (%)
43. Tie-In Cost / Actual Project Cost (%)
44. Clean-Up Cost / Actual Project Cost (%)
45. Testing Cost / Actual Project Cost (%)
46. Total Clearing Work hours / Total Site Work hours (%)
47. Total Ditching Work hours / Total Site Work hours (%)
48. Total Grading Work hours / Total Site Work hours (%)
49. Total Bending Work hours / Total Site Work hours (%)
50. Total Welding Work hours / Total Site Work hours (%)
51. Total Tie-In Work hours / Total Site Work hours (%)
52. Total Clean-Up Work hours / Total Site Work hours (%)
53. Total Testing Work hours / Total Site Work hours (%)

5.1.3.8 Different Risks Associated with Pipeline Projects

During the interviews, participants were asked about different risks they identified with pipeline projects.

List of identified categories and risks are:

5.1.3.8.1 Operational Risks:

Availability of Labor

Availability of Material

Safety

Pipe Bents

Geo tests and Directional Drilling: Soil Conditions

Major Crossing

Normal Logistics Risks

5.1.3.8.2 Strategic Risks:

Applying on Time for Permits

Planning and Scheduling

Execution Strategy

Availability of Experienced Contractors

5.1.3.8.3 Contextual Risks:

Public and NGOs Opposition: First nations' issue

Regulatory Risks: Considering all codes and protocols

Market Conditions after startup and commissioning

Migrations of Caribous

5.1.3.9 Permission for Next Round of Interaction

At the end of the interviews, participants' permissions were requested in order to follow up with the results of the interviews and also conducting a survey as a validation process.

Finally, it has been asked from the experts if they know anyone else in their organizations, which could help with such interview process.

CHAPTER SIX: SURVEY FINDINGS

Chapter six presents and explains the findings on the 31 responses collected from pipeline experts via survey. This survey was conducted as an online web-based tool in the beginning of year 2013.

6.1 The Survey

An online web based survey was conducted as the last phase of study research. The purpose of the survey was to validate the collected data. Survey tried to find new results regarding the importance of collected metrics and also if different companies try to gather the related data elements. The survey results could indicate which elements are mostly hard and which are easier to be collected. The survey has been sent to about 40 people in relevant industry including the experts who were involved in the interviews. The survey has been conducted online and web-based Out of 40 people, 31 answers came back anonymously. The questions can be retrieved from Appendix II. Each section in this chapter describes each question included in survey and also the collected information. Moreover, some of the results are presented as graphs, tables and figures.

6.2 Survey's Purpose and Participant's Consent

Before start of the survey, brief history of the benchmarking project and the purpose of the survey were given to the participant. Moreover like the interview phase, the ethical considerations in regards to the survey explained to each participant. Consents and permissions for usage of the gathered information were achieved. All 31 participants gave the consents, however all the participants did not answer all of the questions. Following section gives some general information about the survey.

6.3 Survey's General Information

The survey started on January 3rd, 2013 at 12:00 pm and was closed on February 5th at 12:00 pm. 3 out of 31 surveys were incomplete and it means the participant didn't finish answering all the questions. 28 out 31 surveys have the complete status. Table 6.1 shows the time spent on the survey by each participant. The participants could spend as much time as they needed in order to complete the surveys; however only one answer could be accepted by the host website from each computer and each IP. This feature could help the author to receive only one answer from each expert.

Respondents	**Status**	**Date**	**Time Spent on the Survey**
Respondent #1	Complete	03-Jan	15 minutes
Respondent #2	Complete	03-Jan	13 minutes
Respondent #3	Complete	04-Jan	25 minutes
Respondent #4	Complete	06-Jan	22 minutes
Respondent #5	Complete	07-Jan	4 hours 39 minutes
Respondent #6	Complete	07-Jan	14 minutes
Respondent #7	Complete	07-Jan	22 minutes
Respondent #8	Incomplete	09-Jan	10 minutes
Respondent #9	Complete	09-Jan	44 minutes
Respondent #10	Complete	10-Jan	2 days 21 hours
Respondent #11	Complete	10-Jan	50 minutes
Respondent #12	Complete	10-Jan	45 minutes
Respondent #13	Complete	13-Jan	17 minutes
Respondent #14	Incomplete	15-Jan	3 hours
Respondent #15	Incomplete	16-Jan	5 minutes
Respondent #16	Complete	20-Jan	2 days 20 hours
Respondent #17	Complete	22-Jan	11 minutes
Respondent #18	Complete	24-Jan	48 minutes
Respondent #19	Complete	25-Jan	32 minutes
Respondent #20	Complete	25-Jan	1 hour 28 minutes
Respondent #21	Complete	26-Jan	21 minutes
Respondent #22	Complete	27-Jan	10 minutes
Respondent #23	Complete	28-Jan	19 minutes
Respondent #24	Complete	29-Jan	11 minutes
Respondent #25	Complete	02-Feb	33 minutes

Respondents	Status	Date	Time Spent on the Survey
Respondent #26	Complete	03-Feb	27 minutes
Respondent #27	Complete	03-Feb	11 minutes
Respondent #28	Complete	04-Feb	28 minutes
Respondent #29	Complete	05-Feb	35 minutes
Respondent #30	Complete	05-Feb	1 hour 14 minutes
Respondent #31	Complete	05-Feb	17 minutes

Table 6.1 Survey Responses Statuses and Completion Date

The average time spent on the survey after eliminating the outliers was about 23.4 minutes.

Some participants finished the surveys in 2 different days as the survey website had the ability of saving the progress of each participant. These numbers do not indicate the accurate average time and are considered only as facts in regards to survey process.

6.4 Participants' General Information

31 participants have answered the survey anonymously, however they were asked about their roles and their experiences in industry. Table 6.2 shows the mentioned information. The participants had different roles including cost estimation leader, project engineer, cost estimator, benchmarking coordinator, project controls leader, project analyst and project manager.

The average years participants spent in the industry were about 14.20 years. Figure 6.1 shows the roles' diversity and experiences of participants in the survey.

General Information	
Role	**Experience in Industry (Years)**
Cost Estimator	8
Cost Estimator	20
Senior Project engineer	10
Manager of Estimating for Oil Sands	31
Benchmarking Coordinator for Capital Projects	38

General Information	
Role	**Experience in Industry (Years)**
Analyst	2
Project Controls Leader	14
Project Manager	40
Director, Project Controls Governance	35
Project Analyst	6
Project Engineer	12
Project Engineer	12
Benchmarking Coordinator	32
Project Controller	8
Manager	28
Project Engineer	9
Project Controls Leader	8
Project Controls Leader	6
Cost Estimation Leader	20
Senior Estimator	9
Project Controller	6
Project Engineer	8
Benchmark Engineer	2
Project Engineer	9
Project Engineer	9
Senior Estimator	10
Senior Engineer	10
Project Engineer	3
Engineer	10
Project Controls Leader	20
Engineering Manager	5

Table 6.2 Survey Respondents' General Information

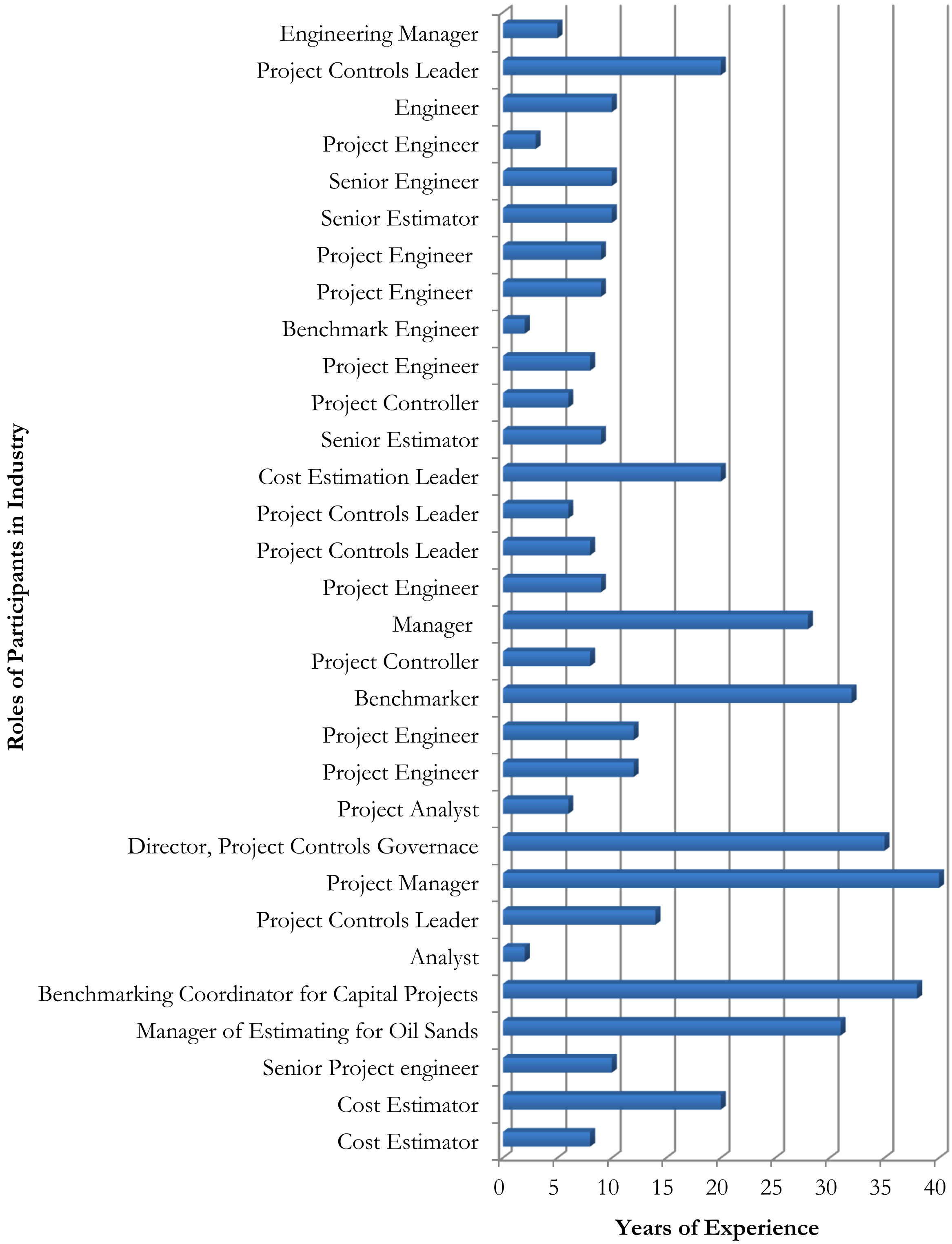


Figure 6.1 The Roles' Diversity and Experiences of Participants in the Survey

6.5 Survey Findings

6.5.1 Definition of a Pipeline Project

As a validation process, the first question in survey was in regards to the definition of pipeline. The participants have been asked to indicate whether they agree or do not agree with the final definition that has been concluded in the first round of interview. The definition indicated "A pipeline moves products or raw materials in pipe from point A to point B which is outside the battery limit and needs right of way."

The answers were designed on likert-scale method with options of Strongly Agree, Agree, Neutral, Disagree, and Strongly Disagree. Each option has been weighted as such:

Likert-Scale Options	Assigned Number
Strongly Agree	1
Agree	2
Neutral	3
Disagree	4
Strongly Disagree	5

Table 6.3 Assigned Numbers for Survey Likert-Scale Options

At the end of surveys, 31 responses were received. Below, please find the results from the survey's first question.

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Total
Assigned Number	1	2	3	4	5	
Answers	17	12	0	1	1	31
Percentage	54.84	38.71	0.00	3.23	3.23	100
Weighted Number	17	24	0	4	5	50.00
Final Score	0.548	0.774	0	0.129	0.161	1.613

Table 6.4 Analysis of Responses to The Survey First Question

Figure 6.2 shows the answers and related percentages to the question.

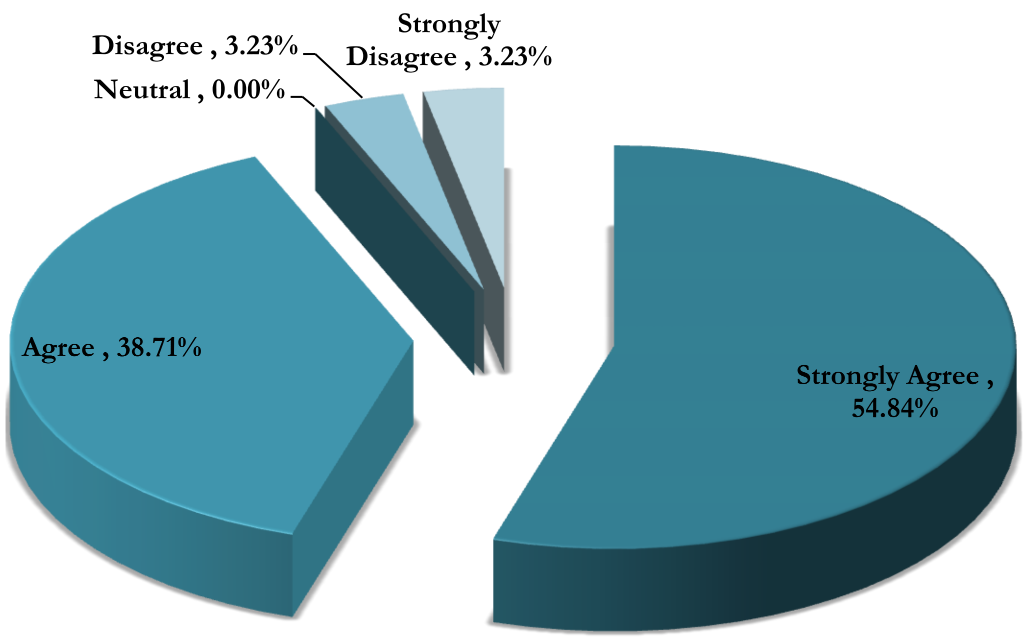


Figure 6.2 Answers and Final Scores for Survey Question 1

Figure 6.3 shows the final scores regarding likert scale options. The final score stands between 1 and 2 accordingly, strongly agree and agree.

