An Integrated Approach for Sustainability Assessment: The Wa-Pa-Su Project Sustainability Rating System

By

Cesar Augusto Poveda

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Department of Mechanical Engineering
University of Alberta

Abstract

As global demand for energy continues to rise, unconventional petroleum extraction and production of petroleum substitutes are both becoming more necessary. Development and operation of unconventional oil projects can have considerable social, economic, and environmental impacts. For example, one the largest unconventional oil deposits in the world is the Athabasca oil sands in northern Canada. Government policy makers, industrial developers, and other stakeholders generally work together to develop oil sands projects in an environmentally responsible manner; however, the projects lack an effective sustainable development (SD) measurement tool.

The development of the oil sands and heavy oil projects has been shaped by different circumstances (e.g., politics, economics, social, etc.) throughout the years. As the development continues, concerns related to the projects' sustainability increases. Developing companies, stakeholders, and society is increasingly interested in understanding the impact that the projects have on present and future generations. Government agencies have issued a series of legal requirements (e.g., regulations) as an attempt to mitigate the impact of the projects. While these provide a general guideline and decisions at senior level are made, they barely assist practitioners and developing companies to accomplish the goals of sustainability in its three fundamentals pillars (e.g., social, economic, environmental).

Trends in building practice and concerns about environmental, social, economic, health, and other impacts in the building industry have led to the development of environmental and sustainability assessment approaches, strategies, models, appraisals, and methodologies. The implementation of green technology and practices towards improving SD performance and accomplishing a certification process has brought along economic, social, and environmental benefits. A series of sustainable rating systems have been developed around the world and used extensively with unquestionable benefits to stakeholders in the building industry; therefore, the framework for developing rating systems for building systems can be extended and applied in other industrial contexts.

The different benefits have been studied to develop the WA-PA-SU project sustainability rating system to measure in a consistent manner the SD of the oil sands and heavy oil projects. The rating system is a decision making tool that can be used by companies, stakeholders, and policy makers to measure and understand the range of impacts that the projects may have over time. This assessment framework includes but is not limited to regulatory requirements, and includes approaches for measuring sustainability on social, economic, environmental, and health grounds. This research presents a description of the different components of the rating system including the structure, the sustainable development indicators (SDIs) pre-selection process, the credit weighting tool (CWT), and the credit and overall sustainability assessment score allocation methodology.

Preface

Canadian oil sands developments are of interest to oil producers because of the size of the proven reserves; but the scale of development and the perceived enduring impacts are of concern to different stakeholders.

Currently, the oil and gas industry –which includes oil sands operations- does not possess standardize environmental or sustainability rating systems to measure and benchmark performance. Oil and gas projects are typically large in size and duration. Different aspects are to be considered in the development and implementation of a rating system to break into a new industrial context with effective engagement, participation and stakeholder management as primary area of consideration.

The development of the structure of the WA-PA-SU project sustainability rating system considers three main aspects: areas or categories of excellence, each with a set of criteria; areas or subdivisions of an oil sands or heavy oil project; and management integration.

The structure of the rating tool considers the complexity and size of oil sands and heavy oil projects, dividing them in ten different areas or sub-divisions: project integration, provisional housing/buildings, permanent housing/buildings, roads, oil transportation & storage, mining process, in-situ process, upgrading & refining, shutdown & reclamation, and CO2, SOx & other greenhouse gases (GHGs) capture and storage. The development of the WA-PA-SU project sustainability rating system offers a proactive approach, which aligns with sustainability principles, for oil sands and heavy oil projects throughout their life cycle phases, the project management processes (e.g. initiation, planning, execution, monitoring and control, and close-out), and the life cycle of sub-projects and processes.

The resources involved in project development, expectations of stakeholders, and potential environmental impact define the ten areas or categories of excellence: project & environmental management excellence

(PEME); site & soil resource excellence (SSRE); water resource excellence (WRE); atmosphere & air resource excellence (AARE); natural & artificial lighting excellence (NALE); energy resource excellence (ERE); resources & materials excellence (RME); innovation in design & operations excellence (IDOE); infrastructure & buildings excellence (IBE); and education, research & community excellence (ERCE).

As the structure of the rating system is defined, the focus turns to identify the different parameters to address the “what” and the “how” in sustainability assessment. What should be measured or included in the assessment (SDIs [sustainable development indicators]) and how to measure those parameters (e.g., metrics).

SDIs can be found within currently-existing approaches, strategies, models, appraisals, and methodologies for environmental and sustainability assessment. Conceptually, the design and implementation of SDIs brings together different stakeholders towards finding the balance among economic, social, and environmental development; however, questions surround SDIs for the assessment of sustainability of projects (e.g. surface mining operations) or industries (e.g. oil and gas) for which the development of SDIs still is in its infancy: (1) Do the SDIs properly align theory with practice?, (2) Do the SDIs meet their intent?, and (3) Can the stakeholders and project proponents afford the implementation of SDIs? Individual efforts have been made to establish a set of SDIs by companies developing projects; and regulatory systems (in some way predecessors of SDIs) require certain levels of investment to meet a minimum level of performance, particularly on environmental grounds.

But large industrial projects (such as oil sands projects, which include surface mining operations) do not have a comprehensive set of SDIs to benchmark sustainable performance and/or measure SD. Questions remain regarding the rate at which extractive industry companies align with more sustainable practices, whether it is the applicability of SDIs, their degree of usefulness, or the cost of development and implementation of SDIs, or other factors

The creation of the World Commission on Environment and Development (WCED)—commonly known as the Brundtland Commission—and the publication in 1987 of its report, “Our Common Future,” marked a turning point towards finding the balance among society, economy, and environment. Since then, governments have improved existing regulations or created others, organizations for standardizations have developed new standards, management and process practices have addressed potential gaps, public and private organizations have taken initiative through the creation of committees and programs, and research covering all areas of SD has become a priority for academics and practitioners. These different sources serve as the basis for a pre-selection process of SDIs.

An assertive set of SDIs is not solely based on regulatory systems, as measuring sustainability cannot become a bureaucratic process, and neither can any other SDI’s source single-handedly determine or mandate the final set of indicators, as the real objective is to assist decision-makers (DMs) and effectively engage stakeholders. As the government and oil sands developers are turning towards increasing productivity with a more conscious SD approach, a pre-selection of SDIs is required to assist further formal multi-criteria selection processes.

The structure design defines the organization of the rating system while SDIs selection and metrics design addresses the stakeholders’ vision and needs and the fundamentals, goals and objectives of SD. Subsequently, the assessment methodology utilizes in the rating system measures the relevance of the different criteria to present a numeric result of sustainability assessment or performance score. As a result, sustainability rating systems, properly developed, not only require the identification and design of metrics in the social, economic, and environmental pillars of sustainability, but also weighting of the different criteria. The weighting process can be characterized by its subjectivity in certain areas of assessment; consequently, the stakeholder participation becomes critical from the credibility and validation standpoint. Current multi-criteria decision-making (MCDM) methods present valid alternatives for weighting the various criteria while allowing for the participation of different stakeholders. Among those, the Analytic Hierarchy Process (AHP) structures the decision problem in a manner that is easy for the stakeholders to comprehend and analyze independent sub-problems by structuring the problem in a hierarchy and using pairwise comparisons. However, the relevance of criteria (e.g., weight) can be assessed through the application of other MCDM method.

Measuring the weight is the initial step in the process of assigning the score to the different criteria; the criteria final score (CFS) may be impacted by other factors considered in the calculation of the overall performance of each criterion. The sustainability assessment approach utilized in the development of the WA-PA-SU project sustainability rating system includes three distinctive areas of knowledge: sustainability, continual performance improvement (CPI), and MCDM.

Previously, the discussion of sustainability and the application of environmental and sustainability rating systems led to (1) concluding the need for the development of a rating system for industrial projects, with a particular application to oil sands and heavy oil projects; (2) defining the structure of the rating system; and (3) assisting in the pre-selection of SDIs for surface mining operations. Assessing the sustainability of projects at certain points in time required the application of a methodology selected by the interested groups and/or stakeholders; however, measuring the improvement of projects in SD performance over time (i.e., CPI) presents additional challenges.

Certain industries (i.e., oil and gas), projects (i.e., oil sands or heavy oil), or specific operations (i.e., surface mining) require a rating system with a particular level of flexibility, offering the opportunity for developers to improve the performance of operations, and for stakeholders to understand the difficulties—and benefits—of implementing SDIs and perform up to levels of truly SD.

The Wa-Pa-Su project sustainability rating system presents an integrated approach to sustainability assessment by integrating three distinctive areas of knowledge: 1) SD theory and fundamentals supports the ultimate goal of the rating system of contributing to sustainability, with the aim of finding a path to balance social, economic and environmental needs, 2) CPI becomes primordial due to the duration of the projects, it is critical to allow organizations or projects to improve performance over time, and 3) Multi-Criteria Decision Analysis (MCDA) assists the assessment process through stakeholder engagement and participation, and the design and implementation of a criteria weighting system.

Large-scale projects create a variety of social, economic, and environmental impacts throughout their life cycles. Assessing SD becomes a measurable factor, not only for the organizations directly involved in the development, construction, and operation of projects, but also for a number of other stakeholders. In the oil sands and in heavy oil operations, assessment turns into a periodical task, since the construction and operation phases of the projects can last for a considerable period of time.

The sustainability assessment tool must have the capability for the organizations and/or projects to evaluate and improve performance over time. The Wa-Pa-Su project sustainability rating system's design and characteristics meet the sustainability assessment needs of the oil sands and heavy oil operations; therefore, the development of its structure is based to support each area of operation (i.e., sub-divisions) and address the diverse impacts (i.e., areas of excellence) in each pillar of sustainability (i.e., social, economic, and environmental). Though the different SDIs are incorporated with the aim of measuring the SD of the oil sands projects, the assessment methodology used for measuring sustainability can be implemented in a large range of projects and organizations due to its integrated approach which allows the measurement of performance based on CPI with high degree of stakeholder participation through the assessment process.

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Abbreviations

AARE	atmosphere & air resource excellence
ABGR	Australian Building Greenhouse Rating
EC	Environment Canada
AE	awareness & education
AEC	architects, engineers, constructors
AENV	Alberta Environment
AEW	area of excellence weight
AHP	Analytic Hierarchy Process
AIDA	Analysis of Interconnected Decision Areas
ANP	Analytic Network Process
API	American Petroleum Institute
AQI	Air Quality Index
ASRD	Alberta Sustainable Resource Development
ASSIPAC	Assessing the Sustainability of Societal Initiatives and Proposed Agendas for Change
Bbl(s)	barrel(s)
Bbl/d	barrels per day
BCA	benefit-cost analysis
BdIA	biodiversity impact assessment
BEARS	Building Environmental Assessment and Rating System
BEE	Building Energy Environment
BEES	Building for Economic and Environmental Sustainability

BEPAC	Building Environmental Performance Assessment Criteria
BEQUEST	Building Environmental Quality Evaluation for Sustainability through Time
BIA	biophysical impact assessment
BMPs	best management practices
BOE	barrels of oil equivalent
BRE	Building Research Establishment
BREEAM	Building Research Establishment Environmental Assessment Method
BSC	balanced scorecard
BSI	British Standards Institution
BTU	British thermal unit
CAMs	comparative assessment methods
CAPP	Canadian Association of Petroleum Producers
CASBEE	Comprehensive Assessment System for Built Environment Efficiency
CBA	cost-benefit analysis
CBoC	Conference Board of Canada
CDS	City Development Strategies
CEA	cost-effectiveness analysis
CEAA	Canadian Environmental Assessment Act
CED	cumulative energy demand
CEIA	cumulative environmental impact assessment
CEMA	Cumulative Environmental Management Association
CEN	European Committee for Standardization
CESI	Canadian Environmental Sustainability Indicators

CFC	chlorofluorocarbon
CFS	criteria/criterion final score
CFW	criteria/criterion final weight
CHOPS	cold heavy oil production with sand
CI	composite indicator
CIA	community impact analysis
CIB	Conseil International du Batiment
CIE	community impact evaluation
CIM	Canadian Institute of Mining, Metallurgy, and Petroleum
CIS	criteria/criterion initial score
CMIC	Canada Mining Innovation Council
CNRL	Canadian Natural Resources Limited
CO	carbon monoxide
CO2e	equivalent carbon dioxide
COI	community of interest
COPOLCO	Consumer Policy Committee
CPI	continual performance improvement
CRC	Cooperative Research Center
CRISP	Construction and City Related Sustainability Indicators
CSA	Canadian Standards Association
CSD	Commission on Sustainable Development
CSIRO	Commonwealth Scientific and Industrial Research Organization
CSR	corporate social responsibility
CSS	cyclic steam stimulation

CuEA	cumulative effects assessment
CVM	Contingent Valuation Method
CWF	criterion weight factor
CWT(s)	credit weighting tool(s)
DCFROR	discounted cash flow rate of return
DDT	dichlorodiphenyltrichloroethane
DEFRA	Department of Environment, Food and Rural Affairs
DEH	Department of Environment and Heritage
DGBC	Dutch Green Building Council
DIA	demographic impact assessment
DM(s)	decision maker(s)
DPS	driving force-pressure-state
DPSIR	driving force-pressure-state-impacts-response
DSR	driving force-state-response
DSS(s)	decision support system(s)
EA	energy and atmosphere
EAB	Environmental Appeals Board
EC	European Commission
EcIA	economic impact assessment
ECIFM	Environmental Challenges in Farm Management
EEA	European Environmental Agency
EFIA	economic and fiscal impact assessment
EIA	environmental impact assessment
ELECTRE	Elimination and Choice Expressing Reality
EMS	Environmental Management Systems
ENGOs	Environmental Non-Governmental Organizations

EPC	engineering, procurement, and construction
EPIs	environmental performance indicators
EPS	earnings per share
ERCB	Energy Resources Conservation Board
ERCE	education, research & community excellence
ERE	energy resource excellence
ERR	economic rate of return
ESIA	environmental and social impact assessment
ESSD	environmentally sound and sustainable development
EU	European Union
EUB	Energy and Utilities Board
FESC	financial evaluation of sustainable communities
FSC	Forest Stewardship Council
GAIA	Geometrical Analysis for Interactive Aid
GBCA	Green Building Council of Australia
GDP	gross domestic product
GDSS	Group Decision Support System
GHEM	Green Home Evaluation Manual
GHG(s)	greenhouse gas(es)
GIB	green infrastructure & building
GJ	gigajoule
GMI	Green Mining Initiative
GNP	gross national product
GPI	Genuine Progress Indicator
GRI	Global Reporting Initiative
ha	hectare

HBC	Hudson's Bay Company
HIA	health impact assessment
HKBEAM	Hong Kong Building Environmental Assessment Method
HKSDU	Hong Kong Sustainable Development Unit
HPM	Hedonic Pricing Method
H2S	hydrogen sulphide
IBE	infrastructure & buildings excellence
ICLEI	International Council for Local Environmental Initiatives
ICMM	International Council on Mining and Metals
ID	innovation in design
IDOE	innovation in design & operations excellence
IEA	International Energy Agency
IEQ	Indoor Environmental Quality
IGOs	Inter-Governmental Organizations
IIA	integrated impact assessment
IIED	International Institute for Environment and Development
iiSBE	International Initiative for a Sustainable Built Environment.
IISD	International Institute for Sustainable Development
IO	innovation in operations
IOGC	Indian Oil and Gas Canada
IOM3	Institute of Materials, Minerals, and Mining
IRIS	Institute for Research and Innovation in Sustainability
IRR	internal rate of return

ISA	integrated sustainability assessments
ISCAM	Integrated Sustainable Cities Assessment Method
ISO	International Organization for Standardization
IUCN	International Union for Conservation of Nature
IVM	Institute for Environmental Studies
km	kilometer
KPIs	key performance indicators
kT	kiloton
KTH	Royal Institute of Technology
L	environmental load
LA21	Local Agenda 21
LBS	Light Beam Search
LCA	Life Cycle Assessment
LCA-OST	Life Cycle Assessment of Oil Sands Technologies
LCT	life-cycle thinking
LEED	Leadership in Energy & Environmental Design
LL	location & linkages
LR	reduction of building environmental loadings
LR-1	energy
LR 2	resources and materials
LR-3	off-site environment
LUDA	Large Urban Distressed Areas
MAC	Mining Association of Canada
MACBETH	Measuring Attractiveness by a Categorical Based Evaluation Technique
MATISSE	Methods and Tools for Integrated Sustainability

	Assessment
MAUT	Multi-Attribute Utility Theory
MCA	multi-criteria analysis
MCDA	Multi-Criteria Decision Analysis
MCDM	Multi-Criteria Decision Making
MDGs	Millennium Development Goals
MDSC	Multi-Disciplinary Stakeholder Committee
MEND	Mine Environment Neutral Drainage
MI	material input
MIPS	Material Intensity Per Service Unit
MMBOE	million barrels of oil equivalent
MMbpd	million barrels per day
MMER	Metal Mining Effluent Regulations
MMLER	Metal Mining Liquid Effluent Regulations
MMSD	Mining, Minerals, and Sustainable Development
MMSD-NA	Mining, Minerals, and Sustainable Development North America
MOSS	Alberta's Mineable Oil Sands Strategy
MPIs	management performance indicators
MR	materials and resources
MSC	Multi-Stakeholder Committee
NALE	natural & artificial lighting excellence
NBI	Norwegian Building Research Institute
NEB	National Energy Board
NEPA	National Environmental Policy Act
NGOs	Non-Governmental Organizations

NIST	National Institute of Standards and Technology
NOx	nitrogen oxides
NO2	nitrogen dioxide
NPD	neighborhood pattern & design
NPV	net present value
NRCan	National Resources Canada
NZGBC	New Zealand Green Building Council
O3	ozone
OECD	Organization for Economic Co-Operation and Development
OGIP	Optimierung der Gesamtanforderungen ein Instrument furs die Integrale Planung
OPIs	operational performance indicators
OSRIN	Oil Sands Research and Information Network
OSTC	Oil Sands Tailings Consortium
OSTRF	Oil Sands Tailings Research Facility
PA	performance actual
PAHs	polycyclic aromatic hydrocarbons
PB	performance baseline
PCBs	polychlorinated biphenyls
PDCA	plan do check act
PeM(s)	performance measurement(s)
PEME	project & environmental management excellence
PETUS	Practical Evaluation Tool for Urban Sustainability
PIA	privacy impact assessment
PIF(s)	performance improvement factor(s)
PLA	project lifecycle assessment

PM	particulate matter
PPA	political and policy assessment
PPP	plans, policies, and programs
PROMETHEE	Preference Ranking Organization Method for Enrichment of Evaluations
PUB	Public Utilities Board
Q	environmental quality
Q-1	indoor environment
Q-2	quality of service
Q-3	outdoor environment on site
RAMP	Regional Aquatics Monitoring Program
RCR	reclamation certificate received
RME	resources & materials excellence
RMW	Regional Municipality of Waterloo
RMWB	Regional Municipality of Wood Buffalo
ROI	return on investment
ROR	rate of return
RSC	Royal Society of Canada
S	number of service unit
SAGD	steam-assisted gravity drainage
SB	sustainable building
SBAT	Sustainable Building Assessment Tool
SBi	Danish Building Research Institute
SBSc	sustainability balanced scorecard
SCIs	Sustainable Community Indicators
SCO	synthetic crude oil

SD	sustainable development
SD-KPIs	sustainable development key performance indicators
SDIs	sustainable development indicators:
SDS	sustainable development strategy
SDW	sub-division weight
SEA	strategic environmental assessment
SEEA	System of Integrated Environmental and Economic Accounting
SERI	Sustainable Europe Research Institute
SIA	social impact assessment
SLL	smart location & linkage
SOx	sulphur oxides
SO2	sulphur dioxide
SPARTACUS	System for Planning and Research in Town and Cities for Urban Sustainability
SPMS	Sustainability Performance Management System
SPIs	sustainability performance indicators
SRB	Surface Rights Board
SRI	socially responsible investing
SROI	social return on investment
SS	sustainable sites
SSRE	site & soil resource excellence
STARS	Sustainability Tracking, Assessment & Rating System
SuIA	sustainability impact assessments
TACTIC	Treatment of the Alternatives According to the Importance of Criteria
TBL	triple bottom line

TCT	Travel Cost Theory
TIA	technology impact assessment
TQA	Total Quality Assessment
TQM	Total Quality Management
TRACI	Tool for the Reduction and Assessment of Chemical and other Environmental Impacts
TSM	Towards Sustainable Mining
TSS	total suspended solids
TWh	terawatt-hours
UIA	urban impact assessment
UN	United Nations
UNCED	United Nations Conference on Environment and Development
UNEP MRF	United Nations Environment Programme's Mineral Resources Forum
USGBC	United States Green Building Council
UTA	Utility Additive
VAPEX	vapor extraction process
VECs	valued ecosystem components
VIMDA	Visual Interactive Method for Decision Analysis
VOCs	volatile organic compounds
WBC SD	World Business Council for Sustainable Development
WCED	World Commission on Environment and Development
WE	water efficiency
WMI	Whitehorse Mining Initiative
WRE	water resource excellence
WRI	World Resources Institute.

WSSD	World Summit on Sustainable Development

1. Chapter One – Introduction

1.1 Motivation and Problem Statement

As world energy demands increase, so will the exploration and exploitation of alternative energy resources. The present level of energy generation cannot meet the needs of future generations if the pace of population growth and energy consumption continues at the current rate. While some unconventional energy sources are still in research and development phase, others have been effectively implemented.

The impacts of different energy operations are still being debated, with respect to environmental, social, economic, and health effects. The definition of sustainable development (SD) adopted by United Nations (UN) uses the expression "…meets the needs of the present…" to indicate the required development by a current generation to maintain its standard of living while minimizing environmental, economic, social impacts. Large industrial developments will affect a range of stakeholders, and may entail cultural and political change. The level of impacts and their implications depends on many characteristics of the development, such as its size, production rate, duration of exploitation, processes used (including treatment of waste streams), and regulatory standards. While local communities, businesses and surrounding areas are first expected to be impacted, certain developments can attract global attention.

Developing a new assessment tool in the area of SD requires a strategic methodology for a cohesive and logical framework incorporating relevant theory and practical experience, building on a critical analysis of the state of the art. The assessment process implies the existence of tools, instruments, processes, and methodologies to measure performance in a consistent manner with respect to pre-established standards, guidelines, factors, or other criteria. Sustainability assessment scientists and practitioners have developed an increasing variety of tools with the aim of demonstrating progress towards the different facets of SD.

Measures for assessing the environmental, social and economic impacts and long-term overall sustainability will become an increasingly important requirement in industrial project management. The concept of sustainability influences all aspects of a project, from its earliest phases: development procedures, design of facilities and infrastructure, operation of the industrial facility, and economics. Project management researchers and practitioners are working together to find effective and efficient methods and techniques to minimize environmental, social, economic, and health impacts that projects carry.

Sustainable rating systems are structured decision-making tools in support of measuring environmental, social, and economic performance throughout the project life cycle, not only complying with government & non-government regulations, but also meeting internal and external standards, procedures, processes, and requirements. The majority, if not all, rating systems created to date focus on buildings and residential housing construction which demonstrates the need for gaining ground in the implementation of similar sustainability assessment methodologies in other industrial context.

The rationale behind SD indicates the balance of social, economic and environmental needs. For stakeholders, the rationalization process of sustainability consists of quantifying the different impacts found in the operations and developments of companies and/or projects throughout their life cycle; however, as some areas are subjective in nature, the quantification process of the different impacts and assessment of SD performance becomes an arduous task of development, validation and application of scientific and empiric methods with the intrinsic objective of finding an agreement among the involved parties (i.e., stakeholders). Several environmental and sustainability assessment tools, instruments, processes, and methodologies have been developed; rating systems stand up and have gained attention and credibility demonstrated by the vast number of certified projects around the world and the widely known usefulness and advantages of their application.

1.2 Research Objectives

The overall aim of this research thesis is to development a framework (i.e., rating system) for sustainability assessment of industrial projects with application in oil sands and heavy oil projects. The development of the assessment methodology consists of an analysis of the “state-of-the-art” in environmental and sustainability assessment methods, the design of a rating system structure, the selection of sustainable development indicators (SDIs), the definition of the relevance of the different criteria through a weighting process, and the development of an integrated assessment methodology to define the criteria final scores (CFS) and overall sustainability assessment score. This framework, the Wa-Pa-Su project sustainability rating system, introduces an integrated assessment methodology that provides organizations and project owners a useful tool that incorporates in its design the fundamentals of SD and effective engagement and participation of stakeholders through the project’s life cycle. The detailed objectives of this research are as follows:

- To develop a framework (i.e., rating system) for sustainability assessment of industrial projects with application in oil sands and heavy oil projects.
- To design an assessment framework structure consisting of identifying the sub-divisions of oilsands and heavy oil projects, into which the different processes can be grouped to facilitate sustainability assessment performance and selection of the categories into which the “green” and sustainable strategies and efforts towards sustainable practices can be organized.
- To identify the different social, economic, and environmental criteria within a selected sub-division of the rating system, thereby demonstrating the flexibility and practicability of the assessment

tool.

- To define a SDIs pre-selection methodology through the analysis of the different resources available for the identification of SDIs.
- To develop a criteria weighting system that reflects the relevance of each criterion and interactions between criterion, as well as the dynamism among the different factors included in the assessment process.
- To develop a criteria and overall project sustainability assessment score system to be used in the rating system to assess the "greenness" and sustainability level of an organization or project.
- To demonstrate the applicability of the assessment methodology framework by applying the developed tool in a simulated case study of implementation.

The simulated implementation demonstrates how the assessment methodology can be utilized by the users of the rating system to determine progress toward SD by comparing criteria performance against previously-established baselines and thresholds, and allocating criteria and overall sustainability assessment scores. Since the Wa-Pa-Su project sustainability rating system is the first of its kind focusing on industrial projects with an emphasis on oil sands and heavy oil, it must be understood that a variety of SDIs have not yet been measured, and the data required for this purpose have not been collected; therefore, the objective of the simulated case study of implementation and sustainability assessment using the developed integrated approach is to highlight the flexibility and applicability of the rating system.

1.3 Expected Contributions

1.3.1 Academic Contributions

- The proposed sustainability assessment methodology improves the current set of tools for sustainability assessment of projects in the oil and gas industry: the methodology introduces the development and explores the implementation of a sustainability assessment tool for the oil & gas industry, which supports stakeholders in the decision-making process throughout the project's life cycle.

- The proposed sustainability assessment methodology presents an integrated approach for sustainability assessment, integrating three distinctive areas of knowledge: SD theory and fundamentals, continual performance improvement (CPI), and Multi-Criteria Decision Analysis (MCDA).
- The proposed integrated sustainability assessment methodology improves upon previous approaches used in environmental and sustainability rating systems by developing a methodology to assign criteria and overall sustainability assessment scores based on CPI.

1.3.2 Industrial Contributions

- The proposed sustainability assessment methodology contributes to the oil and gas industry by combining SD theory and fundamentals, CPI, and MCDA in an integrated approach for sustainability assessment of oil sands and heavy oil projects to ensure early alignment between SD plans, policies, and programs (PPP) at macro levels, and goals and objectives at the organizational and project levels.
- The proposed sustainability assessment methodology contributes a decision-making tool for practitioners to make educated decisions through the project's life cycle.
- The proposed sustainability assessment methodology contributes a tool to implement green and sustainable performance excellence during the different phases of the project's life cycle while reducing and/or controlling environmental, social and economic impacts due to the project's construction and operations.

- The implementation of the proposed sustainability assessment methodology allows organizations and projects to: 1) meet environmental, social, and economic goals and objectives; 2) provide productive positive publicity; 3) express civic leadership; 4) improve morale and engagement of employees and stakeholders; 5) support strong local economies; 6) assist with market transformation; 7) demonstrate a continual improvement and innovation vision; and 8) stimulate the implementation of energy-efficient processes.
- The proposed sustainability assessment methodology assists practitioners in the management of stakeholders by adopting engagement and participatory processes to assist with the development and implementation of the rating system and the measurement and reporting of sustainability performance of the organization and/or its projects.

1.4 Assessment Methodology Components

The proposed sustainability assessment methodology comprises the following main components:

- A ratings system structure, which includes the selection of projects or organizations' sub-divisions, areas of excellence, and criteria codification, which itself includes the definition of the relationship amongst sub-divisions, areas of excellence, and criteria.
- An SDIs pre-selection process, which identifies environmental, social, and economic aspects to be included in the assessment; the pre-selection process is assisted by the different resources for the identification of SDIs.
- A weighting methodology, which defines the relevance of the criteria, sub-division, and areas of excellence through the use of Multi-Criteria Decision Making (MCDM) methodologies that allow for the development of a multi-disciplinary participatory stakeholder

process.

- The integrated sustainability assessment methodology, which incorporates SD theory and fundamentals, CPI, and MCDA to allocate criteria and overall sustainability assessment performance scores.

1.5 Thesis Organization

Chapter 1 provides the motivation and a statement of the problem. This chapter also explains the research objectives, expected contributions and the components of the assessment methodology.

Chapter 2 discusses a range of fundamental approaches, as well as specific and integrated strategies for sustainability assessment, as the foundation of a new rating system being developed for large industrial projects. Assessment methods identified by different schemes are also described. The focus then shifts onto environmental and sustainable rating systems, emphasizing the more popular tools. Chapter two is thus a review of the status of sustainability development and its different assessment tools: approaches, strategies, models, appraisals, and methodologies. Chapter two also presents a description of the credit weighting tool (CWT) used by the most popular sustainability and environmental rating systems.

Chapter 3 introduces the development of a rating system to measure the environmental performance of oil sands and heavy oil projects, called the WA-PA-SU project sustainability rating system. A brief history of the concept of sustainability is discussed, and correlated with the three integrated areas related to the development of a sustainable rating system for this industrial sector: oil sands and heavy oil projects, regulations, and rating systems. Chapter three also discusses the tools and techniques applied in the development methodology of a sustainable rating system, lists some of the expected benefits based on previous use of others ratings systems around the world.

Chapter 4 introduces the Wa-Pa-Su project sustainability rating system structure consisting of its sub-divisions and areas of excellence. This chapter also explains the criteria codification and the interactions between the different phases in the oil sands and heavy oil projects, the project management process groups for a projects, sub-projects life cycle, and process life cycle.

Chapter 5 presents a discussion and analysis of the economic, social, environmental, health, and other impacts of current operations in Canadian oil sands that are of concern to different stakeholders, including some uncertainties in levels and persistence of impacts. An overview is provided of efforts undertaken by government and developers to minimize impacts; and comments are offered on possible future strategies.

Chapter 6 presents an analysis of six different sources for pre-selecting SDIs, accompanied by a methodology to then finalize with a set of SDIs for the surface mining operations in oil sands projects.

Chapter 7 analyzes the development and implementation of SDIs in surface mining operations for oil sands projects, highlights the benefits of using SDIs, proposes an alternative framework for SDI in the Canadian oil sands industry, and offers recommendations for the use of SDIs to measure SD of surface mining operations.

Chapter 8 introduces the performance improvement factor (PIF), which can be determined using three different methodologies: relevance factor or subjective stakeholder valuation, comparative assessment methods (CAMs), and links to metrics. Additionally, CPI indicator measurement is suggested and discussed for a pre-selected set of SDIs for surface mining operations in oil sands projects. Finally, a brief preamble discusses the proposed integrated approach for sustainability assessment and the part it plays in CPI, offering a foreword to upcoming manuscripts that discuss the other complementary parts of the integrated approach.

Chapter 9 presents the application of the Analytic Hierarchy Process (AHP) to weight the different criteria to measure the sustainability of surface mining operations. Prior to the application of the AHP method, the various criteria were preselected using a preliminary selection method consisting of the identification of criteria from six different sources. Criteria with different common sources of origin, as well as discretionary project and stakeholder relevance were the two characteristics for criteria to make the preselected list. The different social, economic, and environmental criteria were classified in ten different areas of excellence to facilitate the application of the weighting method. Therefore, each criterion's final weight was determined by the weight that it itself and the area of excellence obtained in the application of the AHP method. The results of the weighting process assist scientists and practitioners not only by identifying those criteria that stakeholders consider relevant in the sustainability assessment process, but also by expressing the degree to which the criteria should be addressed in order to accomplish the project's and/or organization's sustainability goals.

Chapter 10 presents the integrated approach to sustainability assessment implemented in the Wa-Pa-SU project sustainability rating system. This chapter also highlights the reasoning behind the integration of three distinctive areas of knowledge for sustainability assessment: SD theory and fundamentals, CPI, and MCDA. The principles of the assessment methodology and the intersection between the different areas of knowledge are described.

Chapter 11 highlights the flexibility and applicability of the rating system by presenting a simulated case study of implementation and sustainability assessment using the integrated approach adopted in the Wa-Pa-Su project sustainability rating system

2. Chapter Two – A Review of Sustainability Assessment and Sustainability/Environmental Rating Systems and Credit Weighting Tools (CWTs)[1]

2.1 Introduction

The term sustainability appeared in the early 1970s as the rapid growth of the human race and the environmental degradation associated with increased consumption of resources raised concerns. Finding a way for consent between environment, advancement, and well-being of the world's poor was discussed in the United Nation's 1972 Stockholm Conference. 'Sustainable development' was presented by Ward and Dubos (1972). The concept is not necessarily modern: Gibson, Hassan, Holtz, Tansey and Whitelaw (2010) imply that the concept of sustainability, as an old wisdom, has been around since the dawn of time in most communities.

The definition of sustainability given by the Brundtland Commission, formally known as the World Commission on Environment and Development (WCED), was a turning point for government policy makers, scientists, politicians, sociologists, and economists. "The development that meet the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland, 1987) is a definition for sustainability that challenged the traditional ways of doing business, changed the interpretation of the word development, and helped scientists and practitioners to understand not only the environmental impacts but also the social and economic effects of projects as the human race

[1] A version of this chapter has been published. Poveda & Lipsett 2011. Journal of Sustainable Development. 4(6): 36-55.

interacts with its surroundings. The report also contains two key concepts: the concept of 'needs', in particular the essential needs of the world's poor, to which overriding priority should be given; and the idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs.

Society, economy and the environment, as the three pillars of sustainability, pose three characteristics: independency, inter-relation/inter-connection, and equality. Based on those characteristics, an alternative definition for SD is stated as the path to balance social, economic, and environmental needs. From a series of reports, including that resulting from the Rio Summit (UNCED, 1992), Mitchell, May and McDonald (1995) identified four principles underlining that developing in a sustainable manner goes beyond environmental aspects. These principles are: equity, futurity, environment, and public participation. Collin and Collin (2010) state: "The protection of the environment is at the forefront of sustainable development, and this can be accomplished only through collaborative decisions, increased regulations, and each individual becoming a steward of the environment on a personal and global level," which implies that a sustainable future is in the hands of all of us, and the responsibility is shared, not left to politicians and policy decision makers (DMs).

Since that time, the importance of SD has continued to grow, transforming and adapting according to the social, environmental, economic, and geopolitical conditions in different jurisdictions. Sustainability has become a primary and essential area of concern for a number of politicians, academics, and members of communities. A community of practice has also developed, as shown by bibliometric indicators such as annual conference proceedings, journal publications per year on sustainability, and university and college degrees and certificates offered around the world related to sustainability. In the past few decades, significant international conferences have taken place with a variety of objectives, such as finding sustainability assessment guidelines, forging agreements amongst governments, setting targets for sustainability, and so on.

The growth of SD will depend on advancing three elements of the assessment framework: unification of criteria; common definitions for guidelines, processes, and methodologies; and adequate implementation of concepts to develop best practices. As SD evolves, sustainable assessment will likely move toward more pro-active approaches, such as involving DMs in the very early stages of projects that have sustainability targets.

Progress has been made in sustainability assessment. The number of tools, methodologies and processes for assessing sustainability is in the hundreds. Finding the appropriate assessment instrument is critical to match theory with practice, and to have successful outcomes in improving sustainability. Although the existing mechanisms for assessment offer useful alternatives for academics and practitioners, clear answers for questions remain to be found regarding what measures are important and how they can be quantified, especially for social and economic dimensions.

2.2 Measuring Sustainability

In sustainability, assessment and measurement are concepts that go hand in hand; but assessment and measurement each entail a different process. In the measurement process, variables related to SD are identified and data are collected and analyzed with technically appropriate methods. During the assessment process, the performance is compared against a standard for a criterion (or for a number of criteria). Assessments are practical undertakings in evaluation and decision making with expected participation by stakeholders. These exercises must be meaningful for all the parties involved.

Francescato (1991) points out that achieving a meaningful assessment requires that the value system underlying performance and criteria must be shared by members of the public and by experts. Brandon and Lombardi (2011) highlight a series of principles that should underlie all assessments in sustainability to obtain the maximum benefits. Assessments should be: holistic, harmonious, habit-forming, helpful, hassle-free, hopeful, and humane. Gibson et al. (2010) highlight a series of sustainability requirements as decision criteria: social-ecological system integrity, livelihood sufficiency and opportunity, intragenerational equity, intergenerational equity, resource maintenance and efficiency, socio-ecological civility and democratic governance, precaution and adaptation, illustrative implications, and considerations. Gibson et al. (2010) also explains the twelve main components of the so-called 'sustainability assessment law.'

The inclusion of the public and experts throughout the process does not guarantee the application of SD practices. In an industrial project, management plays the key role of bringing stakeholders together with the goal of reaching harmony amongst them (to move the project forward with acceptable metrics for project completion). Furthermore, the decision-making environment must consider all the factors with a structured approach, in which every aspect is included and all parties are aware of the process and the critical milestones along the way (Brandon & Lombardi, 2011).

2.2.1 Fundamental and Generic Approaches

Different approaches have been taken by practitioners and researchers to promote sustainability principles, in particular with respect to environmental issues, including energy consumption, pollution of different resources (terrestrial, aquatic, and atmospheric), conservation of flora and fauna, and conservation of historical artifacts. Each of these approaches contributes to preservation of the environmental status quo; however, they only address one part of the problem. Peter S. Brandon and Patricia

Lombardi (2011) identify a series of fundamental and generic approaches aimed at assisting SD: the natural step, the concept of community capital, the ecological footprint, monetary (capital) approach, the driving force-state-response model, issues or theme-based frameworks, accounting frameworks, and frameworks of assessment methods tool kits. Additionally, the authors propose a new holistic and integrated framework based on the Dooyeweerd's Theory of the 'Cosmonomic Idea of Reality' (Dooyeweerd, 1968; 1979).

[a] The Natural Step, created by Dr. Karl-Henrick Robert in the 1980s, considered that all the environmental problems facing society are wide and complex (yet unclear), and so basic science is the foundation of a consensus view, calling this framework The Natural Step (Robert, 2002). There are four basic scientific principles on which this concept is based: a) matter and energy cannot be destroyed; b) matter and energy tend to disperse; c) material quality can be characterized by the concentration and structure of matter (energy is not consumed, only its exergy); and d) net increases in material quality on earth can be produced by sun-driven processes. Disorder increases in all closed systems; therefore, an exergy flow from outside the system is needed to increase order. The concept of quality in this case refers to value in which higher value equals more useful material. The energy generated by the sun has driven the creation of better materials through natural processes, and this constant cyclical process produces quality by reprocessing and concentrating waste into more valuable resources. According to Robert, this cycle can take place by providing a framework for assessing and monitoring, which consists of four basic sustainable conditions that are meant to be met in order to become a sustainable society:

> "a) eliminate our contribution to the progressive buildup of substances extracted from the Earth's crust (for example, heavy metals and fossil fuels), b) eliminate our contribution to the progressive buildup of chemicals and compounds produced by

society (for example, dioxins, PCBs [polychlorinated biphenyls], and DDT [dichlorodiphenyltrichloroethane]), c) eliminate our contribution to the progressive physical degradation and destruction of nature and natural processes (for example, over harvesting forests and paving over critical wildlife habitat); and d) eliminate our contribution to conditions that undermine people's capacity to meet their basic human needs (for example, unsafe working conditions and not enough pay to live on)" (Robert, 2011a).

The key word in the first three parts is progressive, meaning that some activities may occur, but the overall effect should not increase over a reasonable period of time. The natural step has been endorsed by more than sixty local communities, more than fifty of Sweden's leading scientists, and companies around the world, such as: IKEA, OK Petroleum, Electrolux, Scandic, Gripen, Bilspedition, SJ (Swedish rial), The Interface Corporation, Home Depot, McDonalds, Placon, Mitsubushi Electric (USA), Collins Pine (Forest products), and Nike (Brandon & Lombardi, 2011).

[b] Community Capital is based on the concept of capital is well known in economics and refers to accumulated wealth. This concept can be applied to more broad categories, such as human capital, intellectual capital, and social capital. The concept of community capital described by Maureen Hart (1999) includes three main contributors: built and financial capital, human and social capital, and natural capital. These three contributors are represented as a pyramid, in which natural capital is the base, human and social capital is added, and built capital is at the apex.

The first layer, natural capital, refers to the Natural Step concept; however, this layer includes other aspects that the community finds attractive and beautiful. Natural capital includes natural resources (e.g. food, water, metals, wood, energy), eco-system services (e.g. fisheries, fertile soil, water filtration, CO_2-oxygen), and beauty of nature (e.g., mountains, seashores, sunlight, rainbows, bird song, etc.).

The second layer, human and social capital, contains people (e.g. skills, health, abilities, education) and connections (e.g. family, neighbours, community, companies, and government).

The third layer, built capital, is the support for human and social capital, referring to physical infrastructure and supplies (e.g. buildings, equipment, information, and infrastructure). Monetary resources are not included, because money is considered to be only a medium used to exchange goods and services, and not capital itself; but financial and market systems could be included as the infrastructure for commerce to take place.

Each form of capital is measured differently, which makes them difficult to compare and contrast; however, techniques such as cost-benefit analysis (CBA) are used to have some basis for comparison. All three levels of capital are managed by communities that need to be nurtured and improved (Hart, 1999). The concept of investment strategy is to use capital (without consuming or degrading it) to generate income, rather than spending the capital itself. Applying this analogy to natural capital implies that using non-renewable resources reduces natural capital over time. The community capital concept takes this idea one step further, by considering that quality of life not only depends on food, shelter, and access to natural resources, but also depends on how people care for themselves, interact, create, assimilate, and celebrate. These wants have an impact on our natural capital: if they are balanced, then the consumption of natural capital cannot exceed the rate at which it is replaced (Hart, 1999).

[c] Ecological Footprint was conceived in 1990 by Mathis Wackernagel and William Rees at the University of British Columbia (Global Footprint Network, 2011). It is based on "the impact that an individual or an individual development has on the environment and/or the community in which they live or are developed" (Brandon & Lombardi, 2011). The footprint is directly linked with the amount of resources that an individual consumes. Particular lifestyles add to the size of the footprint. The world average is 4.68 acres per person. In India, the average ecological footprint in acres per person is 1.04; in the Netherlands, it is 8.6; in Canada, it is 11.18; and, in the USA, the footprint is 13.26 acres per person (Wackernagel & Rees, 1995). The ecological footprint includes embodied energy, which refers to the impact of the extraction and processing of materials used by an individual. In any given construction project, the footprint must be calculated starting with the extraction of material, transportation of material, goods and labour, the construction process itself (e.g., infrastructure), building materials, water and energy supply, etc. During the operational stage, the project developers must consider the heating, cooling, organization/operational costs, etc. At the end of the life cycle, the costs of demolition and disposal are included, as well the waste management costs throughout the project lifetime. For cities and buildings to accomplish sustainability goals, their ecological footprint must be equal to or smaller than their physical footprint. The ecological footprint approach has been criticized by some, who debate that the true carrying capacity of the biosphere cannot be calculated, measured or predicted with any accuracy (Haberl, Fischer_Kowalski, Krausmann, & Winiwarter, 2004; Van Kooten & Bulte, 2000; Pearce, 2005). Others criticize aggregated indicators, suggesting that they do not reflect the real issues in some areas (Bossel, 1998) and the idea of aggregating impacts in a simple index is reminiscent of the problems found in economic indicators such as gross domestic product (GDP) (Doughty & Hammond, 2004). Bossel (1998) also criticizes aggregate and checklist types of indicators, arguing that they do not reflect the systematic and dynamic nature of urban processes. Furthermore, Fiala's (2008) criticism states, "the arbitrariness of assuming both zero greenhouse gas (GHG) emissions and national boundaries, that the footprint is in fact a measure of inequality, historical evidence that intensive, rather than extensive, investment is the main driving force of production growth, though the footprint is an entirely static measure and so cannot capture this technological change, and the lack of correlation between land degradation and the ecological footprint, which obscures the effects of larger sustainability problems."

[d] Monetary approach calculates the national wealth of different kinds of capital as their sum or the interaction amongst them. The kinds of capital included in this model are financial capital, produced capital goods, social capital, human capital, natural capital, and institutional capital. For comparative assessment, these types of capital should be expressed in a common unit of measurement, which is usually monetary. Frameworks designed using the monetary capital approach try to define development in order to then find the most appropriate way to accomplish the development in a sustainable manner. The main challenge presented by the monetary approach relates to finding all the forms of capital expressed in monetary terms; however, data availability and the substitution and integration of intra-generational equity within and across countries present additional challenges (UN, 2007a).

[e] The Driving Force-State-Response (DSR) Model was based on the pressure-state-response model (OECD, 1994). Later, the driving force-state-response (DSR) model was expanded into the framework known as DPSIR (driving force-pressure-state-impact-response). The drivers, such as human activities and external forces, induce changes/impacts on different environments (e.g., biophysical and socio-economic) and the state of human settlements. The drivers produce certain amounts of positive or negative pressures (also termed forces), which change the quality and quantity of the natural resources base of air, water, soil, flora and fauna, and non-renewable resources. Based on the impacts generated by this pressure, society must react by developing policies and programs to prevent, reduce, or mitigate not only the impact (outputs) but also the pressure generated (inputs). As expected, changes in policies and programs generate incentives to use certain technologies and abandon others. As in any other cyclical process, these responses produce new pressures that must then be addressed. Linking the three main components (pressure/force, state, and response) are information linkages between pressure/forces and responses, between the state and the pressures/forces, and from the state to the response. These interactions allow better understandings of the consequences of policy and technological intervention.

[f] Issues or Theme-Base Frameworks are widely known and commonly used in official national indicator sets. The indicators are grouped into a variety of issues that relate to SD. The policy relevance determines the issues. The issues or theme-base frameworks are successful because of their ability to link indicators to policy processes and targets. This linkage provides clarity to DMs, thus easing the challenge of communication and monitoring processes and increasing public awareness. These frameworks are flexible, because they easy adjust to upcoming priorities and policies targets over time; however, benchmarking is complicated because of the lack of homogeneity in the themes across nations (UN, 2007a).

[g] Accounting Frameworks do not take into consideration all aspects of SD; but some integrated efforts are working towards expanding the applicability of accounting to include sustainability. These frameworks obtain the indicators from a database that compiles all indicators, and then they are aggregated and can be used in a consistent manner for classification and definition purposes. A widely-known accounting framework is System of Integrated Environmental and Economic Accounting (SEEA), which is a joint effort between the United Nations Statistical Commission, the International Monetary Fund, the World Bank, the European Commission (EC), and the Organization for Economic Co-operation and Development (OECD) (UN, 2003a). SEEA provides an internationally agreed-upon conceptual framework to measure the interactions between economics, the environment, and the state of the environment (UN, 2011). SEEA contains three main parts: [1] a Central Framework, which includes internationally agreed-upon standard concepts, definitions, classifications, tables, and accounts; [2] Experimental Ecosystem Accounts; and [3] Extensions and Applications. Presently, SEEA is under revision and will build upon its predecessors: SEEA-1993 and SEEA-2003.

[h] Frameworks for Assessment Method Tool Kits comprise a comprehensive classification system of assessment methods, with their main objective being to provide DMs with support in following the process, as well as to provide timely and structured information. These frameworks provide a set of assessment methods, indicators, models, appraisals, and procedures to DMs. Frameworks such as Building Environmental Quality Evaluation for Sustainability through Time (BEQUEST), Construction and City Related Sustainability Indicators (CRISP), Large Urban Distressed Areas (LUDA), Sustainability-Test, and the Conseil International du Batiment (CIB) network provide the basis for planning, structuring, and developing assessment method tool kits.