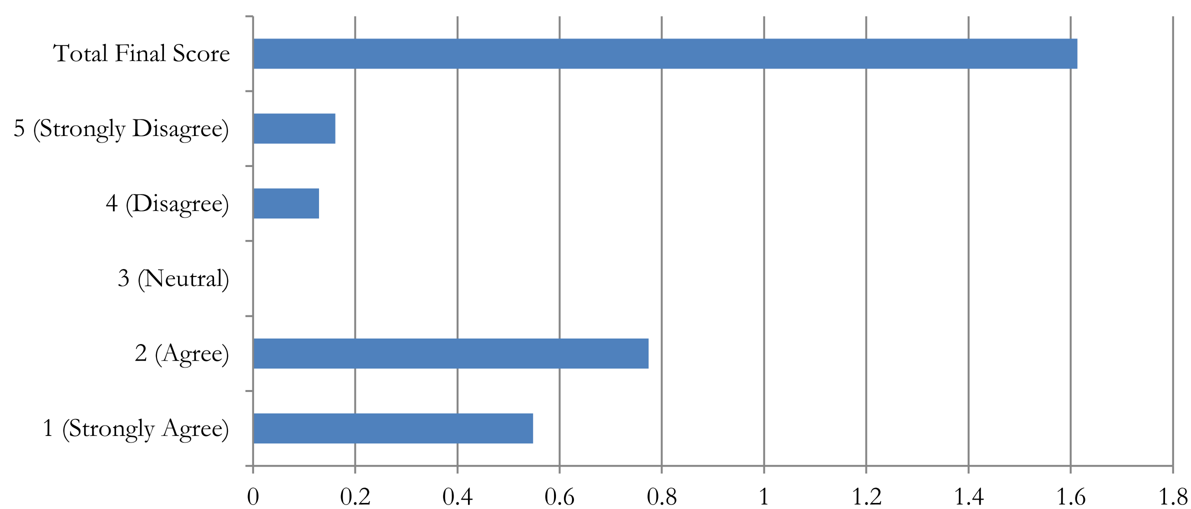


Figure 6.3 Final Scores for Question 1 Likert-scale Options

According to the participants' answers on the website only two participants did not agree with the definition. The experts were asked to indicate their opinions in case they would not agree with the definition. The answer given by one expert who did not agree with the definition was:

"Numbers of projects are installing pipelines within our boundary and does not necessarily require right of way." According to literature review and first rounds of interviews, this definition stands in the classification of piping projects. As final score (1.61) indicates the definition can be used as definition of a pipeline project.

6.5.2 New Categorizations for Pipeline Projects

As indicated before, results of the conducted interviews showed a need for separating pipeline project into two different categories based on the size of the pipes. These two different categories include bigger size (over 20 inches) and smaller size (under 20 inches) pipeline projects. Also, some metrics were collected, defined and developed for the purpose of general performance assessment of the pipeline projects.

During interviews, Participants were asked to indicate that which category is suitable for development of these metrics. Table 6.5 shows the answers for each metric. Figure 6.4 is a bar chart presentation of the metrics and the results.

Collected Metrics	**Small Size (Under 20")**	**Big Size (Over 20")**	**Suitable for Both Categories**	**Not Suitable for any Category**	**Total Answers**
Actual Length of Pipe / Construction Phase Duration (Days) (Km/day)	0% 0	36% 9	60% 15	4% 1	25
Actual Length of Pipe / Estimated Length of Pipe	0% 0	4% 1	93% 26	4% 1	28
Actual Project Cost / Average Diameter / Actual Statute Length of Pipe (CDN$/inch-Km)	0% 0	21% 6	75% 21	4% 1	28
Bending Cost / Actual Project Cost (%)	0% 0	44% 11	52% 13	4% 1	25
Clean-Up Cost / Actual Project Cost (%)	0% 0	48% 12	44% 11	8% 2	25

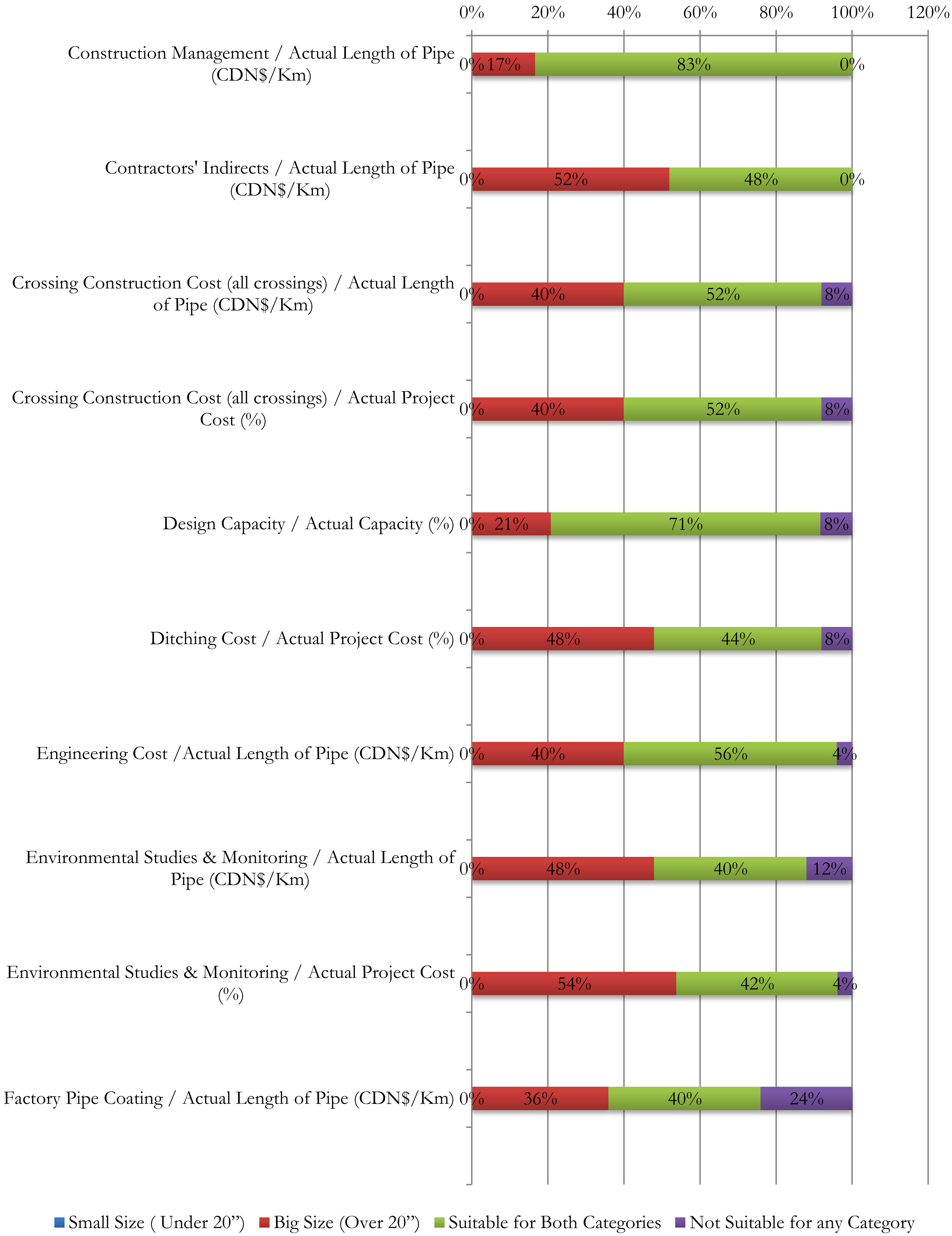
Collected Metrics	Small Size (Under 20")	Big Size (Over 20")	Suitable for Both Categories	Not Suitable for any Category	Total Answers
Clearing Cost / Actual Project Cost (%)	0% 0	50% 13	42% 11	8% 2	26
Coated Pipe Freight Cost / Actual Length of Pipe (CDN$/Km)	0% 0	38% 9	42% 10	21% 5	24
Construction Cost / Actual Length of Pipe (CDN$/Km)	0% 0	32% 8	64% 16	4% 1	25
Construction Cost / Average Diameter / Actual Statute Length of Pipe (CDN$/inch-Km)	0% 0	22% 6	74% 20	4% 1	27
Construction Equipment Cost / Total Project Cost (%)	0% 0	23% 6	73% 19	4% 1	26
Construction Management / Actual Length of Pipe (CDN$/Km)	0% 0	17% 4	83% 20	0% 0	24
Contractors' Indirects / Actual Length of Pipe (CDN$/Km)	0% 0	52% 13	48% 12	0% 0	25
Crossing Construction Cost (all crossings) / Actual Length of Pipe (CDN$/Km)	0% 0	40% 10	52% 13	8% 2	25
Crossing Construction Cost (all crossings) / Actual Project Cost (%)	0% 0	40% 10	52% 13	8% 2	25
Design Capacity / Actual Capacity (%)	0% 0	21% 5	71% 17	8% 2	24
Ditching Cost / Actual Project Cost (%)	0% 0	48% 12	44% 11	8% 2	25
Engineering Cost /Actual Length of Pipe (CDN$/Km)	0% 0	40% 10	56% 14	4% 1	25
Environmental Studies & Monitoring / Actual Length of Pipe (CDN$/Km)	0% 0	48% 12	40% 10	12% 3	25
Environmental Studies & Monitoring / Actual Project Cost (%)	0% 0	54% 14	42% 11	4% 1	26
Factory Pipe Coating / Actual Length of Pipe (CDN$/Km)	0% 0	36% 9	40% 10	24% 6	25
Freight Cost (bare pipe to coater)/Actual Length of Pipe (CDN$/Km)	0% 0	40% 10	44% 11	16% 4	25
Grading Cost / Actual Project Cost (%)	0% 0	48% 12	48% 12	4% 1	25
Health, Safety, and Environment (HSE) Costs / Actual Project Cost (%)	0% 0	48% 12	40% 10	12% 3	25
Land Cost / Actual Length of ROW (CDN$/Km)	0% 0	42% 10	54% 13	4% 1	24

Collected Metrics	**Small Size (Under 20")**	**Big Size (Over 20")**	**Suitable for Both Categories**	**Not Suitable for any Category**	**Total Answers**
Mainline Construction Cost / Total Site Workhours (WH) (CDN$/hour)	0% 0	20% 5	80% 20	0% 0	25
NDT Costs / Actual Length of Pipe (CDN$/Km)	0% 0	27% 7	69% 18	4% 1	26
Number (#) of Major Crossings / Actual Length of Pipe (#/KM)	0% 0	8% 2	88% 21	4% 1	24
Owner Costs for Project Management (PM) / Actual Project Cost (%)	0% 0	25% 6	75% 18	0% 0	24
Owner Costs for Project Management (PM) / Construction Cost (%)	0% 0	33% 8	58% 14	8% 2	24
Percent (%) of Project with Heavy Wall Pipe (By Length of Pipe) (%)	0% 0	50% 12	50% 12	0% 0	24
Permit Fees / Actual Project Cost (%)	0% 0	32% 8	64% 16	4% 1	25
Pipe / Short Ton (CDN$/ton)	4% 1	35% 8	48% 11	13% 3	23
Pipe Cost / Actual Length of Pipe (CDN$/Km)	0% 0	0% 0	89% 25	11% 3	28
Pipe Cost / Actual Project Cost (%)	0% 0	0% 0	100% 27	0% 0	27
Project Cost / Number (#) of Spreads (CDN$/each)	0% 0	4% 1	89% 25	7% 2	28
ROW Initial Restoration / Actual Length of Pipe (CDN$/Km)	0% 0	46% 11	46% 11	8% 2	24
Site Preparation / Actual Project Cost (%)	0% 0	48% 12	48% 12	4% 1	25
Surveying Costs / Actual Length of Pipe (CDN$/Km)	0% 0	12% 3	80% 20	8% 2	25
Testing Cost / Actual Project Cost (%)	0% 0	44% 11	52% 13	4% 1	25
Tie-In Cost / Actual Project Cost (%)	0% 0	52% 13	44% 11	4% 1	25
Total Bending Work hours (WH) / Total Site Work hours (WH) (%)	0% 0	52% 13	44% 11	4% 1	25
Total Clean-Up Work hours (WH) / Total Site Work hours (WH) (%)	0% 0	48% 12	40% 10	12% 3	25
Total Clearing Work hours (WH) / Total Site Work hours (WH) (%)	0% 0	52% 13	40% 10	8% 2	25

Collected Metrics	**Small Size (Under 20")**	**Big Size (Over 20")**	**Suitable for Both Categories**	**Not Suitable for any Category**	**Total Answers**
Total Ditching Work hours (WH) / Total Site Work hours (WH) (%)	0% 0	52% 13	40% 10	8% 2	25
Total Grading Work hours (WH) / Total Site Work hours (WH) (%)	0% 0	52% 13	44% 11	4% 1	25
Total Indirect Work hours (WH) / Total Direct Work hours (WH) (%)	0% 0	32% 8	68% 17	0% 0	25
Total Number of Welds / Welding Phase Duration (welds/day)	0% 0	8.33% 2	91.67% 22	0% 0	24
Total Site Work hours (WH) / Actual Length of Pipe (work hours/Km)	0% 0	28% 7	68% 17	4% 1	25
Total Testing Work hours (WH) / Total Site Work hours (WH) (%)	0% 0	48% 12	48% 12	4% 1	25
Total Tie-In Work hours (WH) / Total Site Work hours (WH) (%)	0% 0	52% 13	44% 11	4% 1	25
Total Welding Work hours (WH) / Total Site Work hours (WH) (%)	0% 0	48% 12	52% 13	0% 0	25
Weight (Tons) / Actual Length of Pipe (ton/Km)	0% 0	25% 6	67% 16	8% 2	24
Welding Cost / Actual Project Cost (%)	0% 0	44% 11	56.00% 14	0% 0	25