[i] The Holistic and Integrated Framework proposed by Brandon and Lombardy (2011) was based on a simplified version of the philosophical theory of the Cosmonomic Idea of Reality. Deakin, Curwell and Lombardi (2001) recognize the need for new approaches to decision making for SD —namely the holistic approach— to integrate the different dimensions of urban systems and different points of view. It recognizes different levels of information and attempts to integrate key aspects to provide a continuum for harmony and decision making, based on fifteen modalities (or aspects of reality): numerical, spatial, kinematic, physical, biological, sensitive, analytical, historical, communicative, social, economic, aesthetic, juridical, ethical, and creedal. The modalities are placed in logical order; earlier modalities serve as bases for the next. The holistic approach claims to be flexible, take into account different scenarios and planning and design issues, and include easy-to-check and relevant criteria for the DMs.

2.2.2 Strategic Approaches

Throughout the assessment process, DMs encounter a large number of choices. First and foremost, DMs must decide on which sustainability assessment approach meets the needs of a specific project, and how SD goals are to be met. In assessments, the DMs are faced with critical decisions that affect the project in some way. A sustainable choice could affect the budget, risk assessment, schedule, and other factors in a project; and project factors can influence a sustainability choice. The uniqueness of particular projects makes decision making more challenging. Furthermore, sustainability assessments should be more flexible in the sense of being more sustainability-focused decision making based on suitable sustainability principles. At times advocates for sustainability have taken matters into their own hands by drafting, testing, and listing a set of core criteria related to the decision, with sustainability as the ultimate goal.

In Appendix 2 of Sustainability Assessment – Criteria and Processes, Gibson et al. (2010) present a series of strategic approaches (e.g. fundamental objectives, key challenges, essential strategy components, foundation principles, or design imperatives), without implying that the set of approaches is complete. In this series of selected sustainability assessment approaches, criteria and processes were developed and/or adopted by specific individuals and/or organizations, recognizing that local differences can be important and additions and elaborations are needed in each specific case/project. The list presented below represents a brief sample of the multiple strategic sustainable assessment approaches designed and used around the world:

[a] The International Council for Local Environmental Initiatives (ICLEI) (ICLEI, 1996; 2004) and International Council for Local

Environmental Initiatives-Europe (ICLEI, 1997), Local Agenda 21 (LA21) proposes a participatory planning process for communities, which has been applied to over 6000 cities; [b] the Government of British Columbia presents a growth management strategies law and a process for the pursuit of sustainability through the preparation of planning strategies by municipalities in expanding urban regions (Government of British Columbia, 1997); [c] B. Sadler approaches sustainability assessment as the next generation of environmental assessment (Sadler, 1996); [d] B. Becker reviews sustainability values, concepts, and methodological approaches (Becker, 1997); [e] D. Lawrence takes on a basic approach to the integration of sustainability into assessment requirements (Lawrence, 1997); [f] D. Devuyst (1999) describes the Assessing the Sustainability of Societal Initiatives and Proposing Agendas for Change (ASSIPAC) method for sustainability assessment, noting it was designed chiefly for urban planning uses, but is broadly used; [g] the Government of United Kingdom puts forward a strategy for SD (Government of United Kingdom, 1999); [h] J. Ravetz describes the Integrated Sustainable Cities Assessment Method (ISCAM), which was proposed in light of a case review of integrated planning for sustainability for Greater Manchester (Ravetz, 2000); [j] IUCN (International Union for Conservation of Nature) Monitoring and Evaluation Initiative offers a sustainability assessment method for evaluating human and environmental conditions that are progressing towards sustainability (Guijt, Moiseev, & Prescott-Allen, 2001); [10] the Mining, Mineral. and Sustainable Development (MMSD) project outlines the basic components of integrated impact assessment (IIA) (MMSD, 2002); [k] the North American working group of MMSD project develops a sustainability assessment framework for mining projects (MMSD-NA, 2002); [l] the Global Ecovillage Network Community Sustainability Assessment compiles a comprehensive checklist for evaluating the sustainability of individual communities (Global Ecovillage Network, undated); [m] the Hong Kong Sustainable Development Unit

(HKSDU) designs an assessment system for integrated consideration of proposals (HKSDU, 2002); [n] Bradley, Daigger, Rubin and Tchobanoglous (2002) use sustainability criteria to evaluate onsite wastewater treatment technologies; [o] the Stockholm Environment Institute uses sustainability assessment of World Trade organization negotiations in the food crops sector (Maltais, Nilsson, & Persson, 2002); [p] Equator Principles are used for decision making on major project financing, prepared and adopted by a voluntary association of major financial institutions for the assessment of environmental and social risk of proposed projects expected to cost over US$50 million (Equator Principles, 2003); [q] Jenkins, Annandale and Morrison-Saunders (2003) propose a comprehensive sustainability assessment framework to the Western Australia State Sustainability Assessment Working Group; [r] Nelson, Azare, Sampong, Yeboah, Fosu, Tagu, Dare and DarkoMensah (2004) develop a strategic environmental assessment (SEA) for sustainability appraisal of Ghana's Poverty Reduction Strategy; [s] the Forest Stewardship Council (FSC) creates a series of certification principles, criteria, standards, and processes for forestry operations and wood products (FSC, 2004); and [t] the Regional Municipality of Waterloo (RMW) develops the terms of reference for the assessment of a rapid transit initiative (RMW, 2005).

2.2.3 Integrated Approaches

Sustainability is a complex and multi-dimensional area, which is under continuing development. Though the existing assessments contribute to the sustainability agenda, established tools are not yet working effectively (Gibson, 2001), leading to a call for holistic approaches (Brandon & Lombardi, 2011) or holistic impact assessments (Kwiatkowski & Ooi, 2003). Rotmans (2006) addresses the point that—even though new tools such as sustainability impact assessments (SuIA) have been adopted by the European Union (EU)—there is a need for more strategic approaches, such as integrated sustainability assessments (ISA). Sustainability targets and criteria are used by ISA to comprehensively assess international and national policy programs. The MATISSE (Methods and Tools for Integrated Sustainability Assessment) project was launched as a response to the challenge of unsustainability, and under its context a two track-strategy is proposed (Rotmans, 2006). The aim of MATISSE is to propose procedures, methods, and tools for effectively and efficiently integrated sustainability into policy development process and institutions. Furthermore, MATISSE defines ISA as "a cyclical, participatory process of scoping, envisioning, experimenting, and learning through which a shared interpretation of sustainability for a specific context is developed and applied in an integrated manner in order to explore solutions to persistent problems of unsustainable development" (SERI, 2011). Varey (2004), founder of EMRGNC, considers that any integrated approach with sustainability as its goal may include the processes and expertise of any, or all, of the disciplines of environmental impact assessment (EIA), SEA, environmental and social impact assessment (ESIA), political and policy assessment (PPA), privacy impact assessment (PIA), economic and fiscal impact assessment (EFIA), technology impact assessment (TIA), demographic impact assessment (DIA), health impact assessment (HIA), social impact assessment (SIA), urban impact assessment (UIA), biodiversity impact assessment (BdIA), cumulative effects assessment (CuEA), triple bottom line (TBL) assessment, IIA, and sustainability appraisal and sustainability assessment. Furthermore, an integrated approach does not imply the integration of different approaches, but the principles of sustainability must be the base for an integral assessment that is an integral component of PPP and decision making processes. The new generation of ISA tools and instruments are meant to use the so-called Triple I approach: Innovative, Integrated, and Interactive, as required by the demands of SD (Rotmans, 2006). More flexible and participatory focused methodologies are emerging as SD evolves. Different tools (methodologies, approaches, models, and appraisals) are re-visited to look for ways of adjusting and improving them to meet the different needs of stakeholders, projects, and ultimately, the needs of a balance development.

2.3 Assessment Methods

Assessment methods are required to make progress toward a purpose. They are designed to present the status of the environmental capacity, measure whether progress has been made, and support DMs on present and future decisions (Brandon & Lombardi, 2011). Not only has the evaluation process become relevant, but also the monitoring of the progress has a definitive role in accomplishing SD goals.

The sustainability needs of the oil sands and heavy oil projects and the expected benefits by the implementation of the WA-PA-SU project sustainability rating system (Poveda & Lipsett, 2011a) and its unique structure (Poveda & Lipsett, 2011b) determine which existing assessment tool characteristics can be adopted into its sustainability assessment methodology. Presently, there is no agreement among scholars under which framework to place the evaluation methods (Horner, 2004; Curwell, Deakin, & Symes, 2005; Deakin, Mitchell, Nijkamp, & Vreeker, 2007). In fact, there is a division between those who believe that environmental assessments contribute to SD (Bergh, Button, Nijkam, & Pepping, 1997; Brandon, Lombardi, & Bentivegna, 1997; Nijkamp & Pepping, 1998) and those who consider that the present methods are unable to evaluate non-market goods and services and therefore present methods make limited contributions to SD (Guy & Marvin, 1997).

There are a large number of assessment methods available, and classifying them can be a challenge. Different projects and studies present inventories of the available tools: the ‘Sustainability A – Test’ EU project, the ECO2 Cities study, the LUDA project, and the BEQUEST project, among others.

The Sustainability A – Test EU project applies a consistent and comprehensive evaluation framework to validate a series of SD tools (i.e., methodologies, models, approaches, and appraisals). The project includes, as shown in Table 2.1, assessment frameworks, participatory tools, scenario analysis, multi-criteria analysis (MCA), CBA and cost-effectiveness analysis (CEA), modeling tools, accounting tools, physical analysis tools, and indicator sets. The Sustainability A – Test project was led by the Institute for Environmental Studies (IVM) and carried out by four Dutch partners, thirteen other European partners, and one Canadian partner. It was commissioned by the EU FP6-STREP programme. Examples of the tools included EIA, scenario tools, MCA, CBA and accounting tools (IVM, 2011).

The World Bank launched an initiative to help cities in developing countries achieving greater ecological and economic sustainability. The Eco^2 Cities: Ecological Cities as Economic Cities program provides practical, scalable, analytical, and operational support to cities. The program develops an analytical operational framework to be used by cities around the world towards accomplishing their sustainability goals:

> “Urbanization in developing countries is a defining feature of the 21st century. Some 90 percent of global urban growth now takes place in developing countries – and between the years 2000 and 2030, developing countries are projected to triple their entire built-up urban areas. This unprecedented urban expansion poses cities, nations and the international development community with a historic challenge and opportunity. We have a once in a lifetime opportunity to plan, develop, build and manage cities that are simultaneously more ecologically and economically sustainable. We have a short time horizon within which to impact the trajectory of urbanization in a lasting and powerful way. The decisions we make together today can lock-in systemic benefits for the present and for future generations” (World Bank, 2011).

Suzuki, Dastur, Moffatt, Yabuki and Maruyama (2010) in their ECO2 Cities: Ecological Cities as Economic Cities present a different classification of assessment methods. The ECO2 Cities study suggests three categories: [1] methods for collaborative design and decision making—these help the cities to undertake leadership and collaboration; [2] methods for analyzing flows and forms—these analytical methods and combinations provide a transdisciplinary platform to identify the relationships between the spatial attributes of cities (forms) and the physical resource consumption and emissions of cities (flows); and [3] methods for investment planning assessment, which include accounting methods, life-cycle costing, proactive risk mitigation, and adaptation. These methods provide to the cities a decision support system (DSS) for the implementation of more strategic and long term management and decision making.

The LUDA is a research project of Key Action 4—“City of Tomorrow & Cultural heritage”—of the programme “Energy, Environment and Sustainable Development” within the Fifth Framework Programme of the EC. LUDA provides tools and methods for a more strategic approach towards urban rehabilitation, and towards bringing support to cities in initiating and managing the chosen approach in its early stages. The project was conceived in response to the high level of political pressure to assist cities experiencing distress caused by environmental, economic, and social impacts, to make rapid improvements to the quality of life (LUDA Project, 2011). LUDA ran from February 2004 to January 2006. It included sixteen project members and twelve reference cities.

In a survey, the BEQUEST project released a list of 61 assessment methods, tools, and procedures. Table 2.2 presents the results of the BEQUEST survey complemented with other tools (e.g., rating systems) commonly used by different parties in the construction industry: architects, engineers, constructors, producers of buildings products, investors and building owners, consultants, residents, facilities managers, researchers, and authorities (Haapio & Viitaniemi, 2008; Poveda & Lipsett, 2011a). The BEQUEST project surveyed tools currently used in assisting the sustainable urban development process in the planning, design, construction, and operation stages. BEQUEST integrates four dimensions of urban development: development activity, environmental and social issues, spatial levels, and timescale.

After the Brundtland Commission presented its report, "Our Common Future," an explosion of new assessment tools (e.g., methodologies, models, approaches, and appraisals) became available; however, there were instruments already in place before 1987, such as CBA, Contingent Valuation Method (CVM), Hedonic Pricing Method (HPM), travel-cost method, and MCA. Other evaluation procedures considered to be statutory instruments such as EIA and SEA were also already established. The next section presents a brief description of the most commonly used tools: methodologies, models, approaches, and appraisals.

2.3.1 Environmental, Social and Economic Impact Analysis

EIA was developed in 1969 under the National Environmental Policy Act (NEPA) in the United States. The procedure assesses the physical and social impact of projects, and its main objective is to take into consideration—and inform stakeholders and DMs of—environmental implications before decisions are made. Social and economic impact analyses function similarly with their respective issues, and these two components (social and economic) are usually included in an EIA. While the tool allows users to take into consideration the different impacts during the decision making process, there are some limitations in the areas of prediction of impact, definition and measurement, monitoring, use of specific methods, and consultation and participation (Brandon & Lombardi, 2011).

2.3.2 Strategic Environmental Assessments (SEA)

EIA presents a specific challenge because its application is limited to a specific project. The United Nations Economic Commission for Europe recommended the extension of EIA as an integrated assessment for PPP. As a result, SEA supports the DMs in early stages of the process, guaranteeing that proper, prompt, and adequate decisions are made. A difference from the EIA, which is mainly focused at the project level, is that the SEA objective is to develop PPP at a higher level of the decision making process. While SEA allows more participation and facilitates the engagement of the public in the decision making process, the main weakness of the process is that it relies on time and resources. Other issues that can arise relate to data, the mechanism for public participation, and uncertainties; furthermore, social and economic aspects are usually left out.

2.3.3 Cost-Benefit Analysis (CBA)

CBA examines costs and benefits of a project. In an economic decision making approach, it is often called benefit-costs analysis (BCA). This particular approach is meant to be applied in early stages to determine the viability of a project, measuring and comparing the expected costs and benefits of a set of projects that are competing for resources. This approach allows DMs to search for the alternative providing the best return on capital. The NPV (net present value) and IRR (internal rate of return) are the most common capital budgeting tools. The IRR must exceed a threshold return on investment (ROI) criterion for a project to be acceptable.

There are two types of CBA: social and economic. The costs relate to all expenditures carried out by developer, and are expressed in monetary terms and adjusted for the time value of money, whereas the benefits refer to revenues received from the project. A CBA provides a systematic tool with a basis for comparison among projects by using a

Table 2.1 Tools included in the 'Sustainability A – Test' EU project

Group	Sustainable Development Tools (methodologies, models, approaches and appraisals)
Assessment Frameworks	EU impact assessment system Environmental impact assessment (EIA) Strategic environmental assessment (SEA) Integrated sustainability assessment / Transition management
Participatory Tools	Electronic focus groups Tools to inform debates, dialogues & deliberations Consensus conference Repertory grid technique Interactive backcasting Focus group Delphi survey In-depth interviews Citizen`s jury
Scenario Analysis	Trends Cross impact Relevance trees and morphologic analysis Modeling, simulating, training Interactive brainstorming Scenario workshops Integrated foresight management model Ranking method
Multi-criteria Analysis	Multi-attribute value theory Weighted summation Analytic Hierarchy Process (AHP) Preference Ranking Organization Method for Enrichment Evaluations (PROMETHEE) Novel approach to imprecise assessment and decision environments REGIME Dominance method Software for MCA
Cost-Benefit Analysis (CBA) and Cost-Effectiveness Analysis (CEA)	Cost-benefit analysis (CBA) Travel costs Hedonic pricing Cost of illness Contingent valuation Averting expenditures Contingent behavior Market methods Conjoint choice questions Cost-effectiveness analysis (CEA)
Modeling Tools	Family of socio-economic models General economy models Demographic models Public health models Partial economic models Family of bio-physical models Climate models Biogeochemistry models Hydrology models Family of integrated models Land use models Integrated assessment models Qualitative system analysis models Scenario building and planning tools
Accounting Tools, Physical Analysis Tools and Indicator Sets	Measure of economic welfare Sustainable national income Genuine savings National accounting matrix including environmental accounts Index of sustainable economic welfare Ecological footprint Global land use accounting Economy-wide MFA Lifecycle assessment Indicator sets for assessments Vulnerability Assessment: Livelihood sensitivity approach

common basis in terms of present value. Similar techniques have been developed to address the weaknesses encountered in CBA, enhancing its strengths and/or offering alternative applications, including: community impact analysis (CIA), CEA, cost-utility analysis, economic impact analysis, social return on investment (SROI) analysis, and fiscal impact analysis.

2.3.4 Travel Cost Theory (TCT)

Travel Cost Theory (TCT) estimates economic use values related to sites or ecosystems used for recreation. For a recreation site, travel cost includes economic benefits or costs as result of: addition of, change in access costs for, elimination of, changes in environmental quality at a recreation site. Time and travel cost expenses count for the price of access to the recreation site. Using the market idea of willingness to pay for a determined good based on the quantity demanded at different prices, the TCT measures people’s willingness to pay to visit the site, based on the number of trips that they make at different travel costs.

2.3.5 Community Impact Evaluation (CIE)

Initially known as the planning balance sheet (PBS), community impact evaluation (CIE) was developed by Lichfield in 1956. It presents an adaptation of CBA for urban and regional planning. In addition to providing the total costs and benefits of projects, CIE also evaluates the impact on other sectors of the community, illustrating the implications on social justice and equity of decisions made (Lichfield & Prat, 1998). While the strength of the CIE relies on stakeholder participation and the role of the community, the weakness arises in the data selection processes used for evaluation and classification of societal impacts.

2.3.6 Contingent Valuation Method (CVM)

The CVM considers two different criteria. For environmental improvements, CVM considers willingness to pay. For reduction in environmental quality, it assesses willingness to accept. CVM uses Hicksian measures of utility by generating estimates that are obtained through the use of questionnaires. Two critical aspects in the CVM are the hypothetical scenario characterization and the questionnaires development. It is suggested that the participants should be familiar with the hypothetical scenario; in fact, certain scenarios or cases require expert knowledge. While the strength of CVM is its flexibility and capacity to measure non-use values, its main weakness is its limited appropriateness to value entire ecosystems.

2.3.7 Hedonic Pricing Method (HPM)

Based mostly on Lancaster's (1966) consumer theory, the HPM was developed by Rosen (1974). The HPM is used for ecosystems and environmental services to estimate economic values that directly affect the market. The objective of the method is to determine the relationship between the attributes and price of a specific good. If a particular product possesses a certain number of characteristics, each with a specific price, then the price of a certain property can be calculated as the sum of its characteristics.

2.3.8 Multi-Criteria Analysis (MCA)

MCA presents an alternative valuation method to CBA. Since impacts are difficult to assess in monetary terms, the MCA technique weights and ranks impacts in non-monetary terms. The strength of the MCA relies on three factors: [1] information present in the selected criteria, [2] weights given to each criterion, and [3] agreement amongst stakeholders on the weights given to each criterion. Sensitivity analyses are usually used to measure the degree of strength and adjust the weights of criteria. MCA methods can be classified according to the decision rule used or the type of data handled. Based on the decision rule used, there are three different types of methods: compensatory, partial-compensatory, and non-compensatory. In a compensatory method, bad or low performances on a certain criterion can be compensated by good or high performances of other criteria; and so a compensatory method allows the compensability factor to be fully applied. A partial-compensatory method allows some compensation based on a predetermined limit. Non-compensatory methods do not allow any compensation. Methods can deals with quantitative data for each criterion yielding a weighted summation. Qualitative methods process qualitative data, typically by applying some kind of logic ladder. Mixed methods deal with data as they are measured.

2.3.9 Material Intensity Per Service Unit (MIPS)

Material Intensity Per Service Unit (MIPS) was developed at the Wuppertal Institute in the 1990s. To make a product or provide a service, a certain amount of material (or mass) must be moved or extracted. MIPS adds up the overall material to calculate the total material intensity of a product or service by dividing the total material input (MI) by the number of service units (S).

2.3.10 Analytic Network Process (ANP)

MCA offers some alternatives. The AHP offers its most advanced approach through the Analytic Network Process (ANP). The structure of the ANP is a network, while the AHP structure consists of a hierarchy with a goal, decision criteria, and alternatives. The main components of the ANP are clusters, elements, interrelationships between clusters, and interrelationships between elements. Brandon & Lombardi (2011) describe the three main stages of the process: [1] structuring the decision making model, [2] developing pairwise comparison of both elements and clusters to establish relationships within the structure, and [3] achieving the final set of priorities. Both processes—ANP and AHP—use pairwise comparison to determine the weights of the elements in the structure, and then rank the different alternatives. “The ANP allows interaction and feedbacks within and between clusters and provides a process to derive ration scales priorities from the elements” (Brandon & Lombardi, 2011).

2.3.11 Life Cycle Assessment (LCA)

Life Cycle Assessment (LCA) examines a product or service throughout its life cycle to assess environmental impacts. It is also known as life cycle analysis, eco-balance, and cradle-to-grave analysis. The LCA methodology is based on ISO 14040 and BS EN ISO 14041-43. In the case of buildings, software tools—including BRE (Buildings Research Establishment) and BEES (Building for Environmental and Economic Sustainability)—are available to evaluate their impacts. The main interlinked components of LCA are: goal definition and scoping, life cycle inventory, life cycle impact assessment, and improvement analysis (interpretation).

2.3.12 Sustainability/Environmental Rating Systems

Sustainability/environmental rating systems have been designed to measure environmental performance of a variety of projects in the construction industry. Sustainability/environmental rating systems support the decision making process throughout the project life cycle, or for certain phases of a project. In common practice, the designer does not have much interaction with the builder; however, accomplishing the sustainability goals requires an integrated effort between the parties involved, independent of the project delivery method used (e.g. design-bid-build, design-build, integrated project delivery, etc.). An integrated approach assists the decision making process and minimizes design and building errors, among other benefits. The building industry has a wide variety of sustainability/environmental ratings systems to choose from: ATHENA, BEAT 2002, Building Research Establishment Environmental Assessment Method (BREEAM), Leadership in Energy & Environmental Design (LEED), Green Globes, Comprehensive Assessment System for Built Environment Efficiency (CASBEE), and Green Start are some of the existing sustainability/environmental rating systems, as shown in Table 2.2. LEED, for example, initially emphasizes six categories: sustainable

Table 2.2 Sustainability assessment methods, tools, and procedures

Analysis of Interconnected Decision Areas (AIDA) (1)
Analytic Hierarchy Process (AHP) (1)
Assessing the Sustainability of Societal Initiatives and Proposed Agendas for Change (ASSIPAC) (1)
ATHENA (1)
BEAT 2002 (2)
BeCost (previously known as LCA-house) (2)
BRE Environmental Assessment Method (BREEAM) (1)
BRE Environmental Management Toolkits (1)
Building Energy Environment (BEE 1.0) (1)
Building Environmental Assessment and Rating System (BEARS) (1)
Building Environmental Performance Assessment Criteria (BEPAC) (1)
Building for Economic and Environmental Sustainability (BEES 2:0) (1)
Cluster Evaluation(1)
Community Impact Evaluation (CIE) (1)
Comprehensive Assessment System for Built Environment Efficiency (CASBEE) (2)
Concordance Analysis (1)
Contingent Valuation Method (CVM) (1)
Cost-Benefit Analysis (CBA) (1)
DGNB (2)
Eco-Effect (1)
Eco-Indicator 95 (1)
Eco-Instal (1)
Economic Impact Assessment (EcIA) (1)
Ecological Footprint (1)
Eco-points (1)
Ecopro (1)
Eco-Profile (1)
EcoProP (1)
Eco-Quantum (1)
Environmental Impact Assessment (EIA) (1)
ENVEST (1)
Environmental Profiles (1)
Environmental Status Model (Miljostatus) (2)
EQUER (1)
ESCALE (1)
Financial Evaluation of Sustainable Communities (FESC) (1)
Flag Model(1)
Green Building Challenge, changed in Sustainable Building (SB) Tool (1)
Green Globes (2)
Green Guide to Specification (1)
Green Start (2)
GRIHA (2)
Hedonic Analysis (1)
HKBEAM (2)
Hochbaukonstruktionen nach okologischen Gesichtspunkten (SIA D0123) (1)
INSURED (1)
Leadership in Energy and Environmental Design Green Building Rating System (LEEDTM) (1)
LEGEP (previously known as Legoe)
Life Cycle Analysis (LCA) (1)
Material/Mass Intensity Per Service Unit (MIPS) (1)
MASTER Framework (1)
Meta Regression Analysis (1)
Multi-Criteria Analysis (MCA) (1)
NABERS (2)
Net Annual Return Model (1)
Optimierung der Gesamtanforderungen ein Instrument fur die Integrale Planung (OGIP) (1)
PAPOOSE (1)
PIMWAQ (1)
Project Impact Assessment (1)
Regime Analysis (1)
SBTool 2005(2) (formerly known as GBTool)
Quantitative City Model (1)
Planning Balance Sheet Analysis (1)
Risk Assessment Method(s) (1)
SANDAT(1)
Semantic Differential (1)

Table 2.2 Sustainability assessment methods, tools, and procedures (cont'd)

Social Impact Assessment (SIA) (1)
System for Planning and Research in Town and Cities for Urban Sustainability (SPARTACUS) (1)
Strategic Environmental Assessment (SEA) (1)
Sustainable Cities (1)
Sustainable Regions (1)
Transit-oriented Settlement (1)
Travel Cost Theory (TCT) (1)

(1) Assessment methods, tool and procedures listed in the BEQUEST project including some rating system
(2) Additional tools (e.g. rating systems) complementing the BEQUEST project list

sites (SS), water efficiency (WE), energy and atmosphere (EA), materials and resources (MR), indoor environmental quality (IEQ), and innovation in design (ID), adding the regional priority category in its most recent version (USGBC, 2009a). Other categories have been developed for specific rating systems, for example, LEED for neighborhood development. Whereas LEED has been a success in North America and certified LEED projects are present in more than 100 countries, BREEAM (developed in the United Kingdom by the Building Research Establishment [BRE]) has demonstrated its applicability in Europe. BRE has more than 100,000 buildings certified, and operates in dozens of countries. BREEAM uses nine categories: management, health and wellbeing, energy, transport, water, materials, waste, land use and ecology, and pollution. Dividing the criteria in categories facilitates practitioners to make effective and efficient decisions in the use and operation of the resources involved in the planning, execution, and operation of projects.

2.4 Sustainability/Environmental Rating Systems and the Credit Weighting Tools (CWTs)

This section focuses on describing, analyzing, and comparing the different CWTs adopted by the most popular ratings systems around the world. The aim of this section is not to compare the efficacy of the existing sustainability/environmental rating systems on the reduction, mitigation, or elimination of the different impacts (e.g. social, economic and environmental) carried out by certain types of development. A brief description of the structure and components of each rating system is given to then focus on the application of each particular CWT. One of the critical issues in developing a rating system is the distribution of points and weights across the different areas and criteria of the rating system (Trusty, 2008).

As stated earlier, in the assessment process the performance is compared against a criterion or a number of criteria. A quantitative MCA allocates weight to each criterion to then obtain a weighted summation. Since each criterion has a determined weight, the total performance score in a rating system will be given by the addition of every criterion's weight if the project or task has met a pre-established requirement. By definition, a CWT is the methodology adopted to allocate certain weight to a criteria. The CWT refers neither to the systematic way to rate projects, nor to the rating scale used by different sustainable rating systems. A rating scale determines the number of points or parameters for a project to be categorized, certified, or acknowledged as sustainable.

2.4.1 Leadership in Energy & Environmental Design (LEED)

The current version of LEED (e.g., LEED 2009) uses a basic weighting equation to determine the value of the credits (see Graph 2.1). Currently, the new version of LEED is under development (LEED, 2012). LEED 2012 will use a set of categories developed by USGBC that more closely align with the mission and vision for ongoing LEED development (USGBC, 2011a). Since specifics of LEED 2012 have not been released, the CWT description in Graph 2.1 is based on LEED 2009 (current version).

The objective of the equation is to combine information on buildings impacts, buildings functions (a.k.a. building "activity groups"), and performance of individual credits (USGBC, 2009b).

Impact categories are defined and weighted directly by the National Institute of Standards and Technology (NIST) using impact categories defined by US Environmental Protection Agency's TRACI (Tool for the

Reduction and Assessment of Chemical and other Environmental Impacts) project (Bare, Norris, Pennington, & McKone, 2002). The categories and their weights are described as follows:

GHG emissions (29%)

Eutrophication (6%)

Ecotoxicity (7%)

Particulates (9%)

Acidification (3%)

Indoor air quality (3%)

Human health-non-cancer (5%)

Water use (8%)

Fossil fuel depletion (10%)

Smog formation (4%)

Land use (6%)

Human health-cancer (8%)

Ozone formation (2%)

Basic weighting equation

Relative importance of each **impact category**
x
Relative contribution of a building **activity group** to building impacts
x
Association between individual credits and activity groups
=
Credit Weight

Where,

- **Impact Category**: impacts of building on environment and occupants (e.g., TRACI categories)
- **Activity Group**: a building-related function associated with a group of LEED credits (e.g., consumption of energy by building systems, transportation, water use)
- **Association with activity group**: a binary (yes/no) relationship indicating whether or not a credit contributes to reducing an impact.

Graph 2.1 The LEED credit weighting system equation

To determine the weights of the categories, NIST used an AHP. The weights of the categories add to 100%.

Activity Groups reflect the core building functions. All LEED credits fall under one of these activity groups. Activity groups can be associated with specific building impacts in each category. These categories are described as follows:

Building systems (specifically fuel and electricity consumption)

Transportation (commuting and services)

Water consumption (domestic and landscaping-related)

Materials (core, shell, and finishing)

Indoor Environmental Quality (IEQ)

A certain number of credits are represented by each activity group. The percentages of total building-related impacts to each activity group are assigned by using a combination of empirical calculations and LCAs. Each credit is given a binary association with each impact category: 0 = no association, 1 = association. Finally, the weight of each activity group is allocated proportionally to each credit associated with each impact category.

2.4.2 Comprehensive Assessment System for Built Environment Efficiency (CASBEE)

CASBEE assesses buildings using environmental efficiency and impact on the environment. The assessment tool uses two factors: Q and L. Quality (Q) is defined as Building Environmental Quality and Performance, which evaluating improvement in living amenity for the building users within the hypothetical enclosed space (private property). Loadings (L) relates to Building Environmental Loadings, evaluating negative aspects of environmental impact that go beyond the hypothetical enclosed space and outside to public property (CASBEE, 2006). Using Q and L, CASBEE calculates BEE (building environmental efficiency), as the ratio of Q to L as shown in formula 2.1:

$$BEE = \frac{\mathrm{Q}}{\mathrm{L}} \quad [2.1]$$

Environmental Quality Q contains the indoor environment (including acoustics, lighting, thermal comfort, and air quality), service quality (includes adaptability, flexibility, and durability), and outdoor environment. Environmental Load (L) contains energy, materials, and the off-site environment.

Assessment categories. Q (building environment quality & performance) is broken down into three categories: Q-1 (indoor environment), Q-2 (quality of service) and Q-3 (outdoor environment on site). LR (reduction of building environmental loadings) is sub-grouped into LR-1 (energy), LR-2 (resources and material) and LR-3 (off-site environment).

Scoring. Each assessment item has a scoring criterion to meet. The level of technical and social standards at the time of the assessment gives the criteria to be applied to each assessment.

Weighting. Items such as Q-1, Q-2, and Q-3 or LR-1, LR-2, and LR-3 are weighted and the sum of Q adds up to 1.0. The score of each assessment is multiplied by the weighting coefficient, and then the set of coefficients is aggregated to obtain SQ and SLR as total scores for Q and LR respectively.

2.4.3 Building Research Establishment Environmental Assessment Method (BREEAM)

In BREEAM, different environmental issues are grouped in three main areas: [1] global issues, which includes CO2 emissions, acid rain, ozone depletion, natural resources and recyclable materials, storage of recyclable materials, and designing for longevity; [2] local issues, which include transport and cycling facilities, noise, local wind effects, water economy, overshadowing or other buildings and land, reuse of derelict/contaminated land, and the ecological value of the site; and [3] indoor issues, involving hazardous materials, natural and artificial lighting, thermal comfort, and overheating and ventilation.

Each individual issue gets a discrete credit. A credit is given if the design meets the requirements concerning that particular issue; however, there is no intention at weighting the issues (Brandon & Lombardi, 2011).

The sum of the credits gives the overall performance expressed in a semantic scale based on a certain minimum level of credits obtained in each of the three main areas (e.g., global issues, local issues, and indoor issues).

BREEAM contains nine different categories, each with a pre-determined environmental weighting:

Management (12%)	Health & Wellbeing (15%)
Energy (19%)	Transport (8%)
Water (6%)	Materials (12.5%)
Waste (7.5%)	Land Use & Ecology (10%)
Pollution (10%)	

A certain number of achieved available credits in each category determines the percentage obtained in the assessment. The overall score is the percentage sum of all categories.

2.4.4 GBTool

GBTool uses similar approaches to LEED and BREEAM, and includes an assessment scale and best practices. GBTool is based on the LCA methodology, and allows customized weighting of criteria. The scores are assigned in a range of -2 to +5, described as follows:

-2 and -1: the level of performance is below acceptance levels in the specific region

0: the minimum level of acceptable performance in the specific region

3: best practice

5: best technically achievable, without consideration of cost

Scores are provided for phases of building activity, including pre-design, design, construction, and operations. The four levels of parameters included in the system include issues, categories, criteria, and sub-criteria. The issues and category parameters are voted on by team members, and criteria and sub-criteria are assigned automatically. The scores are multiplied by the weights and the weighted scores (PETUS, 2011)

2.4.5 Green Star

Green Star contains nine categories: management, indoor environment quality, energy, transport, water, materials, land use & ecology, emissions, and innovation. These categories assess the environmental impact that is directly linked to project site selection, design, construction, and maintenance. A number of credits follow under each category to address initiatives for improvement or to show the potential for improving environmental performance. Similar to LEED and BREEAM, each category has a certain weight. In the case of Green Star, the category weightings are developed by taking into consideration scientific and stakeholder input, which includes: [1] the OECD (Organization for Economic Co-Operation and Development) Sustainable Building Project Report, [2] the Australian Greenhouse Office, [3] Environmental Australia, [4] CSIRO (Commonwealth Scientific and Industrial Research Organization), [5] the Cooperative Research Center (CRC) for Construction, [6] the Commonwealth Department of Environment and Heritage (DEH), and [7] a national survey conducted by the Green Building Council.

The weightings vary by geographical location. The weighted category score is calculated by using formula 2.2:

$$Weighted\ Category\ Score = \frac{\text{Category Score (\%)}\ x\ Weighting\ Factor\ (\%)}{100} \quad [2.2]$$

A certain number of credits are available in each category. The category score is based on the percentage of achieved available points.

As noted above, the most popular environmental/sustainable rating systems use similar approaches in their CWTs, with the exception of CASBEE. The systems weight the different categories and a number of criteria fall under each category; however, there is no intention of directly weighting each credit. Most rating systems are based on the Life-Cycle Analysis methodology and have similarities to Environmental Management Systems (EMS) (Papadopoulos & Giama, 2009). The main objective of EMS is continual environmental improvement. When evaluating and selecting rating systems, a series of criteria must be taken into consideration. Fowler and Rauch (2006) conducted a survey to identify such criteria: measurability, applicability, availability, development, usability, system maturity, technical content, communicability, and cost.

2.5 Discussion and Conclusions

As the understanding of SD grows, its applicability and usefulness are more accepted. The number of methodologies, models, approaches, and appraisals for assessing sustainability has dramatically increased since the concept of SD was recognized as separate from balancing economic wealth creation and environmental degradation in the 1960s and early 1970s. The number of tools for assessing sustainability is expected to increase as this approach to assessing broad impacts of technology gains popularity. There are already several hundred types of assessment tools. As the number of tools increases, some classification becomes necessary. The present work has laid out a classification of assessment tools as generic, strategic, and integrated, with description of the most-used assessment tools and sustainability and environmental rating systems and their respective CWTs. The classification of the existing tools for assessing sustainability varies with the criteria used. The framework presented in this manuscript serves as support for the development of the WA-PA-SU project sustainability rating system by indicating where it stands in the world of decision making tools for sustainability assessment.

3. Chapter Three – A Rating System for Sustainability of Industrial Projects with Application in Oil Sands and Heavy Oil Projects: Origins and Fundamentals[2]

3.1 Introduction

There are many definitions of sustainability. In 1987, the WCED defined sustainability as: “Development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (UN, 1987). Based on this definition of sustainability, any project that carries a level of environmental impact requires mitigation activities to meet sustainability goals. Alternatively, the project must define the nature and extent of impacts so that other projects may be developed to offset these impacts to meet sustainability goals. The main challenge for practitioners and researchers is to develop an appropriate tool to measure not only the environmental impact of a project during development and construction, but also to estimate how sustainable a project will be in the long term.

Environmental impact plays a key role in the development of most projects. Project considerations throughout the life cycle of a project include: the project size, kind of industry, surroundings, codes, standards, regulations, and stakeholder requirements. A tool used in the construction industry to support these objectives is the sustainable rating system. This rating system is a third-party verification that measures the environmental

[2] A version of this chapter has been published. Poveda & Lipsett 2011. Journal of Sustainable Development. 4(3): 59-71.

rating performance of a project (USGBC, 2011b).

While sustainable rating systems are tools commonly used in the construction industry, they have been developed focusing on the assessment of the environmental high-performance of buildings. This approach can be readily adapted to other industries.

Production of unconventional fossil fuel from heavy oil reservoirs and extra heavy (bitumen) from oil sands deposits is one of the biggest sectors of the Canadian economy, and an increasingly important strategic source of global hydrocarbon supply. Given the energy required to produce transportation fuels from heavy and extra-heavy sources, land disturbance & water use, and GHG generation associated with extraction, conversion, and transportation, there are obvious negative environmental impacts. Oil sands and heavy oil projects have not yet been part of the green rating systems movement, although there are some metrics for assessing the environmental impact of these projects established by legal requirements (regulations) (Alberta Energy, 2011a).

Sustainable rating systems can provide benefits to society by allowing industrial projects to be assessed using agreed upon metrics for economic performance, effects on worker health, non-economic social benefits to a region, and environment impacts. Projects that have used any kind of green rating system perform environmentally more efficiently when compared to those conventionally built to construction codes. The range of benefits of green practices have been documented (Yudelson, 2008) and measured from the cost and financial-benefit point-of-view (Issa, Rankin, & Christian, 2009). While some advocates claim safety benefits and better living environments in certified projects (that is, projects that make use of a rating system), others have not found compelling evidence of such benefits (Rajendran, Gambatese, & Behm, 2009). This may be because the rating system does not track safety or quality of the built environment. The green and sustainability movement has made a compelling argument for project practitioners to develop methods to track environmental performance of projects.

3.2 Areas of Integration

To develop a project sustainability rating system, the general scope of an industrial project needs to be defined; the inputs, processes, and outputs need to be identified; and the requirements to be met must be set, with methods for making measurements. In the case of oil sands and heavy oil projects, the WA-PA-SU project sustainability rating system is being developed to include the technology base of the project, its associated infrastructure, relevant regulations, standards, procedures, and non-regulatory requirements.

It is necessary to analyze and document best practices in each of these three major areas, in order to create an effective and efficient tool to measure environmental performance. Figure 3.1 shows the relationship between areas of integration and the parties involved in each area of integration. A dotted line represents a link that may be missing between the areas of integration, which is the main objective in the development of the sustainable rating system for oil and heavy oil projects.

3.2.1 Key Application Sector: Oil Sands and Heavy Oil Projects

Oil sand is a source of unconventional, extra-heavy fossil fuel. Oil sand comprises bitumen in an unconsolidated matrix of sand, clays, and water. The largest proven reserves of oil sands and heavy oil deposits are located in Canada, with about 80% of the world’s currently recoverable bitumen, and Venezuela, with proven reserves of extra-heavy crude oil representing about 75% of current heavy oil supply. Other deposits occur in United States, Russia, Colombia, Brazil, some countries in the Middle East, and others (Kelly, 2009).

Unconventional fossil fuels are not considered to be part of global proven reserves until technology is demonstrated to extract the oil

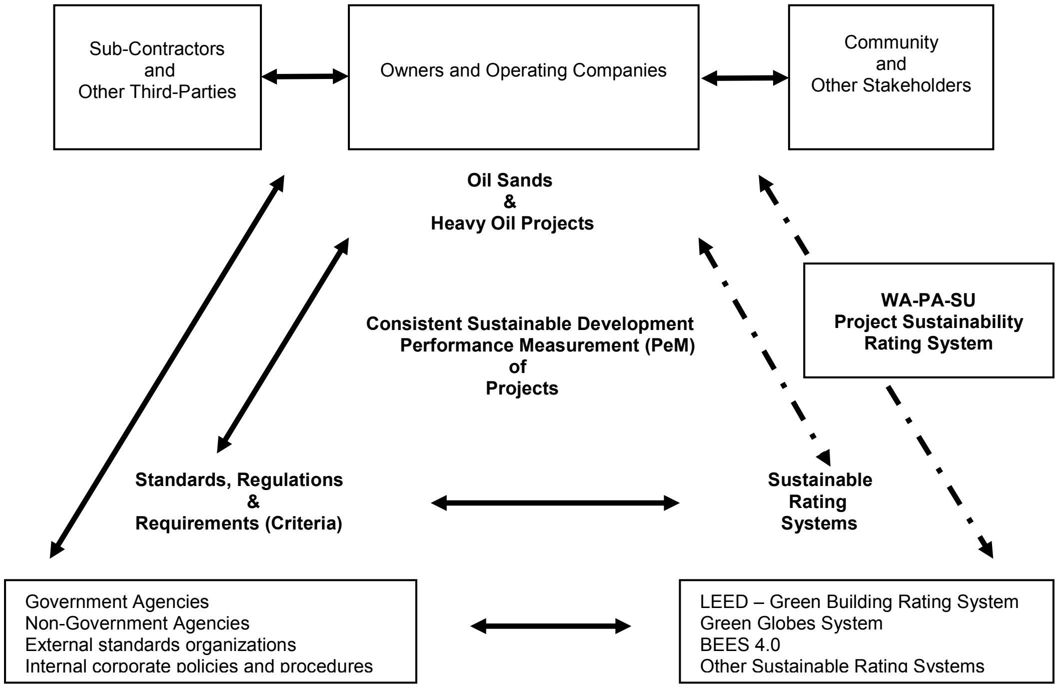


Figure 3.1 Relationships amongst areas of integration and sustainable rating systems

efficiently and reasonably cost effectively. Declining reserves of conventional petroleum, the increasing price of oil, and the development of new technology options for oil extraction have improved reliability and cost-effectiveness of oil sands and heavy oil exploitation to the point that oil sands are now considered to be part of the world's proven oil reserves (Alberta Energy, 2009a). Some studies indicate that in 2009, Albert's total proven oil reserves were 171.3 billion barrels counting for 13% of total global oil reserves; by 2019 the crude bitumen production from the Alberta's oil sands projects is expected to more than double to 3.2 million barrels per day (MMbpd) (Alberta Energy, 2011b)

Global demand for energy is increasing and will grow by approximately 50% by 2030 (IEA, 2010). Heavy hydrocarbon will have a significant impact on future petroleum extraction and its associated environmental effects. Oil sands and heavy oil projects are driven primarily by geotechnical, economic, and geopolitical considerations (Herbst, 2004;

Watkins, 2007). The pace of development for such projects is expected to increase, with governments and oil companies interested in the potential of heavy and extra-heavy oil (Nikiforuk, 1997; Kelly, 2009; Moritis, 2007). Although companies are facing not only financial but also environmental challenges in their efforts to keep up with global oil consumption (Cetron & Davies, 2010; U.S. Government Accountability Office, 2007) there is not a consistent method for assessing how technologies and practices can address these challenges.

Kelly (2009) explains the most common bitumen extraction methods, categorizing them in two basic processes:

(1) mining the sands for bitumen separation in mineral processing plants, and

(2) recovering the oil in-situ (that is, extracting oil without processing the oil sand itself).

Surface mining is appropriate for ore bodies that are close to the surface and which are fairly contiguous. Bitumen recovery from a surface mineable oil sands deposit is on the order of 90%. After overburden removal, the current mining method consists of a five-stage process: (1) the ore is removed from the mine face and moved to a crusher, (2) a crusher reduces lumps of ore to smaller size, (3) the crushed oil sand is mixed with warm water to form a slurry, (4) pipelines move the oil sands slurry from the mine to an extraction plant in a process called hydrotransport, which conditions the slurry to prepare the bitumen for separation from the sand and clay, and (5) a separation circuit separates a bitumen-laden froth for further processing, and directs the nonproduct materials (sand, water, and fine solids) to tailings impoundments (Kelly, 2009).

The depth of oilsand deposits varies. Athabasca oil sands deposits in northern Alberta may be within 75 m of the surface; 500 km2 are under surface mining exploitation of a total of 140,000 km2 (Alberta Energy, 2009a). Surface-based operations use large-capacity excavating shovels to load off-road haul trucks that carry up to 400 tons of ore. Surface mining produces a barrel of crude oil using approximately 2.5 to 4 barrels of water (Canada Association of Petroleum Producers, 2010) and two tons of oil sand (Alberta Energy, 2009a).

The non-product outputs of the mining and extraction process include sediments, water, and small portion of residual oil (approximately 3% carries over), which is placed in settling basins (Kelly, 2009). These large areas, also known as tailing ponds, allow coarse sand to settle, trapping fine solids and water. Process-affected water id decanted from the basin and recycled. Presently, tailing ponds approximately cover 170 km2 due to operations in Alberta. Given the long life cycle of an operating plant, settling basins and partially reclaimed land are part of the tailings management system for up to 30 - 40 years (Canada Association of Petroleum Producers, 2010).

About 80% of the oil sands in Alberta are buried too deep to be recovered using surface mining (Alberta Energy, 2009a). A variety of in-situ processes have been developed, all based on reducing the viscosity of the bitumen in place so that the hydrocarbon will flow into a production well due to a pressure gradient in porous soil. In-situ processes rely primarily on adding thermal energy in the form of steam.

In-situ processes require water resources nearby and sophisticated drilling methods, resulting in the need for efficient recovery factors and water use (Oil Sands Discovery Center, 2010). In-situ processes in the oil sands projects in Alberta use about 17 million m3 per year, increasingly using saline groundwater instead of fresh water as producers are moving away from using fresh water for steam production to brackish water (CAPP, 2009). Surface and in-situ projects can have water recycle rates as high as 90% (Alberta Energy, 2011b).

Steam injection methods attempt to achieve low steam-to-oil ratios so that there is a low amount of thermal energy input for the hydrocarbon energy output. These methods are sometimes augmented with solvents or reagents to promote good recovery without fast loss of porosity in the formation (Galvao, Rodrigues, Barillas, Dutra Jr., & W da Mata, 2009). The two dominant methods are cyclic steam stimulation (CSS) and steam-assisted gravity drainage (SAGD).

In the CSS method, a well is put through cycles of steam injection, soaking, and oil production. In the first step, the steam is injected into a well for a period of weeks to months; then, the well is allowed to sit for days to weeks to allow heat to soak into the formation. Later, the hot oil is pumped out of the well for a period of weeks or months. The advantage of this method is the recovery factor from deep deposits, which is around 20 to 25%, and the disadvantage is the high cost to inject steam (Sunshine Oilsands Ltd., 2011).

SAGD has a higher reliance on directional drilling. Well pairs are drilled—one close to the bottom of an oil sands deposit, and the other about 5 meters above the first well. Wells are drilled in groups off central pads, and can extend for kilometers in every direction. Steam is injected into the upper well, and the heat reduces the viscosity of the bitumen, which allows the bitumen to flow into the lower well, from which the hydrocarbon is then pumped to the surface. Depositional characteristics are important, especially an appropriate cap of rock to prevent depressurization, and staying away from water contact, which affects heating of the formation. “The choice between the CSS and SAGD processes in any in situ well is strictly determinate by the formation” (Kelly, 2009).

Another in-situ process similar to the SAGD method has been demonstrated: the vapor extraction process (VAPEX), an extraction method that injects a light hydrocarbon solvent instead of steam. VAPEX is potentially more energy efficient than steam injection, and it has been demonstrated to do some partial upgrading of bitumen (breaking hydrocarbon chains) right in the formation. Potential disadvantages are solvent compression, solvent losses and potential sensitivity to reservoir heterogeneity (Luhning, Das, Fisher, Barker, Grabowski, Engleman, Wong, Sullivan, & Boyle, 2003).

Finally, injecting air for a controlled combustion process burns a small fraction of the bitumen and generates high levels of heat to liquefy the bitumen. Toe-to-Heel-Air-Injection (THAI) uses this method by combining vertical air injection well with horizontal production well. The advantages of this method are that it requires less water, and has the potential to produces less GHGs than standard steam injection methods, thereby presenting a smaller potential footprint than other production methods. Controllability issues include the maintenance of a stable flame front and preventing wormholing that disrupts the pressure gradient. These issues are the focus of demonstration prototyping using sensors downhole (Kelly, 2009).

The bitumen production methods described above produce a mixture of bitumen, solids, and connate water from the formation. Produced bitumen is ameliorated to remove excess water and solids before heavy oil upgrading into synthetic crude oil (SCO), which is in turn refined into transportation fuels. Solids and water are treated and disposed (Alberta Energy, 2009a).

Oil sands and heavy oil projects are built on a large scale, not only by the value associated with their development, but also by their size and the number of people involved during the phases of planning, execution, operations, and related services. Although developing companies, regulatory agencies, and government monitor resources—such as air, water, and land—the environmental impacts have not been assessed in a consistent manner.

3.2.2 Sustainable Rating Systems

A new concept in the construction industry has become increasingly popular over the past twenty years to make projects more environmentally friendly. Green and sustainable construction focuses on increasing the efficiency of resource use—energy, water, and material—while reducing the construction impact on human health and the environment. This approach focuses on improved planning, design, construction, operation, maintenance, renovation and deconstruction compared to conventional remediation projects (U.S. Environmental Protection Agency, 2010a; 2010b).

Sustainable rating systems are assessment tools to measure environmental performance. Among other reasons, some of these sustainable rating systems have been updated from their original version to:

(1) satisfy the industry demand such as reducing buildings operating and maintenance cost and increasing building value among others benefits (Yudelson, 2008);

(2) meet customer and stakeholder satisfaction by adopting efficient construction practices to minimize cost and deliver sustainable projects;

(3) decrease the environmental impact which can be accomplish, for example, by implementing improved technology, adopting improved processes and procedures, and minimizing energy consumption; and,

(4) comply with new and updated standards and regulations which are

often included as criteria.

Sustainable rating systems are not only a decision making tool. They also can be used to measure environmental performance in a consistent manner for different technologies and practices. It may be difficult to determine which design variant has the best results for energy saving and CO2, because of a lack of calculation methods and techniques at the district level (Vreenegoor, Hensen, & De Vries, 2008). Moreover, rating systems change with time and so they must be periodically reviewed and updated.

Some of the most popular ratings systems are: ATHENA, BEAT 2002, BeCost (previously known as LCA-house), BEES 4.0, BREEAM, CASBEE, EcoEffect, EcoProfile, Eco-Quantum, Envest 2, Environmental Status Model (Miljostatus), EQUER, ESCALE, GB Tool, Green Globe, Green Start, LEED, LEGEP (previously known as Legoe), PAPOOSE, and TEAM. These and other currently used rating systems are listed in Table 3.1. Some of the building type assessed by these ratings system are: existing buildings, new buildings, refurbished buildings, building products/components, residential buildings (multi-unit), residential buildings (single family), and office buildings.

In the construction industry, these ratings are being used by architects, engineers, builders, producers of building products, investors and building owners, consultants, residents, facilities managers, researchers, regulatory authorities and government agencies, and – increasingly – users (Yudelson, 2008). Therefore, the ratings system can support a project throughout its life cycle, starting in the planning stage and finishing with disposal at the end of the project life cycle, as shown in Figure 3.2. Each rating system offers particular benefits depending upon the user, building type, and project life cycle phase, making comparison between different rating systems difficult (Haapio & Viitaniemi, 2008).

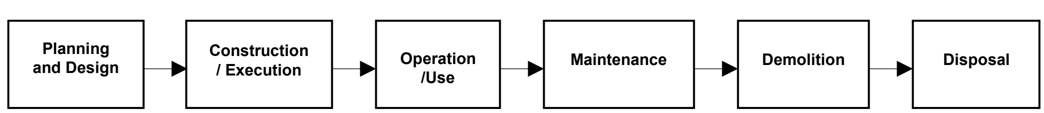


Figure 3.2 Phases of life cycle of a building

The most common and successful rating system, based on the number of projects certified and square per meter built, LEED has been developed by the USGBC. The LEED green building program is a third-party certification that helps builders to adopt green and sustainable practices during the design, construction, and operation of high-performance buildings (USGBC, 2009a). LEED bases the environmental assessment on the “triple bottom line,” a term coined by John Elkington in 1994 to denominate and coordinate three interests: “people, planet, and profit.” LEED adopted this term and uses it as a foundation for its definition of sustainability, which is based in three similar aspects: social responsibility, environmental stewardship, and economic prosperity (USGBC, 2009a). (Post, 2007) states that the LEED system needs to be more focused on the performance of the building rather than implementation of new technology, because during the project operation phase a building may not meet the standards for a green and sustainable performance. Another claim made by experienced practitioners is based on the fact that the certification process is too complicated, and its criteria are not green and sustainable enough to meet the environmental challenges of high performance projects. As well, practitioners would like to see more credit points given for innovation and design (Post, 2007).

LEED rating systems address different types and scopes of projects: LEED for new construction and major renovations, LEED for core and shell, LEED for commercial interiors, LEED for schools, LEED for healthcare, LEED for retail, LEED for existing buildings (operations and maintenance), LEED for homes, and LEED for neighbourhood development. The strategy of the LEED rating system is to divide the project into six categories: SS, WE, EA, MR, IEQ, and ID. Each category comprises prerequisites and credits. Prerequisites are required elements and requirements that must be met to be eligible for any credit point; however, credit points are optional and meeting them adds points towards certification (USGBC, 2009c).

"While it is possible to build a LEED basic Certified and sometimes LEED Silver building at no additional cost, as buildings teams try to make a building truly sustainable, cost increments often accrue" (Yudelson, 2008). Using rating systems and applying green and sustainable technologies go hand-in-hand. The rating systems help to identify the areas where these technologies are needed to reduce environmental impact and meet regulations, standards, and requirements held by regulatory agencies, government, and/or stakeholders. Studies even suggest that the initial investment of 2% extra can even rise over ten times throughout the life cycle of the building (Kats, 2003); however, these costs can easily be mitigated due to the lower operational cost of environmentally high-performance buildings. The cost of design and construction added to green projects averages 1.84% including all certification levels, with a range between 0.66% (certified certification level) to 6.50% (platinum certification level). However, the ROI is less than three years, with a large number of benefits facilitating the business case for green buildings: (1) economic (reduced operating costs, reduced maintenance costs, increased building value, tax benefits), (2) productivity, (3) risk management, (4) health, (5) public relations and marketing (stakeholder relations and occupant satisfaction, environmental stewardship, and a more competitive product in the market place), and (6) recruitment and retention (Yudelson, 2008).

Each sustainable rating system offers advantages and disadvantages, and practical comparisons among them have been extensively done (Haapio & Viitaniemi, 2008; Fenner & Ryce, 2007; Xiaoping, Huimin, & Qiming, 2009). LEED has been compared to other rating systems such as Green Globe (Smith, Fischlein, Suh, & Huelman, 2006), which is another rating system that used in the U.S., but less popular than LEED. Although almost every developed country has a rating system in place, as Table 3.1 shows, other industries aside from the construction industry appear to have made less progress in the development of a rating system to rate their performance and compliance with environmental standards and regulations.

There are challenges that sustainable ratings systems face, for example, the implementation and integration of ratings within management processes and design. In general, the integration of sustainability and management can be done efficiently with great benefits for the construction industry. Eid (2004) integrated SD into the project management processes using the Project Management Institute approach in project management. The challenges of integrating design and project delivery were laid out by Hellmund, Van Den Wymelenberg and Baker (2008a; 2008b). Wu and Low (2010) studied some lessons for the ratings systems from the project management point of view, concluding that project management must be considered by practitioners, not only within the processes but also in practice when it comes to meeting the requirements of being green and sustainable. Integrated design can

Table 3.1 Building rating systems and developers

Name	Developer
ATHENA	ATHENA Sustainable Material Institute. Canada
BEAT 2002	Danish Building Research Institute (SBi). Denmark
BeCost	VTT. Finland
BEES 4.0	U.S. National Institute of Standards and Technology (NIST). USA
BREEAM	Building Research Establishment (BRE). UK
CASBEE	Industry-academic-government collaboration, support of the Ministry of Land, Infrastructure, Transport and Tourism. Japan
DGNB	German Sustainable Building Council. Germany
Eco Effect	Royal Institute of Technology (KTH). Sweden
EcoProfile	Norwegian Building Research Institute (NBI). Norway
Eco-Quantum	IVAM. the Netherlands
Envest 2	Building Research Establishment (BRE). UK
Environmental Status Model (Miljostatus)	Association of the Environmental Status of Buildings. Sweden
EQUER	Ecole des Mines de Paris, Centre d'Energetique et Procedes. France
ESCALE	CTSB and the University of Savoie. France
GBTool 2005	iiSBE, International Initiative for a Sustainable Built Environment.
Green Globes	Green Building Initiative for green building design, operation and management. USA
Green Start	GBCA, Green Building Council of Australia. Australia
Green Start NZ	NZGBC, New Zealand Green Building Council. New Zealand
GRIHA	The Energy and Resources Institute. India
HKBEAM	Beam Society. Hong Kong
LEED	U.S. Green Building Council. USA
LEGEP	University of Karlsruhe. Germany
NABERS	Department of Environment and Heritage (DEH). Australia
PAPOOSE	TRIBU. France

present great cost benefits playing a key role in a green project (Yudelson, 2008). Building information models have been used in the early stages to analyze consumption, and to evaluate sustainability of architectural design. Optimization models have helped in the selection of materials to meet a rating system requirement, among other benefits.

There is clear potential to apply an environmental monitoring framework to any construction and operation of a project that has ongoing environmental impact. The development of a sustainable rating system would contribute a potentially useful tool for assessing the impact of different technology options in oil sands and heavy oil projects.

3.2.3 Regulations for Canadian Operations

In Canada, oil sands and heavy oil projects are monitored closely for compliance with regulations and standards.

Regulatory agencies include both provincial and federal governments (depending on the jurisdiction). Even before a project is approved, an extensive scrutiny process takes place including the participation of ordinary citizens and other intervenors in a public hearing. At the provincial level, the main regulators in Alberta are: (1) Alberta Environment (AENV), (2) the Energy Resources Conservation Board (ERCB), and (3) Alberta Sustainable Resource Development (ASRD). At the federal level, regulators include: (1) Environment Canada (EC), (2) the Department of Oceans and Fisheries, and (3) Transport Canada (OSDG, 2009a). A licence to operate stipulates performance requirements above and beyond general regulations and standards. Even though Canadian oil sands and heavy oil projects operate within some of the most stringent and comprehensive environmental standards and regulations, they mainly focus on three resources: water, land, and air.

The Oil Sands Developers Group (OSDG) (2009b) describes the different regulators by resource: [1] The air resource is regulated by multiple authorities in the areas of air emissions and ambient air quality, and includes: ERCB, Canadian Council of Ministers of the Environment (CCME), and AENV, among others. Emissions and air quality are also monitored by the Wood Buffalo Environmental Association (WBEA) [2]. The land resource presents challenges on its own: oil sands reclamation challenges are unique in the world (e.g., liquid tailing, pit lakes), and so the reclamation guidelines developed for the oil sands and heavy oil projects in Alberta are unique, and no exact equivalents can be found elsewhere in the world. Any regulatory approval requires participation in reclamation research through the Cumulative Environmental Management Association (CEMA) or the Canadian Oil Sands Network for Research and Development (CONRAD). The primary regulatory agencies are EC and ASRD. [3] Water resources are monitored by the Regional Aquatics Monitoring Program (RAMP), and regulated by AENV and the Department of Fisheries and Oceans (DFO), among others.

3.3 Knowledge Gaps to Be Filled

Having the means to assess the environmental impact of oil sands and heavy oil projects is crucial to support developers in finding more environmentally friendly processes, and to go beyond simply demonstrating their compliance to regulations. This is necessary when stakeholder expectations change, or when there is lack of agreement between developers and stakeholders. Some groups oppose any oil sands development, and there is no consensus on how oil sands development should be done. Reports in the media and from Environmental Non-Governmental Organizations (ENGOs) are at times highly critical of oil sands projects, not only on the grounds of the environmental performance but also perceptions of long-term negative impacts on the environment and on human health.

A communication problem does exist between the industry and the public in general: the industry is unable to effectively communicate to the community its efforts to minimize environmental impact and the results accomplished by investing in technology to make effective use of natural resources with reduced impact compared to previous methods. Other factors may contribute to communication problems: (1) there is not enough public knowledge of the comparison between past and recent environmental performance and achievements made by the industry, (2) the public is not familiar with current environmental performance monitoring, (3) there is a lack of public knowledge of environmental regulations and practices, and (4) technologies and processes in place and new technologies under development are not well known. Ecosystem dynamics and effects on human health are very complex, and so local correlation may not have any causal relationship; but it is very difficult to refute a claim of a causal relationship between a health issue and industrial development. Persistence of an environmental impact is not well understood. A short-term impact that naturally recovers to a self-sustaining ecosystem may be acceptable in the long term. Determining whether reclamation (artificial or natural) results in a return to equivalent environmental capability requires clear definition and long-term monitoring to agreed measurement criteria.

The lack of common definitions and understanding of impacts aggravates the communication issue. This is an argument for establishing straightforward and effective measures of sustainability for the oil sands and heavy oil projects. These measures can be found through structured analysis of large hydrocarbon projects using common definitions. Oil sands and heavy oil projects have yet to take advantage of any of the systematic benefits that a sustainable rating system can provide; but there has been progress. Industry associations are attempting to develop common definitions and standards by which environmental performance can be assessed, and to move beyond ad hoc approaches. A rating system can facilitate this process by supporting owners, contractors, government, and the public in general throughout a project life cycle.

3.4 Sustainable Rating System Development Methodology

The development of the WA-PA-SU project sustainability rating system is an eight-stage process:

(1) Understanding oil sands and heavy oil projects' structure and their environmental regulations and standards.

(2) Considering the role of project management in the integration of design, planning, execution, and operations into green and sustainability practices.

(3) Using environmental and sustainable assessment tools as part of the development of the sustainable rating system.

(4) Creating the sustainable rating system structure (subdivisions, areas of excellence, and criteria).

(5) Using rating systems as EIA performance tools.

(6) Developing the rating system scale and CWT based on five criteria: energy consumption, GHG emissions, water and terrestrial impact, relevance in the project, and investment (Quantitative Assessment).

(7) Obtaining industry and expert feedback to generate consensus.

(8) Verifying the sustainable rating system through a case study.

A sustainable rating system goes beyond standards and regulations. The main objective is to accomplish excellence in environmental performance, not to meet government and environmental agency requirements; however, these have been included in the design of the weighted rating scale, since a company must meet legal requirements as a minimum condition for maintaining its operating licence. While oil sands and heavy oil projects may be developed around the world the sustainable rating system development focuses on Canadian processes and practices, mandatory regulations imposed by government and non-government organizations, and non-compulsory internal and external standards, requirements, processes, and procedures.

Existing sustainable rating systems do not consider environmental management to be sufficiently relevant to have management processes as criteria, nor do they allocate many points for project management in the rating scale. In this respect, ratings are more outcome-based than process-based, which ignores the established concept that management—the planning phase in particular—is the basis for the success of a project. The rating system methodology looks at the significance of management in delivering excellence in environmental performance. Some areas included to support the relevance of management in green and sustainable projects are: [a] integration of sustainability and project management, [b] implication of integrated design in different phases of the project planning, execution, and operation, and [c] role of management in green and sustainable decision making processes. One example of management's role is justifying additional capital costs on more sustainable materials and practices for a project on the basis of long-term returns.

Environmental and sustainable assessments have been used around the world and across almost every industry (Fischer, 2007; Gibson, Hassan, Holtz, Tansey, & Whitelaw, 2010; Therivel, Wilson, Thompson, Heaney, & Pritchard, 1992; Dalal-Clayton & Sadler, 2008). In addition, environmental risk management has also become relevant in the assessment of environmental performance (Pritchard, 2000). Conceptual challenges are encountered at this stage of development: uniqueness of the oil sands and heavy oil projects, complexity of processes and procedures, and geographical location of projects. The development of a sustainable ratings system must take these aspects into consideration to integrate the accurate environmental assessment tool into the weighting scale, to pre-assess the projects for a preliminary structure of the sustainable rating system, and to apply an appropriate existing environmental assessment process (or consider developing one) to address the specific assessment requirements of oil sands and heavy oil projects. Three areas are part of the environmental and sustainable assessment: energy consumption, GHG emissions (e.g., carbon dioxide, water vapour, methane, and ozone), water and terrestrial impacts, and/or relevance factor. These three factors are considered when developing or adjusting existing sustainable and environmental assessment tools to the needs of the sustainable rating system.

Sustainable rating systems use various forms of categories and classification to differentiate the requirements for a specific area, or resources and criteria that fall under them. This structure consists of: [a] Project phase, in which identified criteria are classified according to which project phase it follows under (e.g., planning, construction, operation); [b] Subdivisions of the project. , which divides the project into different areas to easily manage the complex and distributed project information, classify the criteria, and facilitate the applicability of the sustainable rating system; [c] Areas of excellence, which are groupings that make logical sense for the system, and which align with frameworks for managing the project and its ongoing operations, with each subdivision of the project containing the areas in which criteria follows under; and [d] Criteria, which are identified according to three factors related to sustainability: energy consumption, GHG emissions (e.g., carbon dioxide, water vapour, methane, and ozone), and/or sustainability relevance factor, and then classified and allocated under each subdivision, area of excellence, and project phase.

Implementation of a sustainable rating system usually encounters challenges. To highlight benefits and potential contribution to the industry, government, society, and environment, a series of ongoing activities are planned to gauge the alignment of a rating system with current practices related to assessing environmental and social impact, to introduce the sustainable rating system to practitioners, to engage government agencies (such as AENV) and non-government organizations, and to conduct informal interviews with members of industry associations and other groups.

The first part in this stage is to develop a rating scale. According to the number of points allocated to a project by meeting the different criteria, which includes environmental standards and regulations, the green and sustainable level will be designated. A comparative study is considered, taking into consideration other sustainable ratings systems presently used around the world. Decision making theories and mathematical models are applied when designing the rating system scale. Going from one level to another in the rating scale requires developing a theoretical model. Ease of implementation and alignment with business processes will be considered, but these implementation issues do not drive the selection of criteria.

The second part in this stage consists of the development of a CWT. Different sustainable rating systems use weighting scales as a tool to allocate points to each criterion. The allocation of the points to each criterion is critical. The proposed principle of the CWT is based on considering four main criteria to allocate points: relevance of the criterion to the project, GHG emissions, water and terrestrial impacts, and energy consumption.

One of the most difficult challenges faced by the sustainable rating system development will be encountered during its validation process, for several reasons. Due to the magnitude of the oil sands and heavy oil projects, it is nearly impossible to persuade the industry to implement the sustainable rating system without substantial evidence of its utility. Due to the time frame required to determine whether project decisions have positive or negative long-term impact, short case studies would not collect enough information to prove the rating system benefits. A qualitative approach to verification of the method can be taken through surveys or interviews to obtain feedback on different aspects of the ratings system, such as: [a] structure, [b] practicality and viability, [c] the credit weighting points tool, [d] the rating scale, [e] sub-divisions, areas of excellence, and criteria, and [f] the future of the rating system and willingness to implement it.

The consistency of the sustainable rating system can be evaluated and tested by using available public data for existing projects, even though they are not following a decision-making process based on the system. Since there are no parameters for comparison with other rating systems (because of the lack of sustainable rating systems for oil sands and heavy oil projects), expert opinions and environmental studies results of existing projects is compared with the results obtained using the WA-PA-SU project sustainability rating system. This comparative approach should highlight areas for improvement. Based on the results obtained during a verification process, the sustainable rating system structure will be modified if necessary, and criteria weighting will be adjusted. According to the results obtained in this stage, the rating scale proposed in stage six is assessed and/or verified.

3.5 Discussion

The WA-PA-SU project sustainability rating system has been conceived to contribute to more SD of oil sands and heavy oil projects, by assisting with the implementation of enhanced strategies to enhance positive environmental, health, economic, and social impacts from project developments.

Following the model of other sustainable ratings systems developed for buildings, such as LEED, the sustainable rating system is designed to allow adjustment for changes in regulations, market demands, and requirements, processes, and procedures (within and external to the owner/operator company). Another relevant characteristic of the sustainable rating system consists of the potential to be adapted to other industry sectors or jurisdictions.

The development of the WA-PA-SU project sustainability rating system is based on the applicability of the benefits already identified in the implementation of existing sustainable ratings system for buildings. These benefits are expected in the areas of economic contribution, productivity, risk management, health, public relations, employee recruitment and retention, and other areas (Yudelson, 2008).

Considering the challenges that oil sands and heavy oil projects are facing, their potential to deliver positive benefits while mitigating negative effects, and the contributions and benefits that a sustainable rating system possesses, there would likely be great benefit to having a project sustainability rating system that project stakeholders can endorse and use.

The development of the sustainable rating system consists of eight different stages, which have been identified and take into account the relevance, environmental requirements, limitations of owners and constructors, limited availability of information, and expectations of the stakeholders of the projects in question.

Future work will focus on developing appropriate criteria with measures that will be accurate, simple to measure, and having weighting scales that are appropriate and relate as much as possible to established decision-making (such as having decision aligned with business units). Specific topics for future work are:

(1) Establishing a structure consisting of a) the project life cycle phases that the sustainable rating system will support (e.g., planning, construction/execution, operation, etc). b) different subdivisions due to size and complexity into which the project will be divided, and c) areas of excellence in which the different criteria fall;

(2) Developing the CWT, the rationale and mathematical model behind the allocation of credits points will be discussed;

(3) Setting the rating scale and criteria, which will be classified according to project life cycle phases, area of excellence, and subdivision, and

(4) Conducting a case study to verify the process for using the rating system, and to understand how measurements should be made for validation of the weightings.

The results of this future work will be published as they develop.

The WA-PA-SU project sustainability rating system is intended to act as a bridge amongst all parties to work with a common goal in mind: to make large industrial projects, such as oil sands and heavy oil developments, more sustainable for the benefit of Canadian society, its economy, and the environment.

4. Chapter Four – A Rating System for Sustainability of Industrial Projects with Application in Oil Sands and Heavy Oil Projects: Areas of Excellence, Sub-Division, and Management Interactions[3]

4.1 Introduction

Rating systems have been very successful in influencing design and operation of buildings in more sustainable ways. This approach can be applied to other types of built environment, such as the development, operation, and close-out of heavy industrial facilities. The construction industry, including architecture and engineering practices, has been revolutionized by the implementation of sustainable rating systems, compelling practitioners to examine the effects of project work from a broader perspective than merely meeting a narrow set of technical specifications and a budget (Yudelson, 2008). The transformation of the building market reflects a growing public awareness of environmental matters, beyond what is regulated as a matter of public policy. Stakeholder expectations have also evolved in oil sands and heavy oil development. There is growing recognition by owners and operators oil sands and heavy oil projects that the environmental and social impacts of these projects require just as much planning and stewardship as economic performance and compliance with regulations. While the buildings industry can use a wide variety of environmental assessment tools or sustainable rating

[3] A version of this chapter has been published. Poveda & Lipsett 2011. Journal of Sustainable Development. 4(4): 3-13.

systems, the oil and gas industry lacks the necessary tools to assess the overall SD performance of the projects.

The building industry worldwide has developed a number of rating systems. BREEAM was established in 1990 in the UK (BREEAM, 2009). This was followed by several others, including the LEED 1 pilot in 1998 (USGBC, 2007). Environmental assessment tools have been designed to meet the requirements of the construction industry (e.g., buildings); and they can be used to assess building components, whole building frameworks, and whole buildings. Different types of buildings can be assessed: existing buildings, new buildings, refurbishment of a building, and building product/component. According to building use, assessment tools can be classified for residential buildings, office buildings, and other applications, such as healthcare and education. Specialized sustainable rating systems have been designed as the industry recognizes the applicability and benefits, for example LEED for Neighbourhood Developments.

Among the users of the sustainable rating systems are engineers, architects, constructors, consultants, building products fabricators, owners and/or investors, government and non-government authorities, and researchers. Haapio and Viitaniemi (2008) included in their study six phases of a building life cycle: production of material and components, construction, use/operation of building, maintenance, demolition, and disposal (recycling, landfill, incineration for energy recovery, etc). Most rating systems users employ the sustainable rating system throughout the project life cycle, but some focus on specific areas, for example, building product fabricators, who contribute to only part of the entire cycle.

Designing a new sustainable rating system in a new application area involves considerations of how to implement a practical system, which goes beyond enumerating a set of technical issues to how decisions are made. In a large industrial application, decision influencers come from different stakeholder groups, not just the client and neighbours who may be affected by the introduction of a new building. Since the WA-PA-SU project sustainability rating system is the first of its kind it faces several challenges, mainly because the primary focus of the tool is projects in oil sands and heavy oil. Buildings are a sub-division of such projects; and existing sustainable rating systems focus on environmental performance of buildings. In large industrial projects, the major expected environmental impacts occur in areas of the projects beyond buildings; and a sustainable rating system has not yet been developed for these other areas.

Because of the type of buildings, the different users, and the project life cycle phases supported by the sustainable rating systems, different interested parties have become involved since rating tools have been applied. Government organizations, non-governmental agencies, and research groups have contributed through experience and development of new technology. Moreover, Technical Committee (TC) 59 and Subcommittee (SC) 17 of the key Standardization (ISO) is currently working in defining standardized requirements for the environmental assessment of buildings (ISO, 2006a; 2006b; 2007; 2008; 2010a); the Technical Committee (TC) 350 of European Committee for Standardization (CEN) is developing a voluntary standardized methods for the assessment of the sustainability aspects of new and existing construction works and for standards for the environmental product declaration of construction product (CEN, 2009a; 2010a; 2010b; 2010c); and Committee B/558 of British Standards Institution (BSI) is developing a set of standards on sustainability of building construction (BSI, 2007a; 2007b; 2010).

Rating systems can be categorized. Trusty (2000) describes the “Assessment Tool Typology” introduced by ATHENA institute which has three levels: Level 1, product comparison tool and information sources; Level 2, whole building decision support tools; and Level 3, whole building assessment framework or systems. The International Energy Agency (IEA) Annex 31 grouped the tools in two main categories: interactive software and passive tools. IEA Annex 31 (2005) explains that environmental assessment tool should truly measure factors having environmental impact, easily adapt to specific buildings and locations, quickly rank results, and be transparent in their assumptions.

Challenges experienced during development and implementation of other sustainable rating systems are being taken into consideration to design a tool that meets the needs of the oil sands and heavy oil project owners, operators, and stakeholders. Although most sustainable rating systems support the users in each of the described phases of the project life cycle, the WA-PA-SU project sustainability rating system also includes the phases of project planning and design, by defining criteria to meet environmental regulations and standards. These two phases are critical for the success of the projects, because specifications defined during project development link to the points that are allocated to each criterion in the rating system. In this way, the project plan can ensure that the project can satisfy the criteria in the rating tool.

Stakeholder expectations, industry type, and project size are some of the criteria considered to develop the WA-PA-SU project sustainability rating system structure. This structure consists of phases of the project life cycle, areas or sub-divisions of the project, and areas of excellence related to economic, environmental, and social performance. As described above, the tool is applied over time, from the planning stage through to project decommissioning and closure. The complexity and scale of a project makes it necessary to subdivide the project in two ways: according to processes (e.g., mining process, in-situ process) and engineering areas (e.g., permanent housing/buildings, roads). This differentiation leads to nine areas or subdivisions within a project. Ten areas of excellence are also defined, according to the natural resources that are affected by a project. These areas of excellence will be discussed in the following section.

4.2 Areas or Categories of Excellence

Each sustainable rating system uses different areas of environmental impact, categories of interest, and strategies for analysis and decision-making processes. The structure varies according to the developer of the particular tool.

In the construction industry, two of the most recognized environmental assessment methodologies – that is, sustainable rating systems - are BREEAM and LEED (Inbuilt, 2010). BREEAM operates in dozens of countries and more than 200,000 buildings have obtained the required score to be certified under one of the five categories: pass, good, very good, excellent or outstanding (DGBC, 2010). BREEAM uses eight categories to address environmental issues: management, health & well-being, energy, transport, water, materials & waste, land use & ecology, and pollution. LEED has presence in over 90 countries with 2,476 certified projects and 19,524 registered projects (USGBC, 2009d). LEED addresses five key areas/categories: SS, WE, EA, MR, and IEQ. ID and Innovation in Operations (IO) were added in the latest version of LEED. Additional areas or categories are used in specific LEED rating systems. Examples include location & linkages (LL) and awareness & education (AE) in LEED for homes, and smart location & linkage (SLL), neighborhood pattern & design (NPD), and green infrastructure & building (GIB) in LEED for neighborhood development (USGBC, 2011b; 2011c).

The WA-PA-SU project sustainability rating system takes into consideration the resources involved in project development, stakeholder expectations, and potential environmental, economic, and social impacts; these three general facets of the project comprise ten areas of excellence: project & environmental management excellence (PEME); site & soil resource excellence (SSRE); water resource excellence (WRE); atmosphere & air resource excellence (AARE); natural & artificial lighting excellence (NALE); energy resource excellence (ERE); resources &

materials excellence (RME); innovation in design & operations excellence (IDOE); infrastructure & buildings excellence (IBE); and education, research & community excellence (ERCE). Each of these areas is described below.

[a] Project & Environmental Management Excellence – PEME

Effective management is critical to project performance and sustainability, because management practices have an impact throughout the project life cycle, in activities such as planning, commissioning, construction, operations, etc. The PEME area of excellence considers management focus areas, including (but not limited to) commissioning practices, targets for operational improvement, EMS, environmental risk management, employee retention, documentation & manuals, and PPP implemented at the top level of management.

[b] Site & Soil Resource Excellence – SSRE

Project site and soil resources have impacts on the three areas of the foundation of sustainability: economy (e.g., costs related to man-made infrastructure), environment (e.g., destruction and restoration of wildlife habitat), and society (e.g., protection of diverse animal and plant species as people seek connections with their natural surroundings and with each other). A number of related aspects are considered: effective use of areas (e.g., brownfield site), transportation, site design, ecological enhancements, stewardship of existing ecological features, handling of storm water, pollution mitigation, erosion prevention, etc. The interaction between project and site, and the impact that the project has on the ecosystems and other resources, are part of developing a more sustainable site. The key goals of the SSRE area of excellence are to promote responsible site development & soil management, and to minimize environmental, social and economic impacts on different ecosystems.

[c] Water Resource Excellence – WRE

As development expands in a region, the consumption of water increases and the available water supply may decrease. Oil sands and heavy oil projects require industrial and potable water to operate. While a significant amount of water is needed for industrial processes, potable water is also required to meet the needs of buildings systems and the occupants. The operation of oil sands and heavy oil projects impacts rivers, lakes, and other water sources in the neighborhoods of the area of operation. Produced water from deep geological features may be saline and inorganic compounds. Production may lead to contamination of some water inventories with process chemicals (such as surfactants), metals & metal salts, organic compounds, other chemicals, and waste from the plant. The WRE objectives range from optimizing water consumption to preventing water contamination in the open environment.

[d] Atmosphere & Air Resource Excellence – AARE

The operation of oil sands and heavy oil projects entails a certain level of air pollutants: carbon monoxide, carbon dioxide, nitrogen oxides, ozone, sulphur oxides, and particulate matter (PM). High levels of air contaminants have direct effects on the environment (e.g., acid rain and vegetative stress) and humans (e.g., respiratory health issues). While the quality of the air is monitored where industrial processes occur (e.g., mining processes and surroundings), other areas of the projects to be considered include indoor air quality (e.g., buildings). AARE aims to monitor, control and minimize air quality pollutants.

[e] Natural & Artificial Lighting Excellence – NALE

While 20% to 50% of total the energy consumed by an average building (e.g., home and offices) is due to lighting (Hawken, Lovins, & Hunter, 1999), buildings are a relatively small component of oil sands and heavy oil projects capital, material usage, and energy-related expenditure. Different components of the projects use considerably different amounts of artificial lighting (indoor and outdoor). For instance, mining operations require spot lighting in some parts of the operation, and refinery facilities are lit so that operators and maintainers can do check equipment checks and maintenance safely. The availability of natural light changes with the time of year. The principles of NALE are to reduce the use of artificial lighting, maximize natural lighting across the projects, and monitor and control lighting quality.

[f] Energy Resource Excellence – ERE

GHG emissions are directly linked to energy consumption, especially in facilities that are powered by fossil fuels. Carbon dioxide, methane, ozone, water vapour, and nitrous oxides are the most abundant GHGs in the atmosphere. Large industrial operations and buildings are among the larger consumers of energy. For policymakers, energy is an economic and environmental issue that impacts the development of projects, from the earliest stages of planning and commissioning. To meet its objectives, ERE addresses energy management, energy demand, energy efficiency consumption, energy performance, and renewable energy throughout the project life cycle.

[g] Resources & Materials Excellence – RME

This area of excellence considers not only the raw materials used and but also the embodied energy used to develop the elements in the different facilities that comprise an oil sands or heavy oil project. Due to the different equipment and systems of these projects, the range and amount of materials used has a direct impact on the environment, economy, and society. RME focuses on the waste management strategy of reducing, reusing, and recycling to minimize waste. Among the range of materials that can be employed, RME considers materials with low embodied energy, regional materials, use of sustainable resources, renewable materials, and life cycle impacts.

[h] Innovation in Design & Operations Excellence – IDOE

The success of an industry relies on the ability to improve its processes and procedures through technological innovation and changes in business practices. Implementing these changes brings economic and environmental benefits, along with an impact on society. IDOE motivates practitioners to find efficient and effective alternatives for delivering their projects. Aligning proactive approaches to sustainability with industry goals is the main objective of IDOE.

[i] Infrastructure & Buildings Excellence – IBE

Complex projects are composed of a variety of equipment with associated infrastructure, such as buildings, bridges, roads, piping, and utilities. Oil sands and heavy oil projects are no exception. All elements of each structure in the project must work in harmony and as an integrated whole to deliver project requirements, as well as to achieve sustainable goals and excellence in environmental performance. Most infrastructure impacts specific resources (e.g., soil or water) while affecting the structure as a whole. The intent of this area of excellence is to monitor elements that affecting the functionality of the project infrastructure are to minimize any negative environmental and social effects.

[j] Education, Research & Community Excellence – ERCE

The engagement of different stakeholders is crucial for successful SD of oil sands and heavy oil projects. Companies have been putting increasing effort into effective engagement with regional stakeholders. This area of excellence mainly addresses the societal element of a project, and linking impacts to the other two pillars of sustainability: economy and environment. ERCE focuses on the involvement of the community, with education, training, and research programs.

4.3 Sub-Divisions

Evaluation of a project generally requires assessment of elements of the project. Existing rating systems are mostly for environmental assessment of an entire building, or for product comparison and information resources.

The type of buildings supported by each rating system differs. LEED and BREEAM developed different versions for a variety of building types. LEED Accredited Professional program is integrated by a number of specialties, divided in five main categories: [1] Green Building Design & Construction (LEED for New Construction and Major Renovations, LEED for Core & Shell Development, LEED for School, LEED for Healthcare, and LEED for Retail New Construction); [2] Green Interior Design & Construction (LEED for Commercial Interior and LEED for Retail Interiors); [3] Green Building Operation & Maintenance (LEED for existing Buildings: Operations & Maintenance); [4] Green Neighborhood Development (LEED for Neighborhood Development); and [5] Green Home Design & Construction (LEED for Homes) (USGBC, 2011b; 2011c).

BREEAM offers a wide range of tools to assess the environmental performance of any type of new or existing building. For common buildings, BREEAM developed standard versions. Other types of buildings are assessed against tailored criteria using the Bespoke BREEAM version. BREEAM has different versions for courts, retail stores, offices, schools, prisons, healthcare facilities, industrial plants, multi-residential buildings, and other specialized buildings (DGBC, 2010; BREEAM, 2010).

Other rating systems also specialize in environmental assessment of buildings; in fact, buildings have been the main focus of the green building revolution. Even though buildings are a component of the oil sands and heavy oil projects, they do not originate the main economic, social, and in particular environmental impact.

Due to the complexity of oil sands and heavy oil projects, the WA-PA-SU project sustainability rating system methodology divides a project into ten different sub-divisions: project integration, provisional housing/buildings, permanent housing/buildings, roads, oil transportation &

storage, mining process, in-situ process, upgrading & refining, and shutdown & reclamation. A direct relationship exists between the areas or categories of excellence and these sub-divisions, as illustrated in Table 4.1. The assessment criteria follow under each area or category of excellence, depending on the relevant sub-division. When evaluating the sustainability contribution of a particular aspect of a project, credit cannot be claimed more than once, if the value has been accrued by implementing the requirements within a different subdivision(s).

[a] Project Integration considers PPP, regulations, processes, procedures, and other information that concerns the project as a whole. Other sub-division criteria are subsidiaries of the project integration sub-division criteria. In case of confusion as to whether the value of a part of a project belongs in one sub-division or another, the project integration criteria prevail and are the base for clarification in case of synergies and/or trade-offs.

[b] Provisional Housing/Buildings include mobile homes, temporary buildings or any other structure for a purpose of human living or offices. Mobile homes are usually built off-site, and so green standards during installation, operation, and demobilization must be met by the supplier. Temporary building and other structures are built with similar standards as permanent housing/buildings, yet their life cycle period is typically shorter. The provisional housing/building sub-division also includes structures outside the project limits. Developing companies also operate in areas in which the operation phases of the projects have not yet started (e.g., exploration). Also included are community programs that require construction of temporary living accommodations.

[c] Permanent Housing/Buildings are designed and built for durability. Long-term structures for human habitation, offices and meeting places, parking and green areas, and walkways located close to permanent structures are included in this sub-division. As in the provisional

Table 4.1 Relationship between sub-divisions and areas or categories of excellence

1.Project Integration	2. Provisional Housing/Buildings
1.1 Project & Environmental Management Excellence – PEME	1.1 Project & Environmental Management Excellence – PEME
1.2 Site & Soil Resource Excellence – SSRE	1.2 Site & Soil Resource Excellence – SSRE
1.3 Water Resource Excellence – WRE	1.3 Water Resource Excellence – WRE
1.4 Atmosphere & Air Resource Excellence – AARE	1.4 Atmosphere & Air Resource Excellence – AARE
1.5 Natural & Artificial Lighting Excellence – NALE	1.5 Natural & Artificial Lighting Excellence – NALE
1.6 Energy Resource Excellence – ERE	1.6 Energy Resource Excellence – ERE
1.7 Resources & Materials Excellence – RME	1.7 Resources & Materials Excellence – RME
1.8 Innovation in Design & Operations Excellence – IDOE	1.8 Innovation in Design & Operations Excellence – IDOE
1.9 Infrastructure & Buildings Excellence – IBE	1.9 Infrastructure & Buildings Excellence – IBE
1.10 Education, Research & Community Excellence – ERCE	1.10 Education, Research & Community Excellence – ERCE
3. Permanent Housing/Buildings	**4. Roads**
1.1 Project & Environmental Management Excellence – PEME	1.1 Project & Environmental Management Excellence – PEME
1.2 Site & Soil Resource Excellence – SSRE	1.2 Site & Soil Resource Excellence – SSRE
1.3 Water Resource Excellence – WRE	1.3 Water Resource Excellence – WRE
1.4 Atmosphere & Air Resource Excellence – AARE	1.4 Atmosphere & Air Resource Excellence – AARE
1.5 Natural & Artificial Lighting Excellence – NALE	1.5 Natural & Artificial Lighting Excellence – NALE
1.6 Energy Resource Excellence – ERE	1.6 Energy Resource Excellence – ERE
1.7 Resources & Materials Excellence – RME	1.7 Resources & Materials Excellence – RME
1.8 Innovation in Design & Operations Excellence – IDOE	1.8 Innovation in Design & Operations Excellence – IDOE
1.9 Infrastructure & Buildings Excellence – IBE	1.9 Infrastructure & Buildings Excellence – IBE
1.10 Education, Research & Community Excellence – ERCE	1.10 Education, Research & Community Excellence – ERCE
5. Oil Transportation & Storage	**6. Mining Process**
1.1 Project & Environmental Management Excellence – PEME	1.1 Project & Environmental Management Excellence – PEME
1.2 Site & Soil Resource Excellence – SSRE	1.2 Site & Soil Resource Excellence – SSRE
1.3 Water Resource Excellence – WRE	1.3 Water Resource Excellence – WRE
1.4 Atmosphere & Air Resource Excellence – AARE	1.4 Atmosphere & Air Resource Excellence – AARE
1.5 Natural & Artificial Lighting Excellence – NALE	1.5 Natural & Artificial Lighting Excellence – NALE
1.6 Energy Resource Excellence – ERE	1.6 Energy Resource Excellence – ERE
1.7 Resources & Materials Excellence – RME	1.7 Resources & Materials Excellence – RME
1.8 Innovation in Design & Operations Excellence – IDOE	1.8 Innovation in Design & Operations Excellence – IDOE
1.9 Infrastructure & Buildings Excellence – IBE	1.9 Infrastructure & Buildings Excellence – IBE
1.10 Education, Research & Community Excellence – ERCE	1.10 Education, Research & Community Excellence – ERCE
7. In-situ Process	**8. Upgrading & Refining**
1.1 Project & Environmental Management Excellence – PEME	1.1 Project & Environmental Management Excellence – PEME
1.2 Site & Soil Resource Excellence – SSRE	1.2 Site & Soil Resource Excellence – SSRE
1.3 Water Resource Excellence – WRE	1.3 Water Resource Excellence – WRE
1.4 Atmosphere & Air Resource Excellence – AARE	1.4 Atmosphere & Air Resource Excellence – AARE
1.5 Natural & Artificial Lighting Excellence – NALE	1.5 Natural & Artificial Lighting Excellence – NALE
1.6 Energy Resource Excellence – ERE	1.6 Energy Resource Excellence – ERE
1.7 Resources & Materials Excellence – RME	1.7 Resources & Materials Excellence – RME
1.8 Innovation in Design & Operations Excellence – IDOE	1.8 Innovation in Design & Operations Excellence – IDOE
1.9 Infrastructure & Buildings Excellence – IBE	1.9 Infrastructure & Buildings Excellence – IBE

Table 4.1 Relationship between sub-divisions and areas or categories of excellence (cont'd)

1.10 Education, Research & Community Excellence – ERCE	1.10 Education, Research & Community Excellence – ERCE
9. Shutdown & Reclamation	**10. CO2, SOx & Other GHGs Capture Storage**
1.1 Project & Environmental Management Excellence – PEME	1.1 Project & Environmental Management Excellence – PEME
1.2 Site & Soil Resource Excellence – SSRE	1.2 Site & Soil Resource Excellence – SSRE
1.3 Water Resource Excellence – WRE	1.3 Water Resource Excellence – WRE
1.4 Atmosphere & Air Resource Excellence – AARE	1.4 Atmosphere & Air Resource Excellence – AARE
1.5 Natural & Artificial Lighting Excellence – NALE	1.5 Natural & Artificial Lighting Excellence – NALE
1.6 Energy Resource Excellence – ERE	1.6 Energy Resource Excellence – ERE
1.7 Resources & Materials Excellence – RME	1.7 Resources & Materials Excellence – RME
1.8 Innovation in Design & Operations Excellence – IDOE	1.8 Innovation in Design & Operations Excellence – IDOE
1.9 Infrastructure & Buildings Excellence – IBE	1.9 Infrastructure & Buildings Excellence – IBE
1.10 Education, Research & Community Excellence – ERCE	1.10 Education, Research & Community Excellence – ERCE

housing/buildings, these structures may be located outside of the project limits, but must link to the project in some way.

[d] Roads are classified in three ways. Primary roads are main thoroughfares built and maintained by government agencies (e.g., highway # 63, highway # 881); secondary roads connect the projects with primary roads; and tertiary roads are located within the project limits. Technical requirements vary for each type of road, and minimum standards will be mandated by regulation and operating licenses. The roads sub-division includes roads built and maintained by developing companies, which usually involves only secondary and tertiary roads. The WA-PA-SU project sustainability rating system includes in its assessment the roads in which the developing companies participate in construction and/or maintenance of any kind.

[e] Fluid Transportation & Storage consists of the multiple pipeline systems within the project. Pipelines are used to transport bitumen-rich slurries prior to separation, and to transport bitumen, condensate, and oil products to other locations. Pipelines are also used to transport produced solids for storage and eventual reclamation. Oil storage usually occurs in tanks, generally above ground close to the upstream production facility and where any upgrading process occurs. Stored oil is transported to end users or further storage facilities using pipelines or road tankers.

[f] Mining Process and other related processes to recover bitumen by removal of overburden from an oil sands deposit are included in this sub-division. Current mining methods are based on shovels to fragment and load the ore onto trucks which transport the ore to a slurrying facility, where the oil sands are mixed with hot water and reagents to promote bitumen separation in a centralized extraction plant. Following bitumen separation, a hydrocarbon diluents is added to improve the bitumen quality by removing water and solids. The mining process sub-division includes the processes to the point in which dry bitumen can be transported to an upgrader, and the handling of non-product materials stored in settling basins and engineered tailings structures.

[g] In-situ Process uses drilling to access and produce hydrocarbon, and does not leave behind large tailings ponds after recovering the bitumen. This process is used for heavy oil production, and for bitumen that is too deep for economical surface mining and is in a favourable geological formation, typically with cap rock to prevent loss of formation pressure, typically from deposits at depths of 350-600 meters below the surface. Current processes include CSS, SAGD, VAPEX, cold heavy oil production with sand (CHOPS), and others (Kelly, 2009). This sub-division includes processes and equipment to the point at which heavy oil or diluted bitumen can be transported for upgrading. Among others aspects in this sub-division, reduced energy consumption and prevention of long-term contamination of aquifers are key SD objectives.

[h] Upgrading & Refining processes occur separately from upstream production of heavy oil and bitumen. The bitumen from the oil sands is thick and viscous with deficiency in hydrogen. The upgrading process balances the product by either removing carbon or adding hydrogen, to produce lighter hydrocarbon products with higher economic value than the original feedstock. The upgrading process also removes contaminants, such as sulphur, nitrogen, heavy metals, and salt. Upgrading comprises three basic processes: [1] hydroprocessing to convert the residuals and asphaltenes by coking or hydro-conversion, possibly with solvent deasphalting; [2] distillation to separate products with different boiling points; and [3] hydrotreating to add hydrogen to improve product quality (Speight, 2009). As well there are other processes to remove contaminants that would affect the quality of the SCO. The downstream refining process transforms upgraded bitumen or SCO into usable petroleum products. Heavy oil and bitumen are typically used as feedstocks for transportation fuels (diesel, gasoline, butane, kerosene, and jet fuel).