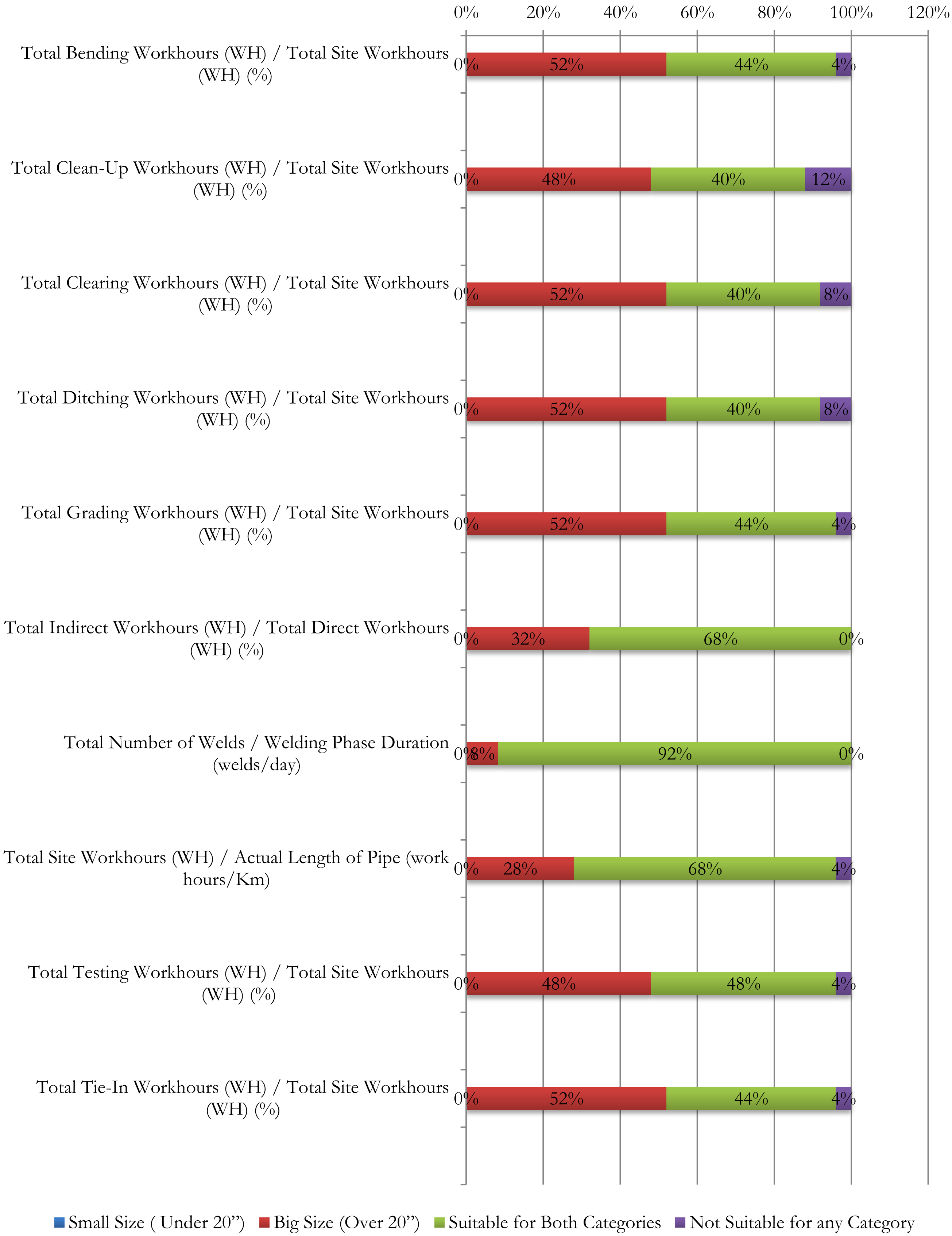
Table 6.5 Answers to Survey Question 2 Metrics

0%
20%
40%
60%
80%
100%
120%
Actual Length of Pipe / Construction Phase Duration (Days) (Km/day)
0%
36%
60%
4%
Actual Length of Pipe / Estimated Length of Pipe
0%
4%
93%
4%
Actual Project Cost / Average Diameter / Actual Statute Length of Pipe (CDN$/inch-Km)
0%
21%
75%
4%
Bending Cost / Actual Project Cost (%)
0%
44%
52%
4%
Clean-Up Cost / Actual Project Cost (%)
0%
48%
44%
8%
Clearing Cost / Actual Project Cost (%)
0%
50%
42%
8%
Coated Pipe Freight Cost / Actual Length of Pipe (CDN$/Km)
0%
38%
42%
21%
Construction Cost / Actual Length of Pipe (CDN$/Km)
0%
32%
64%
4%
Construction Cost / Average Diameter / Actual Statute Length of Pipe (CDN$/inch-Km)
0%
22%
74%
4%
Construction Equipment Cost / Total Project Cost (%)
0%
23%
73%
4%
Small Size (Under 20")
Big Size (Over 20")
Suitable for Both Categories
Not Suitable for any Category


0%
20%
40%
60%
80%
100%
120%
Construction Management / Actual Length of Pipe (CDN$/Km)
0%
17%
83%
0%
Contractors' Indirects / Actual Length of Pipe (CDN$/Km)
0%
52%
48%
0%
Crossing Construction Cost (all crossings) / Actual Length of Pipe (CDN$/Km)
0%
40%
52%
8%
Crossing Construction Cost (all crossings) / Actual Project Cost (%)
0%
40%
52%
8%
Design Capacity / Actual Capacity (%)
0%
21%
71%
8%
Ditching Cost / Actual Project Cost (%)
0%
48%
44%
8%
Engineering Cost /Actual Length of Pipe (CDN$/Km)
0%
40%
56%
4%
Environmental Studies & Monitoring / Actual Length of Pipe (CDN$/Km)
0%
48%
40%
12%
Environmental Studies & Monitoring / Actual Project Cost (%)
0%
54%
42%
4%
Factory Pipe Coating / Actual Length of Pipe (CDN$/Km)
0%
36%
40%
24%
Small Size (Under 20”)
Big Size (Over 20”)
Suitable for Both Categories
Not Suitable for any Category


0%
20%
40%
60%
80%
100%
120%
Freight Cost (bare pipe to coater)/Actual Length of Pipe (CDN$/Km)
0% 40% 44% 16%
Grading Cost / Actual Project Cost (%)
0% 48% 48% 4%
Health, Safety, and Environment (HSE) Costs / Actual Project Cost (%)
0% 48% 40% 12%
Land Cost / Actual Length of ROW (CDN$/Km)
0% 42% 54% 4%
Mainline Construction Cost / Total Site Workhours (WH) (CDN$/hour)
0% 20% 80% 0%
NDT Costs / Actual Length of Pipe (CDN$/Km)
0% 27% 69% 4%
Number (#) of Major Crossings / Actual Length of Pipe (#/KM)
0% 8% 88% 4%
Owner Costs for Project Management (PM) / Actual Project Cost (%)
0% 25% 75% 0%
Owner Costs for Project Management (PM) / Construction Cost (%)
0% 33% 58% 8%
Percent (%) of Project with Heavy Wall Pipe (By Length of Pipe) (%)
0% 50% 50% 0%
Small Size (Under 20”)
Big Size (Over 20”)
Suitable for Both Categories
Not Suitable for any Category


0%
20%
40%
60%
80%
100%
120%
Permit Fees / Actual Project Cost (%)
Pipe / Short Ton (CDN$/ton)
Pipe Cost / Actual Length of Pipe (CDN$/Km)
Pipe Cost / Actual Project Cost (%)
Project Cost / Number (#) of Spreads (CDN$/each)
ROW Initial Restoration / Actual Length of Pipe (CDN$/Km)
Site Preparation / Actual Project Cost (%)
Surveying Costs / Actual Length of Pipe (CDN$/Km)
Testing Cost / Actual Project Cost (%)
Tie-In Cost / Actual Project Cost (%)
0% 32% 64% 4%
4% 35% 48% 13%
0% 89% 11%
0% 100% 0%
0% 4% 89% 7%
0% 46% 46% 8%
0% 48% 48% 4%
0% 12% 80% 8%
0% 44% 52% 4%
0% 52% 44% 4%
Small Size (Under 20”)
Big Size (Over 20”)
Suitable for Both Categories
Not Suitable for any Category


0%
20%
40%
60%
80%
100%
120%
Total Bending Workhours (WH) / Total Site Workhours (WH) (%)
0%
52%
44%
4%
Total Clean-Up Workhours (WH) / Total Site Workhours (WH) (%)
0%
48%
40%
12%
Total Clearing Workhours (WH) / Total Site Workhours (WH) (%)
0%
52%
40%
8%
Total Ditching Workhours (WH) / Total Site Workhours (WH) (%)
0%
52%
40%
8%
Total Grading Workhours (WH) / Total Site Workhours (WH) (%)
0%
52%
44%
4%
Total Indirect Workhours (WH) / Total Direct Workhours (WH) (%)
0%
32%
68%
0%
Total Number of Welds / Welding Phase Duration (welds/day)
0%
8%
92%
0%
Total Site Workhours (WH) / Actual Length of Pipe (work hours/Km)
0%
28%
68%
4%
Total Testing Workhours (WH) / Total Site Workhours (WH) (%)
0%
48%
48%
4%
Total Tie-In Workhours (WH) / Total Site Workhours (WH) (%)
0%
52%
44%
4%
Small Size (Under 20”)
Big Size (Over 20”)
Suitable for Both Categories
Not Suitable for any Category

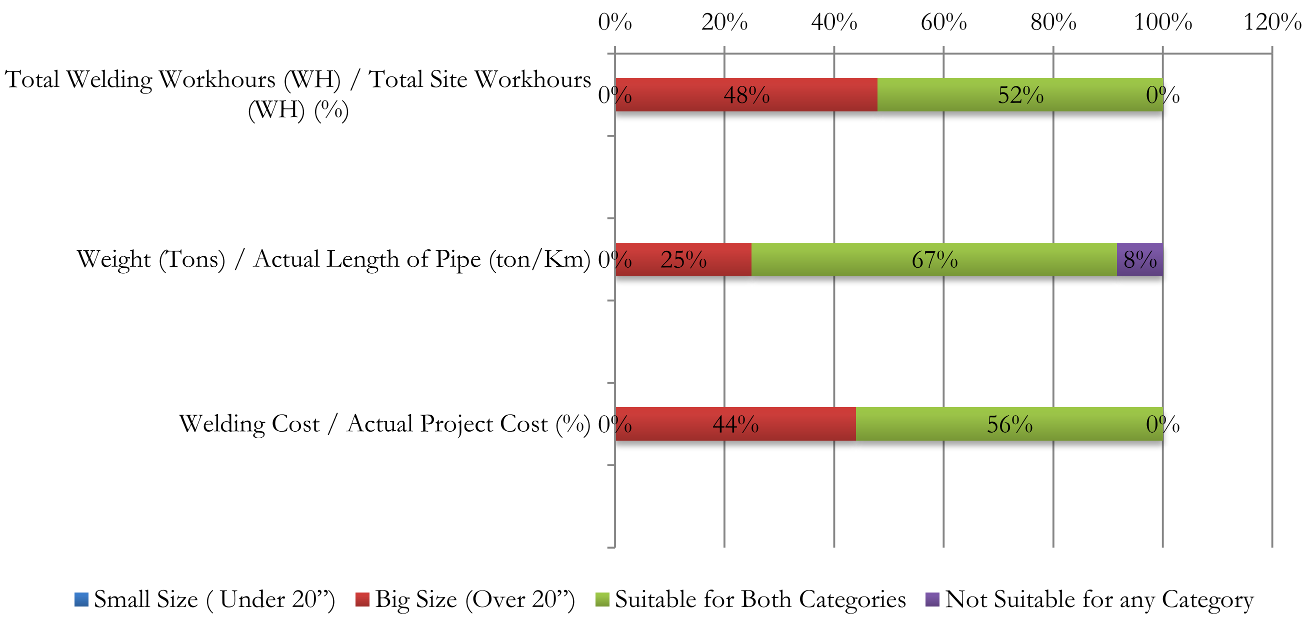


Figure 6.4 Metrics and Results for Survey Question 2

The outcome results can help with developing of two different categories with different metrics in order to benchmark performance of pipeline projects.

6.5.3 The Metrics and Their Priorities

In the next question, the author tried to understand the importance and priority of metrics among different companies. Table 6.6 shows the answers of participants in regards the priority of metrics.