[i] Reclamation & Closure are the activities that occur after the wells or mining pits have been exhausted. Some equipment is mobile and reusable in other operations, and other equipment can be scrapped and recycled. Reclamation restores terrestrial and aquatic ecosystems to the state of equivalent environmental capability to the original ecosystems that were present before the industrial activity took place. The reclamation process differs depending on the process that took place (e.g., mining process, in-situ process), and may include restoration of pits at mine sites, removal of infrastructure, capping of tailing impoundments, construction of landforms, and long-term monitoring for geotechnical stability and viability of engineered ecosystems as they transition to naturally sustaining ecosystems.

[j] CO2, SOx & Other GHGs Capture and Storage refers to those structures built to minimize, control, and/or monitor the emissions of GHGs and other air contaminants substances. These structures can be located in or outside of other sub-divisions.

4.4 Management Interactions

The success of the WA-PA-SU project sustainability rating system and achievement of its objectives depends on its interaction with different levels of management within the project and operating organization. As a decision-making support tool, the rating system must support an oil sands project or heavy oil projects throughout the project life cycle, which will include the project management processes, groups existing in internal projects (i.e., sub-projects), and process life cycles. Management is divided into three levels within the rating system: project, fundamental, and operational, as illustrated in Figure 4.1 Criteria for gauging their effectiveness in delivering sustainable business performance involve all three levels.

[a] Project Level: Project Life Cycle. Alberta Energy (2009b) divides an oil sands project into four stages. Stage 1 is comprises the resource assessment and rights and exploration phases, to estimate the recoverable reserve for a potential project. Stage 2 involves project development, project approval, and construction. Stage 3 is operating the plant, which generates sales and royalties. Stage 4 closes the project through reclamation activities and closure. During the life cycle of the oil sands and heavy oil projects, a series of internal projects (that is, sub-projects) and processes occur. These sub-projects and process align with the PPP of a project. The developing company may have a stake in more than one project as part of its strategy. Subsequently, different project management processes are applied; but not all of them take place in each sub-project or process, either in the same order or degree of rigour. Even though every project is unique, oil sands and heavy oil projects have similar phases and deliverables, albeit with varying duration of each phase and quantity of deliverables.

[b] Fundamental Level: Project Management Processes Groups. Since each developing company manages projects in a specific way, the WA-PA-SU project sustainability rating system implements rating criteria based on standard management practices, which are generic to any project. The Project Management Institute identifies five project management processes groups: initiation, planning, executing, monitoring

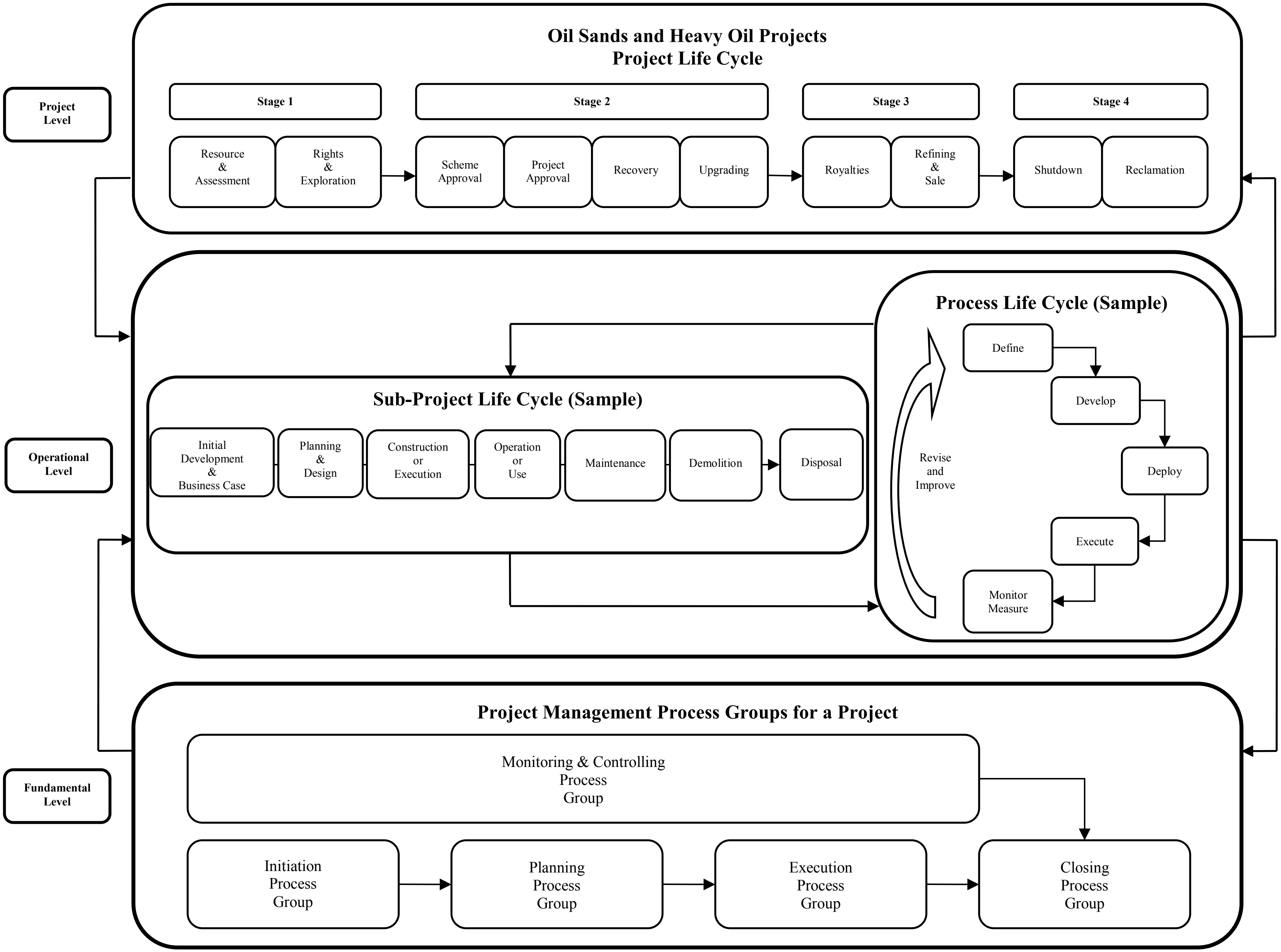


Figure 4.1 Interaction amongst project, fundamental, and operation levels for the oil sands and heavy oil projects

and control, and closing (PMBok, 2008). “A project phase is not a project management process group” (PMBok, 2008). Each project or sub-project process or phase is aligned and connected to facilitate coordination and to increase the probability of project success. The activities occurring in a project management process group affect decisions and actions taken in other groups. In oil sands and heavy oil projects, some processes are iterated several times and others have long durations. Differentiation is made as the processes are applied to the project level or operational level.

[c] Operational Level: Sub-Projects Life Cycle and Processes Life Cycle. Development of an oil sands project or heavy oil project consists of a series of endeavours categorized in sub-projects and processes. Sub-projects such as building construction are projects on their own, which occur within the main project. Some processes in a project repeat themselves numerous times, especially during the operational stage. Sub-projects and processes use the project management groups to organize, direct, and execute the activities within their respective scope. The interaction between the operational level and fundamental and project level is critical to minimize negative impacts and to maximize the positive outcomes expected in the project. Communication channels are an effective support tool to reduce interferences amongst different sub-projects and processes.

[d] Criteria. A direct relationship exists amongst the three management levels (e.g., project, fundamental, and operational) and criteria for a rating system. Each area of excellence contains a series of criteria which are classified according to the sub-project or process phase, and where and when it occurs in the overall project. Figure 4.2 shows an example of a sub-project life cycle - the life cycle of a building - and its associated criteria. Each area of excellence examines sub-projects and processes to determine the different criteria. Criteria use acronyms to differentiate between each other; for example, ERCEP&D3xx refers to certain criteria (xx) that belong to sub-division three (3) for the education, research, and community excellence area (ERCE) during the planning & design (P&D) phase.

4.5 Conclusions

The design of the WA-PA-SU project sustainability rating system considers the three components of sustainability: economy, social, and environment. As every project has a certain level of environmental impact, it is recognized that not every project has the same level of social and economic impact. Sustainability principles and different types of impacts define the WA-PA-SU project sustainability rating system as a transparent verification process to assist companies in demonstrating SD performance during project life cycle through the implementation of enhanced strategies to mitigate environmental and social impacts while delivering economic benefits.

Air, water, and land are the three main resources related to operations and environmental impact of oil sands and heavy oil projects; however, there are also other resources to consider. The ten areas of categories of excellence in the WA-PA-SU project sustainability rating system revisit not only the resources that are potentially environmentally impacted by the projects, but also social and economic areas that contribute to SD. Resources and materials used during construction and operation of an industrial project are included due to the impact throughout their life cycle. Research, education, community involvement, and innovation are among the areas that contribute to the success of a project, and yet they are not commonly measured or included in a sustainability rating system. People, planet, and profit are all considerations when assessing the viability of a project.

The different sub-divisions included in the WA-PA-SU project sustainability rating system align with different phases included in oil sands and heavy oil projects. Certainly, most of the sub-divisions refer to sub-projects in the construction, operation, and close-out stages; but the

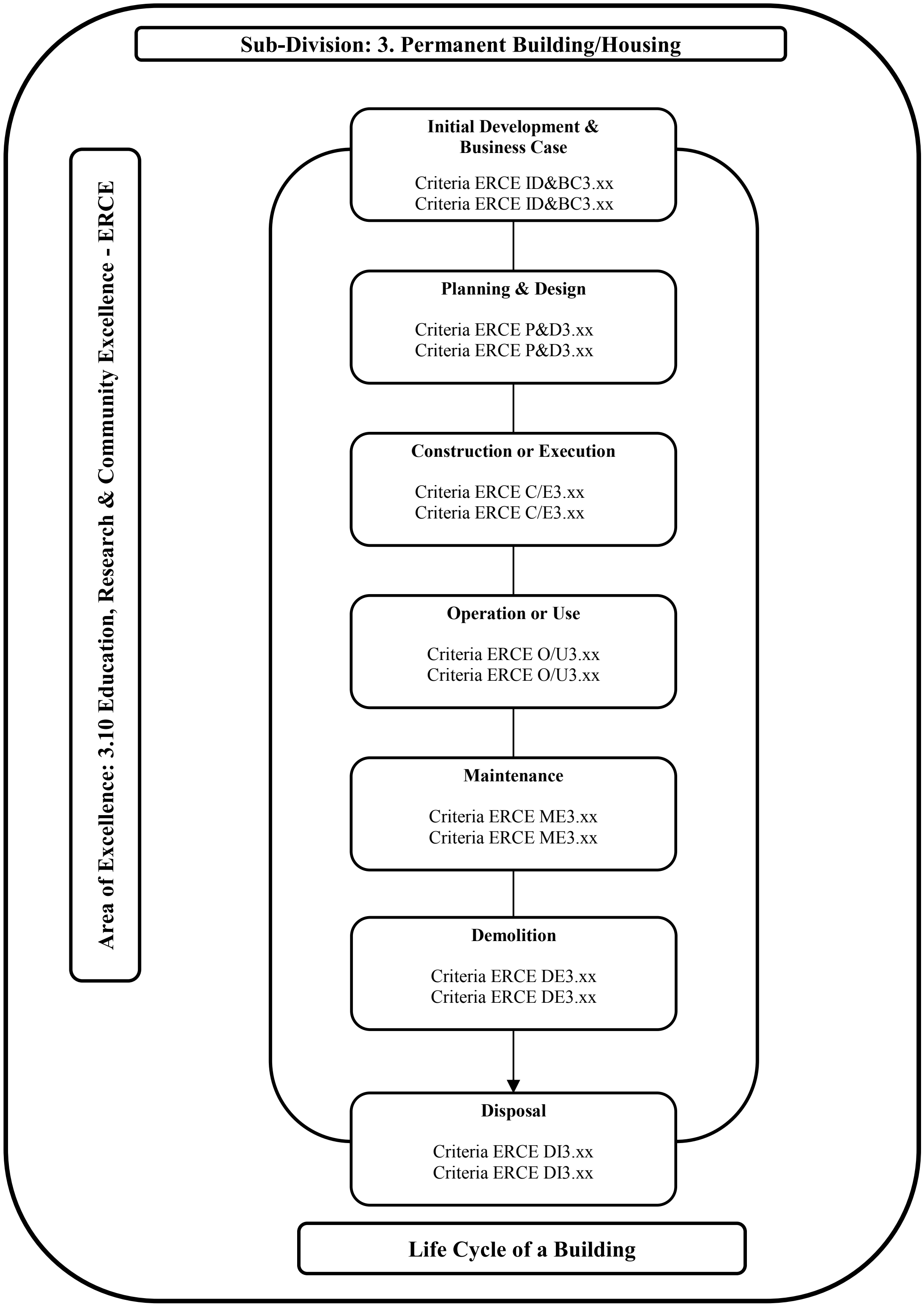


Figure 4.2 Relationship amongst areas of excellence, subdivision, project life cycle and criteria

project integration sub-division includes criteria that refer to the initial project development. The main objective behind each sub-division is to support the sub-projects and processes of an overall large project throughout their life cycle, which means that each phase of an oil sands project or heavy oil project (or an expansion) is supported by the tool as well. Each sub-division is intended to be independent and contains specific criteria according to the social, economic, and environmental goals; however, they are not in fact completely separate. For this reason, integration management ties up the other eight sub-divisions, so that projects work in harmony and synergistic aspects of a project can be captured and evaluated.

As different areas or categories of excellence and sub-divisions work together to avoid overlapping and negative synergies, management also acts in a coordinated fashion. The structure of the WA-PA-SU project sustainability rating system is meant to help management to apply appropriate criteria in different project contexts, whether it is a project management process, execution of a sub-project, operating a process, or delivering a project phase. This interaction assists different parties to meet the goals of the organization, while being able to steward to SD targets.

This proposed framework can be used to develop specific criteria for each element within a sub-division and area of excellence, in each stage of a large industrial project. These criteria should be as objective as possible, and- to the degree possible – should not duplicate data collection that the company does for its own business purposes and for regulatory reporting. The decision process should be as open and transparent as possible, so that results are verifiable and less prone to interpretation. This transparency is important, because the implementation of the WA-PA-Su project sustainability rating system requires engagement of all parties that are involved in a large industrial project, from developing companies and contractors, through government officials and regulators, to community & regional stakeholders. The approach used in the design and development facilitates data collection and interpretation of each criterion, without leaving out any important facet of the project impact (whether positive or negative). Work remains to be done to develop a rational method to compile an overall score for a project's sustainability. But the success of a rating system depends on the trust that the different parties have in the assessment tool, as much as in the approach for generating the assessment.

5. Chapter Five – The Canadian Oil Sands: Environmental, Economic, Social, Health, and Other Impacts[4]

5.1 Introduction: oil and gas resources

With continued growth in emerging economies around the world, the global oil demand has steadily grown over the past 20 years from 60 to 88 million MMbpd (CAPP, 2012a). Crude oil is not only one of the most traded commodities in the world, but also one of the most volatile; the commodity is influenced by a variety of factors that produce fluctuations in oil prices, thereby affecting supply and demand.

Production of oil and gas is classified as either conventional or unconventional: unconventional oil is extracted or produced using techniques other than the conventional oil well method. Since the sources of conventional oil are in decline, efforts are turning to unconventional reserves to meet the growing demands; however, unconventional oil production carries not only some extra monetary extra costs, but also a bigger environmental footprint. Moreover, conventional oil is easier extract, and creates fewer GHG emissions than unconventional oil production (CAPP, 2012a).

Conventional oil is either light or heavy, depending on its consistency (API [American Petroleum Institute] gravity). Light oil can flow naturally to the surface or be extracted using pumpjacks (i.e., the oil well method). Extraction techniques for conventional oil have been used for decades; therefore, certain acceptable levels of efficiency in the extraction process have been accomplished, with incremental improvements in

[4] A version of this chapter has been published. Poveda & Lipsett 2013. Sustainable Development and Planning VI. 575-587.

enhanced oil recovery. In contrast, development of efficient techniques for unconventional oil production. takes high levels of investment and considerable time; however, producers and developers recognize the necessity of optimizing extraction techniques, not only to increase production but also to reduce their environmental footprint.

The IEA reports different sources of unconventional oil and gas: oil sands-based synthetic crudes and derivative products, oil shales, coal-based liquid supplies, biomass-based liquid supplies, and liquids arising from the chemical processing of natural gas (IEA, 2012). Out of these unconventional oil sources, oil sands is at the top of the list, because the amount of proven reserves is very large, and the largest deposits are located in stable geo-political regions (e.g., Canada).

Canadian energy production has almost doubled since 1980 due to the rapid development of the proven oil sands reserves in the province of Alberta. As of 2010, Canada produces 1.22 MMbpd of conventional oil, 1.5 MMbpd of oil sands, and 14.7 billion cubic feet per day of natural gas, making Canada part of the global crude oil markets (IEA, 2012). In fact, Canada's richness in oil and gas resources can be measured based on its global presence: it is the third largest producer of natural gas, the fifth largest energy producer, and the largest producer of crude oil with the biggest deposits of oil sands in the world (CAPP, 2012b).

The oil and gas industry in Canada is currently present in 12 of its 13 provinces and territories. In global oil reserves, Canada places third, following Venezuela and Saudi Arabia; however, the scenario is promising if feasible oil sands deposits in the province of Saskatchewan change from the non-proven to the proven reserves category.

Unconventional oil and gas extraction and production from any of the different sources raises a variety of concerns. Social, economic, health, and especially environmental impacts are expected; however, finding a balance among the three pillars of sustainability offers a feasible sustainable path. The primary affected pillar of sustainability noticed by stakeholders refers to environmental impacts; in unconventional oil and gas extraction and production, those impacts of major concerns include waste management, use of chemicals and energy, and air pollutions (e.g., GHG emissions). Major concerns arise due to the large amounts of mildly hazardous tailings and waste in the mining process during oil extraction and production. In addition to the concerns in light oil production, heavy oil requires the use of heat to pump the product out of the ground. Exploration of oil shale raises questions regarding net unit energy production efficiency and carbon dioxide emissions, in addition to oxides and pollutants and the use of chemicals mixing with underground water. Similarly, oil obtained from coal or natural gas produces large amounts of carbon dioxide.

Environmental impacts are not the only concerns related to unconventional oil and gas extraction and production; however, the general first impression of government, developers, local communities, and stakeholders regarding SD refers to that specific pillar of sustainability (i.e., environmental). Social, economic, and health impacts involving the development of unconventional oil (e.g., oil sands) can be equally, if not more, relevant than those affecting the environment, as they are interconnected.

5.2 The Canadian Oil Sands

Put simply, oil sands are an unconsolidated mixture of sand, clay and/or other minerals, water, and bitumen; therefore, the extracted product must be treated before it can be used by refineries to produce usable fuels. Even though oil sands deposits can be found around the world, including Russia, Venezuela, the United States, and Colombia, Canada possesses not only the largest deposit in the world, but also the most developed, as advanced technology is used in the production process.

While Alberta’s oil sands proven reserves are currently stated to be

178 billion barrels, the estimated total volume of bitumen in place is 1.6 trillion barrels (Alberta EUB, 2004). The 178 billion of barrels can be recovered with current technology, and would be sufficient to meet the Canadian crude oil demand for approximately 250 years. The current developed area of the Canadian oil sands concentrates in three main areas (i.e., Peace River, Athabasca, and Cold Lake) located in the Province of Alberta; however, the development will eventually be extended to the Province of Saskatchewan. Surpassing Canada's conventional oil production, the production for Alberta's oil sands is approaching 1.7 MMbpd (Honarvar, Rozhon, Millington, Walden, & Murillo, 2011a; 2011b). And because a combination of unique factors—large untapped reserves, a stable political environment, and openness to investment in an environment of high oil prices (CBoC, 2012)—Canada is expected to be the fourth largest oil producer by 2035.

The rapid development of the oil sands, which appears to be exponential, has raised major concerns for different sectors of society. Although Albertans recognize the economic benefits of the oil sands development, environmental, social, and health impacts that may be present in each phase of the life cycle are not to be ignored by those directly affected. These projects have grabbed not only national but also international attention.

The oil sands resource life cycle, as shown in Figure 5.1, starts with the assessment of prospects and ends with a reclamation process, which consists of leaving the exploration and production areas as equally productive (or equivalent environmental capability) as they were before their use. Independent of the extraction method utilized—surface mining or in-situ—companies proposing a development go through similar project approval processes, which generally include public consultation and a variety of required studies. The major impacts are encountered in the processes of recovery, upgrading, and refining: Canada's oil sands

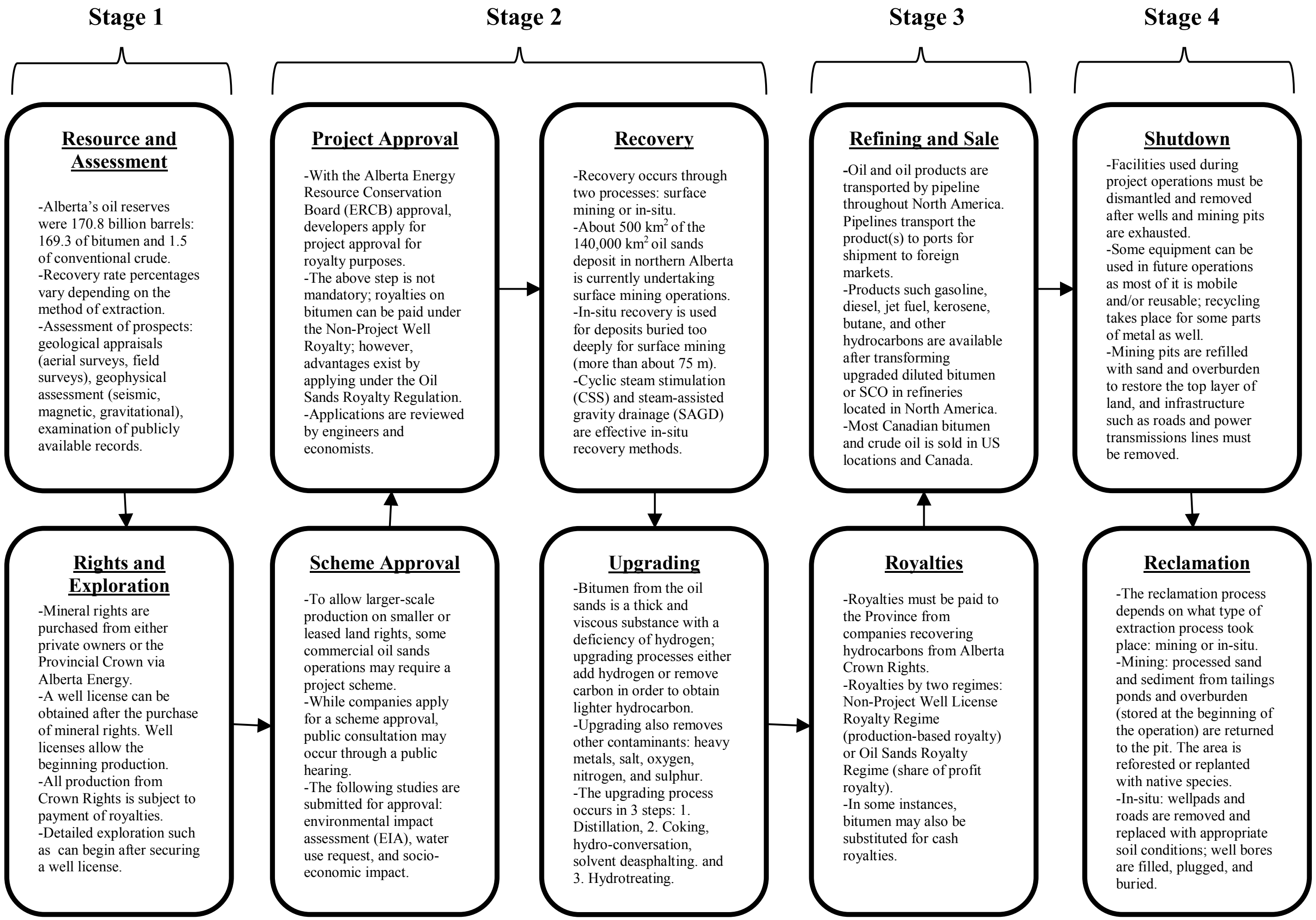


Figure 5.1 Oil sands resource life cycle

projects (extraction, upgrading, and distribution to downstream refineries) require multi-billion-dollar infrastructure, for which construction, operation, and maintenance affects primarily uninhabited land as well as local and Aboriginal communities.

5.3 Sustainability: The Triple Bottom Line

Before 1987, when the Brundtland Commission (formally known as the World Commission on Environment and Development [WCED]) defined SD, the movement did not enjoy major support, and its origins can be debatable. Since then, the development of sustainability assessment tools has faced unprecedented growth, and sustainable strategies have grabbed the attention of public and private organizations and stakeholders in general.

In Canada, the concept of SD has been integrated into federal government policies, programs, and legislation; however, provincial and territorial governments are key partners in the development of projects in a sustainable manner (NRCan, 2011a; UN, Undated).

Canada's oil sands are not only an unconventional oil and gas resource, but also a non-renewable resource for which exploration, extraction, and production challenge the different stakeholders' ability to meet the needs of the present without compromising for the needs of future generations. As social, economic, environmental, and health impacts occur during the development of the oil sands, a sustainable path consists of finding the balance to different stakeholder needs, which are influenced by the different positive and negative impacts encountered in any of the three pillars of SD (i.e., social, economic, and environmental).

Interdependency and balance between impacts and gains (benefits) is meant to be understood by observing the graphic representation of SD which is usually shown using 3 mutually intersected circles. Gibson, Hassan, Holtz, Tansey and Whitelaw (2010) describe the fundamentals of sustainability as a mindset where "economic imperatives rule, social arrangements are judged by how well they serve the economy, and the biosphere (environment) is treated mostly as a source of resources." But economic factors are major drivers in the decision-making process (Gosselin, Hrudey, Naeth, Plourde, Therrien, Van Der Kraak, & Xu, 2010).

The balance between impacts and gains is influenced by perception and subjectivity. While environmental impacts are usually observed as negative, economic impacts place on the other side of the spectrum. Subjectivity refers to factors like priorities and emphases, which level of confidence stakeholders and experts have regarding the feasibility and sufficiency of certain approaches, and what makes the list of priorities and considerations to meet the needs of policy and project activities (Gibson et al., 2010). Oil producers are advertising in public media to emphasize that economic benefits are not regional, but rather national.

Economic impacts are mostly interpreted as positive. Negative environmental impacts are obvious, but progress is being made on reducing energy intensity and disturbed land footprint (although with additional projects the overall rate increases). Social impacts, for the most part, are uncertain and immeasurable due to subjectivity and qualitative factors. Health impacts unpredictable, as some effects may appear long after the exposure to contaminants, and demonstrating the illness and source linkage needs credible and reliable evidence resulting from scientific intervention.

5.3.1 Environmental Impacts

The rapid development of the oil sands has increased the pressure on Alberta's natural environment. The total area of Alberta's oil sands covers 140,200 km2. To date, about 715 km2 of land have been disturbed by surface mining activities, and up to 1.25 percent of Alberta's boreal forest could potentially be disturbed, although not permanently (Alberta Energy, 2012a).

The World Resources Institute (WRI) (Undated) reports well-documented environmental impacts of mining: presently [mining] is the primary method of oil sands extraction with 53% of the total production in 2010 and the other 47% using in-situ methods; however, only 20% of the oil sands is recoverable through mining, while approximately 80% is recoverable by in-situ processes (Alberta Energy, 2012a). While the WRI reported impacts make reference to mining in general, Alberta's oil sands are not excluded from facing similar challenges: waste management issues (sedimentation, acid drainage, metal deposition), impacts on biodiversity and habitat, indirect impacts, and poverty alleviation and wealth distribution. Furthermore, environmental impacts involving the oil sands development can be divided into impacts on land, air, and water resources.

As part of the land management and reclamation program and Alberta's legislation, disturbed lands must be productive again; therefore, companies must remediate and reclaim such areas meeting AENV's strict standards guaranteeing the land can support activities similar to its previous use. Currently, only 67 km2 of disturbed land have been reclaimed but not certified, which indicates less than 10 percent of the total disturbed area (EC, 2009). Moreover, Gosseling et al. (2010) report on reclamation and adequacy of financial security, underlining that reclamation is not keeping with the pace of development, and "current practices for obtaining financial security for reclamation liability leave Albertans vulnerable for major financial risks" (Gosselin et al., 2010).

Impacts on air as a resource are one of the major worries for government, developers, local communities, and other stakeholders. More than 1,400 known pollutants are emitted by oil sands operations, but only a few are monitored: sulphur oxides (SOx), nitrogen oxides (NOx), hydrocarbons, and fine PM (PM2.5) (Gosselin et al., 2010). Even though the Canadian oil sands projects have reduced their carbon dioxide emissions intensity by up to 33 percent since 1990, their contribution to the Canadian GHG emissions (GHGs) account for 6.5 percent of the nation's total, and less than 0.1 percent to the world's total GHG emissions. Additionally, the GHG emissions per barrel have been reduced between 1990 and 2009 by an average of 29%; however, emissions of (SOx) and other sulphur compounds (NOx), as well as total hydrocarbons, have been rising for the past decade due to the growing increments in production (Gosselin et al., 2010). AENV measures the cleanliness of outdoor air, also known as ambient air, through the Air Quality Index (AQI), which includes the measurement of concentration of five major air pollutants: carbon monoxide, nitrogen dioxide, ozone, sulphur dioxide, and fine PM. In reference to air quality, the Royal Society of Canada (RSC) concluded that there has been minimal impact from the oil sands, except for noxious odour emissions, over the past two years (Gosselin et al., 2010). However, odours can only be assessed subjectively, using trained observers.

In 2009, 90 facilities in Alberta reported that their combined GHG emissions equalled 113.1 megatonnes in carbon dioxide equivalent (Mt of CO2e [equivalent carbon dioxide]). About 41.9 Mt of CO2e are emissions from oil sands facilities: 26.9 Mt of CO2e are from the oil sands mining and upgrading, and 15 Mt of CO2e are from in-situ projects' facilities. In 2011, oil sands production emitted an estimated 80 million tons of CO2 (Salameh, 2012). The production and upgrading of the oil sands are more energy-intensive than the production of conventional oil; as a result, higher GHG emissions are expected. However, if considering the complete life cycle, which includes the refinement, transportation, and consumption of oil, 80 percent of the total emissions occur at the end of the cycle (consumption) from burning fuel. Nevertheless, the new levels of bitumen production create challenges for Canada to meet international commitments for overall GHG emissions reduction, which the current technology does not resolve (Gosselin et al., 2010).

Water consumption, contaminants emissions, and groundwater quality and quantity are three of the major concerns in reference to water resources. Water consumption in the oil sands development projects varies based on whether the extraction method utilized is in-situ or surface mining. In mining operations, 2.5 to 4 barrels of water is used for every barrel of bitumen produced; however, up to 90 percent of the water utilized is recycled, and as a result, only 0.5 barrels of water is needed to make up for the deficit (Alberta Energy, 2012a). As for surface mining operations, 7.5 to 10 barrels of water is used per barrel of bitumen, but the recycle rate is currently up to 70 percent, translating to 3 to 4.5 barrels of water to make up for the deficit to maintain production (Alberta Energy, 2012a).

Almost all of this water is captured in the pores of tailings deposits, produced in the process of separating bitumen from the oil sands. Inventories of hydrocarbon-contaminated water are impounded in earth dams or in mined-out pits. Untreated water is not to be released to water bodies off the mine site. Oil sands tailings comprise water, sand, clay, residual bitumen, and chemicals, which includes small amounts of polycyclic aromatic hydrocarbons (PAHs), naphthenic acids, heavy metals, and mineral ions. The functions of the ponds are to provide a disposal area for coarse and fine tailings, to allow water to separate from solid waste materials, to store water from recycling, and to hold contaminants (EC, 2009). Even though new technologies have emerged for improving tailings management, these have not stopped the growing inventory of tailings ponds.

An additional factor in water management refers to groundwater quantity and quality. Not only concerns about the RAMP have been raised, but also the regional cumulative impact on groundwater quantity and quality has not been assessed (Gosselin et al., 2010).

5.3.2 Social Impacts

If sustainability is still in its infancy, then the social dimension is the youngest of the three pillars; however, it is not less relevant than the other two (economic and environmental). Based on the equality factor, the three dimensions are interchangeably relevant, and a sustainable path translates to a balance between the three dimensions. The social dimension of SD is subjective, qualitative, difficult to assess, and involves stakeholders' diverse views on the issues; but it is recognized that social impacts occur at different social scales involving individuals, families, businesses, community groups, communities as a whole, ethnic groups, cultures, and broader society (UN, Undated). Individuals will identify with some or all of these divisions.

Social impacts are, as expected, linked to other types of impacts such as health. In the Athabasca region, the health indicators are consistent with the "boom town" effect. Small towns suddenly face rapid growth, which affects communities' health and social infrastructure. Gosselin et al. (2010) indicate that the Government of Alberta has recognized some of the shortfalls due to the rapid population growth caused by the accelerated pace of the oil sands development; however, there is no evidence of addressing the serious population health issues. In fact, it has been recognized that better understanding is needed about the social impacts of development on some Alberta regions (e.g., Forth McKay, Fort McMurray), including demographic information regarding population changes, migration, and the impact of migration patterns (such as labour force statistics and income statistics) (Shipley, 2005).

Even though the lack of statistical data makes it difficult to assess the different impacts, concerns have been raised by Aboriginal and local communities, including the influx of non-Aboriginal people onto traditional lands, the loss of traditional resources due to development, the level of migration of people to local communities, the outward migration of First Nation and Métis communities due to lack of housing, and the loss of traditional culture. Additionally, Shipley (2005) highlights some effects of the oil sands development on education: funding conditions, infrastructure costs, staff recruitment and retention, and the effectiveness of adult education programs and their barriers.

Additional concerns have been raised due to the use of industrial camps. Because of the size of the oil sands development and the large number of personnel required to build, operate, and maintain the projects, developers often use industrial camps to allocate personnel, rather than relying on housing in the community (which has a very low vacancy rate). This type of allocation generates a series of additional concerns, including but not limited to the increased potential of forest fires, recreational pressure on the environment, safety (primarily the increased number of vehicles on local roads), and the potential destruction of sacred sites (Shipley, 2005).

Social impacts are expected to occur as the development of the oil sands projects goes on; however, in order to mitigate and/or eliminate the impacts, the first step towards a SD consists of assessing the impact, followed by monitoring the programs. The main challenge encountered in achieving the assessment and monitoring the social impacts revolves around the fact that scientists and industry seem to be facing a major obstacle regarding two main questions: what should be measured (e.g., indicators), and how should they be measured (e.g., metrics). Government, developers, local communities, and other oil sands stakeholders are not exempt from stumbling upon similar issues.

5.3.3 Economic Impacts

As one of the largest development projects in Canada's history, the cumulative investment in oil sands in the past decade alone has surpassed \$100 billion (2010 CAD\$)[5] (CBoC, 2012). However, any discussion of the future and current economic impacts of Alberta's oil sands development is based on a series of assumptions and constraints,including (1) that the current announced project will proceed, (2) the size of the initial, remaining, and new established reserves, and (3) the current project will keep and/or increase production. The economic impacts (benefits) of Alberta's oil sands may differ from study to study based on the assumptions, constraints, and methodology used; however, findings always point toward a series of positive economic impacts instead of negative, as presented in some statistics ahead. Most studies measure economic impacts (therefore, the terms “positive” or “benefits” are used) in terms of changes in three major indicators: GDP, employment and labour income, and government revenue (Honarvar et al., 2011a; 2011b; Timilsina, LeBlanc, & Walden, 2005). Naturally, any major development of a resource with large reserves (e.g., unconventional oil) of national and/or international interest has inherently positive impacts on major economic indicators (e.g., GDP, employment, revenue); however, “real” (negative) impacts on the average citizen may be overlooked in the decision-making process, with the aim of giving the “green light” to development projects.

The analysis of the economic impacts of the oil sands must not only take into consideration current operations, but also those projects that have grabbed the attention of government, stakeholders, and the public in general, related to transport of hydrocarbon products from oil sands projects: TransCanada’s Keystone XL Pipeline; Enbridge’s northern Gateway Pipeline from Bruderheim, Alberta to the port of Kitimat, British Columbia; and Kinder Morgan’s Trans Mountain Pipeline system’s northern Leg expansion to Kitimat, British Columbia.

Over the 2010-2035 period for different scenarios, the estimated investment, reinvestment, and revenues from the operation of the oil sands projects range from $2,197 to $4,783 billion (Honarvar et al., 2011b). The $4,783 B estimate is reached with the assumption that announced oil sands projects will go ahead and pipelines will be built to get the product out. While all provinces in Canada are affected by the development of the oil sands, Alberta carries the highest positive economic impact of all, followed by Ontario, British Columbia, Quebec, and Saskatchewan, respectively (CBoC, 2012).

Honarvar et al. (2011a; 2011b) offer an analysis of the economic impacts of the oil sands development under these different scenarios over the 25-year period:

- The total Canadian GDP impact as a result of the investment shocks is estimated to range from $2,283 to $4,925 billion.

- Canadian employee compensation can range from $650 billion to $1,417 billion.

- Employment creation, including direct, indirect, and induced, is expected to grow from 390,000 up to 1,600,000 jobs in 2035 if the best scenario presents.

- Alberta royalties may grow from $3.56 billion to $65.2 billion.

Additionally, the US market is expected to be economically impacted by the oil sands development:

- US GDP impacts as a result of the investment shocks is estimated to range from CAD$210 to CAD$775 billion.

- US employee compensation can range from $100 billion to $68 billion.

- US employment, including direct, indirect, and induced, is expected to grow from 80,000 up to 600,000 jobs in the best of the scenarios.

The lower range value in each case represents the economic impacts of existing operations and those that are still under construction. The top range value assumes that all the announced oil sands projects will go ahead, and pipelines will be constructed with adequate capacity to move the product. Existing pipeline export capacity is at 3.5 MMbpd of crude oil, and in the best scenario, the capacity will increase up to 7 MMbpd.

Although still positive, the Conference Board of Canada (CBoC) presents a slightly different employment forecast through a detailed supply chain analysis. $364 billion in price-adjusted investment is expected for the next 25 years, which will support 3.2 million person-years of employment in Canada (880,000 person-years of direct employment) (CBoC, 2012).

Not everything regarding economic impacts of the oil sands is positive, and even though economic impacts mostly sound positive due to high levels of cash flow as a consequence of the rapid development of the project, there is another side of the coin. Shipley (2005) discusses negative impacts, which include the cost of living as impacted by development. This translates into suitable accommodation for new residences, affordable and comfortable homes for regional residents, and the ability to attract and retain employees. Additionally, concerns regarding housing include increased costs of building material, increased costs and scarcity of tradespersons, high building and maintenance costs, and high costs of rental property, which affect those with low-paying jobs.

5.3.4 Health and Other Impacts

Similar to other impacts, the oil sands development projects' impacts on health require rigorous monitoring. Though some effects on health are measurable in the short term, other impacts affecting local communities may not appear until after several years have passed.

For those health indicators that are monitored in the Regional Municipality of Wood Buffalo (RMWB), the majority of those indicators show poorer levels than other Alberta regions and the provincial average. Based on current levels of monitoring, there is not credible evidence of environmental contaminant exposures causing elevated human cancer rates; however, rigorous monitoring is needed to find the causes and to address the concerns of First Nations and other communities (Gosselin et al., 2010). Additionally, public health cannot be limited to exposure to environmental contaminants, since there are other health indicators to assess major negative effects on local communities. Health impacts are tightly linked to other impacts (e.g., environmental and social); therefore, finding the link between cause and effect becomes a priority in areas of rapid development (e.g., the Athabasca region [Alberta]) to effectively, rapidly, and efficiently mitigate and/or eliminate the risks.

In addition to economic, social, environmental, and health impacts, Alberta's oil sands development carries other potential impacts due to disruption to ecosystems and local communities. The oil sands projects require access to land, other natural resources such as water, and subsequent land development to accommodate the needs for the execution, operation, and maintenance of the projects, not only during construction but also during operations and decommissioning.

In addition to conflicts between different land users that may arise, Aboriginal and local communities may oppose the development of the projects. Government provides funding to address community needs and develops new regulations to address social concerns. Some stakeholders criticize that the regulations imposed by regulatory bodies are not stringent enough. Developing companies have implemented programs for stakeholder engagement to improve their relationships and obtain the so-called "social license." Furthermore, local communities in the role of "active" or "inactive" stakeholders are ready to act as issues concerning them arise.

A common worry amongst Albertans involves the equality factor. The oil sands resource results in not only provincial but also national economic growth. However, the benefits of mining are not always equally ("fairly") shared (WRI, Undated); the same feeling of "unfairness" is shared by some Albertans who believe that the resource belongs to the province, and it is argued that Albertans do not get their "fair" share from other industries/resources (e.g., fishing) existing in other provinces. This issue of fairness is felt in other regions, and it can affect inter-jurisdictional negotiations, such as conditions for British Columbia approval of the northern Gateway pipeline project.

5.4 Conclusions

Canada's oil sands are in an advantageous and unique position as the biggest deposit of unconventional oil and gas in the world. Conventional oil sources face not only the threat of scarcity, but also unequal geographic distribution of the remaining oil; therefore, unconventional oil sources have grabbed national and international attention. For most, the volume of the deposits has taken the back seat, since the current technology will enable 178 billion of barrels to be recovered and meet the Canadian demand for about the next 250 years. The attention has now shifted to improving technology involving the extraction of the remaining resource, and identifying and mitigating the increasing impacts (social, economic, and environmental) inherent in the exploration, extraction, and production processes of the resource.

Indisputable, varied impacts are expected with the development of large scale projects; the focus of government, developers, local communities, and other stakeholders is not only to mitigate and/or eliminate impacts, but also to find a balanced approach for social, economic, and environmental needs. The rapid development of the Canadian oil sands may have taken government and developers by surprise; such development is under pressure by oil importers who see Canada as an ally that brings a feasible energy resource alternative with considerably-sized deposits that are in the middle of a stable geo-political scenario.

Efforts made by government and developers towards mitigating and/or eliminating impacts are falling short from the standpoint of local communities, environmentalists, national and international watchdogs, and other stakeholders. Not only is the on-going assessment, monitoring, and reporting of performance required, but stakeholder engagement in decision-making and informing/educating the public is also essential to facilitate and benefit the process.

6. Chapter Six – Pre-selecting Sustainable Development Indicators (SDIs) for Surface Mining Operations in Oil Sands Projects[5]

6.1 Introduction: Sustainable Development Indicators (SDIs)

Local, regional, national, and international public and private organizations identify sustainability trends by using SDIs, which are also frequently applied to measure the effectiveness and efficiency of SD policies, businesses, and projects. The use of indicators facilitates the communication of positive and/or negative developments towards sustainability (EC, 2001; Bell & Mores, 2003); however, the use of SDIs is still in its infant stage (Bell & Mores, 2003; MacGillivray & Zadek, 1995). The design of SDIs differentiates between quantitative and qualitative indicators. These include areas that are not easily identifiable, and involve a variety of interested groups and stakeholders with specific expectations, socioeconomic needs, and political and external influences (Asher, 1995; Johnson, 1999). The objective of the measure defines the kind of indicators to be used, although quantitative indicators are more often applied (Gallopin, 1997). Moreover, the use of indicators and indices—which are a combination of indicators—prevails among other tools and methodologies to assess SD; however, in sustainability indicators development, the selection and specification of the reference condition or start up point is crucial (Gilbert, 1996). Here, a distinction between principles, criterion, and indicators deserves a closer look. Mendoza and

[5] A version of this chapter has been published. Poveda & Lipsett 2014. Surface Mining Operations in Oil Sands: Establishing Sustainable Development Indicators (SDIs).

Prabhu (2000), in their work describing the selection of criteria and indicators of sustainable forest management, define a principle [as] a fundamental truth or law as basis for reasoning or action, [a] criterion [as] a principle or standard that adds meaning and operationality to a principle without itself being a direct measure of performance, and an indicator [as] any variable or component of the relevant management system used to infer attributes of the sustainability of the resource and its utilization.

SDIs are designed to embody the different pillars of sustainability, the named environment, economy, and society. Although in the 60s and 70s, at the beginning of the SD movement, the main focus pointed to environmental issues, today the perspectives on sustainability have broadened to also emphasize the social dimension (EC, 2002). Furthermore, to design effective SDIs, the aspects of the essence of sustainability must be understood. These aspects include balanced development, equity and shared responsibility extended over time and space, and participation (Alkan-Olsson, Hilding-Rydevik, Aalbu, & Bradley, 2004). An extensive debate has raged over the economic, social, and environmental aspects of sustainability and how to achieve the best balance between them. A variety of tools and methodologies have been developed (Poveda & Lipsett, 2011c), but as more tools become available, the deepness of the debate increases. Several questions challenge society, policy-makers, scientists, and stakeholders: What should and should not be measured? How should those be measured? Who should participate? These questions, among other issues, remain open for debate and resolution. The answers to these and many other questions may still be far from resolved; however, the participatory process in the achievement of SD highly recommends the inclusion of stakeholders in determining what needs to be done and how (Guy & Kibert, 1998). It is contradictory to think of an effective stakeholder engagement in the development of sustainability indicators, as there is a weak involvement process of DMs in the initial setting of them, and an existing gap between the scientists or technically-oriented individuals and the DMs who dominate the socio-political arena (Clement & Hansen, 2001). Furthermore, the process for selecting criteria and indicators demands transparency in the decision-making process [8] and a methodology that differs from an ad hoc process, as these can lead to unwanted and unpopular decisions (McDonough, 1991; Shannon, 1987).

Alkan-Olson et al. (2004) emphasize designing SDIs that reflect the tight relationship and interconnection between economy, society, and environment, instead of having a "one-problem, one indicator" approach. In addition, the authors suggest the integration between different views of the world, SD, time, scale, and all the participants involved in the process. To accomplish such objectives, SDIs literature offers a variety of rules, considerations, and/or characteristics that the indicators should meet. Harger and Meyer (1996) describe the following considerations when generating a suitable list of environmentally sound and sustainable development (ESSD) indicators: simplicity, scope, quantification, assessment, sensitivity, and timeliness, while Alka-Olson et al. (2004) present a compendium based on SD literature suggesting that indicators should be specific, measurable, pedagogical, sensitive, reliable, based on accessible data, cost-effective, relevant, and usable. Hart (1999) evaluates the characteristics of indicators when developing sustainable communities, suggesting that indicators must: address the carrying capacity of community capital; be relevant; be understandable; be usable; show the links among the economy, environment, and society; focus on the long range view; advance local sustainability, but not at the expense of others; and be based on reliable and timely data. Additionally, the ISO presents a series of rules for establishing a system of indicators, and points out that under a specific system in some countries, a number of indicators are already covered by existing building regulations (ISO, 2011a).

Directly linked to the conceptual frameworks of the driving force-pressure-state model (DPS) and basic satisfaction, two main approaches are identified when deciding what a sustainable indicator should measure: target indicators and direction-defined indicators. Directed to policy-makers and DMs, the first types of indicators are designed with the aim of equalling a pre-determined target. Even though target-driving indicators are the most commonly used (Mitchell et al., 1995; Tschirley, 1997; Woodhouse, Howlett, & Rigby, 2000), the main weakness relies on the lack of a more proactive approach. Instead of defining a target, the second group of indicators are designed by selecting a predetermined direction that other indicators are expected to follow. Subjectivity is linked to these type of indicators, as there is no immediate association between the indicator and the action measured. Opschoor and Rejinders (1991) offer a different classification approach for environmental indicators: (1) environmental pressure indicators reflect the change in levels of use of environmental functions, and (2) impact indicators are used to express changes in the environment regarding quantity and quality over time. Independent of the classification used in developing SDIs, it is necessary to define the scale against which the target or changes can be measured, verified, and compared (Harger & Meyer, 1996).

6.2 Environmental, Economic and Social Impacts: Oil Sands, Heavy Oil, and Surface Mining Projects

Conventional oil extraction techniques differ from those used to extract bitumen; for that purpose, surface mining and SAGD are methods frequently implemented. Different impacts (social, economic, and environmental) do not take long to surface. Physical disturbance and indirect hydrological impacts are among the several expected consequences of the exploration and operations. Furthermore, land cover change, habitat fragmentation, and potential loss of diversity are expected due to disturbance of forest, wetlands, and river basin hydrology.

Environmental and social impacts of mining can be divided into waste management issues, impacts to biodiversity and habitat, indirect impacts, and poverty alleviation and wealth distribution, each of which are described below:

[a] Waste Management Issues: Larger quantities of waste are expected for open-pit mines than for underground mines. The pollution of water bodies often results from three primary factors: sedimentation, acid drainage, and metals deposition. In terms of sedimentation, disturbances change the characteristics of stream sediments (Johnson, 1997): higher sediment concentrations cause an increase of the turbidity of natural water, which decreases the available light for the photosynthesis process undertaken by aquatic plants (Ripley, Redmann, & Crowder, 1996); an increase in sediment loads impacts the food source, migration, and spawn of fish (Johnson, 1997b); and a decrease in the depth of streams results in an increased risk of flooding in times of high stream flow (Mason, 1997). Acid drainage impacts aquatic life, due to the fact that many fish are highly sensitive to acid water; in fact, some cannot breed at pH levels below 5, and others will even die if the pH level is less than 6 (Ripley et al., 1996). Metal deposition in large quantities is toxic; while small quantities of metals are essential for the survival of some species, heavy concentrations cause a decrease in animal and plant species.

[b] Biodiversity and Habitat: The impact of mining may be noticed far from the original mine site. The removal of vegetation alters the food availability and shelter of wildlife. Mine operation and oil development may impact ecosystems such as forests, wetlands and mangroves, mountainous and arctic environments, arid environments, and coral reefs.

[c] Indirect Impacts: Compared to other land use activities, mining projects are small and limited by the location of economically viable reserves. The location may conflict with sensitive ecosystems and indigenous communities' lands. Due the location of the projects, the building of new roads is usually a forced task to be performed, and leads to the subsequent colonization of the area. Other land uses may conflict with mining projects, and communities face the critical decision of choosing what is in the best interest of their people. For example, displacement resulting from mining projects may lead to social problems such as marginalization, social breakdown, food insecurity, and loss of access to common resources and public services (MMSD, 2002).

[d] Poverty Alleviation and Wealth Distribution: Mining projects developers seek to provide revenue to all the parties involved; however, projects do not always contribute to the country's economic growth, and in some cases contribute to increasing poverty levels (Ross, 2001). Additionally, in some cases where the mining projects contribute to the national overall wealth, it seems that the benefits are not equally shared, and the communities close to the physical location of the projects can suffer the most. As mining projects are typically temporary, communities nearby experience relatively short-lived increases in job demand and employment wages during the project's operational phase. Areas that become increasingly dependent on a mining project's operational phase face critical times, especially when the projects close. Furthermore, other negative impacts on nearby communities include prostitution, alcoholism, and sexually transmitted diseases (Miranda, Blanco-Uribe, Hernandez, Ochoa, & Yerena, 1998).

In the international context, mining projects around the world may experience similar environmental, economic, social, and health impacts as those described above. The mining and dams in Benguet, Philippines have had devastating impacts on the environment and on the Kankanaey and Ibaloy people in the province, including land destruction; subsistence and water loss; pollution of water and soil; siltation; health problems due to water, soil, and air pollution; loss of flora, fauna, biodiversity, and food security; and dislocation of indigenous people from ancestral lands and traditional livelihoods (UN, 2007b). Singh (2008) presents the environmental and social impact of coal mining in India. The exploration and exploitation of the world's most abundant and widely distributed fossil fuel resource has demonstrated several negative environmental impacts on air quality, mine fires, dust suppression and control, water regime, land, noise, and vibrations. On the social side, the author has encountered issues regarding landlessness, joblessness, homelessness, risk of marginalization, changes in population dynamics, cost of living, health risks, disruption of formal educational activities, and addictions. In the country of Ghana, the Anglogold Ashanti mining activities present a series of environmental and health impacts. Among others, land degradation leads to limited local food production, pollution affecting water resources, air and noise pollution, and, as a result of environmental effects, a number of health issues resulting in diseases such as malaria, respiratory tract infections, and skin diseases (Yeboah, 2008). Australia Environment (2002), in reference to mining and energy extraction and processing operations, identified several potential problems: wind and water erosion, changes to surface and ground water flows and levels, contamination of surface or ground water, damage to soil, dust or noise nuisance, vibration and reduction of visual landscape values, generation of tailings and other wastes, gaseous emissions, possible sudden failure of engineered containment structures, acid mine drainage, loss of flora, loss of fauna, damage to heritage sites, and destruction of adjacent habitats.

Transitioning from the global to the national environment, the oil sands projects in the northern Alberta region of Canada become of great interest not only to groups at the national level (i.e., First Nations, environmentalists, industries, governments, and other stakeholders) but also to the international community. The main environmental and public health issues refer to GHG emissions, the impact of non-GHG emissions on air quality, the effect on water quality and quantity, wastewaters stored in tailings pond, land disturbance from the surface mining operations, and land impacts from in-situ mining operations and public health (Gosselin et al., 2010).

6.3 The Surface Mining Process

The surface mining process involved in oil sands development projects is an integral element of infrastructure projects. Government, DMs, the public, and stakeholders in general all play fundamental roles in influencing each project's economic, social, and environmental effects. Shen, Wu and Zhang (2011) argue that infrastructure projects often contain significant economic benefits, but tend to have negative social and environmental impacts. However, these impacts are poorly assessed during the feasibility study phase of the projects, and as a result, are often left behind to be identified during or after the implementation of the projects (World Bank, 2006). Additionally, the principles of sustainability suggest equality and balance among its economic, social, and environmental pillars throughout the project's life cycle.

Recognizing the different impacts (i.e., social, economic, environmental, and health) is the first step toward finding a feasible mitigation alternative. Additional questions surround sustainable assessment, including the identification and quantification of SDIs (i.e., "What SDIs should be included?" and "How should SDIs be measured?"). Even though each surface mining project possesses unique characteristics, similar surface mining processes occur. Moreover, before selecting SDIs, the scope of the work needs to be clearly defined. Oil sands projects occur in four distinctive stages, including the recovery process (for both surface mining and in-situ extraction) in stage two (Alberta Energy, 2012b). The methodology for pre-selecting SDIs for surface mining operations do not include the processes for the production of SCO or end products such as gasoline, diesel, or jet fuel. Additionally, reclamation and tailing ponds are two processes that may merit more detailed scrutiny, as not all steps within each process are considered in the surface mining process, per se. Reclamation begins with mine planning and ends with certification, while tailing ponds are the result of water use in oil sands mining operations. Reclamation and tailing ponds are distinctive activities, but both are directly linked to surface mining operations. Reclamation, as a result of mining operations, and the creation and use of tailing ponds are each composed of different processes, which are not all necessarily included in the SDIs for surface mining operations. Processes occurring after material extraction is complete (e.g., backfilling, recontouring, revegetation, monitoring, and certification) or activities after a tailing pond's life cycle ends (an additional mix of water, sand, clay, a small amount of bitumen, and chemicals that cannot be disposed) are included in the reclamation stage, and are thus not part of the surface mining processes for the identification of SDIs.

Similar to iron ore, coal, diamond, and copper mine operations, oil sands surface mining requires an open-pit mine operation (Government of Alberta, 2012). Before the recovery process begins, a number of activities occur: resource assessment, licensing and approvals (e.g., royalty approval), and other preliminary regulatory requirements including public hearings. Turning oil sands ore into SCO starts with clearing the land of trees. Then overburden (e.g., topsoil, muskeg, sand, clay, and gravel) is drained and stored for later use in the reclamation process; other overburden, combined with sand stripped of its oil, is used to fill in the mine pits and build the base for the reclaimed landscape. The recovery process continues with shovels excavating the oil sands ore and then placing it into haul trucks. After transporting the ore to central locations, it is dumped into hoppers to be ground up and mixed with water. Using hydro-transport pipelines, the material is piped to extraction plants, where bitumen is separated from the sand. A small amount of unrecovered bitumen, fine clays, and sand are sent to settling basins (i.e., tailings ponds), while the recovered bitumen is transported for further upgrading. Therefore, the processes of oil transportation and storage, upgrading and refining, shutdown and reclamation, and in-situ recovery methods are not included in the selection of SDIs for the surface mining process.

6.4 Resources for Pre-Selecting Sustainable Development Indicators

Selecting SDIs offers a challenge for researchers and practitioners. The question of what should be measured or which SDIs should be included is crucial for effectively measuring SD. An alternative that could be used before a formal set of SDIs can be implemented involves pre-selecting social, economic, and environmental indicators based on different resources presently used. Independently of directly referring to a certain process (e.g., surface mining) these resources offer a variety of SDIs that may indicate their usefulness based on proven performance. A pre-selected set of SDIs illustrates to DMs a collection of possible indicators that they may have not initially considered in their SD performance metrics. The different resources vary, and include governmental organizations, research and academia, and public and private institutions, as the following subsections explain.

6.4.1 Governmental Regulations

Even though regulations do not guarantee the proper set of indicators to accomplish the objectives of SD, regulatory-based indicators are relevant enough to be considered part of the path towards SD. As stakeholders, the regulatory governmental agencies are part of the decision-making process, and are accountable for putting in place an appropriate set of rules to guarantee fairness, equality, and opportunity, and ensure operations are adjusted to current laws. Stakeholders can possess different attributes, including power, legitimacy, and urgency (Mitchell, Agle, & Wood, 1997). Parent and Deephouse (2007) found that power is the most influential on stakeholders' salience, followed by urgency and legitimacy—a conclusion that is confirmed by de Bussy and Kelly (2010) in the political arena. In practice, power seems to have a more important role than legitimacy in determining stakeholder salience among political DMs. The authors argue that in principle, in a political context, legitimacy is the most important attribute; however, politicians and their advisors value power and urgency the most when asserting their influence.

In addition to having a key role in the decision-making process, government legislators are elected by the people and legislate on their behalf; the interests of the community take priority over those of an individual or selected group. Regulatory-based criteria put a certain amount of pressure on the government legislators to have the proper set of regulations in place. Furthermore, these regulations must be adjusted to the needs of the community and the requirements of the projects to which the regulations are directed.

As they cannot be considered the expected goal, governmental regulations set the starting point towards SD, and are meant to be immersed in the SD set of indicators. In fact, a series of criteria based solely on regulations does not guarantee sustainability, and instead creates a bureaucratic tool. Out of the three pillars of sustainability, the environment receives the strongest assistance from the regulatory bodies, while the social and economic aspects would be significantly weakened if they relied purely on regulations to set SDIs.

Environmental, economic, social, health, and political impacts of surface mining operations are evaluated by the national, provincial and/or local governments that have jurisdiction over each specific project. Although the current oil sands operations in northern Alberta, Canada, are highly criticized and have gathered international attention and garnered calls by different stakeholders for a tougher body of governmental regulations (CAPP, 2011), the developers face a well-structured regulatory system consisting of approvals, licenses, dispositions, permits, and registrations required for exploratory and operations activities. Furthermore, the oil sands projects operate within one of the world's most stringent and comprehensive regulatory bodies (OSDG, 2012a), including a focus on water, land, and air, which are meticulously monitored during each project's life cycle. The oil sands projects not only face the governmental regulatory system, but also a long process that starts with extensive public reviews and generally leads to public hearings, in which the different stakeholders have their say.

In fact, the Canadian oil sands place third in the world in proven crude oil reserves, after Saudi Arabia and Venezuela (Alberta Energy, 2012c). Out of 170.4 billion barrels of recoverable oil, 20% is expected to be extracted through mining, making the oil sands one of the largest surface mining operations in the world and the reason federal, provincial and local authorities are acting through regulations to guarantee the proper operations of the projects. A report presented to the UN explains that regulations are designed to be applied during the life cycle of the mine, starting in the planning phase and continuing to the final closure and remediation; however, closure and remediation are two aspects not properly addressed during or after the course of the operations (UN, Undated).

Canada is good example of how regulations can evolve to address communities' environmental concerns related to the development of projects. Canada is a confederation with two levels of government: federal and provincial/territorial. The energy industry sector operations, including oil and gas activities, are meticulously scrutinized by three main levels of authority, those being federal, provincial, and local agencies. At the federal level, authorities regulate some aspects of oil and gas activities, depending on the location and purpose of the proposed projects. Indian and Northern Affairs Canada, EC, Natural Resources Canada (NRCan), the National Energy Board (NEB), Indian Oil and Gas Canada (IOGC), Fisheries and Oceans Canada, the Canadian Environmental Assessment Agency, and Transport Canada are, among others, federal regulatory agencies. The provincial agencies under the mandate of the Government of Alberta are Alberta Energy, ERCB, AENV, and ASRD. Additionally, the Alberta Surface Rights Board (SRB) and the Environmental Appeals Board (EAB) are independent bodies: the intent of the former is to fairly determine compensation for providing entry to well sites and pipelines except for First Nations and Métis settlements and federal land, while the latter gives communities an opportunity to appeal decisions made by AENV. Other provincial agencies that may have some jurisdiction are: Alberta Culture and Community Services; Alberta Health and Wellness; Alberta Municipal Affairs; Alberta Transportation; Alberta Tourism, Parks, and Recreation; and Alberta Employment and Immigration. Local authorities also have the responsibility of regulating surface mining projects. Municipalities, counties, and others are responsible for identifying the impact of projects' operations and addressing them promptly. Awareness is expected by project proponents on property tax assessment and taxes payable to local authorities.

At the federal level, the Canadian Environmental Assessment Act (CEAA) is the legal basis for environmental assessment (EA) processes. Together with associated regulations, the CEAA outlines procedures, requirements, and responsibilities for the environmental assessment of projects. Similarly, for projects in which the Government of Canada has decision-making responsibility, the CEAA has in place a process for establishing the potential environmental impacts. Mining projects require Navigable Waters Protection Act permits, Fisheries Act authorizations, and/or Explosive Act licenses, among others, and any of these triggers an environmental assessment under the CEAA. Provincial regulatory agencies also require permits, authorizations, and/or licenses, and therefore environmental assessments are required at the provincial or territorial level. However, federal and provincial agencies usually have cooperative agreements in place, in order to avoid the duplication of efforts. Other pieces of legislation applying to the mining industry include the Metal Mining Effluent Regulations (MMER), which replaced the Metal Mining Liquid Effluent Regulations (MMLER). MMER applies to all operating metal mines in Canada, and MMLER applied to operations that began before 1977 and mining operations that did not use cyanide in the milling process (UN, Undated). The MMER establishes a series of regulated parameters (pH, Radium 226, arsenic, copper, cyanide, nickel, lead, zinc, and total suspended solids [TSS]) and their concentration limits to be discharged to waters frequented by fish. Since the MMER has some limitations, EC enacted the Environmental Code of Practice for Metal Mines to deal with aspects that influence environmental impacts of mining operations.

6.4.2 Committees and Organizations for Standardization

Standards are codes of best practices developed with the aim of improving safety, efficiency, interoperability, and trading (BSI, 2012). Different organizations around the world are dedicated to identifying and developing what different markets and industries require. Organizations for standardization can be found on the global, regional, and national scale. The ISO has a strong global presence. Out of 205 countries in the world, 163 are represented in the ISO as one of three categories: member bodies, correspondent members, and subscriber members. The ISO's well-structured standards development process consists of six different stages—proposal, preparatory, committee, enquiry, approval, and publication (ISO, 2011b)—and requires committee members, who represent countries around the world, to reach agreements by consensus. This process makes the ISO a democratic organization interested in stakeholder involvement. At the regional level, the CEN mostly comprises country members of the EU, 28 of which are active members joined by the Former Yugoslav Republic of Macedonia, Turkey, Iceland, Norway, and Switzerland (CEN, 2009b). In 1991, ISO and CEN signed the Vienna agreement, with the aim of avoiding duplication of standards between both bodies. Since then, CEN has adopted several ISO standards. Among different national organizations for standardization, the BSI and the Canadian Standards Association (CSA) have active roles in the production of standards and the supply of standards-related services.

Even though organizations for standardization have recently focused on developing standards related to SD, their main focus has been the building construction industry. Directly related to the development of SDIs is ISO 21929-1: “Sustainability in buildings construction—Sustainability indicators, Part 1: Framework for the development of indicators and a core set of indicators for buildings.” The standard describes and presents a series of different guidelines to be considered for buildings in developing systems for sustainability indicators. Additionally, a series of core indicators are given for three levels relative to a building(s) and its curtilage (object of assessment): location-specific indicators, site-specific indicators, and building-specific or process-oriented indicators (ISO, 2011a). ISO 15392, “Sustainability in building construction—General principles,” presents general principles of sustainability related to the built environment (buildings and civil engineering), and supports the decision-making process by presenting the basis for deriving evaluation criteria and indicators for the assessment of buildings in terms of SD (ISO, 2008). Other ISO standards focus on building products, performance assessment, and audits and reviews. ISO 21930: “Sustainability in building construction—Environmental declaration of building products” assists users in making educated decisions to address the environmental impact of products by providing uniformity in the means for expressing environmental product declarations (ISO, 2007). With the aim of benchmarking performance and monitoring progress towards SD, ISO developed standard 21931-1: “Sustainability in building construction—Framework for methods of assessment of environmental performance of construction works, Part 1: Buildings” (ISO, 2010a). Furthermore, planning and designing towards sustainability is a small part of the overall goal. Construction projects require attention during every phase, including operation and maintenance. To that end, ISO 15686-3: “Buildings and constructed assets—Service life planning, Part 3: Performance audits and reviews” “deals with measures to ensure that the life care of a constructed asset is considered through each stage of decision making from project conception and initial briefing, through design and construction, to occupancy and eventual disposal and reinstatement of the site" (ISO, 2002). In addition to the active ISO standards, there are several others under development. Directly related to sustainability indicators, ISO/DIS 21929-2 refers to sustainability in buildings and civil engineering works, and emphasizes the development of indicators for civil engineering works (ISO, 2011c). Other standards currently being drafted are ISO/DIS 20121: "Event sustainability management systems—Requirements with guidance for use" and ISO/DIS 10987: "Earth-moving machinery—Sustainability—Terminology, Sustainability factors and reporting" (ISO, 2011d; 2011e).

Supporting ISO standards that have been directly developed to meet SD goals and objectives are others, such as ISO 26000 and ISO 14001. Environmental management was a focus at the 1992 Rio Earth Summit, and in the 2002 World Summit on Sustainable Development (WSSD), the attention was re-directed to cover broader issues such as poverty reduction and social development. Furthermore, the concept of corporate social responsibility (CSR) assists in the evolution of the traditional approach towards SD (IISD, 2012). To fill the existing gap, ISO rapidly identified the need for and benefits of socially responsible behavior. ISO 26000: "Guidance on social responsibility," recognizes the value of improving the efficiency of corporate environmental management included in ISO 14001: "Environmental management system standard." The standard also considers the report prepared by the ISO Consumer Policy Committee (COPOLCO), and includes experts from 90 countries and 40 organizations around the world involved in social responsibility and its different aspects (ISO, 2010b). Even though ISO 26000 does not highlight a set of criteria per se, it offers a number of core subjects and issues of social responsibility to be addressed. In general, the standard "provides guidance on the underlying principles of social responsibility, recognizing social responsibility and engaging stakeholders, the core subjects and issues pertaining to social responsibility and one way to integrate socially responsible behavior into the organization" (ISO, 2010b).

A sustainability family of standards is included in the CEN system. Some are presently active, while others are in draft format. While some CEN standards support the different goals and objectives of SD (e.g., CEN CEN/TR 15941, CEN EN 15643-1, CEN EN 15978, CEN PREN 15804), others present a specific set of criteria to assess the different areas of sustainability. By developing a standard dedicated to each pillar of sustainability (i.e., economy, social, or environmental), the CEN presents a unique approach to sustainability performance assessment. Similar to ISO, CEN has also focused its efforts toward developing standards for the building industry; however, the given best practices guidelines can serve as starting points for other type of projects. Standard CEN EN 15643-2: "Sustainability of construction works—Assessment of buildings, Part 2: Framework for the assessment of environmental performance" presents a set of environmental indicators divided into three groups: (1) output indicators for environmental impacts (e.g., acidification of land and water resources, climate change, destruction of the stratospheric ozone layer, eutrophication, formation of ground-level ozone), (2) input indicators for materials and energy use (e.g., use of non-renewable resources other than primary energy, use of renewable resources other than primary energy, use of non-renewable primary energy, use of renewable primary energy, use of freshwater resources), and (3) output indicators for secondary raw material, waste, and exported energy (e.g., materials for recycling, materials for energy recovery, non-hazardous waste to dispose, hazardous waste to dispose [other than radioactive waste], radioactive waste to dispose) (CEN, 2011). The social pillar of sustainability is covered by standard CEN PREN 15643-3: "Sustainability of construction works—Assessment of buildings, Part 3: Framework for the assessment of social performance." Five different categories are used to describe the social performance of buildings: (1) health and comfort (e.g., thermal performance, humidity, quality of water for use in buildings, indoor air quality, acoustic performance, visual comfort), (2) accessibility (e.g., for people with specific needs), (3) maintenance (maintenance requirement), (4) safety/security (resistance to climate change, fire safety, security against intruders and vandalism, security against interruptions of utility supply [e.g., electricity, water, district heating, etc.]), and (5) loadings on the neighborhood (noise, emissions, glare, shocks/vibrations) (CEN, 2010d). Standard CEN PREN 15643-4: "Sustainability of construction works—Assessment of buildings, Part 4: Framework for the assessment of economic performance" includes economic performance indicators that are classified based on the different stages of buildings (i.e., before use stage, use stage, end of life) (CEN, 2010c).

At the national level, organizations for standardizations—such as BSI and CSA—have not developed standards with reference to SD criteria; however, both organizations have adopted a few standards in the area of sustainability. The BSI presently has active the standards BSI BS ISO 15392, BSI BS ISO 15686-3, BSI BS ISO 21930, and BSI BS ISO 21931-1, all adopted from the ISO. Meanwhile, the CSA possesses in its collection the CSA ICT Protocol (ICT GHG reduction project protocol: Quantification and reporting—Version 1), CSA Plus 4010 (Technical Guide Performance improvement for small- and medium-sized water utilities), and Z2010-10 (Requirements and guidance for organizers of sustainable events—First Edition).

6.4.3 Management and Processes Best Practices

Different industries use the concept of best management practices (BMPs) to measure operational and management performance. Different processes and procedures are part of the set of guidelines in the production of a product and/or service (Szwilski, 2007). BMPs can be developed by government agencies, industry associations, focus groups, and temporary partnerships, among others, or embedded in management systems or standards. BMPs are set as guidelines for organizations and practitioners to improve their performance; however, environmental and governmental regulations may mandate the minimum requirements (i.e., monitoring, inspections, design requirements, water effluents, air emissions, etc.). Sustainable BMPs embedded in corporate management programs give organizations a competitive advantage. Galayda and Yudelson (Galayda & Yudelson, 2010) present five key steps for establishing a corporate sustainability program: setting the vision, staffing the effort, establishing metrics to measure progress, implementing strategic initiatives, and communicating the results to all stakeholders. Embedding best practices in management systems or standards has also been effectively used; Szwilski (2007) argues that EMS have an effect on environmental, management, and operational improvement. EMS are based on the 'plan-do-check-act' process present in the Total Quality Management (TQM) concept; furthermore, the ISO 14000 EMS assist DMs by setting procedures for monitoring and measuring appropriate performance indicators, including management, operational, and environmental performance indicators (MPIs, OPIs, and EPIs). However, once a standard or management system is implemented, the functional structure of the organization tends to change to adjust to new processes and procedures. Best practices in management and processes may not have deep impacts on the functionality of the organization, as standards or management systems; though this enhances the flexibility characteristic of BMPs. Moreover, when applied to a specific industry such as mining, setting up BMPs is crucial in order to meet sustainability goals and objectives. BMPs are meant to be flexible so they can meet varying requirements, such as types of mining operations, climate, surrounding environment, topography, social demands, and stakeholder expectations. In fact, local governments with jurisdiction over mining projects have developed guidelines for BMPs throughout the mining project life cycle (Environment Australia, 2002; Idaho Department of Lands, 2011; Republic of South Africa Department of Water Affairs and Forestry, 2008). However, the main opportunities to reduce impacts of mining operations are in the planning and design phase, rather than during operation or post-closure (Stewart & Petrie, 2007). Nevertheless, sustainability principles are focused in each phase of a project's life cycle and do not act in isolation (McLellan, Corder, Giurco, & Green, 2009).

In an early attempt to set up BMPs and environmental performance benchmarks in the mining industry, a partnership between the Australian Environmental Protection Agency and the mining industry focused on the principles of EIA and environmental management; the variety of factors included water quality, noise, transport, air, land use, biological resources, and socio-economic issues. In 2002, Environment Australia presented an updated version of its early booklet titled "Overview of Best Practice Environmental Management in Mining." Although implementing the best practices methodologies developed by the Australian mining industry can represent up to 5 percent of the capital and operating costs, and cannot be directly applied to other countries' social, economic, environmental, or technical contexts, it is an example of how the benefits of implementing BMPs can prevent or minimize environmental and social impacts, improve certainty of the outcome of projects, lower the risk of non-compliance, develop a better stakeholder engagement, optimize mine closure and rehabilitation processes, and decrease the risk for liabilities in the post-closure phase, among others (Environment Australia, 2002). Environment Australia's development of over 20 different booklets describing best practices for key environmental management aspects can easily be interpreted as an attempt to set up a number of SD criteria covering the different aspects of the mining process: (1) mine planning for environmental protection; (2) community consultation and involvement; (3) EIA; (4) environmental management system; (5) planning a workforce environmental awareness training program; (6) cleaner production; (7) energy efficiency; (8) environmental risk management; (9) onshore minerals and petroleum exploration; (11) tailings containment; (12) hazardous material management, storage, and disposal; (13) managing sulphidic mine wastes and acid drainage; (14) water management; (15) noise, vibration, and airblast control; (16) cyanide management; (17) dust control; (18) atmospheric emissions; (19) environmental monitoring and performance; (20) environmental auditing; (21) rehabilitation and revegetation; (22) landform design for rehabilitation; (23) contaminated sites; and (24) mine decommissioning.

Among the different elements affected by surface mining activities, primarily water and air are impacted (Republic of South Africa Department of Water Affairs and Forestry, 2008). In South African surface mining operations, water management measures included in BMPs are: integrated water management modeling, separation of waters, collection, conveyance, storage, siting, design and operational considerations, maintenance, closure, and exemptions. As the life cycle of a mining process follows a distinctive sequence (exploration, feasibility, planning, construction, operation, and decommissioning [including closure and post-closure aftercare]), the BMPs developed by the South African government consider the different aspects of the mining process and components of the water management system at the mines (Lin, Chen, Chen, Lee, & Yu, 2006). Similarly, clay mining operations have high impacts on water and air. Operations in northern Taiwan implemented a set of BMPs to mitigate the impacts of clay mining, which typically contains high concentrations of suspended solids (SS), Fe-ions, and [H+] concentrations. These best practices consist of water quality sampling, pollution control strategies (short-term and long-term pollution control strategies), and modeling analyses of the pond treatment train system (Sloat & Redden, 2005). Pollution, erosion, and sediment control are other aspects to consider in surface mining operations. A proactive planning approach for erosion and sediment control includes assessing soils and conducting hydrology assessments of involved surface areas and near-surface seepage areas.

Water management systems assist with erosion and sediment control; self-sustaining vegetative cover is one of the most effective methods of erosion control, while sediment control practices use gravity to capture soil particles once the particles have been transported away by water or wind. Additional BMPs for erosion and sediment control are sediment fences, sediment traps, erosion control blankets, hydro-seeding, and tracked contouring (Sloat & Redden, 2006). Minimizing pollution to air, water, and land also starts at the planning stage of the project; however, technologic, economic, and legislative barriers prevent projects from using the different technologies (i.e., high-tech flue gas desulphurization, wastewater treatment, chemical detoxification) and strategies (i.e., environmental protection, pollution prevention) presently available (Hilson, 2000).

BMPs not only include engineered and technical aspects; management, project management processes, innovation, and safety are among other areas that impact the overall performance of mining projects and contribute to meeting the SD objectives. BMPs in management include effective communication of the mission and strategy, leadership by example, setting realistic targets, communication of management style, and clear and careful strategic planning, among others. These can be accomplished through different techniques (i.e., benchmarking, forecasting, financial planning, strategic planning, performance monitoring) and key performance indicators (KPIs) for monitoring performance. Reducing production costs and improving productivity are benefits associated with innovation; however, mining companies are not always are driven by reason to improve. Instead, external factors—such as competitive market pressures, new market opportunities, regulatory pressures, and the ‘voice of society’—force them to include innovation as part of the corporate management strategy to remain competitive (Warhurst & Bridge, 1996). Society, employers, government, and employees can participate in the innovation process, in areas such as safety. Cooperation between employers and employees in implementing safety practices and minimizing hazard exposure is part of the success in the area of safety in surface mining operations. Regulatory agencies for mining activities in Alberta, Canada require, among others, hazard assessments, procedures to mitigate identified hazards, training in safe work procedures, and reporting of incidents with potential for injury (Hindy, 2007; Government of Alberta, 2009a). Additionally, safety-related best practices include training for emergency response personnel each site; enforcement of policies encouraging cooperative working relations between inspectors, employers, and workers; and regular inspections by content experts (Hindy, 2007).

6.4.4 Surface Mining Industry Standards and Programs

Standards define a series of benchmarks expected to be followed. Differentiation is made based on the resource of the standards: governmental or statutory standards enforced by law (e.g., regulations) are different from proprietary standards developed by firms and organizations, which in turn differ from voluntary standards established by consultation and consensus for use by their respective industry, organization, or individual. Voluntary standards are not legally binding and are expected to be enforced by the members of each particular association. The standards referred to in this section are voluntary standards the mining industry has adopted toward accomplishing the goals and objectives of SD and minimizing the different impacts (i.e., social, economic, environmental, health) the mining operations intrinsically carry in each phase of the projects. Industry occasionally relies on outside resources to set up their standards (e.g., ISO, CEN, BSI); in other instances, collaborative work is part of their agenda toward specific programs. The International Council on Mining and Metals (ICMM) conducted a two-year consultation process with stakeholders that led to the implementation of a SD framework, in which key issues relating to mining and SD were identified. The framework consists of three steps: (1) integrating 10 principles and 7 supporting position statements, which were identified and benchmarked against leading international standards (e.g., Rio Declaration, Global Reporting Initiative (GRI), Global Compact, OECD Guidelines on Multinational Enterprises, World Bank Operational Guidelines, OECD Convention on Combating Bribery, ILO Conventions (98, 169, 176), and Voluntary Principles on Security and Human Rights), into corporate policy; (2) setting up transparent and accountable reporting practices with public access, and in which performance against the 10 principles is presented, following the GRI guidelines; and (3) allowing a third-party verification of compliance of performance in sustainability and evaluation of their reporting quality (ICMM, 2011a).

The Institute of Materials, Minerals, and Mining (IOM3) and its SD group highlights the different standards that support SD during the life cycle of manufactured products, including not only the usual flow of materials, but also the flow of information and interactions with the environment. IOM3 recommends and refers to other standards as well, such as those created by the BSI, the European Centre for Standardization (CEN), and the ISO, including ISO 14001:2004, ISO 14004:2004, ISO/CD 14006, ISO 14040:2006, ISO 14044:2006, ISO/WD 14045, ISO 14050:2009, ISO/TR 14062:2002, and ISO 10303-203/210/214/223/235/239 (IOM3, 2009). Similarly, the IOM3, under its SD group, is engaged in a variety of programs and industry guidelines that promote SD, including life-cycle thinking (LTC) for the design of new products and processes (IOM3, 2012).

Mining practices may vary from project to project due to geographic location and external factors as a consequence of particular environmental, social, economic, or geo-political conditions. Mining organizations (e.g., associations, institutes) around the world adopt standards that meet the needs of regional mining operations. Though certain standards applied in European mining operations may apply in other projects that are geographically different, the worldwide benchmarking of mining operations and the industry's SD performance have proven to be challenges that the industry has yet to overcome. Therefore, national or regional associations become a key performance factor for the industry. In Canada, two organizations—the Mining Association of Canada (MAC) and the Canadian Institute of Mining, Metallurgy, and Petroleum (CIM)—presently have different standards and programs that work toward setting processes and practices for sustainable mining operations. MAC and its members constitute an active and leading body, not only in the creation and implementation of national and international standards, but also in research programs and the development of best practices. "Towards Sustainable Mining (TSM) Guiding Principles" is a series of guidelines developed by MAC in collaboration with communities and stakeholders (MAC, 2011a). TSM is a mandate for the industry and its members. The TSM also contains a series of performance indicators to support the guiding principles. These indicators address the areas of crisis management, energy and GHG emissions management, tailings management, biodiversity conservation management, safety and health, and Aboriginal relations and community outreach (MAC, 2011b). Each area contains a set of performance indicators. For example, in the area of energy and GHG emissions management, six performance indicators have been established: energy use management systems, energy use reporting systems, energy intensity performance targets, GHG emissions management systems, GHG emissions reporting systems, and green gas emissions intensity performance targets (MAC, 2011c).

An essential standard for the mining industry involves the reporting of mineral resources and reserves. Though at first, most may think the crucial aspect of reporting does not connect with SD, the reality is that mineral resources have an impact on the commodity wealth of countries; attract political attention; and affect financial, accounting, and investment communities (Weatherstone, 2008). Therefore, economic, social, and political aspects of SD may be impacted by the different objectives and outcomes of reporting systems. Similar to other industry standards, international and national mining organizations have released standards and guidelines for classifying, valuing, and reporting mineral resources and reserves (Weatherstone, 2008; Vaughan & Felferhof, 2002; CIM, 2003; CIM, 2012; Camisani-Calzolari, 2004). As SD criteria are identified for each stage of the projects, the reporting systems are included as management criteria for the sustainability of mining operations.

In addition to standards, mining industry organizations engage in programs and initiatives for a number of reasons, including research, benchmarking, and development, among others. The program or initiative goals are usually mandated by the needs of the industry and its members. In the case of SD, the mining industry is requested to align with international, national, and local governmental mandates, attend to the different needs of stakeholders, and/or increase productivity with more efficient and effective processes. Below is a snapshot of the variety of programs and initiatives—at the national and international level—with which the mining industry is or has been engaged. The list is meant to illustrate diversity, and is not a compendium of the programs and initiatives:

(a) Whitehorse Mining Initiative (WMI): A multi-stakeholder group that meets to discuss SD and the mining industry (NRCan, 2011a).

(b) Mine Environment Neutral Drainage (MEND): A multi-stakeholder partnership that seeks to develop technologies to predict, prevent, treat, and control acidic drainage (NRCan, 2011b).

(c) Green Mining Initiative (GMI): A multi-stakeholder initiative that seeks to improve environmental performance in mining, promote innovative mining operations, and position Canada as a leader in green mining operations (CMIC, 2011a).

(d) Canada Mining Innovation Council (CMIC): A collaborative network of industry, government, and academic leaders working toward responsible mining through education, research, innovation, and commercialization (CMIC, 2011b).

(e) Mining, Minerals, and Sustainable Development (MMSD): An independent research and consultation project with the aim of finding ways for the mining and mineral sector to contribute to the global transition to SD (Weber, 2005; IIED, 2011a).

(f) International Council on Mining and Metals (ICMM): Bringing together 21 mining and metal companies and 31 national and regional mining associations and global commodity associations, ICMM aims to improve SD performance in the mining and metal industry (ICMM, 2011b).

(g) United Nations Environment Programme's Mineral Resources Forum (UNEP MRF): An information resource for issues related to mining, minerals, metals, and SD (Weber, 2005).

6.4.5 Local, Regional, National, and International Organizations

A Non-Governmental and Intergovernmental Organizations (NGOs, IGOs) work toward developing, monitoring, interpreting, and communicating sustainable indicators frameworks. As the interest in SD increases, organizations such as the UN and its agencies have focused their attention on creating a comprehensive set of indicators to monitor and measure progress toward overall societal well-being. These indicators address social, economic, environmental, institutional, and policy-related aspects, among other aspects of sustainability. The UN is not acting alone in this challenging effort; local, regional, national, and other international organizations have also acted, either by adapting the UN framework of indicators or developing their own (IRIS, 2004).

Delegates at the 1992 Earth Summit, also known as the United Nations Conference on Environment and Development (UNCED), were amongst the first to recognize and publicly identify the importance of developing SDIs. SDIs assist countries in making informed decisions regarding SD. With the premise of forming a solid foundation for decision-making, Charter 40 of Agenda 21 urges countries (i.e., the national level) and international, governmental, and NGOs to identify and develop SDIs. In 1995, the Commission on Sustainable Development (CSD) approved its Work Programme on Indicators of SD. Early sets of SDIs were tested between 1994 and 2001. The latest set of SDIs came as a response to the CSD and the WSSD in 2002. The CSD group of SDIs is divided into fourteen themes: (1) poverty; (2) governance; (3) health; (4) education; (5) demographics; (6) natural hazards; (7) atmosphere; (8) land; (9) oceans, seas, and coasts; (10) freshwater; (11) biodiversity; (12) economic development; (13) global economic partnership; and (14) consumption and production patterns (UN, 2007). Each theme is broken down into sub-themes, and within these sub-themes are core indicators and other indicators whose purpose is to measure progress. A core set of 50 indicators is part of a larger set of 96 indicators of SD under the CSD. Additionally, the United Nation, in its report "Indicators for Monitoring the Millennium Development Goals," presents what have become known as the eight Millennium Development Goals (MDGs), including 18 time-bound targets. Recognized by 189 countries, including 147 heads of state and government, the Millennium Declaration of 2000 marks the commitment to different aspects of SD, equality, peace and security, and the eradication of poverty (UN, 2003b). Different World Summits and conferences have helped to shape the MDGs and indicators. The eight MDGs are: eradicate extreme poverty and hunger; achieve universal primary education; promote gender equality and empower women; reduce child mortality; improve maternal health; combat HIV/AIDS, malaria, and other diseases; ensure environmental sustainability; and develop a global partnership for development. Each goal includes time-bound targets, and different indicators are linked to each target. The MDGs indicators currently total 58, and were presented by the Secretary-General of the United Nation in 2007 after a revision of the MDGs monitoring framework. Even though some overlap between the two sets of indicators (CSD and MDGs) and confusion among policy-makers and practitioners between the two sets occurs, the objectives of each set of indicators are well-defined. Among other differences, the CSD indicators were developed as a reference for countries to track progress towards nationally-defined goals, while the MDGs indicators are meant for monitoring global progress toward meeting internationally-established goals (UN, 2007).

Instead of using a global framework of indicators, region-specific organizations focus on developing frameworks to meet local social, economic, and environmental needs. In the EU system, Eurostat, a directorate-general of the EC, and the European Environmental Agency (EEA) specify that SDIs "are to be developed at the appropriate level of detail to ensure proper assessment of the situation with regard to each particular challenge" (EC, 2009). SDIs developed by Eurostat use a hierarchical theme framework and are divided into ten themes. These are further divided into sub-themes to reflect the operational objectives and actions of the sustainable development strategy (SDS). The indicators are also built as a three-level pyramid (overall objectives, operational or priority objectives, and actions). The ten themes identified by Eurostat are: socio-economic development, sustainable consumption and production, social inclusion, demographic changes, public health, climate change and energy, sustainable transport, natural resources, global partnership, and good governance. The indicators included in each theme are divided into three levels, reflecting the SDS.

Organizations not only focus on developing indicators, but also on interpreting the application and the connection between theory and practice. Global organizations such as the WRI believe in the efficacy of indicators as agents of change: they can simplify and quantify information while improving communication between different DMs (Hammond, Adriaanse, Rodenburg, Bryant, & Woodward, 1995). Working with government, companies, and civil society, the WRI builds solutions to urgent environmental challenges. Launched in 1982, its objective centered on policy research and the analysis of global resources and environmental issues (WRI, 2012). Instead of giving a set of indicators, the WRI proposes an explicit conceptual model to guide the development of environmental indicators; the model describes four types of interactions between human activity and the environment: source, sink, life support, and impact on human welfare (Hammond et al., 1995). Similarly, rather than developing the 'ideal' set of indicators to assess SD, the International Institute for Sustainable Development (IISD) concentrates its efforts on identifying principles to link theory and practice. Moreover, the Bellagio Principles for Assessment serve as guidelines for the entire assessment process, starting from system design and the identification of indicators and continuing through the measurement, compilation, interpretation, and communication of results. The ten Bellagio Principles for Assessment are: (1) guiding vision and goals, (2) holistic perspective, (3) essential elements, (4) adequate scope, (5) practical focus, (6) openness, (7) effective communication, (8) broad participation, (9) ongoing assessment, and (10) institutional capacity (Hardi & Zdan, 1997). While global organizations work toward goals abroad, local organizations and governments work toward specific goals that are meant to be aligned with global and national mandates. In 1994, the UK Government launched its Strategy for Sustainable Development, following the commitment made at the Earth Summit in 1992. The set of indicators developed under the UK SDS are grouped into 21 families of SD issues, with the main objective being to inform the government, industry, NGOs, and the public in general about relevant matters concerning SD. Those issues are: the economy, transport use, leisure and tourism, overseas trade, energy, land use, water resources, forestry, fish resources, climate change, ozone layer depletion, acid deposition, air, freshwater quality, marine, wildlife and habitat, land cover and landscape, soil, mineral extraction, waste, and radioactivity (ECIFM, Undated).

The UK Government is not acting alone. Different countries around the world are acting on their commitment after the Earth Summit in 1992. The Canadian Government has also developed a series on environmental sustainability indicators (EC, 2011); similarly, a variety of initiatives in the public and private sector are in place, either at the national or local scale. Although one of the largest surface mining operations is located in the province of Alberta, Canada, the projects lack a project-specific framework of indicators to measure sustainability performance. However, the Pembina Institute, also located in the province, developed a 51-indicator framework through the Alberta Genuine Progress Indicator (GPI) project. As the province leading the country in setting publicly-reported indicators to track progress, Alberta uses a series of initiatives to measure the total societal well-being. The GPI consists of 51 indicators including social, economic, and environmental aspects. Sustainable Calgary developed a 36-indicator framework to measure well-being within its borders, and documented its findings in its “State of Our City” report (Taylor, 2006). Far from setting a framework of indicators, the Government of Alberta published a plan that includes a Provincial Energy Strategy and long-term policy direction for the oil sands regions and Alberta`s Industrial Heartland. The plan contains six strategies: (1) develop Alberta’s oil sands in an environmentally responsible way; (2) promote healthy communities and a quality of life that attracts and retains individuals, families, and businesses; (3) maximize long-term value for all Albertans through economic growth, stability, and resource optimization; (4) strengthen our proactive approach to Aboriginal consultation with a view to reconciling interests; (5) maximize research and innovation to further support SD and unlock the deposit’s potential; and (6) increase available information, develop a measurement system, and enhance accountability in the management of the oil sands (Government of Alberta, 2009b).

Finally, even though the private sector can excuse itself from pursuing SD due to the fact that governmental regulations are met, organizations are taking a proactive approach to minimize social, economic, environmental, health, and other impacts related to their projects' daily operations. Suncor Energy, a Canadian integrated energy company, has aligned its report on sustainability with the GRI and Canadian data and statistics to previously-developed systematic indicators that reflect the environmental, social, and economic performance of their operations (Suncor Energy, 2012). Similarly, other organizations are setting internal SDIs, either because of a conscious shift in their approach to the different impacts of their operations, or because of the external pressure from different stakeholders.

6.4.6 Academically -and scientifically- authored Resources

Due to the large variety of SDIs sets that exist or are under development, the categorization, classification, or benchmarking process proves that an agreement on what should be included to measure sustainability and how to measure each aspect has yet to be reached. Nowadays, the focus of academics and researchers includes every aspect of sustainability, as the area has become a leading interest for the primary stakeholder of public and private projects: society. As pre-established or existing sets of SDIs support the indicators selection process, when pre-selecting indicators, none can be overlooked. Instead, thoughtful analysis and preselecting methodologies are highly recommended without isolating a specific ecosystem, project, or industry; in fact, Fricker (1998) describes how sustainability goes beyond measuring and monitoring economic, social, and environmental conditions, as the term 'sustainability' also refers to ecological integrity, quality of life, and transformation or transcendence. An integration of all aspects of sustainability is needed to decisively assert the set of SDIs. Although Hilson and Basu (2003) make reference to the lack of a credible attempt to develop a framework of SDIs suitable for application at the corporate level of the mining industry, after the Earth Summit in Rio in 1992, the debate around the applicability of sustainability principles in mining operations (exploration, operation, and closure stages) has increased exponentially. Circumstantially, this manuscript demonstrates how different sectors—public and private—are approaching and “overcoming” the challenges of sustainability. Moreover, the International Institute for Environment and Development (IIED) (2011a) presents a comprehensive overview of the relevance to the mining sector of a variety of reporting and indicator initiatives divided into integrated, environmental, social, and economic performance measurements (PeMs). The report indicates that SDIs can assist in the actual assessment, management and monitoring of impact of mining on SD, as well as the reporting of performance, if they are developed within an overall Sustainability Performance Management System (SPMS) (IIED, 2011b).

Different impacts related to surface mining operations affect communities and their development. The interactions between people in local, regional, national, and global communities reflect the balance between internal and external activities; therefore, sustainable communities indicators are to be studied and considered in pre-selecting the indicators for the sustainability of specific projects. By studying the SDIs applied to achieve the SD goals of cities and communities, the different industries find themselves in better positions to align their operations to minimize the various impacts and to avoid disrupting the balance of internal interactions in nearby cities and communities. Sustainable Community Indicators (SCIs) give an indication of that balance by linking the long-term social, economic, and environmental health of a community. Hart (1999) presents a series of indicators in three categories—economy, society, and environment—for measuring the sustainability of communities while comparing traditional indicators with sustainable ones. The author takes into consideration the several different types of capital (i.e., built and financial, human and social, and natural) in the context of sustainability and the transactions within the community (i.e., economic transactions, social relationships, and environmental interdependency). Similarly, City Development Strategies (CDS)—an urban strategic planning approach to attain in sustainability in cities—offers another resource for SDIs. The different approaches to CDS by organizations such as the World Bank, Cities Alliance, and UN-Habitat consider a variety of themes. The World Bank's themes include livability, bankability, competitiveness, and good governance (World Bank, 2000); the UN-Habitat's themes include shelter, social development and eradication of poverty, economic development, governance, and environmental management (ECON Analysis & CLG-UTS, 2005); and the Cities Alliance's themes consist of livelihood, financial resources, governance, environmental sustainability, and spatial forms and infrastructure (Cities Alliance, 2006). Moreover, urban strategic planning considers the relationship between SD and planning: specific research focuses on evaluating local governments' and cities' plans for sustainability while identifying different aspects of SD and specific sets of indicators (Saha & Paterson, 2008; Portney, 2003; Jepson, 2004; Conroy, 2006).