Collected Metrics	Most Important (1)	Important (2)	Neutral (3)	Unimportant (4)	Not Important at All (5)	Total Answers
Actual Length of Pipe / Construction Phase Duration (Days) (Km/day)	8% 2	54% 14	31% 8	8% 2	0% 0	26
Actual Length of Pipe / Estimated Length of Pipe	19% 5	59% 16	11% 3	11% 3	0% 0	27
Actual Project Cost / Average Diameter / Actual Statute Length of Pipe (CDN$/inch-Km)	42% 11	46% 12	12% 3	0% 0	0% 0	26
Bending Cost / Actual Project Cost (%)	8% 2	36% 9	32% 8	24% 6	0% 0	25
Clean-Up Cost / Actual	8%	24%	40%	28%	0%	

Collected Metrics	Most Important (1)	Important (2)	Neutral (3)	Unimportant (4)	Not Important at All (5)	Total Answers
Project Cost (%)	2	6	10	7	0	25
Clearing Cost / Actual Project Cost (%)	8% 2	31% 8	35% 9	27% 7	0% 0	26
Coated Pipe Freight Cost / Actual Length of Pipe (CDN$/Km)	0% 0	28% 7	36% 9	28% 7	8% 2	25
Construction Cost / Actual Length of Pipe (CDN$/Km)	33% 8	42% 10	25% 6	0% 0	0% 0	24
Construction Cost / Average Diameter / Actual Statute Length of Pipe (CDN$/inch-Km)	42% 11	38% 10	19% 5	0% 0	0% 0	26
Construction Equipment Cost / Total Project Cost (%)	16% 4	44% 11	28% 7	12% 3	0% 0	25
Construction Management / Actual Length of Pipe (CDN$/Km)	12% 3	72% 18	8% 2	8% 2	0% 0	25
Contractors' Indirects / Actual Length of Pipe (CDN$/Km)	12% 3	32% 8	44% 11	12% 3	0% 0	25
Crossing Construction Cost (all crossings) / Actual Length of Pipe (CDN$/Km)	4% 1	32% 8	52% 13	12% 3	0% 0	25
Crossing Construction Cost (all crossings) / Actual Project Cost (%)	4% 1	32% 8	56% 14	8% 2	0% 0	25
Design Capacity / Actual Capacity (%)	4% 1	27% 7	50% 13	8% 2	12% 3	26
Ditching Cost / Actual Project Cost (%)	8% 2	31% 8	38% 10	23% 6	0% 0	26
Engineering Cost /Actual Length of Pipe (CDN$/Km)	8% 2	44% 11	48% 12	0% 0	0% 0	25
Environmental Studies & Monitoring / Actual Length of Pipe (CDN$/Km)	12% 3	28% 7	40% 10	20% 5	0% 0	25
Environmental Studies & Monitoring / Actual Project Cost (%)	16% 4	20% 5	44% 11	20% 5	0% 0	25
Factory Pipe Coating / Actual Length of Pipe (CDN$/Km)	0% 0	29% 7	46% 11	17% 4	8% 2	24
Freight Cost (bare pipe to coater)/Actual Length of Pipe (CDN$/Km)	0% 0	20% 5	40% 10	28% 7	12% 3	25
Grading Cost / Actual Project Cost (%)	8% 2	35% 9	35% 9	23% 6	0% 0	26
Health, Safety, and Environment (HSE) Costs /	8% 2	28% 7	36% 9	28% 7	0% 0	25

Collected Metrics	Most Important (1)	Important (2)	Neutral (3)	Unimportant (4)	Not Important at All (5)	Total Answers
Actual Project Cost (%)						
Land Cost / Actual Length of ROW (CDN$/Km)	4% 1	35% 9	50% 13	8% 2	4% 1	26
Mainline Construction Cost / Total Site Work hours (WH) (CDN$/hour)	12% 3	36% 9	40% 10	12% 3	0% 0	25
NDT Costs / Actual Length of Pipe (CDN$/Km)	7% 2	70% 19	19% 5	4% 1	0% 0	27
Number (#) of Major Crossings / Actual Length of Pipe (#/KM)	8% 2	63% 15	29% 7	0% 0	0% 0	24
Owner Costs for Project Management (PM) / Actual Project Cost (%)	8% 2	40% 10	48% 12	4% 1	0% 0	25
Owner Costs for Project Management (PM) / Construction Cost (%)	0% 0	44% 11	52% 13	4% 1	0% 0	25
Percent (%) of Project with Heavy Wall Pipe (By Length of Pipe) (%)	4% 1	23% 6	50% 13	19% 5	4% 1	26
Permit Fees / Actual Project Cost (%)	4% 1	40% 10	48% 12	8% 2	0% 0	25
Pipe / Short Ton (CDN$/ton)	8% 2	38% 9	33% 8	8% 2	13% 3	24
Pipe Cost / Actual Length of Pipe (CDN$/Km)	23% 6	65% 17	12% 3	0% 0	0% 0	26
Pipe Cost / Actual Project Cost (%)	27% 7	62% 16	12% 3	0% 0	0% 0	26
Project Cost / Number (#) of Spreads (CDN$/each)	23% 6	58% 15	8% 2	12% 3	0% 0	26
ROW Initial Restoration / Actual Length of Pipe (CDN$/Km)	4% 1	35% 9	50% 13	12% 3	0% 0	26
Site Preparation / Actual Project Cost (%)	8% 2	38% 10	50% 13	4% 1	0% 0	26
Surveying Costs / Actual Length of Pipe (CDN$/Km)	4% 1	64% 16	28% 7	4% 1	0% 0	25
Testing Cost / Actual Project Cost (%)	12% 3	36% 9	28% 7	24% 6	0% 0	25
Tie-In Cost / Actual Project Cost (%)	8% 2	35% 9	35% 9	23% 6	0% 0	26
Total Bending Work hours (WH) / Total Site Work hours (WH) (%)	8% 2	28% 7	44% 11	20% 5	0% 0	25
Total Clean-Up Work hours (WH) / Total Site Work hours (WH) (%)	8% 2	20% 5	52% 13	16% 4	4% 1	25

Collected Metrics	Most Important (1)	Important (2)	Neutral (3)	Unimportant (4)	Not Important at All (5)	Total Answers
Total Clearing Work hours (WH) / Total Site Work hours (WH) (%)	8% 2	20% 5	52% 13	20% 5	0% 0	25
Total Ditching Work hours (WH) / Total Site Work hours (WH) (%)	8% 2	28% 7	44% 11	20% 5	0% 0	25
Total Grading Work hours (WH) / Total Site Work hours (WH) (%)	8% 2	28% 7	44% 11	20% 5	0% 0	25
Total Indirect Work hours (WH) / Total Direct Work hours (WH) (%)	22% 6	41% 11	30% 8	7% 2	0% 0	27
Total Number of Welds / Welding Phase Duration (welds/day)	19% 5	50% 13	31% 8	0% 0	0% 0	26
Total Site Work hours (WH) / Actual Length of Pipe (work hours/Km)	23% 6	50% 13	23% 6	4% 1	0% 0	26
Total Testing Work hours (WH) / Total Site Work hours (WH) (%)	12% 3	24% 6	48% 12	16% 4	0% 0	25
Total Tie-In Work hours (WH) / Total Site Work hours (WH) (%)	8% 2	28% 7	44% 11	20% 5	0% 0	25
Total Welding Work hours (WH) / Total Site Work hours (WH) (%)	12% 3	28% 7	48% 12	12% 3	0% 0	25
Weight (Tons) / Actual Length of Pipe (ton/Km)	4% 1	36% 9	40% 10	16% 4	4% 1	25
Welding Cost / Actual Project Cost (%)	12% 3	40% 10	28% 7	20% 5	0% 0	25

Table 6.6 Metrics and Their Priorities

By using a likert-scale analysis method, the score for each metric can be achieved. Most Important choice will be scored as 1, Important as 2, Neutral as 3, Unimportant as 4 and Not Important at All as 5. Normally, each number indicates a range which 1 will be (0-1), 2 will be (1-2), 3(2-3), 4(3-4), 5(4-5). These scores can help indicating the priorities of different metrics. Tables 6.7 and figure 6.5 show the scores of different metrics.

Collected Metrics	Total Answers	Score
Actual Length of Pipe / Construction Phase Duration (Days) (Km/day)	26	2.38
Actual Length of Pipe / Estimated Length of Pipe	27	2.15

Collected Metrics	Total Answers	Score
Actual Project Cost / Average Diameter / Actual Statute Length of Pipe (CDN$/inch-Km)	26	1.69
Bending Cost / Actual Project Cost (%)	25	2.72
Clean-Up Cost / Actual Project Cost (%)	25	2.88
Clearing Cost / Actual Project Cost (%)	26	2.81
Coated Pipe Freight Cost / Actual Length of Pipe (CDN$/Km)	25	3.16
Construction Cost / Actual Length of Pipe (CDN$/Km)	24	1.92
Construction Cost / Average Diameter / Actual Statute Length of Pipe (CDN$/inch-Km)	26	1.77
Construction Equipment Cost / Total Project Cost (%)	25	2.36
Construction Management / Actual Length of Pipe (CDN$/Km)	25	2.12
Contractors' Indirects / Actual Length of Pipe (CDN$/Km)	25	2.56
Crossing Construction Cost (all crossings) / Actual Length of Pipe (CDN$/Km)	25	2.72
Crossing Construction Cost (all crossings) / Actual Project Cost (%)	25	2.68
Design Capacity / Actual Capacity (%)	26	2.96
Ditching Cost / Actual Project Cost (%)	26	2.77
Engineering Cost /Actual Length of Pipe (CDN$/Km)	25	2.40
Environmental Studies & Monitoring / Actual Length of Pipe (CDN$/Km)	25	2.68
Environmental Studies & Monitoring / Actual Project Cost (%)	25	2.68
Factory Pipe Coating / Actual Length of Pipe (CDN$/Km)	24	3.04
Freight Cost (bare pipe to coater)/Actual Length of Pipe (CDN$/Km)	25	3.32
Grading Cost / Actual Project Cost (%)	26	2.73
Health, Safety, and Environment (HSE) Costs / Actual Project Cost (%)	25	2.84
Land Cost / Actual Length of ROW (CDN$/Km)	26	2.73
Mainline Construction Cost / Total Site Work hours (WH) (CDN$/hour)	25	2.52
NDT Costs / Actual Length of Pipe (CDN$/Km)	27	2.19
Number (#) of Major Crossings / Actual Length of Pipe (#/KM)	24	2.21
Owner Costs for Project Management (PM) / Actual Project Cost (%)	25	2.48
Owner Costs for Project Management (PM) / Construction Cost (%)	25	2.60
Percent (%) of Project with Heavy Wall Pipe (By Length of Pipe) (%)	26	2.96

Collected Metrics	Total Answers	Score
Permit Fees / Actual Project Cost (%)	25	2.60
Pipe / Short Ton (CDN$/ton)	24	2.79
Pipe Cost / Actual Length of Pipe (CDN$/Km)	26	1.88
Pipe Cost / Actual Project Cost (%)	26	1.85
Project Cost / Number (#) of Spreads (CDN$/each)	26	2.08
ROW Initial Restoration / Actual Length of Pipe (CDN$/Km)	26	2.69
Site Preparation / Actual Project Cost (%)	26	2.50
Surveying Costs / Actual Length of Pipe (CDN$/Km)	25	2.32
Testing Cost / Actual Project Cost (%)	25	2.64
Tie-In Cost / Actual Project Cost (%)	26	2.73
Total Bending Work hours (WH) / Total Site Work hours (WH) (%)	25	2.76
Total Clean-Up Work hours (WH) / Total Site Work hours (WH) (%)	25	2.88
Total Clearing Work hours (WH) / Total Site Work hours (WH) (%)	25	2.84
Total Ditching Work hours (WH) / Total Site Work hours (WH) (%)	25	2.76
Total Grading Work hours (WH) / Total Site Work hours (WH) (%)	25	2.76
Total Indirect Work hours (WH) / Total Direct Work hours (WH) (%)	27	2.22
Total Number of Welds / Welding Phase Duration (welds/day)	26	2.12
Total Site Work hours (WH) / Actual Length of Pipe (work hours/Km)	26	2.08
Total Testing Work hours (WH) / Total Site Work hours (WH) (%)	25	2.68
Total Tie-In Work hours (WH) / Total Site Work hours (WH) (%)	25	2.76
Total Welding Work hours (WH) / Total Site Work hours (WH) (%)	25	2.60
Weight (Tons) / Actual Length of Pipe (ton/Km)	25	2.80
Welding Cost / Actual Project Cost (%)	25	2.56

Table 6.7 Metrics and the Priority Scores

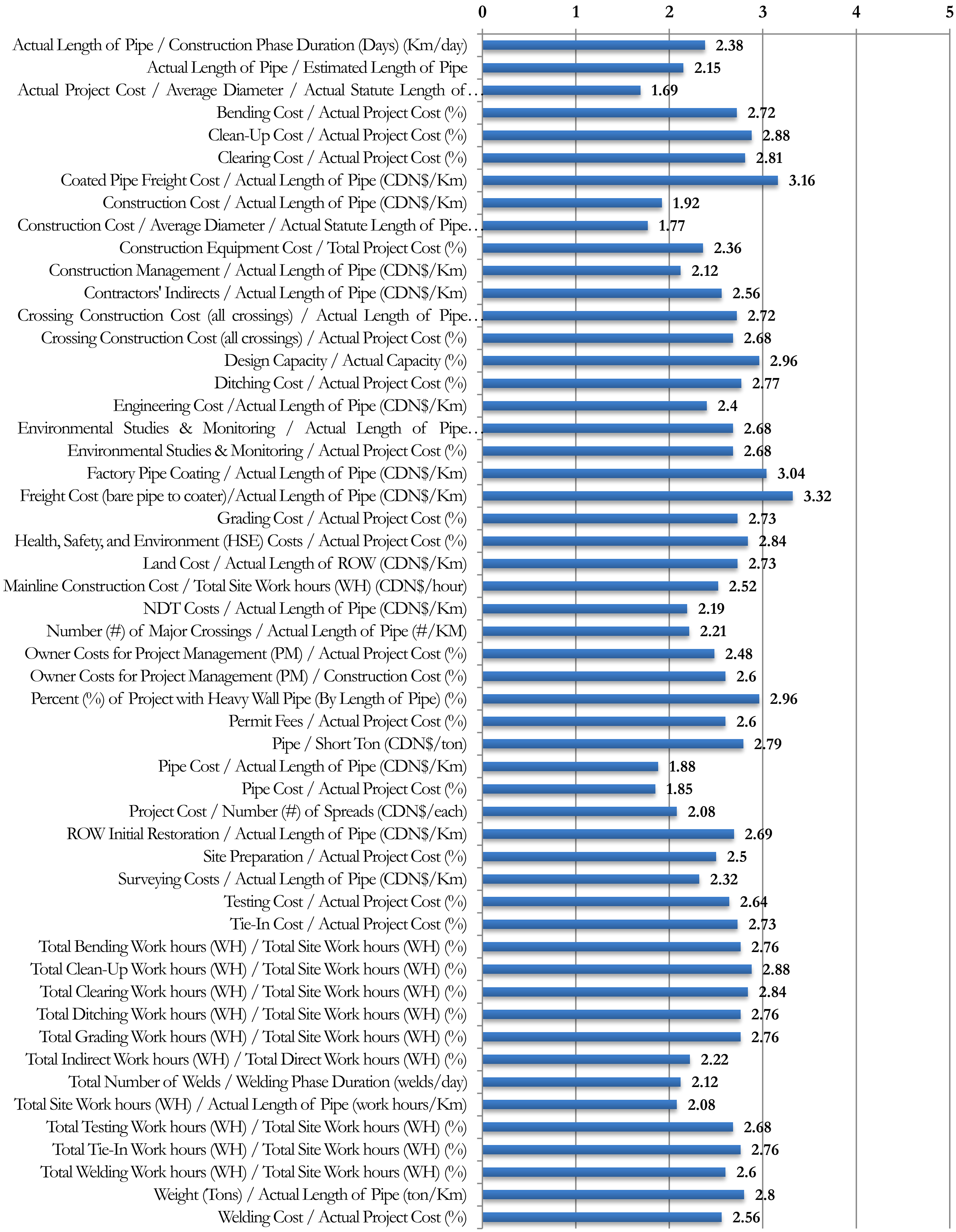


Figure 6.5 Metrics and the Priority Scores

6.5.4 The Data Elements and the Data Collection

In the next question, different elements were presented to the participants. These elements were the base of performance assessment metrics, which have been mentioned in previous questions. Experts were asked to indicate which data element they gather at their companies and whether the required elements are easy or difficult to be collected. The question findings are shown below.