Surface mining operations impact local communities; therefore, understanding what SCIs and CDSs are and how they are measured is a step towards effectively pre-selecting SDIs for the industry. Because of the similarities among others in processes, projects' environments, and regulations, SDIs for other industries may bring a better understanding of the required SDIs for surface mining operations. Shen et al. (2011) argue that prior to their study, no method had incorporated the three dimensions embodied in SD principles (i.e., economic, environmental, and social) in identifying assessment indicators for the sustainability of infrastructure projects. In their paper, the authors identified eight economic, five social, and seven environmental factors. Though the different factors provide a snapshot of a variety of concerns embodied in the three dimensions of SD, they are far from offering a close look at sustainability assessment of surface mining projects, as the authors, in their definition of infrastructure projects, do not include oil sands and heavy oil operations. Even if they did, the set of indicators is too general to include each and every type of project included in the range covered by the definition of infrastructure projects. Even though identifying indicators for a specific industry seems to be the logical approach, general frameworks applicable across industries can be found; however, researchers recognize that more specific indicators are meant to be identified on a case-by-case basis for each different sector (Azapagic & Perdan, 2000). The spectrum of sets of SDIs for each industry sector is an overwhelming resource for the pre-selection process: indicators for major infrastructure projects (Gilmour, Blackwood, Banks, & Wilson, 2011), legacy mine land (Worrall, Neil, Brereton, & Mulligan, 2009), coal mining operations (Craynon & Karmis, 2007), and forest management (Gough, Innes, & Allen, 2008) are a sample of the SDIs set through research that can assist the SDIs pre-selection process for surface mining operations. Additionally, the research on SDIs brings different and more detailed perspectives by studying a single resource, such as energy (Vera & Langlois, 2007); a sole dimension of sustainability (Solomon, Katz, & Lovel, 2008); a specific ecosystem (e.g., river basins) (Guimarães & Magrini, 2008); or sustainability from the corporate standpoint (Hilson & Murck, 2000). Finally, in the SDIs identification process, the three main pillars of sustainability must be balanced amongst themselves in the final set of SDIs, while taking into account the influence of corporate sustainability, including CSR, stakeholder theory, and accountability and transparency.] Lins and Horwitz (2007) examine the interrelationships among these aspects of SD, and present a study conducted by the Brazilian Foundation for Sustainable Development in which thirteen SDIs for five large mining companies are analyzed. The study concludes that even though progress has been made in the Brazilian mining industry, no company met all or even most of the criteria to be considered a fully sustainable business.

Research on sustainable mining is found around the world, as mining operations vary because of the different aspects previously discussed. Regional research groups (funded by the private or public sectors, or both) concentrate on finding the best practices to minimize the different impacts intrinsically found in mining operations. The mining and minerals industry faces several challenges on its road to sustainability. Azapagic (2004) discusses some of these challenges before presenting a SDIs framework which not only identifies social, economic, and social indicators, but also links indicators to the purpose of each indicator, unit, issue addressed, and stakeholder(s) directly affected/interested. Undeniably, balance (social, economic, and environmental) is the target encountered across the board in each set of SDIs. Moreover, Yu (2001) presents a set of SDIs for the mining industry indicating that an integration of and a balance among economic development, environmental protection, and social justice should be inherent when reaching for sustainability. Independently of where the mining operations occur, the mining industry is actively engaged in sustainability through research, development, and innovation. Locally, mining operations and other industries are supported by research conducted by the Government of Canada; subject specialists, researchers, government officials, and representatives of business, financial, and environmental organizations are participating in developing a set of national environment and SDIs (Smith, 2002). Canadian Environmental Sustainability Indicators (CESI) reports the state of the environment and progress on environmental sustainability issues. Even though the set of indicators is not specifically addressed to the mining industry, it certainly provides DMs with a guideline to incorporate into their management plan towards sustainability. Among others, CESI includes GHG emissions, freshwater quality, air quality, and nature indicators (EC, 2012). Additionally, the Canadian mining industry is assisted by educational institutions and innovation. Research conducted by different groups at universities across the country assists in the development of SDIs to effectively monitor, measure, and mitigate social, environmental, economic, and health impacts of mining operations. Located in the province of Alberta, the University of Alberta and the University of Calgary are leaders in research toward the sustainability of oil sands projects; the Oil Sands Research and Information Network (OSRIN), Oil Sands Tailings Research Facility (OSTRF), Oil Sands Tailings Consortium (OSTC), and Life Cycle Assessment of Oil Sands Technologies (LCA-OST) project is a sample of collaborations between industry and researchers. Finally, innovation is playing a major role in measuring progress towards sustainability. Dean, Hughes, Gibbons, Syed, Tsui, Renou, Dow, Mangin and Boivin (2007) use Spot-5, EnvisatAsar, and Meris imagery to monitor SD in the oil sands region of Alberta, Canada. Earth observation (EO) offers a cost-effective global observation not only of the progress made toward the SD of business activities, but also of the direct impact of extraction of bitumen made via surface mining. The authors identify four SDIs: (1) EN11, the location and size of mine lease area (lease area derived by GIS); (2) EN12, the significant impacts of mine activities (activity area derived by earth observation and vegetation habitat impacts derived by EO, geographical information systems, and field data); (3) EN13, the habitats protected or restored (reclamation and future EO monitoring); and (4) EN14, the strategies, current actions, and future plans for managing impacts on biodiversity (EO and geographical information systems are important tools for the management of oil sands operations).

6.5 Pre-selection Process Methodology

The six resources for the pre-selection of SDIs are organized in three distinctive groups, as shown in Table 6.1: (1) indicators agreed on by public or governmental representatives groups through consensus, consisting of governmental regulations and committees and organizations for standardization; (2) indicators identified by academics and practitioners, comprising management and processes best practices and academically- and scientifically-authored resources; and (3) indicators established by organizations, containing the resources from local, regional, national, and international organizations and surface mining industry standards and programs. Grouping the different resources into three types of originators has an impact on determining the indicators' participation in the final set of pre-selected SDIs for surface mining operations.

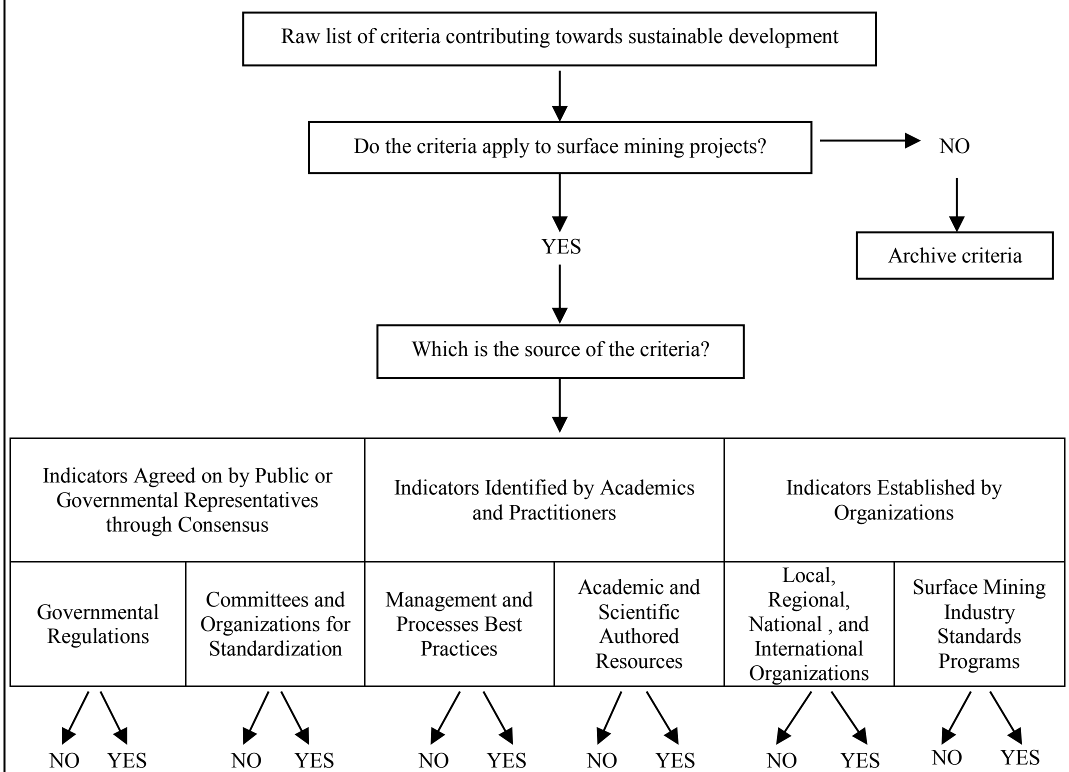
Table 6.1 Grouping sustainable development indicators (SDIs) resources

Group Originator of SDIs					
Indicators Agreed on by Public or Governmental Representatives through Consensus		Indicators Identified by Academics and Practitioners		Indicators Established by Organizations	
Governmental Regulations	Committees and Organizations for Standardization	Management and Processes Best Practices	Academically- and Scientifically-Authored Resources	Local, Regional, National, and International Organizations	Surface Mining Industry Standards and Programs
Available Resources for SDIs Identification					

The pre-selection process begins, as shown in Graph 6.1, with a raw list of indicators identified after an in-depth analysis of the different resources available for SDIs. The applicability and origin of each indicator is then determined. Even though the raw list of indicators may contain a large number of indicators, this initial screening process questioning the applicability of the indicators to surface mining operations serves to limit that number. As a final step, the indicators are organized according to the resource of origin. As expected, indicators may show their origins from multiple resources.

To determine the inclusion of an indicator on the pre-selected list of SDIs, certain criteria must be met, or a minimum number of points must be accumulated. At this point, the indicators are initially screened and categorized, and their origins are identified (independently of having indicators in multiple categories, as they can be found in different resources). All indicators in the preliminary list are assigned one point beforea close scrutiny occurs to select the final set of pre-selected SDIs.

Graph 6.1 Flow diagram to pre-select indicators



Selection Rules:

No	=	0 Points
Yes	=	1 Point

Scores

6 or 5 Points	=	Definitely a criteria
4, 3 or 2 Points	=	A criteria for further consideration. It will be part of the pre-selected group of criteria depending on which sub-section the criteria comes from.
1 Points	=	Not a criteria unless is coming from sub-section Governmental Regulations
0 Points	=	Not a criteria

Six is the maximum number of points an indicator can accumulate. Although zero is theoretically the minimum number of points an indicator could accumulate, if an indicator does not collect any points, then it has not passed the first step of the pre-selection methodology. Therefore, one is the minimum number of points an indicator can collect.

As there is a range of scores (1 to 6 points) possible for each indicator, it is necessary to carry out an analysis of each score and the criteria of inclusion in the pre-selected set of SDIs:

- Score of 6 or 5 points: These indicators are implied to be part of the final set of pre-selected SDIs, as it is understood by the number of points that they come from different resources and from all group originators of SDIs.
- Score of 4 points: Three scenarios are identified: (1) an indicator present in all three group originators of SDIs would automatically make it part of the final set; (2) an indicator coming from only two group originators of SDIs, as long as one of those is the indicator reached through consensus by public or governmental representatives, would be included as part of the final set, as it is supported by governmental regulations; and (3) an indicator coming from two group originators of SDIs (indicators identified by academics and practitioners or established by organizations) would require further analysis to determine its inclusion in the final set. Among others, this analysis would address the indicator's usefulness and applicability, DMs' and stakeholders' considerations, and the goals and objectives of SD.
- Score of 3 points: Three scenarios similar to those under the 4-point score are identified. Therefore, the selection criteria are consistently applied. A fourth scenario may be possible: the indicator includes one point in its score because it comes from the indicators reached through consensus by public or governmental representatives, but particularly from the committees and organizations for standardizations. In this case, the indicator needs further analysis.
- Score of 2 points: The indicator is present in one or two group originators of SDIs. An indicator present in two group originators is stronger. In any case, further analysis is needed. Indicators

collecting one point because they are from the governmental regulations resource are included in the pre-selected SDIs final set.

- Score of 1 point: This is the "weakest" of all cases. Only indicator from the governmental regulations resources are directly included in the final set of pre-selected SDIs; others require further analysis.

Far from being a bureaucratic process because of the inclusion of indicators from the governmental regulations resource, the purpose of the pre-selected methodology is to point out the need for stringent regulations and more governmental participation in SD on behalf of stakeholders and citizens. This pre-selection methodology offers the critical advantage of having considered indicators from all ends of the spectrum. The final set is left to DMs and stakeholders, as it is determined through further MCDM processes or any other methodology available and selected by the practitioner or researcher.

6.6 Pre-selected Sustainable Development Indicators (SDIs) for Surface Mining Operations

A total of 115 SDIs were identified, as shown in Table 6.2. The SDIs are allocated in ten categories (or areas of excellence); these categories were identified based not only on the surface mining operations but also all the different operational sub-divisions of the oil sands projects, as explained by Poveda and Lipsett (2011b): (1) PEME (19 SDIs); (2) SSRE (11 SDIs); (3) WRE (11 SDIs); (4) AARE (4 SDIs); (5) NALE (1 SDI); (6) ERE (3 SDIs); (7) RME (6 SDIs); (8:) IDOE (2 SDIs); (9) IBE (14 SDIs); and (10) ERCE (44 SDIs). A description of the pre-selected SDIs is presented in Appendix A.

While in the sub-division of surface mining some areas of excellence contain one or very few SDIs, other sub-divisions of the oil sands and heavy oil projects (e.g., permanent housing/buildings) may increase the number of SDIs in those areas (e.g., AARE, WRE, NALE, ERE, RME). Based on the previously-described methodology, all group originators of

Table 6.2 Pre-selected SDIs for surface mining operations in oil sands projects

Project and Environmental Management Excellence - PEME	Site & Soil Resource Excellence - SSRE
- Strategic Environmental Assessment (SEA) - Environmental Impact Assessment (EIA) - Cumulative Environmental Impact Assessment (CEIA) (As per cumulative impact threshold requirements for Alberta Oil Sands) - Social Impact Assessment (SIA) - Economic Impact Assessment (EcIA) - Biophysical Impact Assessment (BIA) - Project Lifecycle Assessment (PLA) - Environmental Protection Management Plan - Environmental Risk Management Plan - Emergency Response Management Plan - Water Management Plan - Solid Waste Management Plan - Erosion and Sediment Control Plan - Hazard Management Plan (includes assessments, inspections, and procedures) - Safety Management Plan (includes safety training, reporting, and prevention of incidents) - Environmental Management Systems - Sustainable Public Procurement Strategies - Regulatory Compliance (Approvals, Licenses, and Permits) - Independent Verified Auditing and Reporting Plans	- Mining Effluents[1]: Monitoring, Control, and Reduction - Biological monitoring studies and reports - Overburden Management - Structures to prevent erosion and soil runoff: Implementation and Monitoring - Re-used excavation material - Proportion of non-previously-developed land used - Proportion of protected land used - Total waste extracted (non-saleable, including overburden) - Percentage of resource extracted relative to the total amount of the permitted reserves of that resource - Tree harvest management - Deforestation
Water Resource Excellence - WRE	**Atmosphere & Air Resource Excellence - AARE**
- Mining Effluents[1]: Monitoring, Control, and Reduction - Water supply and consumption - Usage of recycled water - Wastewater management - Ground water resources: Protection and Monitoring - Muskeg drainage: Monitoring, Control and Reduction - Control of formation dewatering - Seepage prevention (from ponds, pits, and landfills) - Construction of water management systems and structures - Acid drainage: Monitoring, Control and Reduction - Aquatic life: Protection and Monitoring	- GHGs[2]: Monitoring, Control and Reduction - Fugitive Emissions: Monitoring, Control, and Reduction - Dust control - Noise and vibration management
Natural & Artificial Lighting Excellence - NALE	**Energy Resource Excellence - ERE**
- Luminosity: Control and Regulatory compliance	- Internal production of energy consumed (Renewable energy use) - Consumption of primary energy (natural gas, LPG (liquefied petroleum gas), petrol, and other fuels) - Consumption of secondary energy (electricity and heat)
Resources & Materials Excellence - RME	**Innovation in Design and Operations Excellence - IDOE**
- Usage of chemical substances - Hazardous material management, storage, and disposal - Improvement in machine application efficiency - Machines material re-use - Solid waste management (non-renewable resources): Reduction, Reuse, and Recycling - Distance (proximity) of materials suppliers	- Investment in Innovation - Clean technology Innovations: Testing and implementation of new technologies
Infrastructure & Buildings Excellence - IBE	**Education, Research, and Community Excellence - ERCE**
- Ecological footprint - Mining location within or proximal to water bodies - Proximity of mining operations and mining material processing and tailing ponds - Wildlife: Monitoring and Protection - Vegetation: Monitoring and Control - Area of habitat created/destroyed (area disturbed by oil sands development) - Affected species: Animal and Vegetal - Biodiversity and habitat (includes biological studies and reports): Monitoring and Protection - Tailings ponds location and impacts study - Reduction of land area used for tailings ponds operations - Total area of permitted developments - Total land area newly opened for extraction activities (including area for overburden storage and tailings) - Transportation distance of customers, business travel,	- Investment in research - Workforce awareness training programs (safety, and environmental, social, economic, and health impacts) - Community awareness programs - Community and stakeholder consultation and involvement - Poverty alleviation of affected areas - Wealth distribution - Contribution to social development of communities - Participation in regional co-operative efforts - Contribution to economic and institutional development of communities - Employment, unemployment and underemployment rates - Contribution to GDP (gross domestic product) - Expenditure on environmental protection - Ethical investment - Percentage of employees that are stakeholders in the company

Table 6.2 Pre-selected SDIs for surface mining operation in oil sands projects (cont'd)

workforce, and community for fly-in and fly-out operations - Communication and Transportation Facilities	- Ratio of lowest wage to national legal minimum - Health, pension, and other benefits and redundancy packages provided to employees as percentage of total employment cost - Expenditure on health and safety - Inflation rate - Internal return ratio - Environmental liabilities - Return of investment - Payback period - Investment in employee training and education - Lost-time injuries - Lost-time injuries frequency - Women/men employment ratio - Percentage of ethnic minorities employed relative to the total number of employees - Work satisfaction - Housing provision for workforce - Housing development for local communities - Projects acceptability - Female to male wage ratio - Net migration rate to projects areas - Number of direct and indirect employees - Net employment creation - Percentage of hours of training - Employee turnover - Fatalities at work - Total number of health and safety complaints from local communities - Percentage of employees sourced from local communities relative to the total number of employees - On-going health monitoring (workers and local communities) - Health care management/first aid facilities - Number of local suppliers relative to the total number of suppliers - Number of local contractors relative to the total number of contractors

[1] Mining effluents include: arsenic, cooper, cyanide, lead, nickel, zinc, total suspended solids, radium, pH

[2] GHGs include: sulphur dioxide (SO2), ozone (O3), nitrogen Dioxide (NO2), particulate matter (PM2.5), carbon monoxide (CO), oxides of nitrogen (NOx), volatile organic compounds (VOCs), hydrogen sulphide (H2S)

SDIs contributed to the final set of pre-selected indicators; however, applicability and number of available resources for SDIs identification in which the SDI was encountered define the potential for the indicator to be selected. If classified in the three pillars of SD, environmental indicators are fairly common in all available resources for SDIs identification. On the other hand, social and economic indicators are mainly encountered in two resources: academically- and scientifically-authored resources, and local, regional, national, and international organizations. Evidently, when it comes to the social and economic pillars of SD, government, industry, and organizations for standardization still face challenges in finding the answers to what indicators to use and how to measure sustainability.

SDIs are designed to assist stakeholders in the decision-making process throughout the project lifecycle; however, a variety of phases (e.g., backfilling, recontouring, revegetation, monitoring, and certification) included in the surface mining operations life cycle have been excluded from the pre-selected set of SDIs, as they are expected to be part of a different operational sub-division of the oil sands projects (Poveda & Lipsett, 2011b). Among the identified pre-selected SDIs, there is a series of assessments, management plans, and systems; oil sands and heavy oil developers, government, and other stakeholders in general are expected not only to meet the SDIs included in the PEME area of excellence by performing each task, but also to follow up any recommendation and requirement identified within. There is a large variety of SDIs for surface mining projects operations, due to the resources used or affected by these projects. Moreover, oil sands and heavy oil projects are complex undertakings that usually test stakeholders' decision-making abilities by forcing them to choose between progress and a diversity of impacts that affect the environment and communities' social, economic, and health "balance." Therefore, stakeholders use SDIs to make educated decisions about development or to set the path for projects and businesses. SDIs are usually identified and classified in environmental, social, and economic indicators; however, extended literature also refers to integrated indicators that combine two or three pillars of sustainability, not only to provide a more holistic assessment of sustainability, but also to reduce the number of indicators in the final set of SDIs (Poveda & Lipsett, 2011b).

The different social, economic, and social impacts of the oil sands projects are encountered at the local, regional, and global scale; therefore, the final set of SDIs is expected to somehow measure sustainability at all three levels. While there is certain level of agreement on environmental and economic SDIs and they are fairly well-developed, measuring the social pillar of sustainability still in its infant stage and requires further development. Moreover, quantification of social issues of projects and businesses' and stakeholders' (employees, communities, government, etc.) values, morals, and interest cannot be defined in physical terms; however, for the overall assessment, it is essential that all three pillars of sustainability are addressed. Social SDIs, then, have an unfair disadvantage, as they are not evenly present in all available resources for SDIs identification. In fact, applying pre-selected methodologies assists DMs not only by narrowing down the large variety of SDIs from different resources, but also by identifying those resources that need further work and efforts towards sustainability. Moreover, the group originator of SDIs number 1 (indicators reached through consensus by public or governmental representatives)—identifiable as the weakest of all—is far behind the other two groups, while academically- and scientifically-authored resources are leading the pack. Therefore, the inclusion of indicators in a pre-selected set of SDIs depends upon further analysis, which includes usefulness, applicability, DMs' and stakeholders' considerations, and goals and objectives of SD. Filling the gap between the different resources represents a real commitment to SD from all the entities communities rely on to find the balance between environment, society, and the economy.

6.7 Conclusions and Future Research

As the number of surface mining projects and production of bitumen from the oil sands increase, the need for identifying SDIs to measure the integrity and a balanced development of the projects becomes evident. Certain groups' stakeholders are increasingly speaking up and/or rebelling against the projects and demanding tougher regulations, more participation in the decision-making process, and measures to mitigate the different impacts (e.g., social, economic, environmental, health). If the intricacy of identifying and measuring impacts, the complexity of the projects, and stakeholders' expectations are added to the fact that itself is still evolving, practitioners and researchers must SD somehow find the starting point to pre-select potential SDIs to measure the sustainability of the projects. Therefore, the aim of the pre-selection methodology and the different resources available for SDIs identification presented in this paper is to assist and increase confidence in the preliminary efforts towards a formal MCDM process.

A primary obstacle in pre-selection methodologies arises because of the lack of SDIs in certain resources for specific projects (i.e., committees and organizations for standardization have not developed any guidelines for SDIs for surface mining operations); as a result, indicators' applicability and stakeholder expectations become a priority in the pre-selection process. Another two main issues prevail in selecting a set of indicators and benchmarking the overall sustainability indicator: (1) each community, business, or project has unique needs; and (2) it is difficult to place some indicators in a specific category. Additionally, the narrow idea of associating sustainability to just the environmental pillar of SD is still present; consequently, there is a need to assist stakeholders and practitioners in general with broadening any pre-conceived idea of SD by presenting a large set of pre-screened SDIs that is still diverse enough to give stakeholders the opportunity they had been calling for to provide input in the participatory decision-making process.

The question of what should be measured is not fully answered, but rather, is emphasized; while researchers and practitioners continue looking for agreement on it, the next step is to try to answer how to measure the diverse number of existing SDIs found in different resources. The sustainability of surface mining operations can be measured independently; however, they contribute to the overall oil sands projects' SD performance. Therefore, the pre-selection process is a preliminary effort before not only choosing the final set of indicators, but also deciding how to express all indicators in a similar measuring scale (i.e., all indicators expressed in money, time, or any other selected unit of measure). Individually, each indicator can be expressed in a different unit, although the overall SD performance must be narrowed into a single assessment value. Consequently, further work is needed to develop methodologies to (1) select the final set of SDIs, based on the given pre-selected set of indicators, and (2) measure all indicators and overall sustainability for surface mining operations in oil sands projects.

7. Chapter Seven – Using Sustainable Development Indicators (SDIs) for Sustainability Assessment of Surface Mining Operations in the Oil Sands Projects: Applicability, Usefulness and Cost[6]

7.1 Introduction: Surface Mining Operations & The Canadian Oil Sands

The Canadian oil sands, an unconventional oil and gas resource, are located in the northern section of the provinces of Alberta and Saskatchewan in three main deposits: Athabasca, Peace River, and Cold Lake, as shown in Fig. 7.1. Out of approximately 174 billion barrels in reserves of Canadian oil, about 169 billion are located in the oil sands. Canada places third in global oil reserves after Saudi Arabia and Venezuela; however, it places first in unconventional oil and gas reserves since the other two deposits are conventional and heavy oil, respectively (CAPP, 2012c).

A mixture of sand, water, clay, and bitumen forms the oil sands. The bitumen extracted from the oil sands is too heavy to flow or be pumped; therefore, the bitumen must be diluted or heated. The extraction process can be achieved by two distinctive methods: in-situ (Latin, meaning “in place”) or open-pit mining (e.g., surface mining). The bitumen extracted using the surface mining method is close to the surface and only counts for 20% of the total Canadian oil sands reserves. The other 80% is

[6] A version of this chapter has been published. Poveda & Lipsett 2013. Energy and Sustainability. 55-67.

extracted using different in-situ techniques (e.g., SAGD, CSS, VAPEX).

Figure 7.1 Oil sands deposits (Alberta Energy, 2012d)

Surface mining operations are currently taking place in about 500 km2 out of the 140,000 km2 in which the oil sands are located. Only oil sands within 75 meters of the surface are extracted using the open-pit mining technique. For deeper oil sands developers use in-situ mining techniques as surface mining is not practical. Surface mining out of the 1.6

MMbpd reached in 2010, 53% of the crude bitumen production used the open-pit mining technique while the other 47% used in-situ methods (Alberta Energy, 2012d).

Similar to coal mining operations, the surface mining process (as shown in Fig. 7.2) uses large electric and hydraulic shovels with capacities up to 45 m3 to scoop the oil sand into trucks—with capacities up to 400 tons—that take the mixture to crushers where the material (i.e., large clumps of earth) is broken down. The mixture is diluted using water and diluent (naphthenic and paraffinic) to then be transported to a plant in which the bitumen is separated from the other components (e.g., clay, sand, water, chemicals). While the bitumen continues its course for upgrading and refining to become synthetic oil, the other components are sent to the tailings ponds areas after maximizing the water recycling process.

To produce one barrel of SCO, about two tonnes of oil sands must be processed using the open-pit mining method. In comparison, the in-situ process represents a higher investment to extract the bitumen; however, no tailings ponds are required—a major area of concern from the environmental standpoint—since the sands remains in the ground and only bitumen is extracted.

The oil sands development has quickly increased during the past couple of decades. As a result, the resource and related projects have captured national and international attention, not only due to the size of the oil reserves, but also because of their diverse inherent impacts. Environmentally, the four areas of main concern are land use, tailings ponds, water use, and GHG emissions. Even though environmental impacts are the most-talked-about area of concern arising from the oil sands development, economic, social, and health impacts are the cause of discomfort and discontent for local communities and a variety of stakeholders. Though the primary economic impacts may be perceived as “benefits” due to the large amounts of cash flow injected into the Canadian economy, there are secondary economic impacts to be considered. Socially, the development has caused great stress to the region due to the "boom town" effect, while health indicators provide evidence of the existence of issues that need to be addressed immediately.

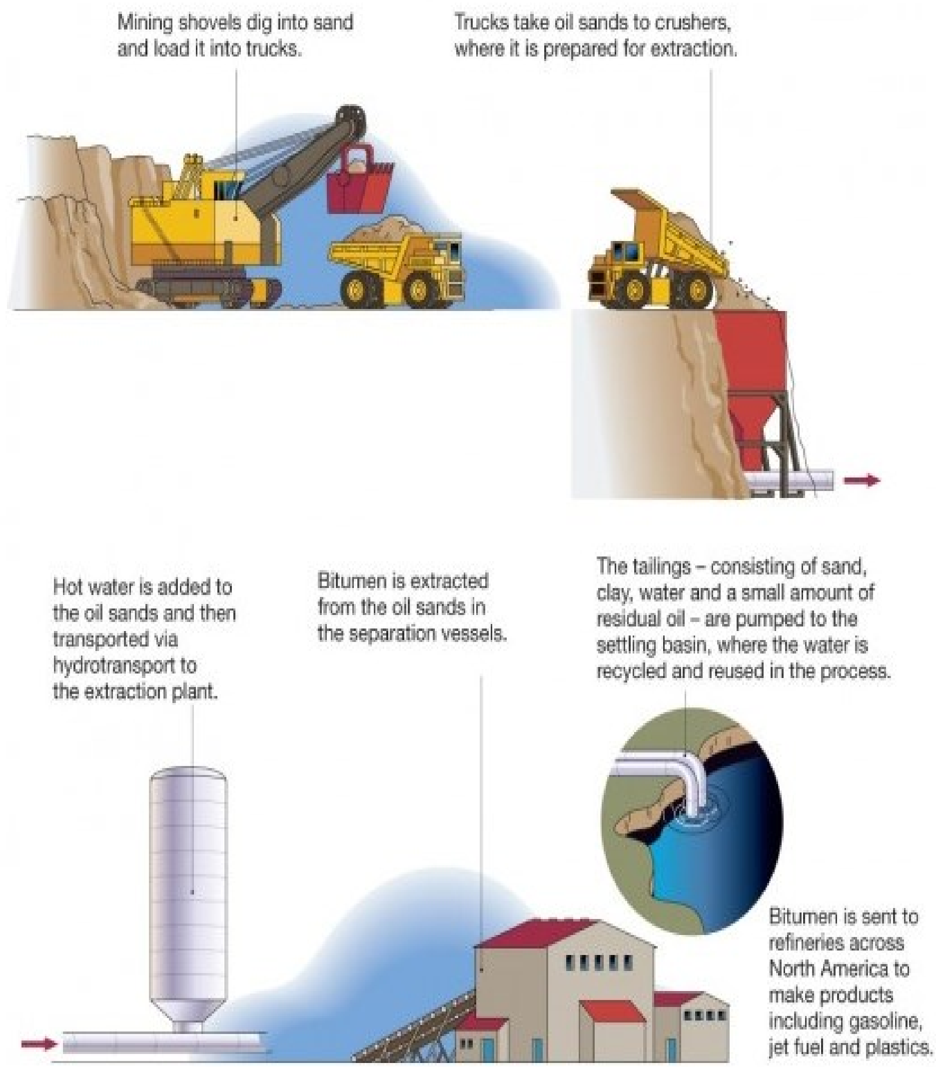


Figure 7.2 The surface mining process (CAPP, 2012d)

Evidentially, diverse factors point out the need for creating a set of indicators to measure how sustainable the development of the oil sands is. The fast development of the region and extraction of the resource, the diverse impacts (i.e., economic, social, environmental, and health), the stakeholders' concerns, and the needs for new oil and gas resources (among other factors) demonstrate the necessity of finding a balance between the social, economic, and environmental needs of the present without affecting the needs of future generations. Moreover, measuring sustainability relies on finding a proper series of SDIs to demonstrate the commitment of government, developers, local communities, and stakeholders in general to develop the resource in a responsible and sustainable manner. However, deciding on what to measure (i.e., indicators) and how to measure those indicators (i.e., metrics) is a complicated task for which the international scientific community still has not found common ground. This manuscript gives an interpretation of three factors—applicability, usefulness and cost— surrounding the application of SDIs to surface mining operations in the Canadian oil sands projects.

7.2 Sustainable Development Indicators (SDIs)

SDIs are also known as KPIs for sustainability. SDIs are used to measure the performance of organizations or projects regarding the different aspects (i.e., triple bottom line) of sustainability. The initial forces behind SD have been the UN and national governments; therefore, the first sets of performance indicators have been developed focusing on national, regional, and community levels (Labuschagne, Brent, & Van Erck, 2005). Moreover, linking the PPP of SD at the macro level with goals and objectives at the project and organizational levels is still a major hurdle for the international community—including governments, scientists, politicians, sociologists, and economists—to overcome.

The use of SDIs assists not only by identifying sustainability trends, but also by measuring the effectiveness and efficiency of SD policies, businesses, and projects; however, the use of SDIs is still in its infancy (MacGillivray & Zadek, 1995; Bell & Mores, 2003). Nevertheless, a set of SDIs can be used as a measuring system of an organization while controlling its behaviour toward SD. Additionally, the implementation of appropriate measuring systems assists in the assessment of effective performance communication (achievement of goals and objectives) and responsiveness to stakeholder concerns (Perrini & Tencati, 2006).

In the literature, two distinct forms of indicators are found: qualitative and quantitative. The type of indicators used is usually mandated by the objective of the measure; however, quantitative indicators are applied more often (Gallopin, 1997), which points towards the desire to avoid the subjectivity that any qualitative measurement intrinsically possesses. Although SDIs are the most commonly used tool to assess SD, the design of SDIs still has challenges to overcome. The triple bottom line, known as the three pillars of sustainability (i.e., social, economic, and environmental), is known globally but not universally accepted. Additionally, the starting point in the design of SDIs is to define what to measure (i.e., indicators), followed by how to measure the indicators (i.e., metrics); in both instances, the debate among different groups—environmentalists, politicians, sociologists, and economists, among others—has not reached consensus on a unified set of indicators for SD.

While the use of indicators facilitates understanding of the performance of organizations or projects toward SD, the action of reporting adds to the debate. SD performance can be presented using indicators or a combination of indicators (i.e., indices). An indicator may be taken as a simplistic form of reporting sustainability performance, and may be used to hide the real issues of the organization or project with regard to sustainability, which raises issues of transparency and credibility. Also, a set of indicators can be designed on a project, organization, or industry basis. Since SDIs are non-compulsory tools, the use of a set of indicators designed to meet the needs of a certain industry relies on the commitment of an organization to report its performance. A set of indicators designed for an industry (e.g., mining) may not meet the needs of all members (as different processes are used for each type of material mined); therefore, the design and use of a set of indicators on an organizational level (i.e., a set of indicators measuring overall sustainability performance in organizations with a variety of projects in their portfolio) represents a viable alternative, but adds the undesired inability to benchmark performance among organizations and/or projects within the same industry.

Therefore, a set of indicators must be designed for a sector of an industry that manages similar projects (e.g., the oil sands); a project basis set of indicators must not only follow the industry guidelines and address the different stakeholders' needs, but must also meet the requirements and fundamentals (e.g., the triple bottom line) of SD in a balanced approach.

The mining industry has moved towards a more sustainable path. Different organizations have developed and/or are implementing a series of sustainability frameworks. After a two-year consultation process, the ICMM implemented a SD framework consisting of integrating 10 principles with 7 supporting position statements, transparent and accountable reporting systems, and a third-party verification process. The IOM3 highlights the standards (e.g., ISO, CEN, BSI) supporting SD during the life cycle of manufactured products. Additionally, IOM3 is currently engaged with a variety of programs and initiatives that promote SD.

Nationally, the MAC and the CIM are presently working towards setting processes and practices for sustainable mining operations. Moreover, MAC has developed a series of guiding principles and performance elements under the Toward Sustainable Mining (TSM) initiative. TSM—a mandate for the MAC members—contains a series of indicators that support the guiding principles and address the areas of crisis management, energy and GHG emissions management, tailings management, biodiversity conservation management, safety and health, and Aboriginal relations and community outreach (MAC, 2012). Other national and international programs and initiatives in the mining industry for issues related to SD include, but are not limited to: the WMI; the MEND program; the GMI; the CMIC; the MMSD project; the ICMM; and the UNEP MRF.

Undeniably, the mining industry has taken steps toward more sustainable and responsible practices; however, as previously discussed, the programs and initiatives are still at the industry level. The mining industry in Canada not only consists of oil sands reserves, but also gold, diamonds, zinc, uranium, aluminium, etc. Therefore, industry-wide initiatives for sustainability may overlook the individual impacts that each mined material carries in each stage of its life cycle. As a result, the development of the Canadian oil sands requires a project-based (i.e., similar processes are followed by developing companies) set of SDIs (i.e., a measuring system), not only to measure sustainability performance, but also to assist developers, government, local communities, and other stakeholders in the decision-making and benchmarking performance processes. The development and implementation of SDI analysis requires answering questions such as: (1) Do the SDIs properly align theory with practice? (i.e., applicability), (2) Do the SDIs meet their intent? (e.g., usefulness), and (3) Can the stakeholders and project proponents afford the implementation of SDIs? (e.g., cost).

7.2.1 Applicability

Corporate performance is transforming. While financial measures continue to be a crucial aspect, non-financial measures are increasingly gaining relevance for corporate sustainability (Robinson, Anumba, Carrillo, & Al-Ghassani, 2005). The application of environmental indicators is a reflection of the advances made in research, education, and stakeholder engagement. Furthermore, interest in the use of non-financial measures is due to the growing interest different stakeholders, including investors and clients, are taking in additional information regarding the organization’s performance (DiPiazza & Eccles, 2002). As a result, organizations implement measurement systems to assist with the transformation; however, a major hurdle encountered in the implementation of measurement systems consists of integrating financial and non-financial measures to reflect an organization's strategic objectives (Butler, Letza, & Neale, 1997). The use of KPIs for sustainability (indicators) as a measuring system assists assessing the financial and non-financial performance of an organization or project. Then, the success of integrating financial and non-financial measures (i.e., indicators) relies on designing the metrics for the selected set of indicators.

Although organizations are identifying the need for measurement systems, the road to implementation may not be easy. Robinson et al. (2005) state the resistance to change and the degree to which construction organizations fail when implementing innovative approaches to improve future business performance; however, the increasing use of KPIs "evidence the cultural change and the progress made in performance improvement measurement and reporting" (Swan & Kyng, 2004). As sustainability continues emerging in businesses and corporate cultures, the use of KPIs assists in identifying those areas in need of improvement while linking the organizations' strategic goals and objectives and facilitating benchmarking against best practices and competitors. Furthermore, the benchmarking characteristics of KPIs for sustainability contribute to the transformation of corporate performance of an entire industry, as "benchmarking tools measure issues such as people, design, environmental performance, and general business performance" (Swan & Kyng, 2004). Nevertheless, the development and implementation of KPIs for sustainability depends on the degree to which the theory supports the practical application of measurement systems.

Although the theory of SDIs (selection of indicators and metrics) is not fully developed in terms of the level of development of each pillar of sustainability, the practice seems to align with the theory, and is reflected by the percentage of indicators used in a given set of SDIs to report the organization's and/or project's social, economic, and/or environmental performance. Additionally, because of the usual limited number of indicators used, a set of SDIs may not accurately reflect the proper measurement of every intended aspect included in the principles and fundamentals of SD. Nevertheless, sustainability is still in its infant stages, and its three pillars are in different levels of development. The design and implementation of SDIs develops in parallel with the understanding of each pillar of sustainability and the interconnections between them. While environmental indicators are the primary type used to report sustainability performance, social and economic indicators have a limited but growing presence.

The current sets of indicators for mining operations contain a handful of indicators, which only address some aspects of sustainability. While environmental impacts and aspects are fairly well-understood and several tools are available to measure environmental indicators (i.e., metrics), the social and economic pillars of sustainability are still far behind; therefore, sets of indicators often focus heavily on measuring environmental performance. As a result, the development and application of a larger range of indicators to measure the sustainability of mining projects is required in order to address the different stakeholders' needs. Since some sectors of stakeholders have requested tougher regulations, the government has been forced to act; however, the use of SDIs is not currently regulated. Nevertheless, the use of SDIs and transparent reporting assists developers in obtaining the "social license" to operate, which is of high priority from the CSR perspective.

The level of practical implementation may not fully reflect the theoretical advances being made regarding each pillar of sustainability. Since the use of SDIs is not regulated, organizations' reporting activities are non-compulsory; therefore, organizations and projects may report those indicators that reflect the areas of good performance, and the only pressure developers have to report performance consists of obtaining the “social license” to operate. Mining projects are large by nature, and their related impacts cover a range of issues (e.g., environmental, social, economic, political, and health-related). For example, the initiative TSM developed by MAC—a mandate for its members—reports on six key areas of operation performance, and is currently working on developing specific indicators for mine closure (MAC, 2012).

In 2011, 20 MAC members reported their performance, which is measured at the facility level, and 6 of those organizations underwent external verification. Even though the TSM initiative demonstrates the industry’s first steps toward more sustainably developed mining operations, the current set of SDIs leaves out areas of SD of crucial importance in order to meet the needs of stakeholders and find a true balance among the social, economic, and environmental pillars of SD. The 6 TSM areas of operation performance are divided as follows: 3 environmental areas (i.e., tailings management, energy use and GHG emissions management, and biodiversity conservation management), 2 social areas (i.e., Aboriginal and community outreach, safety and health), and 1 integrated area (i.e., crisis management), and assist companies in leveraging best practices and critically assessing business performance. As an example, a closer look into the 2 social areas of operation performance included in the TSM initiative illustrates the need for developing a more complete set of SDIs addressing a larger range of social impacts due to the development of mining projects and operations: Aboriginal and community outreach is measured using four performance indicators (i.e., 1. community of interest [COI] identification, 2. effective COI engagement and dialogue, 3. COI response mechanism, and 4. reporting), and safety and health uses five performance indicators (i.e., 1. policy, commitment, and accountability; 2. planning, implementation, and operation; 3. training, behaviour, and culture; 4. monitoring and reporting; and 5. performance) (MAC, 2012).

7.2.2 Usefulness

The increased awareness in measuring the impact on society is in response not only to the need to minimize the environmental effects of construction activities, but also as part of a growing corporate sustainability agenda to give something positive back to society (Robinson et al., 2005). Therefore, the usefulness of SDIs for assessing the sustainability of surface mining operations in the oil sands projects can be analyzed from different perspectives: benchmarking, continuous improvement processes, business PeM, CSR, and stakeholder engagement, among others.

As a benchmarking tool, a set of SDIs (or KPIs for sustainability) supports business improvement. The benchmarking process questions who performs better, why they are performing better, and how a company can improve. Because benchmarking is an ongoing process (Swan & Kyng, 2004), a set of SDIs facilitates organizations and projects reporting performance activities as a continuous activity instead of being a sporadic task of PeM (e.g., audit process). Hřebíček, Misařová, and Hyršlová (2007) state that KPIs help organizations to implement strategies by linking various levels of an organization (e.g., organizational units, departments, and individuals) with clearly-defined targets and benchmarks.

Benchmarking performance does not concentrate on the organization's or project's performance; instead, to realistically improve performance, the comparisons should be made with others (e.g., external organizations or projects performing similar activities) (Swan & Kyng, 2004). It is expected that organizations will need to use environmental KPIs to adequately capture the link between environmental, social, and economic performance (Hřebíček et al., 2007). Presently, mining operations for oil sands projects has limited tools to benchmark performance. The SDIs used to measure sustainability performance are limited not only in number but also in scope and/or do not properly isolate the surface mining process (i.e., SDIs are used to report performance of the overall facility, which includes processes other than mining). In the case of the mining industry, the TSM is an industry-wide tool that not only does not differentiate the material mined, but also uses a limited number of SDIs; therefore, it does not address the specific impacts (i.e., social, economic, environmental, health) carried by surface mining operations in the oil sands projects.

Business PeM models facilitate continuous improvement. They provide a balance between short- and long-term objectives, financial and non-financial measures, and external and internal performance (Robinson et al., 2005). Understandably, organizations are turning to the use of SDIs not only because of the 360-degree performance evaluation that can be accomplished, but also because they can help demonstrate a commitment to performance improvement, corporate reporting responsibility, and stakeholder engagement qualities. Moreover, measuring performance not only identifies the gaps between current and desired performance, but also assists the improvement process by indicating any progress towards closing the gaps (Weber & Thomas, 2005). Bititci and Nudurupati (Undated) explain that PeM should assist organizations in identifying key areas that need improvement, diagnosing and analyzing the reasons behind low performance, planning and implementing changes necessary to improve performance in a quantifiable or measurable way, monitoring the results to find whether they achieved the expected results, and developing a closed-loop control system to promote continuous improvement.

The need for performance evaluation and improvement in mining operations for the oil sands projects is evidence of disconformity among certain groups of stakeholders. Either the developers are not addressing the stakeholders' needs, which can be demonstrated through PeM (i.e., the use of inadequate or limited SDIs), or there are deficiencies in the stakeholder engagement during the projects life cycle, including the performance reporting stage. In fact, progress in the improvement process can be demonstrated through changes in behaviour and attitude, improvements in the key operational and business performance indicators, and the degree to which quality improvement projects are aligned with the company's articulated strategies, policies and guidelines (Dale, 1996). Nevertheless, improvements made within an organization or project must be effectively communicated, not only to stockholders but also to stakeholders. Large projects with a variety of stakeholders (e.g., surface mining operations for oil sands projects) are sensitive by nature due to the intrinsic impacts present during their development. Therefore, as occurs in other decision-making processes, the identification, development, and implementation of SDIs requires stakeholder participation through effective engagement, with the aim of increasing the opportunities to accomplish the intended goals and objectives. The stakeholders' participation offers credibility to the process and accountability of the parties involved; the involvement of stakeholders for mining operations in the oil sands projects has transformed from one-sided or limited to a multi-criteria integrated participatory process.

7.2.3 Cost

The cost of implementing SDIs can be analysed based on the benefits (i.e., wealth and profits) for organizations and the actual costs of setting the measurement systems to monitor and control SD performance.

PeM through continuous improvement methodologies provides organizations and projects with the advantage of demonstrating civic leadership in sustainability. Additionally, continuous improvement adds to an organization's competitiveness (Hyland, Mellor, & Sloan, 2007) as a variety of clients—especially within the public sector—are seeking to work with organizations that are willing to demonstrate their commitment to continuous improvement (Swan & Kyng, 2004). Therefore, organizations not only are looking to win work through the implementation of KPIs systems, but also gain advantages in reporting wider projects requirements besides time and cost (Swan & Kyng, 2004).

From the stakeholder's standpoint, a company can endure over time if it is able to build and maintain sustainable and durable relationships with all members of its stakeholder network. Those ties between organizations and the stakeholder can be built but also strengthened through stakeholder engagement to accomplish SD goals and objectives. From this point of view, a company creates value when it adopts a managerial approach that is sustainability-oriented (Perrini & Tencati, 2006); furthermore, the sustainability of a firm depends on the sustainability of its stakeholder relationships. Companies need appropriate systems to measure and control their own behaviour in order to assess whether they are responding to stakeholder concerns in an effective way, and in order to communicate and demonstrate the results achieved (Perrini & Tencati, 2006).

For organizations, projects, government, communities, and stakeholders in general, it is usually profitable to "go green" and to promote sustainable practices (both financial and non-financial). Bouchery, Ghaffari, and Jemai (2010) use the concept of eco-socio-efficiency as a balance of economic, environmental, and social performance, and argue that the current situation is generally eco-socio-inefficient, with some sporadic exceptions. Therefore, companies are exploring the concept of SD, seeking to integrate their pursuit of profitable growth with the assurance of environmental protection and quality of life for present and future generations. As a result, some companies are beginning to make significant changes in their policies, commitments, and business strategies (DEFRA, 2006).

From the other side of the spectrum, organizations must absorb the cost of implementing a measurement system (i.e., SDIs or KPIs for sustainability). While some organizations can fully implement a measurement system, others can (and must based on the organization's size) use external verification services. With either alternative the organization chooses, third-party firm verifications (i.e., audits) are to be considered, and the organization must be willing to participate. Based on the limitations of the existing SDIs for assessing the sustainability of surface mining operations for the oil sands projects previously discussed, an independent process for the identification, development, and implementation of an improved set of SDIs must be created by a multi-disciplinary team and stakeholder participation, with the aim of having a transparent process to assess SD performance.

7.3 Conclusions

The development of a set of SDIs for surface mining operations in the oil sands projects is applicable, useful, and its cost is manageable and justified. The oil and gas industry must transform to meet the stakeholder demands. The construction industry went through a similar transformation process demonstrating the benefits of SDIs and the implementation of measurement rating systems implementation. Exploitation of natural resources—non-renewable, in the case of the Canadian oil sands—to meet the oil and gas needs of the present generation cannot be accomplished at expense of irreparable damages to the environment and society, regardless of the initial economic benefits (as negative economic impacts also occur). Unconventional oil and gas resources extraction and processing contain higher negative impacts (especially environmental) than conventional resources. As the need for finding alternative oil and gas resources grows due to the scarcity of conventional resources, proper tools (e.g., SDIs and sustainability rating systems) must be created and used in order to develop the resources in a socially, environmentally, and economically sustainable manner.

8. Chapter Eight – Design of Performance Improvement Factors (PIFs) for Sustainable Development Indicators (SDIs) Metrics for Oil Sands Projects with Application to Surface Mining Operations Based on Continual Performance Improvement (CPI)[7]

8.1 Introduction

Organizations and individuals are surrounded by measures. Individuals are expected to increase or evolve in performance to advance and accomplish their personal goals, and organizations must do the same to increase profit and confront aggressive market competition; therefore, PeM offers an opportunity to compare against a pre-established baseline to evaluate improvement over time. PeM improves management processes, develops internal and external channels of communications, and provides fact-based decision-making tools (US Department of Energy, 1996). A key indicator of survival in competitive markets is, to some degree, defined by an organization's ability to measure the most critical processes and improvement (Malik, Khan, Shah, & Gul, 2010). In a timely manner, organizations not only adapt but also react to change through measurement systems or metrics; furthermore, metrics are seen as effective tools to measure present performance and monitor possible upcoming risks (Srivastava, Kogan, & Vaserhelyi, 2001).

Organizations and projects use indicators not only to measure

[7] A version of this chapter has been published. Poveda & Lipsett 2013. Journal of Sustainable Development. 6(8): 52-70.

current performance, but also to identify performance gaps between the current and pre-established goals, to show progress towards closing performance gaps, and to identify areas where actions are required to improve performance and close the gaps (Weber & Thomas, 2005). Moreover, information gathered in PeM processes is used for evaluation and planning, while, similar to indicators, PeM systems provide ways of communicating performance expectations, identifying performance gaps, and supporting decision-making processes (Hyland et al., 2007). Tarr (1996) adds to the debate a distinction between external and internal purposes for PeM, in which internal purposes consist of controlling and redirecting individuals and departments, assisting the process with feedback to adjust performance or targets, and offering a tool to compare performance against strategic and continuous improvement goals.

When it comes to PeM in the area of sustainability, the triple bottom line (i.e., environment, social, economic) is often measured using indicators. In the past, organizational improvement has primarily been a financial concern, but in recent years, social responsibility and sustainability performance have eclipsed finances as the areas where organizations face significant pressure to improve. Regardless of the nature of the businesses, organizations are being forced to demonstrate their commitment to continuous improvement in all three pillars of sustainability to survive in the business environment. Therefore, all industries are turning their attention to finding ways to measure the efficiency and effectiveness of their processes' alignment with the organization's objectives and goals, which must be a reflection of the stakeholders' needs. Environmental performance not only makes good business sense, but also economic and social aspects are included in organizations' periodic reporting. Measuring, managing, and communicating performance brings to organizations the opportunity to make the case for public acceptance to operate and obtain the so-called "social license." Organizations that actively report their performance understand process improvement, cost efficiency, regulations, stakeholder needs, and the market (DEFRA, 2006).

Organizations are not only starting to understand the concept of SD, but also are also seeking to integrate it in their policies, mission statements, commitments, and business strategies (WBC SD, 2002b). In the progress, the responsibility to stakeholders and their needs have an effective impact on the manner in which companies approach the reporting of their operations; therefore, companies need appropriate systems to measure, control, and report their behaviour with a sustainability-oriented managerial approach (Perrini & Tencati, 2006).

Macro-level objectives for sustainability do not explain the transition to an effective decision-making process at the project level. The Bruntland Commission and other committees and organizations developed a series of macro-level objectives for sustainability. Additionally, existing frameworks, sustainability initiatives, strategies, and processes focus on global interpretations of sustainability in national or strategic objectives; however, a proven challenge for different construction professions relies on the ability to understand, translate, and achieve strategic sustainability objectives at the micro- or project-specific level (Ugwu & Haupt, 2007).

Following the measurement of performance, the likelihood for success is controlled through the monitoring and process, though the period between measurements must be considered the connection between goals and daily actions (Romaniello, Renna, & Cinque, 2011). Sustainable rating systems as continuous improvement and monitoring performance systems must be dynamic and flexible, measure performance in real time, show clear trends and goals, and reflect the stakeholders' needs; therefore, based on these elements, the rating system has the intrinsic possibility in its design to trigger a system of continuous improvement. Certainly, the design of indicators and their translation into metrics or measures requires translating the views of stakeholders' needs into business goals and objectives. Even further, to achieve sustainability, the process is required to include the development of customer-driven (stakeholder-driven) performance measures. Additionally, organizations typically substantiate their internal mission statement with a series of indicators (KPIs) to track performance against stated goals and objectives (Dalziell & McManus, 2004).

A group of SDIs for the surface mining industry indicates a step towards improving processes and sustainable operations; however, businesses and organizations are used to measuring financial and environmental performance separately. Given that improvement in non-financial measures drives financial performance (Kaplan & Norton, 1996), organizations and stakeholders are expected to promptly link the need for measuring performance of all three pillars of sustainability. Furthermore, companies are not only pressured to publicly report on their environmental and social performance, but they are also affected by their SD (and its triple bottom line: social, economic, and environmental pillars) performance, which defines business success for organizations in the market arena (WBC SD, 2002).

8.2 Continual Performance Improvement (CPI)

“Clients, investors and other stakeholders are demanding continuous improvement” (Robinson et al., 2005). Organizations aim for survival in continuously-changing environments. Characteristics such as innovation and competitiveness provide organizations with tools to maintain their status or lead in the business arena. While continuous improvement methods support the competiveness of an organization, the culture of continuous improvement is associated with innovation (Hyland et al., 2007; McAdam, Stevensen, & Armstrong, 2000). The PeM of the organization reflects the effectiveness of the efforts by the entity under evaluation (Zairi, 1993). Flexibility, responsiveness, and adaptability are factors affecting the decision-making process of organizations as stakeholders and customers influence change, demanding quick adaptation to their needs. However, meeting the requirements of a dynamic decision-making environment and adapting to continuous changes of strategic objectives are difficult tasks the organizations face; therefore, PeM systems and associated criteria must be constantly evaluated and updated if required (Cai, Liu, Xiao, & Liu, 2009).

PeM of products and services includes the measure of cost, quality, cycle time, quantity, efficiency, and productivity, among others; however, the objective is not to collect data but to predefine performance goals and standards (Malik et al., 2010). PeMs, as continuous improvement tools, monitor and improve actions on a continuous basis; therefore, PeM systems assist by identifying areas in need of improvement, diagnosing low performance, planning and implementing changes, monitoring performance to compare results, and developing control systems (Bititci & Nudurupati, Undated). As improvement is always possible, the PDCA (plan, do, check, act) methodology results in an effective methodology in the continuous improvement process when assisted by the use of performance indicators (Fortuin, 1988). In fact, a primordial component in continuous improvement is defining the performance indicators and their relationships (Bititci & Nudurupati, Undated).

PeM, as an integral part of CPI, can be seen from different perspectives: it may be a process to accomplish goals and objectives (Nanni, Dixon, & Vollmann, 1990), a process that serves as an agent of change (Brignall, 1991), a process of implementing strategies (Fitzgerald, Johnston, Brignall, Silvestro, & Voss, 1991; Neely 1998), or a quantification of the effectiveness and efficiency of past actions (Neely, 1998; Neely, Gregory, & Platts, 1995). Furthermore, Jorgensen et al. (2003) interpret CPI as the implementation of small changes to work processes executed by every member of the organization, making everybody accountable. Nowadays, organizations are more dynamic and willing to adapt to internal and external change; the continuous improvement process assists the organizations in long-term plans for success (Hu, Yang, Shi, & Tian, 2012). Frequently, sustainability is seen as a process to improve performance; however, it is not expected to achieve the ultimate goal of sustainable performance in a short period of time. It takes time, effort, and commitment; therefore, it is a continuous improvement process frequently assisted by innovation and long-term plans that are periodically measured and compared against pre-established targets.

Jaca, Viles, Mateo and Santos (2012) state that the concepts of sustainability and sustainable performance are embedded in the continuous improvement philosophy, and the authors add a number of sustainability factors for continuous improvement: management commitment and involvement, KPIs linked to obtained results, improvement program objectives linked to strategic goals, the achievement and implementation of results, the use of appropriate methodologies, the assignment of specific resources to improvement programs, the involvement of a task force in the improvement program, adequate training, communication of program results to the rest of the organization, getting more people involved, promoting teamwork, providing a facilitator to support the program, selecting the appropriate area of improvement, adapting to the environmental changes, and recognizing or rewarding participants. Moreover, CPI, SD, and PeM are instruments for assessing the sustainability of projects with extended life cycles. To measure sustainability at certain points in time, SD theory and fundamentals and PeM principles offer a simplistic snapshot; however, for industries with projects extended for several years, such as surface mining operations in the oil and gas industry, the CPI principles are to be included in the design of indicators and metrics in order to (1) allow organizations to merge their PPP in the PeM system; and (2) offer the stakeholders an effortless and understandable assessment methodology in which their needs have been attended.

8.3 Sustainable Development Indicators (SDI) for Surface Mining Operations in the Oil Sands Projects

8.3.1 SDIs, KPIs and Metrics

Individuals and organizations are affected by metrics impacting their actions and decisions; behavior is influenced and strategies are created and/or evaluated against them (Hauser & Katz, 1998). Metrics are relevant for an organization to measure progress, but selecting the right metrics is critical for success. Some metrics are easy and simple to measure, but pose counter-productive consequences, while others focus on measuring actions critical for success independently of difficulties and obstacles encountered in the measuring process. Identifying the different KPIs is only part of the continuous improvement process, as any improvement is achieved through continuous planning, monitoring, and execution (Cai et al., 2009). Beck & Oliver (2004) indicate that KPIs drive behavior and are catalysts for success; therefore, measurements are needed to manage strategies, execute initiatives, and evaluate performance. Additionally, KPIs are commonly used to identify work progress improvement areas aligned with objectives; however, the objectives are to be understood as the first step in the continuous improvement process. Thus, KPIs are formulated based on specific targets and objectives. Rosam & Peddle (2003) state that a direct alignment must occur between KPIs and the process or system to be measured, and this must be expressed as a metric; thus, information alone does not possess much benefit for the organization or stakeholders. Additionally, meaningless metrics and a lack of connections between the metrics and goals and objectives do not assist the organization when evaluating resilience (Dalziell & McManus, 2004).

From the customer's perspective, it is critical for organizations to create metrics to measure customer satisfaction while keeping the internal business process and staying profitable and competitive in the business arena. Thus, the organization needs to monitor the changes in its business environment all the time. Stakeholders are customers with different interests in the organization`s operations; therefore, businesses have developed measures for efficiency, effectiveness, quality, and other factors associated with profitable strategies. However, different groups of stakeholders continuously pressure the organizations to develop measures that reflect their sustainable performance. Furthermore, the needs of different stakeholders drive the design of KPIs at the system level (Rosam & Peddle, 2003). In the past, net income, earnings per share (EPS), and ROI—among other financial measures—were used to monitor and reward performance (Srivastava et al., 2001). Even though financial performance offers an understanding of the organization's business accomplishments, these figures are not made available in a timely manner throughout the process, and therefore do not address all stakeholders' needs and concerns in other areas (e.g., environment and social).

SDIs are KPIs for sustainability. They are also known as SD-KPIs or sustainability performance indicators (SPIs), and are used in this manuscript interchangeably. Mistakenly, KPIs are referred to as targets when in fact they are metrics, though Eckerson (2009) points out that the only difference between KPIs and metrics relies on KPIs embodying strategic objectives and measuring performance against goals. Systems' or processes' performances are measured using KPIs; therefore, the relationship between sustainability and KPIs relies on measuring the performance of organizations or projects towards accomplishing the goals and objectives in the social, environmental, and economic areas. External and internal reasons motive the development of SD-KPIs, including stakeholder demands, stakeholder expectations, evolving regulations, and strategic organizational efforts; however, sustainability performance management is still in its infancy (Deloitte, 2012). Macro-level indicators do not contribute to accomplishing the ultimate goals of sustainability; therefore, the areas of impact and potential opportunities must be measured at the micro (project) level, linking clearly-defined targets and benchmarks with various levels of the organization. Such links are used to implement strategies through KPIs (Hřebíček et al., 2007); however, initiatives regarding KPIs for SD are focused on the national, regional, and community levels, as the main forces behind SD have been the UN and national governments (Labuschagne et al., 2005). Moreover, developing KPIs for measuring performance at the micro level presents benefits to organizations and their stakeholders. Nevertheless, additional challenges can be encountered, as incorporating the development of effective KPIs for the performance management of the organization's strategic plan is still considered a new concept (Eckerson, 2009). Additionally, SDIs and criteria for sustainability encounter difficulties for proper assessment: (1) when going forth, macro - to micro - level setting objectives must address the question of "what do we want to measure," taking into consideration stakeholders' needs; (2) agreed-upon and multidisciplinary measurements in assessment methodologies not only consider all pillars of sustainability but also allow benchmarking; and (3) the quality of data or metrology increases credibility in the assessment methodology and results. Not only the characteristics of SDIs and indicators define the usefulness of the assessment tool, but improving the difficulties in the assessment methodology assists in the evolution of decision-making processes (Bertrand-Krajewski, Barraud, & Chocat, 2000).

Ugwo and Haupt (2007) call for transformations in the evaluation of the sustainability of projects, including hierarchical change in the definition of SD to operational decision-making variables, quantitative and vis-à-vis integrated holistic approaches, and a wider SD agenda. Though current sustainability assessment methods mainly focus on the environmental pillar, and attention is centered on the assessment of buildings (Ugwo & Haupt, 2007), the development of sustainable assessment methods in the last few years is assisting or "pressuring" industry and practitioners to demonstrate sustainability performance (Alwaer & Clements-Croome, 2010). However, without proper assessment tools, no industry—including oil and gas—can demonstrate how well (or how poorly) they are performing vis-à-vis “sustainability.” Although SDIs or sustainability KPIs may be assessed using different existing methods—credit-based scoring systems, scaled scoring, comparisons with benchmark or other available options, using credit systems, and involving subjective marking (Ugwu & Haupt, 2007)—the outcomes of the assessment are basically of three types: quantitative, qualitative, or a combination of the two. An outcome is used to analyze the state or progress towards pre-established goals and objectives.

Generic sets of SD-KPIs have been developed, but their usefulness is limited: the applicability of SDIs for different industries demands industry-specific sets of indicators. Therefore, a globally-accepted set of SD-KPIs is a recognizable challenge that is still evolving under the continuous improvement process (Searcy, Karapetrovic, & McCartney, 2005). Agreement regarding SDIs is still under debate, and benchmarking performance across industries or even within the same industry requires the development of specific KPIs for each process in which the tool is meant to be utilized. Primarily, a prerequisite to addressing sustainability includes developing indicators through effective stakeholder participation (Ugwo & Haupt, 2007). Certain characteristics in the design of PeM, including SD-KPIs, are to be considered to adequately meet the original intent: organizations and stakeholders should define if their aim is (1) precision or accuracy, (2) positional measurement or directional measurement, and (3) intended or unintended consequences with the measure (Tar, 1995). However, the set of SD-KPIs must remain available to the constant change that occurs in the business environment or due to stakeholder demands.

In a harmonious, sustainable construction environment of industrial projects, a series of key elements is expected in the process of developing effective strategies: the setting of clear and specific objectives, the identification and evaluation of alternatives, and the implementation of selected alternatives (Ugwo & Haupt, 2007). KPIs allow organizations and stakeholders to follow up performance and compare them with pre-established strategic goals and objectives; tracking KPIs' measures is essential in the continuous improvement process (Rosam & Peddle, 2003). Since KPIs are the primordial part of any asset performance management (ASM), the objectives must match measures used; however, difficulties can be encountered: impact of the measures, accountability, processes required to achieve the targets, frequency of measures, data review, and usefulness (Beck & Oliver, 2004). KPIs are characterized as trendable, observable, reliable, measurable, and specific (Beck & Oliver, 2004). Independent of the characteristics intrinsic in SDIs, KPIs, and metrics, the first step in their design is expected to address the stakeholders' needs and concerns; furthermore, in SD and in any decision-making processes, the early involvement of stakeholders defines the level of success in the implementation phase. Additionally, instead of starting with strategies, the design of any PeM should address the stakeholders, as they are the process starting point (Neely & Adams, 2005).

8.3.2 SDIs for Surface Mining Operations in the Oil Sands Projects

As the use of indicators in PeM makes visible the attributes of the processes (Koskela, 1992), the development and implementation of a set of SDIs for surface mining operations must count with transparency, simplicity, benchmarking ability, effective stakeholder engagement, relatively short cycle time (from data collection to distribution of results) to assist the decision-making process and adjustment capability in a timely manner. Fiksel, Spitzley and Brunetti (2002) indicates that good SDIs measure resource consumption and/or value creation over the product life cycle; therefore, the pre-selected SDIs shown in Table 8.1 include measures to support the decision-making process in every phase of the projects' life cycle. Additionally, the metrics proposed present a set of diverse characteristics. These include those presented by Tarr (1996): precision versus accuracy, static versus vector measures, soft versus hard measures, and intended versus unintended consequences. There is not a preferred number of indicators to use. A large number of indicators may give the illusion of precision, while in reality, they can limit comprehension and limit the relevance of each (Lee & Burnett, 2006). However, indicators should provide a measure of current performance and assist in setting targets for what might be achieved in the future (Jefferson, Hunt, Birchall, & Rogers, 2007). The pre-selection process utilized for determining the SDIs for surface mining operations resulted with four hierarchical categories of indicators: prerequisite (mandatory) indicators, desired indicators, inspired indicators, and non-active or non-applicable indicators. These four categories are also identified in the Design Quality Indicator framework (Design Quality Indicator Framework, Undated). If indicators are to be classified between qualitative and quantitative, they are equality important (Eckerson, 2009). While some are based on quantitative data, others are based on qualitative or subjective data, which is obtained through data collection processes. This presents the additional benefit of engaging different stakeholders in the process.

Environmental and social responsibility are increasingly influencing decision-making and business strategies; therefore, practices for SD evaluation and assessment are gaining ground in all industries, including in those called "too big to fail." However, the oil and gas industry (including surface mining operations) is affected by the same global uncertainty found regarding the ramifications of pursuing the implementation of SD (Berkel, Power, & Cooling, 2008). When it comes to SDIs, social and economic indicators are the least developed (Fiksel et al., 2002). The debates relies on two main questions: what indicators should be measured

Table 8.1 Pre-selected SDIs for surface mining operations in oil sands projects: PIFs & Proposed CPIs

Area of Excellence	Criteria Description	PIF	Proposed CPI Indicator Measurement
Project and Environmental Management Excellence-PEME	- Strategic Environmental Assessment (SEA)	Type I	Relevance Factor
	- Environmental Impact Assessment (EIA)	Type I	Relevance Factor
	- Cumulative Environmental Impact Assessment (CEIA) (As per cumulative impact threshold requirements for Alberta Oil Sands)	Type I	Relevance Factor
	- Social Impact Assessment (SIA)	Type I	Relevance Factor
	- Economic Impact Assessment (EcIA)	Type I	Relevance Factor
	- Biophysical Impact Assessment (BIA)	Type I	Relevance Factor
	- Project Lifecycle Assessment (PLA)	Type I	Relevance Factor
	- Environmental Protection Management Plan	Type I	Relevance Factor
	- Environmental Risk Management Plan	Type I	Relevance Factor
	- Emergency Response Management Plan	Type I	Relevance Factor
	- Water Management Plan	Type I	Relevance Factor
	- Solid Waste Management Plan	Type I	Relevance Factor
	- Erosion and Sediment Control Plan	Type I	Relevance Factor
	- Hazard Management Plan (includes assessments, inspections, and procedures)	Type I or Type III	Relevance Factor or Link to Metrics
	- Safety Management Plan (includes safety training, reporting, and prevention of incidents)	Type I or Type III	Relevance Factor or Link to Metrics
	- Environmental Management Systems	Type I or Type III	Relevance Factor or Link to Metrics
	- Sustainable Public Procurement Strategies	Type I	Relevance Factor
	- Regulatory Compliance (Approvals, Licenses, and Permits)	Type I	Relevance Factor
	- Independent Verified Auditing and Reporting Plans	Type I or Type III	Relevance Factor or Link to Metrics
Site and Soil Resource Excellence-SSRE	- Mining Effluents[1]: Monitoring,	Type I or Type III	Relevance Factor or Link to Metrics
	Control, and	Type II	Comparative Assessment Methods
	Reduction	Type II	Comparative Assessment Methods
	- Biological monitoring studies and reports	Type I	Relevance Factor
	- Overburden Management	Type II	Comparative Assessment Methods
	- Structures to prevent erosion and soil runoff: Implementation and	Type I	Relevance Factor
	Monitoring	Type I or Type III	Relevance Factor or Link to Metrics
	- Re-used excavation material	Type II	Comparative Assessment Methods
	- Proportion of non-previously-developed land used	Type II	Comparative Assessment Methods
	- Proportion of protected land used	Type II	Comparative Assessment Methods
	- Total waste extracted (non-saleable, including overburden)	Type II	Comparative Assessment Methods
	- Percentage of resource extracted relative to the total amount of the permitted reserves of that resource	Type II	Comparative Assessment Methods
	- Tree harvest management	Type II	Comparative Assessment Methods
	- Deforestation	Type II	Comparative Assessment Methods
Water Resource Excellence-WRE	- Mining Effluents[1]: Monitoring,	Type I or Type III	Relevance Factor or Link to Metrics
	Control, and	Type I or Type III	Relevance Factor or Link to Metrics
	Reduction	Type II	Comparative Assessment Methods
	- Water: Supply and	Type II	Comparative Assessment Methods
	Consumption	Type II	Comparative Assessment Methods
	- Usage of recycled water	Type II	Comparative Assessment Methods
	- Wastewater management	Type II	Comparative Assessment Methods
	- Ground water resources: Protection and	Type I or Type III	Relevance Factor or Link to Metrics
	Monitoring	Type I or Type III	Relevance Factor or Link to Metrics
	- Muskeg drainage: Monitoring,	Type I or Type III	Relevance Factor or Link to Metrics
	Control, and	Type I or Type III	Relevance Factor or Link to Metrics
	Reduction	Type II	Comparative Assessment Methods
	- Control of formation dewatering	Type I or Type III	Relevance Factor or Link to Metrics
	- Seepage prevention (from ponds, pits, and landfills)	Type I or Type III	Relevance Factor or Link to Metrics
	- Construction of water management systems and structures	Type I or Type III	Relevance Factor or Link to Metrics
	- Acid drainage: Monitoring,	Type I or Type III	Relevance Factor or Link to Metrics
	Control, and	Type I or Type III	Relevance Factor or Link to Metrics
	Reduction	Type II	Comparative Assessment Methods
	- Aquatic life: Protection and	Type I or Type III	Relevance Factor or Link to Metrics
	Monitoring	Type I or Type III	Relevance Factor or Link to Metrics
Atmosphere and Air Resource Excellence-AARE	- GHGs[2]: Monitoring,	Type I or Type III	Relevance Factor or Link to Metrics
	Control, and	Type I or Type III	Relevance Factor or Link to Metrics
	Reduction	Type II	Comparative Assessment Methods
	- Fugitive Emissions: Monitoring,	Type I or Type III	Relevance Factor or Link to Metrics
	Control, and	Type I or Type III	Relevance Factor or Link to Metrics
	Reduction	Type II	Comparative Assessment Methods
	- Dust control	Type II	Comparative Assessment Methods
	- Noise and vibration management	Type II	Comparative Assessment Methods
Natural and Artificial Lighting Excellence-NALE	- Luminosity: Control and	Type I or Type II	Relevance factor or CAM
	Regulatory compliance	Type I	Relevance Factor
Energy Resource Excellence-ERE	- Internal production of energy consumed (Renewable energy use)	Type II	Comparative Assessment Methods
	- Consumption of primary energy (natural gas, LPG (liquefied petroleum gas), petrol, and other fuels)	Type II	Comparative Assessment Methods
	- Consumption of secondary energy (electricity and heat)	Type II	Comparative Assessment Methods

Table 8.1 Pre-selected SDIs for surface mining operations in oil sands projects: PIFs & Proposed CPIs (cont'd)

Resources and Materials Excellence - RME	- Usage of chemical substances	Type II	Comparative Assessment Methods
	- Hazardous material management, storage, and disposal	Type I	Comparative Assessment Methods
	- Improvement in machine application efficiency	Type II	Comparative Assessment Methods
	- Machines material re-use	Type II	Comparative Assessment Methods
	- Solid waste management (non-renewable resources): Reduction,	Type II	Comparative Assessment Methods
	Reuse, and	Type II	Comparative Assessment Methods
	Recycling	Type II	Comparative Assessment Methods
	- Distance (proximity) of materials suppliers	Type II	Comparative Assessment Methods
Innovation in Design and Operations Excellence-IDOE	- Investment in Innovation	Type III	Link to Metrics
	- Clean technology Innovations: Testing and implementation of new technologies	Type I or Type III	Relevance Factor or CAM
Infrastructure and Buildings Excellence - IBE	- Ecological footprint	Type II	Comparative Assessment Methods
	- Mining location within or proximal to water bodies	Type II	Comparative Assessment Methods
	- Proximity of mining operations to mining material processing and tailing ponds	Type II	Comparative Assessment Methods
	- Wildlife: Monitoring and	Type I or Type III	Relevance Factor or Link to Metrics
	Protection	Type I or Type III	Relevance Factor or Link to Metrics
	- Vegetation: Monitoring and	Type I or Type III	Relevance Factor or Link to Metrics
	Protection	Type I or Type III	Relevance Factor or Link to Metrics
	- Area of habitat created/destroyed (area disturbed by oil sands development)	Type II	Comparative Assessment Methods
	- Affected species: Animal and	Type I or Type II	Relevance Factor or CAM
	Vegetal	Type I or Type II	Relevance Factor or CAM
	- Biodiversity and habitat (includes biological studies and reports): Monitoring and	Type I or Type III	Relevance Factor or Link to Metrics
	Protection	Type I or Type III	Relevance Factor or Link to Metrics
	- Tailings ponds location and impacts study	Type I	Relevance Factor
	- Reduction of land area used for tailings ponds operations	Type II	Comparative Assessment Methods
	- Total area of permitted developments	Type II	Comparative Assessment Methods
	- Total land area newly opened for extraction activities (including area for overburden storage and tailings)	Type II	Comparative Assessment Methods
	- Transportation distance of customers, business travel, workforce, and community for fly-in and fly-out operations	Type II	Comparative Assessment Methods
	- Communication and Transportation Facilities	Type I	Relevance Factor
Education, Research, and Community Excellence-ERCE	- Investment in research	Type III	Link to Metrics
	- Workforce awareness training programs (safety, and environmental, social, economic, and health impacts)	Type I or Type III	Relevance Factor or Link to Metrics
	- Community awareness programs	Type I or Type III	Relevance Factor or Link to Metrics
	- Community and stakeholder consultation and involvement	Type I	Relevance Factor
	- Poverty alleviation of affected areas	Type III	Link to Metrics
	- Wealth distribution	Type I	Relevance Factor
	- Contribution to social development of communities	Type III	Link to Metrics
	- Participation in regional co-operative efforts	Type III	Link to Metrics
	- Contribution to economic and institutional development of communities	Type III	Link to Metrics
	- Employment, unemployment and underemployment rates	Type II	Comparative Assessment Methods
	- Contribution to GDP (gross domestic product)	Type II	Comparative Assessment Methods
	- Expenditure on environmental protection	Type III	Link to Metrics
	- Ethical investment	Type III	Link to Metrics
	- Percentage of employees that are stakeholders in the company	Type II	Comparative Assessment Methods
	- Ratio of lowest wage to national legal minimum	Type II	Comparative Assessment Methods
	- Health, pension, and other benefits and redundancy packages provided to employees as percentage of total employment cost	Type I	Relevance Factor
	- Expenditure on health and safety	Type II	Comparative Assessment Methods
	- Inflation rate	Type II	Comparative Assessment Methods
	- Internal return ratio	Type II	Comparative Assessment Methods
	- Environmental liabilities	Type II	Comparative Assessment Methods
	- Return of investment	Type II	Comparative Assessment Methods
	- Payback period	Type II	Comparative Assessment Methods
	- Investment in employee training and education	Type III	Link to Metrics
	- Lost-time injuries	Type II	Comparative Assessment Methods
	- Lost-time injuries frequency	Type II	Comparative Assessment Methods
	- Women/men employment ratio	Type II	Comparative Assessment Methods
	- Percentage of ethnic minorities employed relative to the total number of employees	Type II	Comparative Assessment Methods
	- Work satisfaction	Type II	Comparative Assessment Methods
	- Housing provision for workforce	Type II	Comparative Assessment Methods
	- Housing development for local communities	Type III	Link to Metrics
	- Projects acceptability	Type II	Comparative Assessment Methods
	- Female to male wage ratio	Type II	Comparative Assessment Methods
	- Net migration rate to projects areas	Type II	Comparative Assessment Methods
	- Number of direct and indirect employees	Type II	Comparative Assessment Methods
	- Net employment creation	Type II	Comparative Assessment Methods
	- Percentage of hours of training	Type II	Comparative Assessment Methods
	- Employee turnover	Type II	Comparative Assessment Methods
	- Fatalities at work	Type II	Comparative Assessment Methods
	- Total number of health and safety complaints from local communities	Type II	Comparative Assessment Methods
	- Percentage of employees sourced from local communities relative to the total number of employees	Type II	Comparative Assessment Methods

Table 8.1 Pre-selected SDIs for surface mining operations in oil sands projects: PIFs and Proposed CPIs (cont'd)

Education, Research, and Community Excellence-ERCE	- On-going health monitoring (workers and local communities)	Type III	Link to Metrics
	- Health care management/first aid facilities	Type I or Type II	Relevance Factor or CAM
	- Number of local suppliers relative to the total number of suppliers	Type II	Comparative Assessment Methods
	- Number of local contractors relative to the total number of contractors	Type II	Comparative Assessment Methods

[1] Mining effluents include: arsenic, cooper, cyanide, lead, nickel, zinc, total suspended solids, radium, pH
[2] GHGs include: sulphur dioxide (SO2), ozone (O3), nitrogen Dioxide (NO2), particulate matter (PM2.5), carbon monoxide (CO), oxides of nitrogen (NOx), volatile organic compounds (VOCs), hydrogen sulphide (H2S)

(i.e., what indicators should be included) and how those indicators should be measured (i.e., which metrics are appropriate to indicate quality of life and community prosperity). Therefore, it is valid to distinguish between indicators and metrics: the first define what is to be measured and the second define how it will be measured. Moreover, trade-offs are an additional problem with performance metrics for which decision-making tools are being used. An option for decision-making tools is to weight each KPI using the AHP. Although the process assists by determining the weight of each KPI, it does not specify the relationship amongst them (Cia, 2009). A good starting point is the balanced scorecard (BSC), which was developed with the aim of integrating non-monetary, qualitative, and "soft" issues related to social and environmental factors (Bieker & Waxenberger, 2002; Figge, Hahn, Schaltegger, & Wagner, 2001; 2002a; 2002b; Schaltegger & Wagner, 2006). Schaltegger and Lüdeke-Freund (2011) take further the concept of BSC to refer to an integrated sustainable PeM, the sustainability balanced scorecard (SBSC), in which the critical factor of integrating financial, non-financial, quantitative, and qualitative information is addressed.

Types of indicators, selection of criteria, and characteristics of the indicators for a set of PeMs are commonly debated, and extensive literature can be found; however, for PeM in an implemented continuous improvement process, the KPIs proposed are quantifiable, meaningful (as the result of being based on available and reliable dates), relevant to the needs of stakeholders, aligned with the chosen strategies, a manageable number (i.e., not too numerous), and comparable over time (Bouchery et al., 2010). Fiksel et al. (2002) suggest a five-step distinctive process when selecting KPIs or SD-KPIS: (1) consider stakeholder needs, (2) identify important aspects, (3) establish company goals and KPIs, (4) select performance indicators and metrics, and (5) set targets and track performance. Within the selection process, certain criteria assist in choosing the appropriate KPIs; as suggested by Hřebíček et al. (2007) and applied to those shown in Table 8.1, KPIs should give an accurate appraisal of the organization's performance; be understandable and unambiguous; allow for year-to-year comparisons; allow for comparisons with sector, national, or regional benchmarks; and allow for comparisons with regulatory requirements.

As improvement needs to be continuously sought and monitored according to the continuous improvement definition (Dale, 1996), so must the SDIs and metrics for surface mining operations in the oil sands projects. From the organization's point of view, a certain level of investment is required to implement a measuring performance system, but a number of benefits are expected in return when managing and reporting performance: cost, productivity, market advantages, image and reputation, and employment recruitment, among others (DEFRA, 2006). Bourne, Mills, Wilcox, Neely and Platss (2000) propose three phases in the design of performance management systems: design of the performance measures, implementation of the performance measures, and use of the performance measures. Even though the literature is dominated by processes that answer the question "what should we measure?" for certain areas, for sustainability performance, the answer is still under ardent debate. However, in the design phases, as suggested by Bourne et al. (2000), two requirements involve identifying the key objectives to be measured and designing the measures. Nevertheless, there is an absence of agreed-upon indicators and metrics, and high uncertainty remains regarding decisions on sustainable technology (Berkel et al., 2008). Since

PeM systems use a set of metrics or individual performance measures to quantify efficiency and effectiveness (Neely et al., 1995), a sustainability rating system—used as a PeM system—can be the crucial tool to link macro—with micro—or project-oriented objectives. Developing and implementing a sustainability rating system for surface mining operations is a relatively difficult task for additional reasons, such as the fact that the oil and gas industry is project-oriented, and projects are usually quite complex; however, since people drive their attention to what can be measured (Waggoner, Meely, & Kennerley, 1999), a PeM system in the form of a rating system cannot be overlooked, and instead, its usefulness can be optimized.

8.4 Performance Improvement Factors (PIFs)

The proposed integrated approach to sustainability assessment consists of three distinctive areas: CPI, sustainability theory and principles, and MCDM. The PIFs for the SDIs metrics for surface mining operations in the oil sands projects are designed in alignment with the principles of the CPI process; therefore, any performance improvement is reflected in the PIF value for each indicator. The PIF will demonstrate the progress of the improvement process. As pointed out by Dale (1996), the progress potentially shows changes in behavior and attitude; improvements in operational and business performance indicators; and the alignment between the company's strategies, policies, and guidelines and projects' quality improvements outcomes.

In performance management, a key principle consists of measuring what you can manage (Weber & Thomas, 2005); however, it is commonly found that even factors that can be managed are not measured, due to factors such as cost, applicability, and/or usefulness. Additionally, the control factor influences the manageability of what is measured; as Peter Drucker states,

> "It is not possible to manage what you cannot control, and you cannot control what you cannot measure."

Conversely, a main challenge in sustainability consists of defining the indicators (i.e., what to measure) and the metrics (i.e., how to measure the indicators) for all the pillars of sustainability. A paradox linking sustainability, performance improvement, and CPI indicates that while trying to manage organizations and projects towards more sustainable results, there is a lack of agreement amongst indicators and metrics to measure any given organization's or project's performance. Therefore, managing, controlling, and determining improvement of indicators and metrics that have not been determined or agreed upon becomes a matter of defining baselines to then improve those measurement factors through research, practice (i.e., experience), benchmarking, and stakeholder engagement, among other alternatives. Certainly, in measuring each area in SD (social, economic, and environmental), challenges are encountered mainly because of the subjectivity encompassed in most factors. Assessment methods that are already developed assist by putting subjective matters into measurable metrics that are easy for stakeholders to comprehend; nevertheless, sustainability assessment still has challenges to overcome. Moreover, the assessment of all pillars of sustainability has not been developed evenly. In fact, literature often refers to social issues as the most under-developed pillar, and the economic issues not far ahead. Interestingly, environmental factors are the center of most assessment methods. This focus may have been influenced by stakeholders, who often associate sustainability with only the environmental impacts of projects and organizations, leaving behind social and economic factors inherent in the fundamentals of SD. Additionally, environmental issues are easier to identify, their impacts more noticeable, and most stakeholders believe they have the right to express their opinions based on idealistic knowledge that most lack.

The measurement of social, economic, and environmental impacts faces additional challenges as a consequence of the subjectivity factor; therefore, linking subjective with tangible (objective) measures presents a valuable alternative. In fact, different assessment methodologies measure impacts in terms of monetary value (a common utilized metric unit). While environmental and economic impacts can mostly be measured using different existing assessment methodologies and/or are directly linked to economic parameters, social impacts assessment methodologies still encounter difficulties in putting value on undefined but notable impacts. A truly effective rating system designed to measure SD must include the three pillars (i.e., social, economic, and environmental) of sustainability. The objective of a rating system is to present the different stakeholders with an overall score instead of segregating each pillar of sustainability; nevertheless, each indicator must have the characteristic of being able to be measured separately, so the users easily identify the roots of each indicator metric and organizations can focus on areas needing some improvement. Once indicators and their metrics have been defined, the improvement (negative or positive) over time needs to be measured. Poveda and Lipsett (2011b; 2011c) propose the WA-PA-SU project sustainability rating system to measure the sustainability performance of projects and organizations. The assessment methodology utilizes the PIF, defines as:

"a factor to determine the degree of negative or positive improvement of a specific criteria (i.e., indicators) during a specific period of time"

or,

$$PIF = \frac{\text{Indictor Performance Actual Value (Metric)}}{\text{Indicator Threshold or Baseline Value (Metric Baseline)}} \quad [8.1]$$

The aim of measuring the PIF is to move the focus from the specific value of an indicator(s) to the CPI process. As indicators can either (1) measure the closeness to a defined target, which is the most commonly used approach, or (2) give the direction of an indicator so the others move in the desired direction, thereby motivating change and performing better over time, the PIF methodology combines both approaches by setting initial baselines but awarding higher scores as the PIF value increases. This motivates projects and organizations to focus on the overall continual improvement process. The PIF is designed with the aim of allowing organizations to not only assess their current performance, but also improve throughout time or the project duration by identifying the indicators that have PIF values that fall below 1. PIFs below the baseline value of 1 are under-performing. In some cases, the baseline may be easier to identify, as they can be imposed by federal, provincial, or local authorities through regulations; however, a value given by a regulation does not guarantee sustainable performance. The baseline of other indicators needs to be created through stakeholder consultation, scientific support, or simply by setting an initial arbitrary threshold with the intent of improving it once additional research is done or stakeholder consensus occurs.

Three types of PIFs are identifiable in the methodology, based on which metrics are used to measure indicators:

- Type I: based on relevance factor measurement (i.e., relevance factor or subjective stakeholder valuation)
- Type II: based on performance improvement (i.e., CAMs)
- Type III: based on level of investment (i.e., link to economic metrics)

The CPI indicator measurements can be achieved by using three different categories of assessment methodologies: (1) quality and performance audits, (2) performance improvement measurements, and (3) impact vs. investment ratio improvement; henceforward, these three different alternatives are proposed to assess the performance of indicators (i.e., metrics), which are typically linked to type I, II, and III PIFs, respectively.

8.4.1 Relevance Factor or Subjective Stakeholder Valuation

For certain indicators, it is frequently found to be difficult to determine their metrics, which adds to the level of uncertainty surrounding their assessment; therefore, alleviating the potential inherent subjectivity becomes a priority. The relevance factor or subjective stakeholder valuation proposes the involvement of stakeholders and the linking of subjective valuations to objectives' measures. In SD, as in any MCDM process, the effective involvement of stakeholders determines the success of the process, due to the accountability factor desired for some and avoided by others. Additionally, objectives measures are recognizable and frequently used by most stakeholders, and measuring them is economically viable with data collection procedures already in place.

To determine the PIF type I, which is based on the relevance factor measurement, it is necessary to define the methodology to calculate at any given time the performance value of a certain indicator that follows under this category; however, a direct indicator performance value is either linked to an objective measure or a 9-point semantic differential scale, as shown in Graph 8.1 and 8.2. In the rating system, users have three different options to calculate the PIF:

- Determining the relevance category (stakeholders' input) linked with the project's or organization's energy consumption (Graph 8.1)
- Determining the relevance category (stakeholders' input) linked with the project's or organization's GHGs generated (Graph 8.1)
- Determining the relevance category (stakeholders' input) linked with the organization's or project's bbl/d or bpd production (Graph 8.2)

Organizations or projects may eventually have information to calculate the PIF of an indicator using more than one option. The intended continual improvement approach suggests using the lowest PIF calculated. Lower PIF values translate into higher levels of energy consumption, GHGs generated, or extraction of non-renewable resources (i.e., oil, gas), as well as a lower number of points obtained in the overall sustainability rating.

Due to limitations found in determining the performance value of certain indicators (metrics), the PIF offers an alternative to calculate the overall performance of an organization or project. Instead of focusing on a particular indicator metric, stakeholders' and objectives' measures link the indicator to more sustainable goals, such as lowering the extraction of non-renewable resources, the production of GHGs, and/or energy consumption. Moreover, instead of focusing on an indicator's performance value, the interest lies in the improvement of the indicator over time; therefore, the PIF is not a metric, but instead, a factor.

The PIF value for indicators in this category ranges from zero (0) to two (2). For indicators under PIF type II and III, once a baseline is determined, the performance improvement is measured by comparing the actual performance against the threshold (see Formula 8.1). An indicator obtains a PIF value of one (1) if it meets the indicator's pre-established baseline; as difficulty arises establishing baselines or thresholds for some indicators, the first measurement serves this purpose. Organizations' and projects' vision regarding sustainability should move towards eliminating energy consumption, GHGs generated, and/or the extraction of non-renewable resources; therefore, a PIF value of two (2) is awarded. As noted in Graphs 8.1 and 8.2, stakeholders assign the relevance category for each indicator. Some may indicate that even with zero energy consumption or generation of GHGs and the elimination of the extraction of non-renewable resources, the organization or project is not able to obtain a PIF value of two (2). The purpose for users, stakeholders, and developers is to eliminate the activity described by the indicator—or at least minimize its impact—to the point that stakeholders consider the indicator relevance category in the range of low-low. As a consequence, a

Energy Comsuption

Joules (Millions)

Relevance Category

High High	High Medium	High Low	Medium High	Medium Medium	Medium Low	Low High	Low Medium	Low Low	Low Low	Low Medium	Low High	Medium Low	Medium Medium	Medium High	High Low	High Medium	High High
0.11	**0.22**	**0.33**	**0.44**	**0.56**	**0.67**	**0.78**	**0.89**	**1**	**1**	**0.89**	**0.78**	**0.67**	**0.56**	**0.44**	**0.33**	**0.22**	**0.11**
0.22	**0.35**	**0.46**	**0.57**	**0.7**	**0.79**	**0.91**	**1.01**	**1.11**	**1.11**	**1.01**	**0.91**	**0.79**	**0.7**	**0.57**	**0.46**	**0.35**	**0.22**
0.33	**0.46**	**0.58**	**0.7**	**0.84**	**0.92**	**1.03**	**1.14**	**1.33**	**1.33**	**1.14**	**1.03**	**0.92**	**0.84**	**0.7**	**0.58**	**0.46**	**0.33**
0.44	**0.57**	**0.7**	**0.82**	**0.98**	**1.04**	**1.16**	**1.26**	**1.44**	**1.44**	**1.26**	**1.16**	**1.04**	**0.98**	**0.82**	**0.7**	**0.57**	**0.44**
0.56	**0.7**	**0.84**	**0.98**	**1.1**	**1.17**	**1.28**	**1.39**	**1.56**	**1.56**	**1.39**	**1.28**	**1.17**	**1.1**	**0.98**	**0.84**	**0.7**	**0.56**
0.67	**0.79**	**0.92**	**1.04**	**1.17**	**1.29**	**1.41**	**1.51**	**1.67**	**1.67**	**1.51**	**1.41**	**1.29**	**1.17**	**1.04**	**0.92**	**0.79**	**0.67**
0.78	**0.91**	**1.03**	**1.16**	**1.28**	**1.41**	**1.53**	**1.63**	**1.78**	**1.78**	**1.63**	**1.53**	**1.41**	**1.28**	**1.16**	**1.03**	**0.91**	**0.78**
0.89	**1.01**	**1.14**	**1.26**	**1.39**	**1.51**	**1.63**	**1.76**	**1.89**	**1.89**	**1.76**	**1.63**	**1.51**	**1.39**	**1.26**	**1.14**	**1.01**	**0.89**
1	**1.11**	**1.33**	**1.44**	**1.56**	**1.67**	**1.78**	**1.89**	**2**	**2**	**1.89**	**1.78**	**1.67**	**1.56**	**1.44**	**1.33**	**1.11**	**1**

0 — 0

Metric Tons (Millions)

GHG Generated

Graph 8.1 Relevance factor relationships 1

Relevance Category																			Relevance category
Low Low	0.11	0.22	0.33	0.44	0.56	0.67	0.78	0.89	1	1	0.89	0.78	0.67	0.56	0.44	0.33	0.22	0.11	Low Low
Low Medium	0.22	0.35	0.46	0.57	0.7	0.79	0.91	1.01	1.11	1.11	1.01	0.91	0.79	0.7	0.57	0.46	0.35	0.22	Low Medium
Low High	0.33	0.46	0.58	0.7	0.84	0.92	1.03	1.14	1.33	1.33	1.14	1.03	0.92	0.84	0.7	0.58	0.46	0.33	Low High
Medium low	0.44	0.57	0.7	0.82	0.98	1.04	1.16	1.26	1.44	1.44	1.26	1.16	1.04	0.98	0.82	0.7	0.57	0.44	Medium Low
Medium Medium	0.56	0.7	0.84	0.98	1.1	1.17	1.28	1.39	1.56	1.56	1.39	1.28	1.17	1.1	0.98	0.84	0.7	0.56	Medium Medium
Medium High	0.67	0.79	0.92	1.04	1.17	1.29	1.41	1.51	1.67	1.67	1.51	1.41	1.29	1.17	1.04	0.92	0.79	0.67	Medium High
High Low	0.78	0.91	1.03	1.16	1.28	1.41	1.53	1.63	1.78	1.78	1.63	1.53	1.41	1.28	1.16	1.03	0.91	0.78	High Low
High Medium	0.89	1.01	1.14	1.26	1.39	1.51	1.63	1.76	1.89	1.89	1.76	1.63	1.51	1.39	1.26	1.14	1.01	0.89	High Medium
High High	1	1.11	1.33	1.44	1.56	1.67	1.78	1.89	2	2	1.89	1.78	1.67	1.56	1.44	1.33	1.11	1	High High
0	1000+									0								1000+	0

BBL/D or BPD (Thousands)

Graph 8.2 Relevance factor relations 2

PIF of two (2) points can be awarded.

8.4.2 Comparative Assessment Methods (CAMs)

The second and most common group of metrics for indicators is conformed for those linking the impact directly to a measurable aspect of the organization or project (e.g., CO2 per ton of bitumen produced, trees harvested per acre). The quantitative characteristics of these metrics serve as an advantage for projects and organizations to report their performance to different stakeholders, though measurability (in some cases) may limit the data collection, which may force a certain level of investment. In the mix of indicators, economic metrics tend to measure at the national or global level (also known as macro-level, e.g., gross national product [GNP], GDP) instead of focusing at the project and organization levels (i.e., micro-levels). In fact, some argue that economic indicators in their current form are not even meaningful measures of economic sustainability (Sheng, 1995). Subjectivity is intrinsic in metrics associated with social indicators; questionnaires with graded scales are usually used to measure perceptions and feelings connected to standards of living or quality of life. The environmental indicators measure the impact in three contexts; air, land, and water. Fortunately, progress has been made by regulatory agencies to set thresholds (i.e., limits) for projects or organizations to reduce the impacts of their operations. Indisputably, stakeholders drive the design of most indicators and metrics. The "social license" to operate is the main aim of projects and organizations, as concerns about corporate environmental and social responsibility has gradually increased. Environmental metrics are far ahead in their design, driven by public perceptions of sustainability, investment of research, and mainly, the creation of limitations by regulatory agencies. However, social and economic performances are less supported by regulations, which tend to be weakly developed and poorly enforced. Measurability and the characteristics of the metrics for each pillar of sustainability imply that CAMs are mostly used by environmental indicators and, to a much smaller degree, for economic indicators, leaving social impacts, for the most part, to subjective stakeholder valuation (i.e., relevance factor) or linked to economic metrics methodologies.