	We collect the element at the company	We don't collect the element at the company	The element is easy to collect	The element is hard to collect	Total Answers
Actual Capacity	67% 16	25% 6	71% 17	21% 5	24
Actual Length of Pipe	92% 24	4% 1	77% 20	8% 2	26
Actual Project Cost	92% 24	4% 1	73% 19	8% 2	26
Average Bending Crew Size (people)	20% 5	76% 19	20% 5	64% 16	25
Average Clean-Up Crew Size (people)	16% 4	80% 20	24% 6	60% 15	25
Average Clearing Crew Size (people)	24% 6	72% 18	24% 6	64% 16	25
Average Diameter	88% 23	8% 2	85% 22	0% 0	26
Average Ditching Crew Size (people)	32% 8	64% 16	24% 6	60% 15	25
Average Grading Crew Size (people)	20% 5	76% 19	24% 6	60% 15	25
Average Testing Crew Size (people)	24% 6	72% 18	24% 6	60% 15	25
Average Tie-In Crew Size (people)	28% 7	68% 17	24% 6	60% 15	25
Average Total Crew Size (people)	72% 18	24% 6	32% 8	56% 14	25
Average Welding Crew Size (people)	32% 8	64% 16	24% 6	60% 15	25
Bending Cost	17% 4	75% 18	33% 8	58% 14	24
Clean-Up Cost	22% 5	70% 16	35% 8	52% 12	23
Clearing Cost	21% 5	71% 17	33% 8	58% 14	24
Coated Pipe Freight Cost	17% 4	78% 18	35% 8	52% 12	23

	We collect the element at the company	We don't collect the element at the company	The element is easy to collect	The element is hard to collect	Total Answers
Construction Cost	81% 21	15% 4	73% 19	8% 2	26
Construction Equipment Cost	61% 14	35% 8	78% 18	13% 3	23
Construction Management Cost	79% 19	17% 4	75% 18	13% 3	24
Crossing Construction Cost (all crossings)	36% 8	55% 12	36% 8	55% 12	22
Design Capacity	80% 20	16% 4	76% 19	8% 2	25
Ditching Cost	25% 6	67% 16	33% 8	58% 14	24
Engineering Cost	73% 19	27% 7	73% 19	8% 2	26
Environmental Studies & Monitoring Cost	58% 14	33% 8	67% 16	17% 4	24
Estimated Length of Pipe	85% 22	12% 3	81% 21	4% 1	26
Factory Pipe Coating Cost	45% 10	50% 11	64% 14	23% 5	22
Grading Cost	21% 5	71% 17	33% 8	58% 14	24
Health, Safety, and Environment (HSE) Costs	39% 9	57% 13	43% 10	43% 10	23
Land Cost	80% 20	16% 4	80% 20	4% 1	25
NDT Costs	75% 18	21% 5	71% 17	17% 4	24
Number (#) of Major Crossings	71% 17	25% 6	71% 17	17% 4	24
Number (#) of Spreads	71% 17	25% 6	75% 18	8% 2	24
Owner Costs for Project Management (PM)	79% 19	17% 4	83% 20	0% 0	24
Percent (%) of Project with Concrete Coated Pipe (by distance) (%)	17% 4	79% 19	38% 9	50% 12	24
Percent (%) of Project with Heavy Wall Pipe (By Length of Pipe) (%)	22% 5	70% 16	52% 12	39% 9	23
Percent (%) of Project with Pipe Weights or Anchors (by distance) (%)	17% 4	79% 19	38% 9	50% 12	24
Percent (%) of Project with Road Ditch (by distance) (%)	13% 3	83% 20	42% 10	46% 11	24
Permit Fees	84% 21	12% 3	72% 18	12% 3	25
Pipe Cost	92% 23	4% 1	84% 21	4% 1	25
ROW Initial Restoration	43% 10	48% 11	52% 12	39% 9	23

	We collect the element at the company	We don't collect the element at the company	The element is easy to collect	The element is hard to collect	Total Answers
Site Preparation Cost	50% 12	46% 11	54% 13	29% 7	24
Surveying Costs	70% 16	26% 6	70% 16	13% 3	23
Testing Cost	35% 8	57% 13	39% 9	52% 12	23
Tie-In Cost	21% 5	75% 18	38% 9	54% 13	24
Total Bending Work hours	22% 5	70% 16	30% 7	61% 14	23
Total Clean-Up Work hours	17% 4	74% 17	30% 7	61% 14	23
Total Clearing Work hours	22% 5	70% 16	30% 7	61% 14	23
Total Direct Work hours	63% 15	33% 8	33% 8	54% 13	24
Total Ditching Work hours	22% 5	70% 16	30% 7	61% 14	23
Total Grading Work hours	26% 6	65% 15	30% 7	61% 14	23
Total Indirect Work hours	54% 13	42% 10	25% 6	63% 15	24
Total Number of Welds	80% 20	16% 4	64% 16	24% 6	25
Total Site Work hours	63% 15	33% 8	33% 8	54% 13	24
Total Testing Work hours	26% 6	65% 15	26% 6	65% 15	23
Total Tie-In Work hours	23% 5	73% 16	27% 6	59% 13	22
Total Welding Work hours	26% 6	70% 16	30% 7	57% 13	23
Weight (Tons)	76% 19	16% 4	80% 20	12% 3	25
Welding Cost	33% 8	58% 14	42% 10	50% 12	24
Welding Phase Duration	65% 17	31% 8	62% 16	23% 6	26

Table 6.8 Data Elements and the Data Collection Process in Different Companies

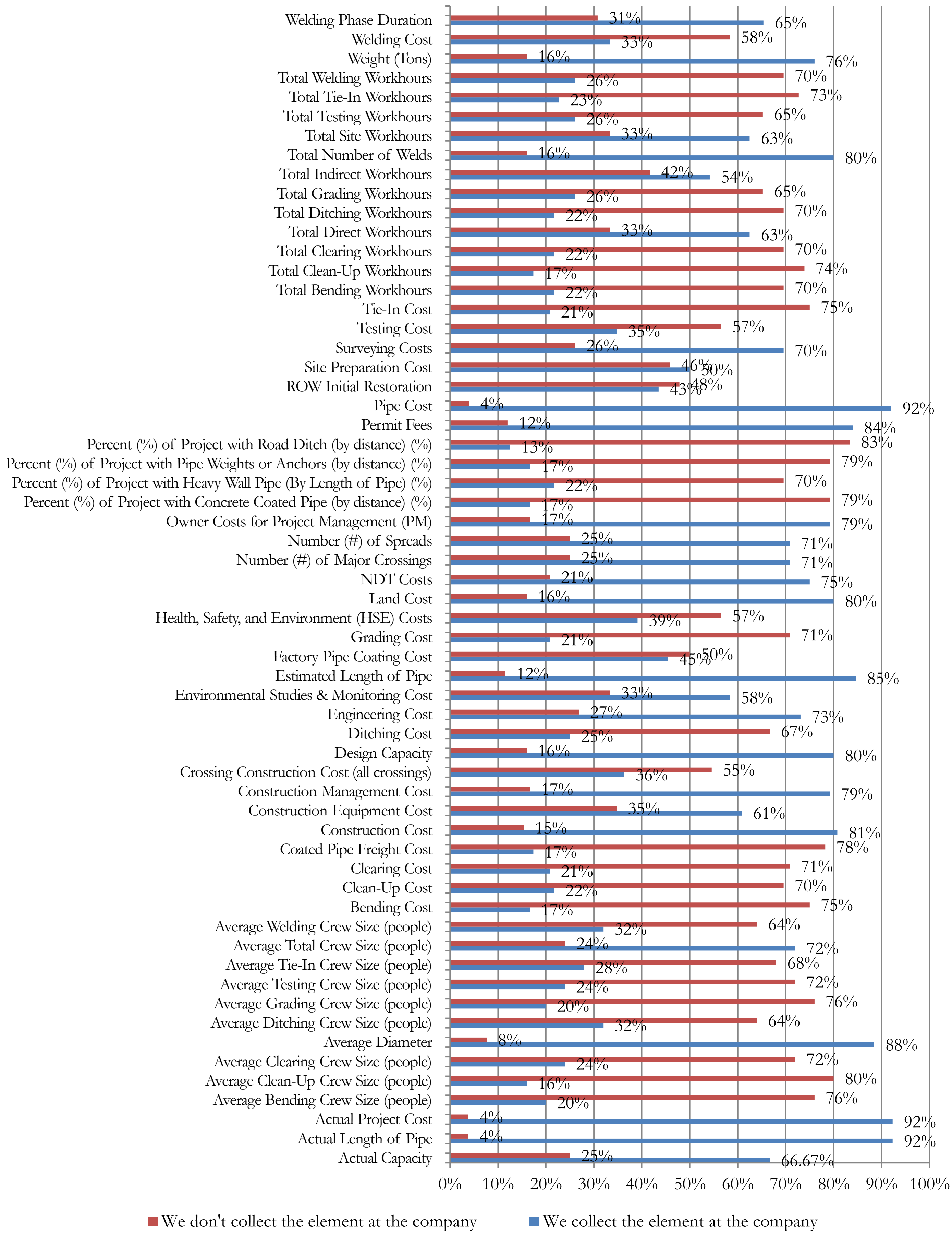


Figure 6.6 Data Elements Collection Process in Different Companies

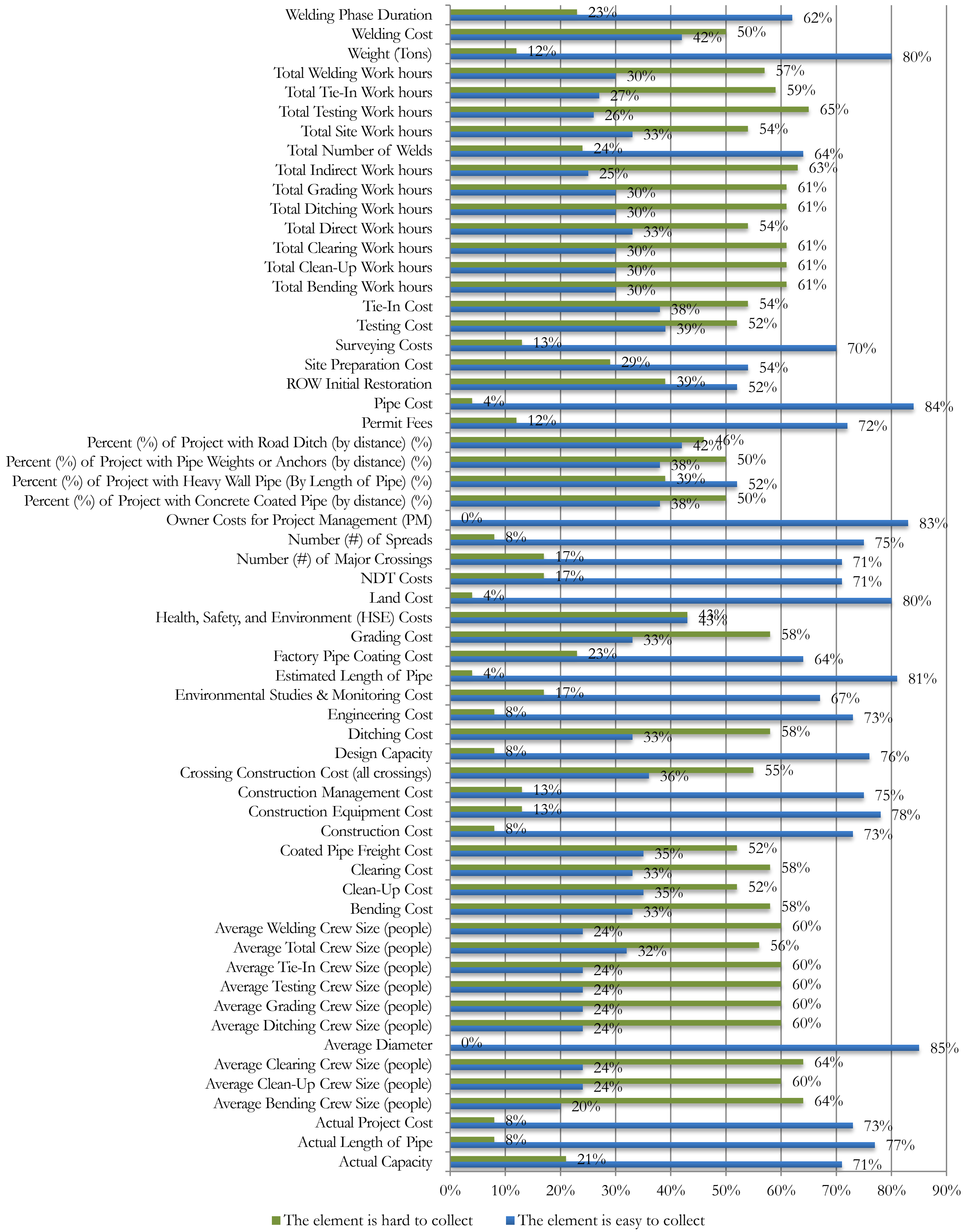


Figure 6.7 Difficulty of Data Collection for Different Elements

These results help in understanding of the elements, which are gathered by the companies in regards to performance assessment of pipeline project. Moreover, the findings show how difficult these elements are to be collected.

Next chapter, chapter 7 presents more analyses, discussions and conclusions of the study findings and the barriers companies prone in the benchmarking of pipeline projects. Moreover, some notes in regards to future studies are presented.

CHAPTER SEVEN: ANALYSIS AND DISCUSSIONS

Chapter seven presents a series of analyses and dicussions regarding the development of benchmarking metrics for the pipeline industry.

7.1 Definition of the Pipeline Project

As mentioned, 93.55% of participants in survey agreed with the proposed definition: "A pipeline moves products or raw materials in pipe from point A to point B which is outside the battery limit and needs right of way." This percentage indicates this definition can be used as the main definition for a pipeline project. This definition also indicates some main differences between a pipeline and a piping project, as such being inside the battery limit and also need for right of way.

7.2 New Categorizations for Pipeline Projects

After conducting the interviews with experts in regards to categorizing the pipeline projects, it has been decided to develop pipelines into one more level of details with two categories; over 20 inches in diameter size and under 20 inches. During survey, participants have given their opinions on the required metrics in these two different categories.

According to the results, participants indicated that all metrics are suitable for big size projects; however, for small size projects, some metrics have been eliminated due to this fact that they are mostly in regards to major activities. The findings show experts in most of the companies do not have intentions to gather these detailed data for small size projects due to lack of project control experts and time shortages. 25 Metrics have been developed for Small Size Projects. The following tables show these two categories with related performance assessment metrics. In order to develop the questionnaire for small size pipeline projects, metrics with the score of more than 40% for big size project have been eliminated. With these two different questionnaires, companies can save times in regards to data entering process. The companies would not be frustrated by answering the metrics they do not have or were not able to collect.

	Questionnaire Metrics for Both Small Size and Big Size Pipeline Projects
1	Actual Length of Pipe / Construction Phase Duration (Days) (Km/day)
2	Actual Length of Pipe / Estimated Length of Pipe
3	Actual Project Cost / Average Diameter / Actual Statute Length of Pipe (CDN$/inch-Km)
4	Coated Pipe Freight Cost / Actual Length of Pipe (CDN$/Km)
5	Construction Cost / Actual Length of Pipe (CDN$/Km)
6	Construction Cost / Average Diameter / Actual Statute Length of Pipe (CDN$/inch-Km)
7	Construction Equipment Cost / Total Project Cost (%)
8	Construction Management / Actual Length of Pipe (CDN$/Km)
9	Design Capacity / Actual Capacity (%)
10	Factory Pipe Coating / Actual Length of Pipe (CDN$/Km)
11	Mainline Construction Cost / Total Site Work hours (WH) (CDN$/hour)
12	NDT Costs / Actual Length of Pipe (CDN$/Km)
13	Number (#) of Major Crossings / Actual Length of Pipe (#/KM)
14	Owner Costs for Project Management (PM) / Actual Project Cost (%)
15	Owner Costs for Project Management (PM) / Construction Cost (%)
16	Permit Fees / Actual Project Cost (%)
17	Pipe / Short Ton (CDN$/ton)
18	Pipe Cost / Actual Length of Pipe (CDN$/Km)
19	Pipe Cost / Actual Project Cost (%)
20	Project Cost / Number (#) of Spreads (CDN$/each)
21	Surveying Costs / Actual Length of Pipe (CDN$/Km)
22	Total Indirect Work hours (WH) / Total Direct Work hours (WH) (%)
23	Total Number of Welds / Welding Phase Duration (welds/day)

	Questionnaire Metrics for Both Small Size and Big Size Pipeline Projects
24	Total Site Work hours (WH) / Actual Length of Pipe (work hours/Km)
25	Weight (Tons) / Actual Length of Pipe (ton/Km)

Table 7.1 Questionnaire Metrics for Both Small Size and Big Size Pipeline Projects

	Additional Questionnaire Metrics for Big Size Pipeline Projects
26	Bending Cost / Actual Project Cost (%)
27	Clean-Up Cost / Actual Project Cost (%)
28	Clearing Cost / Actual Project Cost (%)
29	Contractors' Indirects / Actual Length of Pipe (CDN$/Km)
30	Crossing Construction Cost (all crossings) / Actual Length of Pipe (CDN$/Km)
31	Crossing Construction Cost (all crossings) / Actual Project Cost (%)
32	Ditching Cost / Actual Project Cost (%)
33	Engineering Cost /Actual Length of Pipe (CDN$/Km)
34	Environmental Studies & Monitoring / Actual Length of Pipe (CDN$/Km)
35	Environmental Studies & Monitoring / Actual Project Cost (%)
36	Freight Cost (bare pipe to coater)/Actual Length of Pipe (CDN$/Km)
37	Grading Cost / Actual Project Cost (%)
38	Health, Safety, and Environment (HSE) Costs / Actual Project Cost (%)
39	Land Cost / Actual Length of ROW (CDN$/Km)
40	Percent (%) of Project with Heavy Wall Pipe (By Length of Pipe) (%)
41	ROW Initial Restoration / Actual Length of Pipe (CDN$/Km)
42	Site Preparation / Actual Project Cost (%)
43	Testing Cost / Actual Project Cost (%)

	Additional Questionnaire Metrics for Big Size Pipeline Projects
44	Tie-In Cost / Actual Project Cost (%)
45	Total Bending Work hours (WH) / Total Site Work hours (WH) (%)
46	Total Clean-Up Work hours (WH) / Total Site Work hours (WH) (%)
47	Total Clearing Work hours (WH) / Total Site Work hours (WH) (%)
48	Total Ditching Work hours (WH) / Total Site Work hours (WH) (%)
49	Total Grading Work hours (WH) / Total Site Work hours (WH) (%)
50	Total Testing Work hours (WH) / Total Site Work hours (WH) (%)
51	Total Tie-In Work hours (WH) / Total Site Work hours (WH) (%)
52	Total Welding Work hours (WH) / Total Site Work hours (WH) (%)
53	Welding Cost / Actual Project Cost (%)

Table 7.2 Additional Questionnaire Metrics for Big Size Pipeline Projects

7.3 The Metrics and Priorities

According to pipeline experts, different previously developed metrics in the interviews have different priorities for the companies. Some of them are more important and companies target them for data gathering. The collected data help companies to have better understanding of their benchmarking results.

Survey results, which have been conducted as likert-scale method, indicated importance of the metrics individually. The sorted metrics according to their scores are shown in table 7.3. The numbers indicating the importance of the metric as which 1 is “the most important” and 5 is “not important at all”.

	Collected Metrics	Score
1	Actual Project Cost / Average Diameter / Actual Statute Length of Pipe (CDN$/inch-Km)	1.69

	Collected Metrics	**Score**
2	Construction Cost / Average Diameter / Actual Statute Length of Pipe (CDN$/inch-Km)	1.77
3	Pipe Cost / Actual Project Cost (%)	1.85
4	Pipe Cost / Actual Length of Pipe (CDN$/Km)	1.88
5	Construction Cost / Actual Length of Pipe (CDN$/Km)	1.92
6	Project Cost / Number (#) of Spreads (CDN$/each)	2.08
7	Total Site Work hours (WH) / Actual Length of Pipe (work hours/Km)	2.08
8	Construction Management / Actual Length of Pipe (CDN$/Km)	2.12
9	Total Number of Welds / Welding Phase Duration (welds/day)	2.12
10	Actual Length of Pipe / Estimated Length of Pipe	2.15
11	NDT Costs / Actual Length of Pipe (CDN$/Km)	2.19
12	Number (#) of Major Crossings / Actual Length of Pipe (#/KM)	2.21
13	Total Indirect Work hours (WH) / Total Direct Work hours (WH) (%)	2.22
14	Surveying Costs / Actual Length of Pipe (CDN$/Km)	2.32
15	Construction Equipment Cost / Total Project Cost (%)	2.36
16	Actual Length of Pipe / Construction Phase Duration (Days) (Km/day)	2.38
17	Engineering Cost /Actual Length of Pipe (CDN$/Km)	2.4
18	Owner Costs for Project Management (PM) / Actual Project Cost (%)	2.48
19	Site Preparation / Actual Project Cost (%)	2.5
20	Mainline Construction Cost / Total Site Work hours (WH) (CDN$/hour)	2.52
21	Contractors' Indirects / Actual Length of Pipe (CDN$/Km)	2.56
22	Welding Cost / Actual Project Cost (%)	2.56
23	Owner Costs for Project Management (PM) / Construction Cost (%)	2.6
24	Permit Fees / Actual Project Cost (%)	2.6
25	Total Welding Work hours (WH) / Total Site Work hours (WH) (%)	2.6
26	Testing Cost / Actual Project Cost (%)	2.64
27	Crossing Construction Cost (all crossings) / Actual Project Cost (%)	2.68
28	Environmental Studies & Monitoring / Actual Length of Pipe (CDN$/Km)	2.68

	Collected Metrics	Score
29	Environmental Studies & Monitoring / Actual Project Cost (%)	2.68
30	Total Testing Work hours (WH) / Total Site Work hours (WH) (%)	2.68
31	ROW Initial Restoration / Actual Length of Pipe (CDN$/Km)	2.69
32	Bending Cost / Actual Project Cost (%)	2.72
33	Crossing Construction Cost (all crossings) / Actual Length of Pipe (CDN$/Km)	2.72
34	Grading Cost / Actual Project Cost (%)	2.73
35	Land Cost / Actual Length of ROW (CDN$/Km)	2.73
36	Tie-In Cost / Actual Project Cost (%)	2.73
37	Total Bending Work hours (WH) / Total Site Work hours (WH) (%)	2.76
38	Total Ditching Work hours (WH) / Total Site Work hours (WH) (%)	2.76
39	Total Grading Work hours (WH) / Total Site Work hours (WH) (%)	2.76
40	Total Tie-In Work hours (WH) / Total Site Work hours (WH) (%)	2.76
41	Ditching Cost / Actual Project Cost (%)	2.77
42	Pipe / Short Ton (CDN$/ton)	2.79
43	Weight (Tons) / Actual Length of Pipe (ton/Km)	2.8
44	Clearing Cost / Actual Project Cost (%)	2.81
45	Health, Safety, and Environment (HSE) Costs / Actual Project Cost (%)	2.84
46	Total Clearing Work hours (WH) / Total Site Work hours (WH) (%)	2.84
47	Clean-Up Cost / Actual Project Cost (%)	2.88
48	Total Clean-Up Work hours (WH) / Total Site Work hours (WH) (%)	2.88
49	Design Capacity / Actual Capacity (%)	2.96
50	Percent (%) of Project with Heavy Wall Pipe (By Length of Pipe) (%)	2.96
51	Factory Pipe Coating / Actual Length of Pipe (CDN$/Km)	3.04
52	Coated Pipe Freight Cost / Actual Length of Pipe (CDN$/Km)	3.16
53	Freight Cost (bare pipe to coater)/Actual Length of Pipe (CDN$/Km)	3.32

Table 7.3 Sorted Metrics and the Priorities Final Scores

These results show the concentration of the companies involved in pipeline industry. Also, these metrics can help different involved parties to collect only the most important data in case of difficulties in data collection process due to labor shortage or unavailability of data.

7.4 The Data Elements and the Data Collection

In the last question of the survey, author tried to review different data elements, the companies' behaviors in regards to the data collection and how difficult the elements are to be gathered. According to the survey results, table 7.4 shows the sorted data elements. The table shows the metrics in descending priorities from being collected by the companies. The second column shows the metrics in regards to this fact that they are easy to be collected or not.

Data Elements	**Being Gathered by the Companies**	**Being Easy to collect**
Actual Length of Pipe	92%	76.92%
Actual Project Cost	92%	73.08%
Pipe Cost	92%	84.00%
Average Diameter	88%	84.62%
Estimated Length of Pipe	85%	80.77%
Permit Fees	84%	72.00%
Construction Cost	81%	73.08%
Design Capacity	80%	76.00%
Land Cost	80%	80.00%
Total Number of Welds	80%	64.00%
Construction Management Cost	79%	75.00%
Owner Costs for Project Management (PM)	79%	83.33%
Weight (Tons)	76%	80.00%
NDT Costs	75%	70.83%

Engineering Cost	73%	73.08%
Average Total Crew Size (people)	72%	32.00%
Number (#) of Major Crossings	71%	70.83%
Number (#) of Spreads	71%	75.00%
Surveying Costs	70%	69.57%
Actual Capacity	66.67%	70.83%
Welding Phase Duration	65%	61.54%
Total Direct Work hours	63%	33.33%
Total Site Work hours	63%	33.33%
Construction Equipment Cost	61%	78.26%
Environmental Studies & Monitoring Cost	58%	66.67%
Total Indirect Work hours	54%	25.00%
Site Preparation Cost	50%	54.17%
Factory Pipe Coating Cost	45%	63.64%
ROW Initial Restoration	43%	52.17%
Health, Safety, and Environment (HSE) Costs	39%	43.48%
Crossing Construction Cost (all crossings)	36%	36.36%
Testing Cost	35%	39.13%
Welding Cost	33%	41.67%
Average Ditching Crew Size (people)	32%	24.00%
Average Welding Crew Size (people)	32%	24.00%
Average Tie-In Crew Size (people)	28%	24.00%
Total Grading Work hours	26%	30.43%
Total Testing Work hours	26%	26.09%
Total Welding Work hours	26%	30.43%

Ditching Cost	25%	33.33%
Average Clearing Crew Size (people)	24%	24.00%
Average Testing Crew Size (people)	24%	24.00%
Total Tie-In Work hours	23%	27.27%
Clean-Up Cost	22%	34.78%
Percent (%) of Project with Heavy Wall Pipe (By Length of Pipe) (%)	22%	52.17%
Total Bending Work hours	22%	30.43%
Total Clearing Work hours	22%	30.43%
Total Ditching Work hours	22%	30.43%
Clearing Cost	21%	33.33%
Grading Cost	21%	33.33%
Tie-In Cost	21%	37.50%
Average Bending Crew Size (people)	20%	20.00%
Average Grading Crew Size (people)	20%	24.00%
Coated Pipe Freight Cost	17%	34.78%
Total Clean-Up Work hours	17%	30.43%
Bending Cost	17%	33.33%
Percent (%) of Project with Concrete Coated Pipe (by distance) (%)	17%	37.50%
Percent (%) of Project with Pipe Weights or Anchors (by distance) (%)	17%	37.50%
Average Clean-Up Crew Size (people)	16%	24.00%
Percent (%) of Project with Road Ditch (by distance) (%)	13%	41.67%

Table 7.4 Companies Behaviour in Addition to Difficulty Level of Data Gathering Process

The results show how companies behave in data gathering process. The table also indicates that most of the high ranked data gathered by the companies are easy to collect; however some of the elements are not being gathered even in the case that they are easy to collect like the element

"ROW Initial Restoriation". Moreover, the results determine which metrics are most difficult to be collected. The table shows majority of detailed elements as such crew size or work hours in regards to major activities are difficult to gather.

CHAPTER EIGHT: CONCLUSIONS

Chapter eight presents and explains the conclusions in regards to findings and deliverables of the research study. Moreover, the chapter explains how the outcomes and findings can help the industry to benchmark the pipeline projects efficiently. The existing barriers to benchmarking of pipeline projects are discussed and finally, some recommendations for future studies are presented.

8.1 Summary

The goal of the research was to develop a framework for benchmarking metrics and also to define a set of parameters specifically for pipeline projects that would assist industry participants and also researchers in examining and comparing their projects in pipeline industry. In this study, I developed fifty-three benchmarking metrics specifically for pipeline projects. In addition to this, I identified the environment, context, barriers, and boundaries in pipeline industry that can affect the results.

The following deliverables are outcomes of the research:

- Fifty-three benchmarking metrics specifically for pipeline projects are identified and developed.
- Definition for pipeline project is defined and validated.
- New categorizations based on pipeline size are developed.
- Risks associated with pipeline construction are identified and categorized.
- Industry practices regarding data collection are identified.

8.2 The Barriers to Effective Benchmarking of Pipeline Projects

Despite the fact that Alberta companies involved in pipeline construction have a benchmarking system, there is insufficient data contained in the current benchmarking database to allow for thorough data analysis. According to COAA benchmarking database, only 4 pipeline companies currently participate in the benchmarking system; however, a 2012 Alberta government report lists at least 15 pipeline companies that are currently active within Alberta. Since one purpose of benchmarking is performance improvement, increased participation in the COAA benchmarking system could result in more complete analysis that could lead to improved pipeline project performance. Through the study conduction, two elements have been identified as the main barriers in the benchmarking of pipeline projects. These barriers prevent companies from fully participation in different benchmarking databases.

8.2.1 Labor Shortage and Incomplete Data Collection

The benchmarking process is cost- and time- consuming for the industrial companies. This process needs dedicated crews from different teams and parties such as the project control department, the engineering department, and the management organization. Moreover, an effective benchmarking process should be carried out through the entire project lifecycle with the support of organization members. Pipeline benchmarking can be executed in different levels. The depth of data collection needs to be identified based on the purpose of benchmarking, the intentions of management team, and the availability of resources for accurate data collection. Collecting detailed precise data is vital to the consistency and reliability of the benchmarking process.

One of the huge barriers to accurate and truthful data collection is a lack of competent and capable data collectors. During the interviews, some experts indicated that in times of recessions and terrible economy, project control people are the first to be fired or laid-off. Another reason for inconsistency in the benchmarking process is a lack of organizational culture in regards to the accurate data collection. The actual data needs to be gathered over and over through the lifecycle of a project. The gathered data from involved companies in this study show the majority of companies do not have sufficient information in regards to their past completed projects. The mentioned reasons prevent companies and organizations from participating in an accurate and reliable benchmarking process.

8.2.2 Pipeline Companies and the Competitive Market

Pipeline companies are involved in engineering and construction of pipeline projects. As it has been defined before, a pipeline moves products or raw materials in pipe from point A to point B which is outside the battery limit and needs right of way. As the definition indicates, pipeline companies are participating in a service production market. These companies are mainly different from heavy industrial organizations which are responsible for upstream or downstream projects. Pipeline companies are not producing oil, gas, products, or materials. The pipeline industry's source of income is the service provided for clients such as renting or selling of pipelines as transportation mainlines. These transportation lines transfer the desired materials produced by industrial organizations to important markets. Therefore, pipeline companies find themselves in a competitive market in which any data or information about past completed project is important and highly confidential. This fact prevents companies and management teams from participating in benchmarking of their projects.

8.3 Benchmark the Pipeline Projects Efficiently

Findings of the study indicate how the pipeline companies behave in gathering data for benchmarking purposes. The research also shows the industry opinions in regards to different metrics priorities. These results help pipeline companies in different ways:

1. The final tables and charts direct different involved teams to gather only the related metrics based on the size of their pipeline projects.

2. In the case of labor shortage or insufficient collected data, companies can only gather the important metrics, indicated by the industry experts.

3. The results help companies to identify the most gathered data in the industry, therefore they can assign enough time for an effective data gathering process. With this method they can only focus on the categories they need to benchmark.

4. During interviews, some companies mentioned frustrations in regards to data entering process. New developed questionnaires and metrics help these companies to only look for relevant available data.

5. An effective data gathering process in addition to a valuable benchmarking database would attract more companies and increase the organizations participation rates. Furthermore, companies can be sure about the accuracy and reliability of data.

6. Finally, the developed metrics provide the management team with a framework to know what metrics need to be gathered by different disciplines. Therefore, managers can request the involved departments to start collecting the related data from the beginning of project. In this way, at the time of commissioning, there would be sufficient accurate data to effectively benchmark the project.

8.4 Recommendations for Future Studies

According to what has been discussed in this chapter, future studies should examine how the characteristics of different pipeline projects, the project team, and the industry sector in addition to the social, political, and economic environments in which the projects are being operated may influence the level of benchmarking tool use or the impact they have on project performance.

8.4.1 Risk Management and Benchmarking Metrics

As presented in Chapter Five, different risks associated with pipeline construction are identified during the interviews with pipeline experts. The author suggests future studies to be directed in order to study the relations between different identified risks and different construction activities. Furthermore, with this method, the studies can identify which risks are associated with different developed metrics. These risks are categorized into three different groups: operational risks, strategic risks and contextual risks. Researchers can plan the mitigation processes in regards to different risks by conducting risk management analyses. These mitigation plans can be used by the companies in order to reduce the influence of identified risks on their benchmarking processes and data collections.

8.4.2 Benchmarking Use and Improvement

As indicated in literature review chapter, the majority of pipeline companies do not take part in benchmarking of their pipeline projects; however, increasing momentum has been reported among Albertan companies in use of benchmarking tool. The author suggests future studies be conducted in regards to measuring the usage of benchmarking tools in the pipeline industry. The researchers can focus on different areas such as how the new developed metrics should be implemented. Moreover, future studies can address how the benchmarking metrics indicate a specific company's performance improvement. The researchers can also observe different companies in order to indicate how the use of benchmarking tools would improve their performances.

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Appendix I: Interview Instrument

Developing Benchmarking Metrics for Pipeline Projects in Alberta

A benchmarking system has been developed over the past several years to assess the performance of the Alberta construction projects. In 2008, a benchmarking study completed and established a comprehensive benchmarking system comprised of a customized questionnaire and a dedicated database. An analysis of the results indicated areas of enhancements; furthermore, second benchmarking study would be needed to determine what enhancements and modifications are required regarding this matter. The analysis of the results to this point shows that there is a need for new metrics and modifications to current ones in heavy industrial sector. In addition, developing a new system to measure the performance of pipeline projects in Alberta and in Canada seems to be necessary.

The purpose of the current research project is to expand and extend the previous benchmarking system focusing on activities and methods to design and fabricate the pipeline projects, used by engineering, procurement and construction (EPC) owners and contractors. The study will also focus on the expansion of pipeline projects' definition.

This interview is voluntary. Your organization will not be informed of either your involvement or non-involvement in this interview. The professionals participating in this study may be from project teams that have been involved in the projects under discussion or are members of the organization that completed these projects. The responsibilities of the professionals from these project teams may include management, planning, control, design, procurement and construction. In other words, all members of the project teams in the home office and field locations may participate in this interview as well as other members of the organization.

You can decline to answer any of the questions. You and/or your organization can decide to withdraw from the study at any time, without any negative consequences, by advising the researchers or our supervisors, Dr. George Jergeas and Dr. Janaka Ruwanpura. All information collected from you up to the point of withdrawal will be destroyed and excluded from this research study. There are no known or anticipated risks to those who participate in this study.

We would like to record this interview on audio recording device so that we can use it for reference while proceeding with this study. We will not record this interview without your permission. If you do grant permission for this conversation to be recorded on device, you have the right to revoke recording permission and/or end the interview at any time. Participants and their organizations will be given the option of being named or remaining anonymous. If you wish to remain anonymous, your name and that of your organization will not appear anywhere in this study or in any report or thesis. If references are required in these reports, they will be made by employing some anonymous type of identification for each organization (such as Company A) and for the responsibility for each individual (e.g. Project Leader). Data collected during this research study will be retained for a minimum of two years and a maximum of five years from when the data was collected in a locked cabinet at the University of Calgary. Only researchers associated with this specific research study will have access to this information and the data will ultimately be destroyed within the five year period.

Your organization has contributed financially to this study. You and other professionals from your organization are providing your time to complete this questionnaire survey. Although there is no remuneration for any participant in this study, participating organizations will be provided with a full briefing upon completions of the research project at their request. Any participant or participant organization who is interested in knowing the results of the research project may request a summary of the research findings. In addition, any participant or participant organization may request a question and answer meeting with the researchers.

The University of Calgary Conjoint Faculties Research Ethics Board has approved this research study. The findings of this research study are expected to benefit participating organizations, organizations that undertake oil and gas projects and the academic research community. We thank you in advance for your assistance and involvement in this study.

This consent form, a copy of which has been given to you, is only part of the process of informed consent. It should provide you with basic information concerning the purpose and research methods used in this study and details of what your involvement will be in the study. If you would like more details about anything mentioned here, or about any information that is not included here, you are encouraged to request it from the researchers. Your signature on this form indicates that you have understood, to your satisfaction, the information regarding participation in the research project and agree to participate as a subject. Your signature does not waive your rights nor release the investigators, sponsors, or involved institutions from their legal and professional responsibilities. Your continued participation should be as informed as your initial consent, and in that regard, you are encouraged to ask for clarification or additional information throughout your participation.

You can complete the interview in multiple sessions for a total time commitment of approximately 1-2 hours. The interview may be completed in your office or at a mutually convenient location. If you have further questions concerning matters related to this research, please contact: Dr. Jim Lozon, principal investigator, (403) 466-1449, Hamed Moradi, investigator, (403) 971-5236, Dr. George Jergeas, supervisor, (403) 220-8135 or Dr. Janaka Ruwanpura, supervisor, (403) 220-6892. If you have any concerns about the way you've been treated as a participant, please contact Mr. Russell Burrows, Senior Ethics Resource Officer, Research Services, University of Calgary at

(403) 220-3782, email rburrows@ucalgary.ca . You are free to withdraw from the study at any time by contacting Dr. Jim Lozon, Hamed Moradi, Dr. George Jergeas or Dr. Janaka Ruwanpura. The information gathering process will then stop immediately and the principal investigator will meet with you to address any concerns or questions. All information collected from you up to the point of withdrawal will be destroyed and excluded from this research study.

( ) I give permission to use my name in all reports or:

( ) I wish to remain anonymous in all reports

( ) I give permission to record this interview.

____________________________________ __________________

Participant's Signature Date

Developing Benchmarking Metrics for Pipeline Projects in Alberta

Dear Participant, we would appreciate if you let us know how much time you have for this interview so we can manage the time and questions.

1. General information:
    a. Name:
    b. Company:
    c. Role:
    d. How many years have you been in industry:
    e. Contact Information:
2. As the matter of fact, my background to a certain extent is different from pipeline projects and as the requirements of my degree I have to become more familiar with the materials. Would you please recommend some references and materials to give me a robust and clear understanding of the pipeline projects?

3. I would like to start by asking how your company defines a pipeline project. What's your opinion about the definition, do you agree with that?

4. Have you ever had an industrial project that the **piping** section could be extracted as a separate **pipeline** project?

5. What do you think about the lifecycle of a pipeline project? Is it different from an industrial project life cycle?

6. How do you break down the phases of a pipeline project, in other words what is the approximate percentage (cost-wise and schedule-wise) for each phase in a pipeline project:

   Cost-wise?

   Schedule-wise?

7. If you have to categorize the pipeline project into more level of details, what parameters would you consider for this categorization?

8. In a previous study, pipeline projects were divided into different categories by below parameters:

   Project Type: Green Field/ No Existing ROW
   Expansion/ Looping Utilizing Existing ROW
   Parallel Foreign Pipeline ROW

   Pipe Predominant Diameter: Under 16" Diameter, 16"-24" Diameter, 24"-36" Diameter, Over 36" Diameter

   Type of Pipeline: Above Ground, Buried, Mixed

   What's your opinion on this categorization? Agree, No Opinion, Disagree

   Do you have other parameters in mind that we can use for categorization of the pipeline projects (As one more level of details)?

9. What metrics do you think should be collected for the performance assessment of a pipeline project? In other words, please indicate any metrics for a performance assessment of pipeline projects, which you think is important to be defined as an assessment tool?

   - What does your company collect for the performance assessment?

   - Do the collected metrics by your company give you enough information?

10. What risks do you think are associated with a pipeline project?

11. For the last question, is there anyone else in your organization that you think can help us in such an interview regarding the pipeline projects? Would you also give us permission to comeback as a follow up with you regarding the result of this interview?

Thank you for taking the time to participate in this interview.

Appendix II: Survey Instrument

Developing Benchmarking Metrics for Pipeline Projects in Alberta

A benchmarking system has been developed over the past several years to assess the performance of the Alberta construction projects. In 2008, a benchmarking study completed and established a comprehensive benchmarking system comprised of a customized questionnaire and a dedicated database. An analysis of the results indicated areas of enhancements. The purpose of the current research project is to expand and extend the previous benchmarking system focusing on activities and methods to design and fabricate the pipeline projects, used by engineering, procurement and construction (EPC) owners and contractors.

This survey is voluntary and is considered as a validation process regarding data which have been collected in the first round of interviews with industry. Your organization will not be informed of either your involvement or non-involvement in this survey. You can decline to answer any of the questions. You and/or your organization can decide to withdraw from the study at any time, without any negative consequences, by advising the researchers or our supervisors, Dr. George Jergeas and Dr. Janaka Ruwanpura. All information collected from you up to the point of withdrawal will be destroyed and excluded from this research study.

Participants and their organizations will be remained anonymous. Your name and that of your organization will not appear anywhere in this study or in any report or thesis. If references are required in these reports, they will be made by employing some anonymous type of identification for each organization (such as Company A) and for the responsibility for each individual (e.g. Project Leader). Data collected during this research study will be retained for a minimum of two years and a maximum of five years from when the data was collected in a locked cabinet at the University of Calgary. Only researchers associated with this specific research study will have access to this information and the data will ultimately be destroyed within the five year period.

Your organization has contributed financially to this study. You and other professionals from your organization are providing your time to complete this questionnaire survey. Although there is no remuneration for any participant in this study, participating organizations will be provided with a full briefing upon completions of the research project at their request. Any participant or participant organization who is interested in knowing the results of the research project may request a summary of the research findings. In addition, any participant or participant organization may request a question and answer meeting with the researchers.

The University of Calgary Conjoint Faculties Research Ethics Board has approved this research study. The findings of this research study are expected to benefit participating organizations, organizations that undertake oil and gas projects and the academic research community. We thank you in advance for your assistance and involvement in this study.

If you have further questions concerning matters related to this survey, please contact: Dr. Jim Lozon, principal investigator, (403) 466-1449, Hamed Moradi, investigator, (403) 971-5236, Dr. George Jergeas, supervisor, (403) 220-8135 or Dr. Janaka Ruwanpura, supervisor, (403) 220-6892. If you have any concerns about the way you've been treated as a participant, please contact Mr. Russell Burrows, Senior Ethics Resource Officer, Research Services, University of Calgary at (403) 220-3782, email rburrows@ucalgary.ca . You are free to withdraw from the study at any time by contacting Dr. Jim Lozon, Hamed Moradi, Dr. George Jergeas or Dr. Janaka Ruwanpura. The information gathering process will then stop immediately and the principal investigator will meet with you to address any concerns or questions. All information collected from you up to the point of withdrawal will be destroyed and excluded from this research study.

( ) I give permission to use my answers for research purposes

____ _________________

Participant's Signature Date

Developing Benchmarking Metrics for Pipeline Projects in Alberta

Dear Participant, we would appreciate if you let us know how much time you have for this interview so we can manage the time and questions.

1. General information:
    a. Role in your company:
    b. How many years have you been in industry:
2. After first round of interview, the following definition has been developed regarding a pipeline project. In the scale of one to five, which "one" is strongly agree and "five" is strongly disagree, determine if you agree or not with this definition.

"A Pipeline project is transmission of products or raw materials in pipe from point A to point B which is outside the battery limit and needs right of way."

Strong Agree	Agree	Neutral	Disagree	Strong Disagree

If you do not agree or if you have another definition, please mention it below:

3. At the end of first round of interviews, the results showed a need for separating pipeline projects into two different categories: Bigger size (Over 20 inches) and smaller size (Under 20 inches).

Also, some metrics were collected, defined or developed for the purpose of general performance assessment of the pipeline projects. In your opinion which category is suitable for development of these metrics?

	Small Size (Under 20")	Big Size (Over 20")	Suitable for Both Categories	Not Suitable for any Category
Project Cost / Number (#) of Spreads (CDN$/each)				
Actual Length of Pipe / Estimated Length of Pipe				
Pipe Cost / Actual Project Cost (%)				
Pipe Cost / Actual Length of Pipe (CDN$/Km)				
Actual Project Cost / Average Diameter / Actual Statute Length of Pipe (CDN$/inch-Km)				
Construction Cost / Average Diameter / Actual Statute Length of Pipe (CDN$/inch-Km)				
Design Capacity / Actual Capacity (%)				
Owner Costs for Project Management (PM) / Actual Project Cost (%)				
Owner Costs for Project Management (PM) / Construction Cost (%)				
Engineering Cost /Actual Length of Pipe (CDN$/Km)				
Permit Fees / Actual Project Cost (%)				
Land Cost / Actual Length of ROW (CDN$/Km)				
Environmental Studies & Monitoring / Actual Project Cost (%)				
Environmental Studies & Monitoring / Actual Length of Pipe (CDN$/Km)				
Construction Equipment Cost / Total Project Cost (%)				
Number (#) of Major Crossings / Actual Length of Pipe (#/KM)				
Construction Cost / Actual Length of Pipe (CDN$/Km)				
Contractors' Indirects / Actual Length of Pipe (CDN$/Km)				
Site Preparation / Actual Project Cost (%)				
Percent (%) of Project with Heavy Wall Pipe (By Length of Pipe) (%)				
Pipe / Short Ton (CDN$/ton)				
Weight (Tons) / Actual Length of Pipe (ton/Km)				
Factory Pipe Coating / Actual Length of Pipe (CDN$/Km)				

	Small Size (Under 20")	Big Size (Over 20")	Suitable for Both Categories	Not Suitable for any Category
Coated Pipe Freight Cost / Actual Length of Pipe (CDN$/Km)				
Freight Cost (bare pipe to coater)/Actual Length of Pipe (CDN$/Km)				
Mainline Construction Cost / Total Site Work hours (WH) (CDN$/hour)				
Crossing Construction Cost (all crossings) / Actual Project Cost (%)				
Crossing Construction Cost (all crossings) / Actual Length of Pipe (CDN$/Km)				
Health, Safety, and Environment (HSE) Costs / Actual Project Cost (%)				
Surveying Costs / Actual Length of Pipe (CDN$/Km)				
Construction Management / Actual Length of Pipe (CDN$/Km)				
NDT Costs / Actual Length of Pipe (CDN$/Km)				
ROW Initial Restoration / Actual Length of Pipe (CDN$/Km)				
Actual Length of Pipe / Construction Phase Duration (Days) (Km/day)				
Total Site Work hours (WH) / Actual Length of Pipe (work hours/Km)				
Total Number of Welds / Welding Phase Duration (welds/day)				
Total Indirect Work hours (WH) / Total Direct Work hours (WH) (%)				
Clearing Cost / Actual Project Cost (%)				
Ditching Cost / Actual Project Cost (%)				
Grading Cost / Actual Project Cost (%)				
Bending Cost / Actual Project Cost (%)				
Welding Cost / Actual Project Cost (%)				
Tie-In Cost / Actual Project Cost (%)				
Clean-Up Cost / Actual Project Cost (%)				
Testing Cost / Actual Project Cost (%)				
Total Clearing Work hours (WH) / Total Site Work hours (WH) (%)				
Total Ditching Work hours (WH) / Total Site Work hours (WH) (%)				

	Small Size (Under 20")	Big Size (Over 20")	Suitable for Both Categories	Not Suitable for any Category
Total Grading Work hours (WH) / Total Site Work hours (WH) (%)				
Total Bending Work hours (WH) / Total Site Work hours (WH) (%)				
Total Welding Work hours (WH) / Total Site Work hours (WH) (%)				
Total Tie-In Work hours (WH) / Total Site Work hours (WH) (%)				
Total Clean-Up Work hours (WH) / Total Site Work hours (WH) (%)				
Total Testing Work hours (WH) / Total Site Work hours (WH) (%)				

If you have any other metric or comment in mind please indicate

5. At the end of first round of interviews, some metrics were collected, defined or developed for the purpose of general performance assessment of the pipeline projects. On the scale of 1-5, please indicate the importance of these metrics. 1: The Most Important – 5: the least important

	The Most Important	Important	Neutral	Unimportant	Not Important at All
Project Cost / Number (#) of Spreads (CDN$/each)					
Actual Length of Pipe / Estimated Length of Pipe					
Pipe Cost / Actual Project Cost (%)					
Pipe Cost / Actual Length of Pipe (CDN$/Km)					
Actual Project Cost / Average Diameter / Actual Statute Length of Pipe (CDN$/inch-Km)					
Construction Cost / Average Diameter / Actual Statute Length of Pipe (CDN$/inch-Km)					
Design Capacity / Actual Capacity (%)					
Owner Costs for Project Management (PM) / Actual Project Cost (%)					
Owner Costs for Project Management (PM) /					

	The Most Important	Important	Neutral	Unimportant	Not Important at All
Construction Cost (%)					
Engineering Cost /Actual Length of Pipe (CDN$/Km)					
Permit Fees / Actual Project Cost (%)					
Land Cost / Actual Length of ROW (CDN$/Km)					
Environmental Studies & Monitoring / Actual Project Cost (%)					
Environmental Studies & Monitoring / Actual Length of Pipe (CDN$/Km)					
Construction Equipment Cost / Total Project Cost (%)					
Number (#) of Major Crossings / Actual Length of Pipe (#/Km)					
Construction Cost / Actual Length of Pipe (CDN$/Km)					
Contractors' Indirects / Actual Length of Pipe (CDN$/Km)					
Site Preparation / Actual Project Cost (%)					
Percent (%) of Project with Heavy Wall Pipe (By Length of Pipe) (%)					
Pipe / Short Ton (CDN$/ton)					
Weight (Tons) / Actual Length of Pipe (ton/Km)					
Factory Pipe Coating / Actual Length of Pipe (CDN$/Km)					
Coated Pipe Freight Cost / Actual Length of Pipe (CDN$/Km)					
Freight Cost (bare pipe to coater)/Actual Length of Pipe (CDN$/Km)					
Mainline Construction Cost / Total Site Work hours (WH) (CDN$/hour)					
Crossing Construction Cost (all crossings) / Actual Project Cost (%)					
Crossing Construction Cost (all crossings) / Actual Length of Pipe (CDN$/Km)					
Health, Safety, and Environment (HSE) Costs / Actual Project Cost (%)					
Surveying Costs / Actual Length of Pipe (CDN$/Km)					
Construction Management / Actual Length of Pipe (CDN$/Km)					

	The Most Important	Important	Neutral	Unimportant	Not Important at All
NDT Costs / Actual Length of Pipe (CDN$/Km)					
ROW Initial Restoration / Actual Length of Pipe (CDN$/Km)					
Actual Length of Pipe / Construction Phase Duration (Days) (Km/day)					
Total Site Work hours (WH) / Actual Length of Pipe (work hours/Km)					
Total Number of Welds / Welding Phase Duration (welds/day)					
Total Indirect Work hours (WH) / Total Direct Work hours (WH) (%)					
Clearing Cost / Actual Project Cost (%)					
Ditching Cost / Actual Project Cost (%)					
Grading Cost / Actual Project Cost (%)					
Bending Cost / Actual Project Cost (%)					
Welding Cost / Actual Project Cost (%)					
Tie-In Cost / Actual Project Cost (%)					
Clean-Up Cost / Actual Project Cost (%)					
Testing Cost / Actual Project Cost (%)					
Total Clearing Work hours (WH) / Total Site Work hours (WH) (%)					
Total Ditching Work hours (WH) / Total Site Work hours (WH) (%)					
Total Grading Work hours (WH) / Total Site Work hours (WH) (%)					
Total Bending Work hours (WH) / Total Site Work hours (WH) (%)					
Total Welding Work hours (WH) / Total Site Work hours (WH) (%)					
Total Tie-In Work hours (WH) / Total Site Work hours (WH) (%)					
Total Clean-Up Work hours (WH) / Total Site Work hours (WH) (%)					
Total Testing Work hours (WH) / Total Site Work hours (WH) (%)					

If you have any other metric or comment in mind please indicate

5. These are the data elements that are required to produce the indicated metrics. First, please specify if you do collect them or not and also indicate if they are hard or easy to be collected (Two check marks for each question).

	We collect the element at the company	We don't collect the element at the company	The element is easy to collect	The element is hard to collect
Average Clearing Crew Size (people)				
Average Ditching Crew Size (people)				
Average Grading Crew Size (people)				
Average Bending Crew Size (people)				
Average Welding Crew Size (people)				
Average Tie-In Crew Size (people)				
Average Clean-Up Crew Size (people)				
Average Testing Crew Size (people)				
Average Total Crew Size (people)				
Number (#) of Spreads				
Actual Length of Pipe				
Estimated Length of Pipe				
Average Diameter				
Design Capacity				
Actual Capacity				
Percent (%) of Project with Concrete Coated Pipe (by distance) (%)				
Percent (%) of Project with Pipe Weights or Anchors (by distance) (%)				
Percent (%) of Project with Road Ditch (by distance) (%)				
Number (#) of Major Crossings				
Percent (%) of Project with Heavy Wall Pipe (By Length of Pipe) (%)				
Weight (Tons)				

	We collect the element at the company	We don't collect the element at the company	The element is easy to collect	The element is hard to collect
ROW Initial Restoration				
Total Number of Welds				
Welding Phase Duration				
Pipe Cost				
Owner Costs for Project Management (PM)				
Engineering Cost				
Construction Cost				
Actual Project Cost				
Permit Fees				
Land Cost				
Environmental Studies & Monitoring Cost				
Factory Pipe Coating Cost				
NDT Costs				
Construction Equipment Cost				
Site Preparation Cost				
Clearing Cost				
Ditching Cost				
Grading Cost				
Bending Cost				
Welding Cost				
Tie-In Cost				
Clean-Up Cost				
Testing Cost				
Coated Pipe Freight Cost				
Crossing Construction Cost (all crossings)				
Health, Safety, and Environment (HSE) Costs				
Surveying Costs				
Construction Management Cost				
Total Clearing Work hours				
Total Ditching Work hours				
Total Grading Work hours				
Total Bending Work hours				

	We collect the element at the company	We don't collect the element at the company	The element is easy to collect	The element is hard to collect
Total Welding Work hours				
Total Tie-In Work hours				
Total Clean-Up Work hours				
Total Testing Work hours				
Total Indirect Work hours				
Total Direct Work hours				
Total Site Work hours				

If you have any other element or comment in mind please indicate

Thank you for taking the time to complete this questionnaire.