Simplicity is the main objective of an indicator, and while stakeholders search for it, DMs demand indicators that can be integrated into the relevant levels of the policy-making process; however, environmental and social indicators are brought into the economic policy-making arena without DMs knowing their actual monetary value. Therefore, indicators that are linked to policy targets and compatible with macro-economic indicators and the budgeting process are often preferred. Conversely, not all indicators included in this category (i.e., CAMs) are designed with the support of the policy-making process (i.e., regulatory agencies); some metrics indicators are designed to set a threshold (i.e., baseline) for measuring the impact, making use of practicability and simplicity. For example, the number of trees harvested per acre illustrates such characteristics.

Metrics for indicators designed using CAMs not only are often linked to the policy-making process, but also meet the simplicity objective at different levels: measurement, reporting, and stakeholders' understanding of the indicators used. The difficulty arises when designing a sustainability index, since each indicator uses different metrics; therefore, MCDM is frequently used to decide the weights of each indicator. However, from the CPI point of view, the main focus relies on measuring the improvement of each indicator in a specific period of time. The PIF measurement for indicators using CAMs utilizes Formula 8.1. As a result, PIF type II is calculated in a straightforward manner to measure the performance improvement of those indicators.

8.4.3 Link to Economic Metrics

The third group of metrics for indicators proposed to calculate the PIF type III is based on links to existing and recognizable economic metrics (e.g., level of investment per ROI. Nowadays, projects and organizations often budget or set aside a certain amount of the total cost of projects and/or operations for elements such as quality, risk, and safety; the level of investment (e.g., budget) has increased as organizations became aware of the different inherent benefits. Additionally, the pressure from different groups of stakeholders increased through the years; therefore, organizations found an additional justification for their monetary increment to improve quality, risk, and safety performance. Similarly, as SD is still in its early stages of implementation, which includes education and awareness of the public and stakeholders, the level of investment is expected to increase to (1) mitigate social, economic, and environmental impacts; (2) promote sustainability; and (3) implement sustainable designs and practices. Therefore, designing metrics for indicators that link the impact with the level of investment indicators offer to stakeholders, organizations, and policymakers results in a certain level of confidence in more sustainable operations and a step in the right direction for a compromise in the areas of social and economic responsibility and environmental performance.

In the same way the PIF type II is calculated, PIF type III is a straightforward implementation of Formula 8.1. PIF type III not only presents the performance improvement value of a specific indicator, but also the continuous commitment by the projects and organizations to sustainability; a higher PIF type III value indicates a higher investment to mitigate social, economic, and/or environmental impacts. Additionally, the PIF type III measurement assists practitioners in benchmarking their performance. Instead of associating their performance to a certain amount of investment independent of the project's and/or organization's size, the PIF value compares the ratio of investment amount of projects and/or organizations, putting everybody on similar parameters of assessment.

PIF type III is not exclusively designed for economic indicators. In fact, social and environmental indicators may benefit using metrics that associate the level of investment of projects and/or organizations in mitigating different impacts. Controversially, economic performance indicators have often been used as economic indicators for sustainability. Using the PIF type III assists in linking the macro-level (i.e., global) objective of sustainability with the micro-level (i.e., project or organization) by connecting the SD of industry to factors such as employment and investment in human capital. Indisputably, organizations require a level of profit to survive. However, rather than measuring how wealthy an organization has become in certain period of time, or the contribution of a project to the organization's capital as an indicator of sustainability, organizations should demonstrate their capability (i.e., economic sustainability or sustainable survival) to create a profit while investing in their work-force—health, safety, and staff development; SD of their surroundings (i.e., nearby population centers); and SD initiatives that benefit their stakeholders (e.g., innovation, education). Nevertheless, internal economic indicators (e.g., return of investment) and global indicators (e.g., inflation rate) may be a reflection of a healthy economy for organizations and the government; therefore, they are indicative of sustainability. However, the size of the project, organization, or industry is relevant to measure the contribution of factors such as inflation rate, GDP, and GNP, since those are not a metric of a specific industry, but instead are aggregates of the economic performance of a variety of factors (i.e., industries or sectors).

8.5 Conclusions and Future Research

It is commonly said that we are what we measure; nowadays, with the introduction of sustainability and sustainable practices becoming more popular, we measure what we want to become. This manuscript introduces part I of a new assessment methodology for sustainability of industrial projects, with an emphasis on oil sands for surface mining operations; the concept of the PIF based on CPI offers to organizations and their stakeholders a tool to demonstrate their commitment to sustainable practices throughout the time, allowing adjustments in those areas in which the PIF falls below 1. (Indicators with a PIF below 1 point out performance below the baseline or threshold) Additionally, the PIF presents all indicators to stakeholders as a factor of improvement instead of a different metric for each indicator. This contributes to alleviating the commonly-found confusion factor. Assessment methods present their results for each of the indicators of sustainability; therefore, the stakeholder must get familiar with each metric to understand the assessment. After measuring each indicator's performance, the proposed assessment methodology (i.e., the sustainability rating system [WA-PA-SU Project Sustainability rating system]) presents the improvement of each indicator by measuring its performance against itself in a determined period of time. Conversely, the stakeholders are not to drive their attention to how the indicator is measured, but instead on its improvement over time.

CPI is a critical factor for projects whose operations have a long execution phase, such as surface mining. While some factors can be forecasted and may be controlled or mitigated, others may be unforeseen. Implementing measurement systems (indicators) for sustainability has mostly been focused in projects where most sustainable practices can be implemented during the planning and execution phase (e.g., the building industry), with the expectation of an optimum performance during the operation phase so the project and organizations obtain the expected score in the pre-selected rating system (e.g., BREEAM, LEED, CASBEE) to measure their sustainability performance. The surface mining industry experiences an amalgamation of the execution and operation phases; therefore, most indicators for sustainability are designed to be measured primarily during the operation phase of the projects, instead of during their execution (i.e., construction). Moreover, the indicators for sustainability should reflect the projects' and organizations' performance over long periods of time instead of over a short construction phase period (as occurs in the building industry).

While the PIF is one of the three components in the proposed integrated approach for sustainability assessment, the stakeholders' assessment of indicators and their weights becomes essential for the calculation of the overall rating of sustainability performance. Stakeholder engagement in MCDM processes, including those for sustainability assessment, assists in the design of rating system methodologies by adding the credibility factor and facilitates the implementation of the rating system; therefore, future research requires the assessment of the indicators' weights, and further developments are expected to include the integration of the MCDM process results with the PIF. Additionally, the integrated methodology for sustainability assessment requires further development, including case studies to test the methodology and evaluate its applicability, usefulness, and implementation cost.

9. Chapter One – Weighting Sustainable Development Indicators (SDIs) for Surface Mining Operations Using the Analytic Hierarchy Process (AHP)[8]

9.1 Introduction

The basic components of a sustainability assessment methodology involve three distinct stages: (1) identification of SDIs, which answers the question of what to measure; (2) development of metrics, which addresses the challenge of how to measure the SDIs; and (3) application of assessment models (i.e., assessment methodology), which typically uses a scientific approach to deliver a comprehensive valuation that includes an assessment of the diverse impacts, input of stakeholders' views, and application of mathematical models. Instead of abstract and complex assessment tools, the users and stakeholders favor simplistic, flexible, and practical approaches with an expected numeric value as the result. A numeric result of the assessment facilitates not only an understanding of the methodology but also the internal and external performance benchmarking process. Depending on the methodology, tool, instrument, or process used, the results of the assessment are given in comparative parameters (e.g., time, cost) or simply a value in a numeric scale.

Previous assessments have mainly focused on the environmental criteria instead of integrating the three pillars of sustainability (social, economic and environmental). However, as sustainability is becoming better understood, diverse tools, methodologies, processes, and instruments are developing to integrate social and economic facets with

[8] A version of this chapter has been submitted for publication. Poveda & Lipsett 2013. International Journal of the Analytic Hierarchy Process. 5(2):200-222.

the aim of achieving a balanced approach to sustainability assessment. Furthermore, while a notorious transition has occurred from environmental regulations to environmental assessment, demonstrating substantial levels of maturation in practice and theory, other pillars of sustainability (i.e., social and economic) face challenges in advancing at the same rate.

Sustainability is still in its infant stage, and progress made in the environmental area, which is better understood by stakeholders and the public in general, demonstrates the potential the other pillars of sustainability have to improve. The economics of sustainability tend to be interpreted as how well an organization is doing financially, instead of measuring the economic impacts of its performance, and the social pillar is faced with the major challenge of measuring impacts that are intrinsically subjective.

Several environmental and sustainability assessment tools, instruments, processes, and methodologies have been developed and are continuously evolving to address the stakeholders' needs, and the outcome of scientific research in areas of sustainability are poorly understood. Rating systems stand out and have gained attention and credibility, as demonstrated by the vast number of certified projects around the world and by the widely-known advantages of using them (Yudelson, 2008; Issa et al., 2009).

Green and sustainability rating systems inherently possess a developed scale in which the users are requested to achieve a certain level, with the aim of guaranteeing the sustainability of the project and/or organization. Rating systems are developed to meet the needs of specific characteristics, with the aim of categorizing, certifying or acknowledging the project and/or organization as sustainable. Therefore, the SDIs included in the assessment process are selected to reflect the diverse impacts and/or expected performance of projects and/or organizations during their life cycles.

The use of rating systems has rapidly spread in certain industries (e.g., buildings), which has required the development of a number of rating systems for specific projects (e.g., schools, healthcare, homes, commercial, neighborhoods) within the building industry. However, other projects and industries do not possess such rating systems to demonstrate their performance in SD. Among others, LEED, CASBEE, BREEAM, GBTool, and Green Start lead their local markets and are working to rapidly penetrate markets abroad. Areas of performance (e.g., categories) and criteria are part of most rating systems.

A comparison of the performance against a criterion or number of criteria is typically used in the assessment process. However, the distribution of points and weights across the different areas and criteria of the rating system become a critical issue in the development process (Trusty, 2008). Criteria take the SDI concept (in a rating system context) a step further by allocating weight through a quantitative MCA. Each rating system allocates weight to each criteria and category using specific methodology to then obtain a weighted summation (e.g., final score) by the addition of every criterion's weight if the project or task has met a pre-established requirement. A company and/or project is categorized, certified, or acknowledged as sustainable based on the number of points or parameters accomplished in a pre-determined rating scale.

A range of stakeholders are included in the group of users of rating systems (AEC [architects, engineers, constructors] professionals, producers of buildings products, investors and buildings owners, consultants, residents, researchers, and authorities). Stakeholder participation is not limited to the use of the rating system, but the effective engagement of stakeholders during the development phase of the tool translates into efficient decision-making and sustainability assessment processes. Stakeholder participation increases the credibility factor and facilitates implementation and penetration into the market. Weighting the categories and criteria requires considering the application of MCDM.

Stakeholders are faced with the challenge of evaluating the relevance of distinctive categories (e.g., management, water, materials, and air) and social, economic, and environmental criteria.

MCDM problems are encountered in many aspects of our lives. MCDM has been applied in areas of economy, education, ecology, transport, and industrial production amount areas in which tasks in control, planning, monitoring, and analysis have been addressed using diverse MCDM methodologies (Vassilev, Genova, & Vassileva, 2005). Additionally, the integration of MCDM with DSSs have been widely used in the fields of financial analysis, flood risk management, housing evaluation, disaster management, and customer relationship (Umm-E-habiba & Asghar, 2009).

With the emergence of sustainability not only in practice but also as a solid area of research, the assessment of SD integrating its three pillars develops into using scientific and mathematical approaches with the ultimate goal of meeting and balancing the different stakeholder needs. This manuscript presents a frame for utilizing the AHP to weight SDIs (e.g., criteria) for surface mining operations. This MCDM method is part of an integrated approach for sustainability assessment encountered in the Wa-Pa-Su project sustainability rating system (Poveda & Lipsett, 2011b; 2011c).

9.2 Development, Usage and Weighting of Sustainable Development Indicators (SDIs)

In 1987, the WCED changed the way industry does business by introducing a formal definition of sustainability. Since then, the international community—including governments, scientists, politicians, sociologists, engineers, and economists—has come together in an effort to link the PPP of SD at a macro level, with the goals and objectives at the organizational and project levels. The development and implementation of SDIs have contributed to close the gap; however, the identification and measurement of SDIs is in permanent evolution.

KPIs have largely been used to demonstrate the performance of implemented PPP in a diverse range of organizations and industries. The UN describes the functions of SDIs (UN, 2007a):

> "They can lead to better decisions and more effective actions by simplifying, clarifying and making aggregated information available to policy makers. They can help incorporate physical and social science knowledge into decision-making, and they can help measure and calibrate progress toward sustainable development goals. They can provide an early warning to prevent economic, social and environmental setbacks. They are also useful tools to communicate ideas, thoughts and values."

SDIs or KPIs for sustainability evaluate social, economic, and environmental performance of projects and/or organizations. In 1992, Agenda 21 was adopted after the UNCED to guide programs and actions designed to achieve ESSD at global, regional, and local levels (Harger & Meyer, 1996). Therefore, measuring and assessing the results of implementing ESSD indicators (e.g., SDIs or KPIs for sustainability) has become relevant to define the effectiveness of the PPP. Moreover, benchmarking performance requires the development of metrics and the definition of a scale against which results can be measured, verified, compared, and correlated. However, no benchmarking process can take place unless a common set of SDIs are used to measure the sustainability of similar projects and/or organizations within an industry sector. Consequently, the design and development of SDIs, including the definition of the final assessment set of indicators and their metrics, are activities in which success is measured by the effective engagement and participation of the different stakeholders.

At the macro level, benchmarking performance and progress of developing and developed countries, and comparing the status of whole countries in terms of a specific aspect, are two areas of proven usefulness of SDIs' implementation in addition to measuring the effectiveness of PPP. At the organizational and project level, the linkage with macro-level goals and objectives represents a major obstacle. Additionally, SDIs development faces two major hurdles that are still under international debate among scientists: which indicators should be included in the assessment of sustainability (i.e., What should be measured?) and how those indicators should be measured (i.e., Which metrics are to be used?). Although the set of SDIs to be included in the assessment is a proven task that defines the success of the process, guidelines, considerations, and characteristics for assisting with the design of SDIs have been developed (Gibson, Hassan, Holtz, Tansey, & Whitelaw, 2010; Harger & Meyer, 1996; Hart, 1999; IISD, 2012; Taylor, 2006; UN, 2007a). The design, development, and selection of SDIs can also be supported by different sources: governmental regulations; committees and organizations for standardization; management and processes best practices; academically- and scientifically-authored resources; local, regional, national, and international organizations; and industry sector standards and programs. While following the guidelines of any of these resources does not guarantee a sustainable performance, they serve as a starting point for pre-selecting SDIs.

An SDI measures the performance of a specific subject and is not be used in isolation when assessing sustainability as a whole due to its multi-disciplinary nature. Therefore, different SDIs are developed not only representing the different facets of sustainability (e.g., social, economic, and environmental) but also addressing the different stakeholders' needs of an explicit organization, project, or industry sector. Furthermore, simplification and practicability are the main reasons behind the appeal for the design and use of a sole indicator (i.e., a composite indicator [CI]) to assess sustainability (Gasparatos, El-Haram, & Horner, 2008). However, data aggregation into a sole indicator implies compensability and substitutability between criteria (Munda & Nardo, 2005). Even though these disadvantages are hardly compatible with the vision of sustainability (Gasparatos et al., 2008; Neumayer, 2003), MCDM methods allow an alternative and viable perspective to aggregate the criteria into a CI using techniques such as ELECTRE (Elimination and Choice Expressing Reality) (Figueira, Greco, Roy, & Slowinski, 2010).

9.3 The Wa-Pa-Su Project Sustainability Rating System: Structure and SDIs for Surface mining Operations

The applicability of the AHP, a MCDM method, is demonstrated in the development of the Wa-Pa-Su project sustainability rating system—a verification process to assist demonstrating compliance in SD performance during project life cycle through the implementation of enhanced strategies to mitigate environmental, social, health, and economic impacts (Poveda & Lipsett, 2011b; 2011c). The AHP is a fundamental pillar in an integrated approach for a new methodology for sustainability assessment for long-term projects. The Wa-Pa-Su project sustainability rating system assessment methodology is integrated for three distinctive areas of knowledge: (1) SD theory and fundamentals are the bases for the development of the rating system, since the aim is to find a balanced path to the social, economic, and environmental needs; (2) the MCDA allows for the engagement and participation of stakeholders during the decision-making process of the design and implementation of the criteria weighting system; and (3) the CPI immersed in the assessment methodology assists organizations and/or projects in improving performance over time.

Poveda and Lipsett (2011b) describe the necessity for developing a methodology for the assessment of sustainability, which fills the existing gaps in industrial projects with an emphasis in the oil sands developments. The integrated assessment methodology, initially conceived with oil sands projects in mind, evolved into a methodology with characteristics of applicability to other long-term projects. The Wa-Pa-Su project sustainability rating system with application to oil sands operations consists of ten (10) subdivisions, ten (10) areas of excellence within each subdivision, and a number of criteria within each area of excellence (Poveda & Lipsett, 2011b).

Aligned with the project's life cycle, the Wa-Pa-Su project sustainability ratings system contains the subdivisions of project integration; provisional housing/buildings; permanent housing/buildings; roads; oil transportation and storage; mining process; in-situ process; upgrading and refining; shutdown and reclamation; and CO2, SOx and other GHGs mitigation, capture, and storage. The applicability of the AHP methodology described in this manuscript focuses on the mining process, which, in the case of oil sands projects, occurs for bitumen located within 75 meters of the surface. Hence, the process is also called surface mining to differentiate it from the in-situ mining process. The surface mining sub-division includes the mining itself and other related processes to recover the bitumen by removal of overburden from an oil sands deposit (Poveda & Lipsett, 2011b).

The design of the different areas of excellence is based on three distinctive facets of the projects: the resources involved in project development; stakeholder expectations; and potential environmental, economic, and social impact. The SDIs or KPIs for SD are classified in the ten (10) areas of excellence: PEME; SSRE; WRE; AARE; NALE; ERE; RME; IDOE; IBE; and ERCE.

The pre-selected SDIs for the surface mining operations in oil sands projects are identified in six (6) potential sources and grouped in three (3) areas known as group originators of SDIs. The group of indicators agreed upon through consensus by public or governmental representatives group includes governmental regulations as well as committees and organizations for standardization, management processes best practices; academically- and scientifically-authored resources are grouped into the academic- and practitioners-identified indicators section; and the organizationally-established indicators group includes the local, regional, national, and international organizations and surface mining industry standards and programs. Table 6.2 illustrates the pre-selected indicators in each area of excellence for the surface mining operation in the oil sands projects.

9.4 Multi-Criteria Decision Making (MCDM) Methods and the Analytic Hierarchy Process (AHP)

The unique human ability to make complex decisions using diverse inputs and criteria has long been discussed as one of our species's defining characteristics. Even arguing that decision-making is what distinguishes humans from animals, great philosophers such as Aristotle, Plato, and Thomas Aquinas make reference to such capability in humans (Figueira Greco, & Matthias, 2005). The MCDM and MCDA methods have evolved rapidly, and their applicability has been proven in a variety of areas, including education, transport, economy and finance, supply chain, wastewater and urban sanitation, and ecology. Today, thousands of manuscripts and dozens of books have been devoted to this area of knowledge, and this section focuses on presenting a brief description of the existing MCDM and the context for the AHP in the MCDA environment. The MCDM application is described in this manuscript in the weighting process of SD indicators (SDIs) for surface mining operations in the oil sands projects.

Structuring and solving decision and planning problems with multiple criteria is the focus of MCDM and MCDA studies and research. MCDM problems can be divided into three categories: problems of multi-criteria choice, problems of multi-criteria ranking, and problems of multi-criteria sorting (Vassilev et al., 2005). Independently of the problem or set of problems to solve, there is an additional component that defines the success of the decision-making process. The DM provides additional information in order to select the preferred alternative(s), and provides input based on his/her preferences based on the goals sought to accomplish. With the aim of providing the most feasible solution, several methods have been developed to solve multi-criteria problems and can be grouped in three distinctive classes:

[a] The Multi-Attribute Utility Theory (MAUT) methods give the DM the ability to quantify the desirability of a series of alternatives in which a certain level of uncertainty and risk are considered. The AHP weighting method (Saaty, 1994) and its most recent extension, the ANP; the UTA (Utility Additive) method (Beuthe & Scannella, 2001); the value tradeoff method (Keeney & Raiffa, 1993); the direct weighting method (Von Winterfeldt & Edwards, 1986); and the MACBETH (Measuring Attractiveness by a Categorical Based Evaluation Technique) method (BanaeCosta & Chagas, 2004) are among the most common in the MAUT methods group.

[b] The outranking methods have been developed based on the assumption that there is limited comparability among the alternatives, and in most of the outranking methods, it is assumed that the DM is unable to differentiate among the four binary relations (i.e., the indifference I [reflexive and symmetric], the weak preference Q [irreflexive and antisymmetric], the strict preference P [irreflexive and anti-symmetric], and the incomparability R [irreflexive and symmetric]) used to compare two alternatives. The main exponents of this second group are the PROMETHEE (Preference Ranking Organization Method for Enrichment of Evaluations) methods (Brans & Mareschal, 1994), the ELECTRE methods (Roy, 1996), and the TACTIC (Treatment of the Alternatives According to the Importance of Criteria) methods (Vansnick, 1986). The PROMETHEE methods include PROMETHEE I (partial ranking), II (complete ranking), III (ranking based on intervals), IV (continuous case), V (MCDA including segmentation constrains or MCDA under constraints), and VI (representation of the human brain). The ELECTRE methods (Roy,

1996) include ELECTRE I (choice, crisp S relation), IS (choice, valued S relation), II (ranking, crisp S relation), III (ranking, valued S relation), IV (ranking, valued S relation and no weights on criteria), and TRI (sorting, value S relation), in which crisp S means a yes/no relation (either outranks or not) and value S means that a credibility degree for the outranking is computed in the interval [0,1]. The TACTIC method (Vansnick, 1986) is similar to ELECTRE I, but yields a global preference relation instead of a choice set. Like ELECTRE I, the TACTIC method consists of three main steps: preference modeling, aggregation, and exploitation. The TACTIC method is fairly close to the (weighted) Condorcet method.

[c] Non-classical MCDA approaches require distinguishing between internal and external uncertainties. Internal uncertainties relate to DM values and judgments, while external uncertainties refer to imperfect knowledge concerning consequences of actions (Figueira et al., 2005). Figueira et al. (2005) describes four broad approaches for dealing with external uncertainties: “multi-attribute utility theory and some extensions; stochastic dominance concepts, primarily in the context of pairwise comparisons of alternatives; the use of surrogate risk measures such as additional decision criteria; and the integration of MCDA and scenario planning.” Additionally, some hybrid methods have been developed. The fuzzy set theory has been used for choice, ranking, and sorting problems in the MCDA, taking several different approaches (e.g., fuzzy-PROMETHEE). PROMETHEE-GAIA (Geometrical Analysis for Interactive Aid) uses the visual interactive module GAIA to provide graphical representation support to the PROMETHEE methodology, and procedures such PROMETHEE-GDSS (Group Decision Support System) have been developed based on the PROMETHEE-GAIA to provide additional decision aid to a group of DMs. In addition to these three classes of MCDM, another area of consideration in decision-making is the use of systems support or software systems, which provide support to researchers and/or practitioners (e.g., DM) in different areas/steps of the

decision-making process. Vassilev et al. (2005) classified into three groups the developed systems supporting the solution of MCA and multi-criteria optimization problems: commercial, research or teaching, and experimental. The authors also divide the software systems supporting the solution of MCA problems into two classes: software systems with a general purpose and problem-oriented software systems.

The AHP was originally developed by Saaty (1977, 1980, 1982, 1990), and it is not only flexible but also one of the most easily-implemented MAUT methods (Anselin & Meire, 1989). The AHP technique describes a problem using a hierarchy, which in its simplest case has three levels, and applies a measurement scale to obtain vectors of normalized eights or priorities using pairwise comparisons. Bouyssou, Marchant, Pirlot, Tsoukias, and Vincke (2006) describe the main characteristic of the AHP method: the evaluation model is structured in a hierarchical way, the same assessment technique is used at each node of the hierarchy, and the assessment of the "children" nodes of a common "parent" node is based on pairwise comparisons. The top-level node in the hierarchy represents the main objective of the DM and is the result of the aggregation of the analysis of the alternatives in the second level node. As there are alternatives in each node and nodes can split as many times as there are alternatives, the number of levels in the hierarchy depends on the initial analysis of the problem in hand and how the decision problem has been structured. Saaty (2008) describes the organized way for generating priorities in four steps:

> "[1] Define the problem and determine the kind of knowledge sought.
>
> [2] Structure the decision hierarchy from the top with the goal of the decision, then the objectives from a broad perspective, through the intermediate levels (criteria on which subsequent elements depend) to the lowest level (which usually is a set of the alternatives).

> [3] Construct a set of pairwise comparison matrices. Each element in an upper level is used to compare the elements in the level immediately below with respect to it.
>
> [4] Use the priorities from the comparisons to weight the priorities in the level immediately below. Do this for every element. Then for each element in the level below add its weighted values and obtain its overall or global priority. Continue this process of weighting and adding until the final priorities of the alternatives in the bottom-most level are obtained."

Furthermore, the process of assigning weights or scores to each of the "children" (i.e., alternative) nodes of a "parent" node (except for the bottom nodes) can be summarized as follows:

[a] The participants (e.g., DM, client, stakeholders) are asked to compare the alternatives (e.g., criteria, indicators) in a pairwise comparison in terms of their relative importance and using a conventional semantic scale;

[b] The qualitative assessments given by the participants are quantified (i.e., quantitative interpretation), resulting in an n x n pairwise comparison matrix; and

[c] Using the pairwise comparison matrix, a score or weight wi is obtained to then be computed as the eigenvector corresponding to the maximum eigenvalue of the matrix, and they are normalized to add up to 1.

Lastly, the main criticism facing the AHP techniques refers to the phenomenon called rank reversal, which refers to changes of the relative weights (e.g., score, rankings) of the other alternatives after an alternative is added or deleted. Although a recognized phenomenon, alternatives to avoid rank reversal have been presented (Wang & Elhag, 2006; Schenkerman, 1994), and scholars are divided on the interpretation of the rank reversal, with some indicating that introducing new alternatives should not create the phenomenon while others indicate that there are some cases in which rank reversal is expected.

9.5 Setting the Weighting Process, SDIs Ranking, and the Decision-Makers (DMs)

The AHP methodology assists scientists and practitioners in the decision-making process of weighting a series of criteria that are, for the most part, implicitly subjective. The assessment of sustainability implies the involvement of social, economic, and environmental aspects as minimum requirements mandated by the triple bottom line. However, other scholars include additional areas such policy, culture, and values, while others combine two or more pillars of sustainability using multi-facet or multi-attribute indicators (e.g., socio-economic indicators). Although some areas of sustainability are fairly well-developed and understood (e.g., environmental), others are still in the infant stage (e.g., social) and, at this point, involve a great degree of subjectivity (Poveda & Lipsett, 2013a).

Even though the graphic representation of sustainability in which three equally-sized circles intersect each other implies the balance and equality of the pillars, the indicators within each pillar are to be proportionally weighted. Since the number of indicators and the areas of assessment vary, a preliminary classification of the indicators is recommended. The process can group the indicators using the different pillars of sustainability, areas of a project, pre-determined areas of excellence, or any other classification, with the condition that stakeholders are preliminarily debriefed, as they need to understand what brings those indicators together (i.e., characteristics commonality). To demonstrate the applicability of the AHP methodology in the weighting of SDIs for surface mining operations, the SDIs have been classified in ten (10) different areas of excellence. These areas address the different aspects of surface mining operations that not only concern the various stakeholders but also align with the fundamentals and theory of sustainability. Additionally, the weighting process mandates the prompt and effective engagement and involvement of the stakeholders that are directly impacted or impact the functionality and/or development of an organization or project. The number of indicators in each pillar and the identification and classification of stakeholders are two areas in which scholars, scientists, and practitioners have not reached common ground. However, stakeholders are recognized as critical components in the success of the decision-making and sustainability assessment processes.

Surface mining projects are unique from different standpoints. Not only are impacts on the environment rapidly noted by local communities, but economic benefits are also tangible on local and national levels. Therefore, stakeholders become rapidly knowledgeable regarding how the projects directly affect them. Even though the identification and classification of stakeholders is still an area for development, experience and the "learning-as-you-go" process have resulted in the identification of a number of stakeholders for the surface mining projects for the Canadian oil sands operations/projects. Owner companies, EPC (engineering, procurement, and construction) companies, contractors, suppliers, logistics providers, government/regulators, local communities, local business, aboriginal communities, NGOs, scientists and researchers, media (television, press, radio), industry and community associations, and financiers are some of those interested parties that may be actively or passively engaged in the development of the projects. (Note: development does not imply the approval of the projects or giving the social license to operate.) The Canadian oil sands are a good example of surface mining operations due to the large reserves or resources exploited, the comparatively stringent set of regulations, and the large number of stakeholders engaged in the process, among other valid reasons.

9.6 The Hierarchy

In the AHP, the relative value of surface mining operations' sustainability is viewed as the main objective, which is obtained by way of a combination of a number of criteria (i.e., areas of excellence), each with their own relative importance, relevance, weight, or priority with respect to their influence to the overall objective. These three levels are linked together in a hierarchical structure, as shown in Figure 9.1, where the top level is the objective and the next level consists of the different criteria (i.e., areas of excellence). In our application of the AHP methodology, we consider ten (10) areas of excellence: PEME; SSRE; WRE; AARE; NALE; ERE; RME; IDOE; IBE; and ERCE. Additional criteria can be considered in other sustainability assessment rating systems, which are required to be conceptualized during the development phase of the assessment tool, with the aim of having a level of consistency to be able to benchmark performance between projects and/or organizations. Poveda & Lipsett (2011b) explain each criterion (i.e., area of excellence), and that the main objective for each of them consists of applying fundamentals and principles, as well as the latest advances and technologies, with the aim of targeting a level of excellence in performance. Additionally, the criteria (i.e., areas of excellence) take three aspects into consideration: resources involved in project development; stakeholders' expectations; and potential environmental, economic, social, health, and other impacts.

The next level in the hierarchy materializes once each criterion (i.e., area of excellence) is considered as a cluster, to which a certain number indicators contribute. The number of indicators may vary in each criterion, and each one of the indicators has its own weight, relevance, importance, or priority with respect to the particular criterion (i.e., area of excellence). In our application, the numbers of indicators in each criterion varies. Those indicators reflect the different pillars of sustainability (i.e., social, economic, and environmental) or can be the combination of two or three of the pillars, which are being called multi-facet or multi-attribute indicators. Additionally, the classification of indicators considers when and where a set of activities occurs within the surface mining operations (Poveda & Lipsett, 2011b). In Figure 9.1, the number of indicators in each criterion (i.e., area of excellence) and their acronyms are arbitrary, and the different indicators for surface mining operations are shown in Table 6.2.

9.7 Measurement Scale

The fundamentals of the measurement scale utilized in the AHP method have not changed since the methodology was introduced by Thomas L. Saaty in the 1970s (Saaty, 1977). However, a comparison of the different tables presenting the measurement scale notes slight modifications of how the scale is interpreted, and/or conceptual additions have been introduced and observed in different publications throughout the years (Saaty, 1977; 1980; 1982; 1990; 1994; 2008). Though those differences may be semantic interpretations, the stakeholders must be presented with a consistent and clear measurement scale with the aim of obtaining optimum results. In the application of the AHP methodology in the weighting process of sustainability indicators for surface mining operations, the measurement scale used is represented in Table 9.1.

While the measurement scale adopted for this application considers the principles of the AHP methodology, the information presented considers the different measurement scales introduced throughout the years. Furthermore, the measurement scale illustrates a descriptive and detailed compilation of how the information must be presented to the DMs (i.e., stakeholders) during the process of weighting the indicators.

The measurement scale developed and detailed by Saaty throughout the years addresses the hierarchical structure of the problem by assisting DMs in setting the weights or priorities for each criteria and indicators; it reflects the relative strength of each element at a level in the hierarchy with respect to other elements considered in the weighting process at different levels and between each other. In our application, the weights or priorities of criteria (i.e., areas of excellence) and indicators (i.e., SDIs [social, economic, environmental, and multi-attribute/facet]) are calculated, to then be integrated in the calculations for

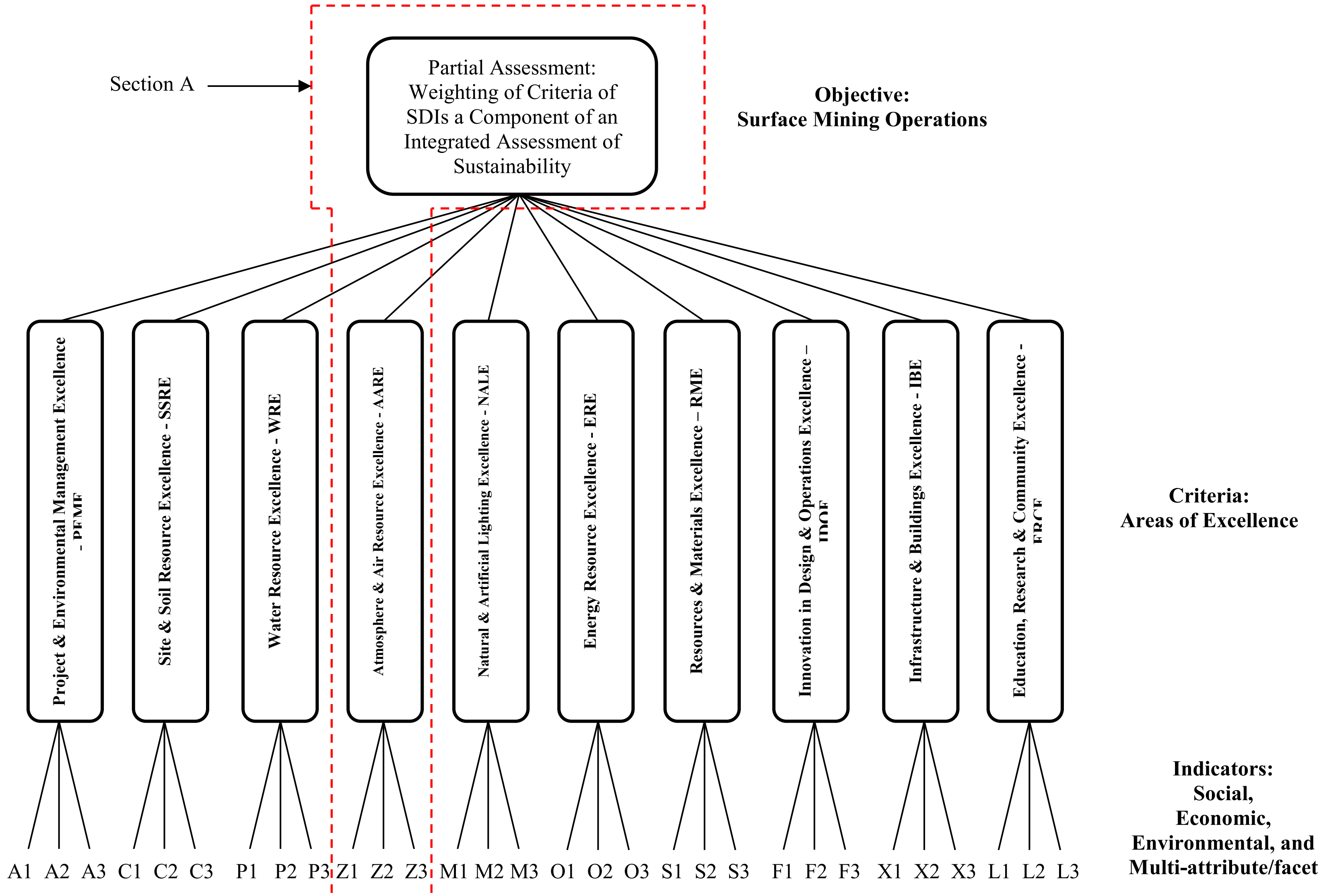


Figure 9.1 Hierarchy structure of the evaluation for sustainability of surface mining operations. The AHP method is used as partial assessment in the weighting of criteria of SDIs as a component of an integrated assessment of sustainability in the Wa-Pa-Su Project Sustainability Rating System (Poveda and Lipsett, 2011a; 2011b).

sustainability assessment developed in the Wa-Pa-Su project sustainability rating system (Poveda & Lipsett, 2011b; 2011c). This serves as an integrated approach for SD of long-term projects (i.e., projects having a life cycle that exceeds a 2-year period [which includes only the execution phase] from start to finish [e.g., mining, industrial, oil and gas, energy]).

Table 9.1 The fundamental scale according to Saaty (1977, 1980, 1982, 1990, 1994, 2008)

Intensity of Importance	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective
2	Weak or slight	
3	Moderate importance of one over another	Experience and judgment slightly favour one activity over another
4	Moderate plus	
5	Essential or strong importance	Experience and judgment strongly favour one activity over another
6	Strong plus	
7	Very strong or demonstrated importance	An activity is favoured very strongly over another; its dominance is demonstrated in practice
8	Very, very strong	
9	Extreme importance	The evidence favouring one activity over another is of the highest possible order of affirmation
Where;		
2, 4, 6, 8	Intermediate values between the two adjacent judgments	When compromise is needed
1.1–1.9	If the activities are very close	May be difficult to assign the best value but when compared with other contrasting activities the size of the small numbers would not be too noticeable, yet they can still indicate the relative importance of the activities
Reciprocals	If activity *i* has one of the above non-zero numbers assigned to it when compared with activity *j,* then *j* has the reciprocal value when compared with *i*	A reasonable assumption
Rationals	Ratios arising from the scale	If consistency were to be forced by obtaining *n* numerical values to span the matrix

The measurement scale consists of nine points. Anselin & Meire (1989) indicate that nine points are chosen because psychologists have concluded that nine objects are the most that an individual can simultaneously compare and consistently rank. The scale ranges from 1, which indicates an equal importance between elements, to 9, which refers to an absolute importance of one element over another. Additionally, the pair values of 2, 4, 6, and 8 indicate intermediate values between two adjacent judgments, and some compromise is needed.

The construction of pairwise matrices and their values within are assisted by the measurement scale, which indicates the level of strength or dominance that an indicator or criterion has over others when they are compared pairwise. Consequently, sets of pairwise comparisons are the result of simultaneous rankings broken down. Consistency in the use of the measurement scale is required within the same pairwise comparison matrix and among different matrices in the event the study requires more than one matrix. However, the construction of a matrix of pairwise comparisons does not impose strong requirements of consistency (Anselin & Meire, 1989).

9.8 Pairwise Comparison Matrices

Pairwise comparison matrices are used to determine the relative importance of a series of elements in terms of each criterion. When an element is compared with itself, the value of the weight becomes 1. The structure followed in this paper consists of a number of elements, M, and a series of criteria, N. N criteria are the same elements M, when forming the pairwise comparison matrix certain element M becomes a N criteria (e.g., M1 = N1). Since elements can be evaluated in terms of the different criteria, the relative importance or weight of each element can be calculated as well. In the pairwise comparison matrices, aij represents the relative importance or weight of an element over a criteria where, i=1,2,3,……M and j=1,2,3,…..N. Therefore, the core of the typical problem to be solved using the AHP methodology to weight the alternatives (criteria) can be represented by the following pairwise comparison matrix:

				Alternative			Alternative/Criteria Absolute Weights
Criteria	M_1	M_2	M_3	M_4	……..	M_M	
N_1	a_{11}	a_{12}	a_{13}	a_{14}	……..	a_{1M}	w_1
N_2	a_{21}	a_{22}	a_{23}	a_{24}	……..	a_{2M}	w_2
N_3	a_{31}	a_{32}	a_{33}	a_{34}	……..	a_{3M}	w_3
N_4	a_{41}	a_{42}	a_{43}	a_{44}	……..	a_{4M}	w_4
.	.	.	.	.		.	.
.	.	.	.	.		.	.
.	.	.	.	.		.	.
N_N	a_{N1}	a_{N2}	a_{N3}	a_{N4}		a_{NM}	w_{NM}

Where;

$M_1 = N_1$,	$a_{11} = w_{N1}/w_{M1}$	$w_1 = w_{N1} = w_{M1}$
$M_2 = N_2$,	$a_{21} = w_{N2}/w_{M1}$	$w_2 = w_{N2} = w_{M2}$
$M_3 = N_3$,	$a_{31} = w_{N3}/w_{M1}$	$w_3 = w_{N3} = w_{M3}$
$M_4 = N_4$,	$a_{41} = w_{N4}/w_{M1}$	$w_4 = w_{N4} = w_{M4}$
⋮ ⋮	⋮ ⋮	⋮ ⋮ ⋮
$M_M = N_N$	$a_{21} = w_{N2}/w_{M1}$, etc	$w_{NM} = w_{NN} = w_{MM}$

The first pairwise comparison compares the different criteria (i.e., areas of excellence) in a 10 x 10 matrix which includes the following elements: PEME; SSRE; WRE; AARE; NALE; ERE; RME; IDOE; IBE; and ERCE. In the assessment process (pairwise comparison), the decision-maker is free to evaluate the relative importance of each alternative/criterion over others. Finding the largest eigenvalue and associated eigenvector, the absolute value of each weight can be calculated from the relative pairwise weights. In detail, if n criteria have known relative weights/importance of w1, w2, …wn, then the comparison of the relative importance of criterion i to criterion j gives a value of N(i, j) = M (i, j) = wi / wj for the element (i, j) in the pairwise comparison matrix N or M (M = N but M is called alternative and N criteria when forming the pairwise comparison matrices). Additionally, alternative/criteria N(j, i) = M (j, i) = wj / wi which justified the use of reciprocals in Table 2. To build the matrix, the alternative and criteria are compared pairwise to then estimate the weight attached to each alternative/criteria using the eigenvector associated with the largest eigenvalue. In this application of the AHP method, there is no pre-established consistency or mathematical sense in implying that N (i, j) x N (j, k) = N(i, k) or that an alternative/criterion follows a semantic relationship with its degree of importance. Therefore, alternative/criterion i is not more important than j, and neither is alternative/criteria j higher than k, or i ranked lower than k. As the value for inconsistency increases, it is expected to find a greater eigenvalue (above n). Therefore, the pairwise comparisons have a poorer representation by the eigenvector. Finally, the values for w1, w2, …wn, can be found by calculating the geometric mean of each matrix row and then normalizing by dividing each number by its total. These represent the corresponding value of importance given to each alternative/criterion.

The second set of pairwise comparison is integrated with alternatives/criteria at the 3rd level. In Figure 9.1, the third level consists of the indicators in each criterion (i.e., area of excellence). The number of alternatives/criteria in each pairwise comparison matrix varies as follows:

- PEME: 19 indicators
- SSRE: 11 indicators
- WRE: 11 indicators
- AARE: 4 indicators
- NALE: 1 indicators
- ERE: 3 indicators
- RME: 6 indicators
- IDOE: 2 indicators
- IBE: 14 indicators
- ERCE: 44 indicators

The identification, pre-selection, and classification methodology of SDIs for surface mining operations was assisted by six different sources grouped in three areas. The group of indicators agreed upon through consensus by public or governmental representatives includes governmental regulations as well as committees and organizations for standardization; academically- and scientifically-authored resources as well as management and processes best practices are grouped into the academic- and practitioners-identified indicators group; and the organizationally-established indicators group includes local, regional, national, and international organizations and surface mining industry standards and programs. Although the assessment of sustainability and SDIs are still areas in an infant stage, the measurement methodology of criteria for surface mining operations was developed based on the CPI methodology (Poveda & Lipsett, 2013b), while the weighting of SDIs can be assisted by using a variety of approaches including the AHP methodology used in this application. Therefore, the weighting of the alternative/criteria in each pairwise comparison matrix follows the same parameters used in the 10 x 10 matrix to weight the criteria (i.e., areas of excellence) at level two (node two) in the hierarchy, with the aim of consistency in the weighting process of each alternative/criteria in each level (node) of the system (hierarchy). Each pairwise comparison matrix at level three (indicators [i.e., social, economic, environmental, and multi-attribute/facet]) is an independent sub-system. The final weight of the each indicator is impacted by the results of that integrates the 10 x 10 pairwise comparison matrix at level two (node two) in which the criteria (i.e., areas of excellence) have been weighted; therefore, the level of relevance or importance to each sub-system (pairwise comparison in level three [indicators level]) must be calculated considering the weight of each criteria (area of excellence).

9.9 Expected Results and Contributions

The expected results can be presented in the two scenarios represented in Figure 9.2: (1) partial assessment for the overall sustainability performance of the oil sands projects, in which the weighting of criteria of SDIs for surface mining operations is a component for the assessment of the project; and (2) overall assessment for sustainability performance of the oil sands projects in which ten (10) sub-divisions represented a component for the assessment of the projects. In Figure 9.3, the same hierarchy structure as in Figure 9.2 a & b and section A in Figure 9.1 is presented, but with the respective criteria and indicators showing the priority weights. To obtain the resulting overall weight for each indicator (SDIs) in Case A of Figure 9.3 (surface mining operations as isolated system in the overall sustainability assessment of the oil sands projects), the priority weights have to be multiplied by the weight of the respective criterion (i.e., area of excellence). For example,

$$SDI1' = SDI1 \times SDI = 0.175 \times 0.325 = 0.056$$

The overall weights must sum to the respective weight of each indicator as noted in Figure 9.3 for the examples illustrated (e.g., SDI = 0.056 + 0.080 + 0.142 + 0.047 = 0.325), while the sum of weights of all indicators must sum to the unit (one [1]) (e.g., Objective [surface mining operations] = 0.115 + 0.051 + 0.145 + 0.325 + 0.055 +0.105 + 0.085 + 0.025 + 0.038 + 0.056 = 1). Similarly, the calculations can be done in Case B of Figure 9.3 (surface mining operations as one of the ten (10) sub-divisions included in the Wa-Pa-Su Project Sustainability Rating System to measure the sustainability of the oil sands projects) (Poveda & Lipsett, 2011b; 2011c). The priority weights also have to be multiplied by the weight of the respective criterion (i.e., area of excellence). However, since the surface mining operation is another sub-division in the system (objectives), an additional step must be included to calculate the weight of each sub-division to then be multiplied by the weight of the respective criterion (i.e., area of excellence). Therefore, the weight of a particular indicator with reference to the overall system can be calculated as:

SDI1’ = SDI1 x SDI x SDI objective = 0.175 x 0.325 x 0.345 = 0.020

In Case B, the overall weight of the objective must sum to the unit (one [1]), while the overall weights of the criteria must add to the weight of a particular objective, and the overall weight of the indicators must sum to the respective total of the multiplication of the weight of the objective by the weight of the indicators (e.g., SDI = 0.020 + 0.027 + 0.049 + 0.016 = 0.112 in which 0.112 = 0.345 x 0.325).

Previously, in order to submit the different SDIs through a weighting process supported by a MCDM methodology, the critical task in sustainability assessment has referred to the identification and design of metrics, which assists DMs in addressing the questions of what to measure and how to measure the SDIs, respectively. Moreover, DMs (stakeholders) are faced with a cost-benefit paradigm of implementing a series of SDIs to demonstrate a certain level of sustainability performance while addressing the stakeholders’ needs. Despite the fact that there is a series of beneficial factors behind the applicability and usefulness of SDIs, there are also certain costs to be considered (Poveda & Lipsett, 2013a). The next query(s) in the decision-maker’s mind refers to the level of relevance or importance of each SDI. The application of the AHP method assists in addressing questions such as (1) should all the SDIs be weighted equally? (2) should the SDIs user expend the same level of resources for each indicator to address the impact (social, economic, environmental) that they represent? and (3) is each indicator equally important for each group of stakeholders? Although finding universally-

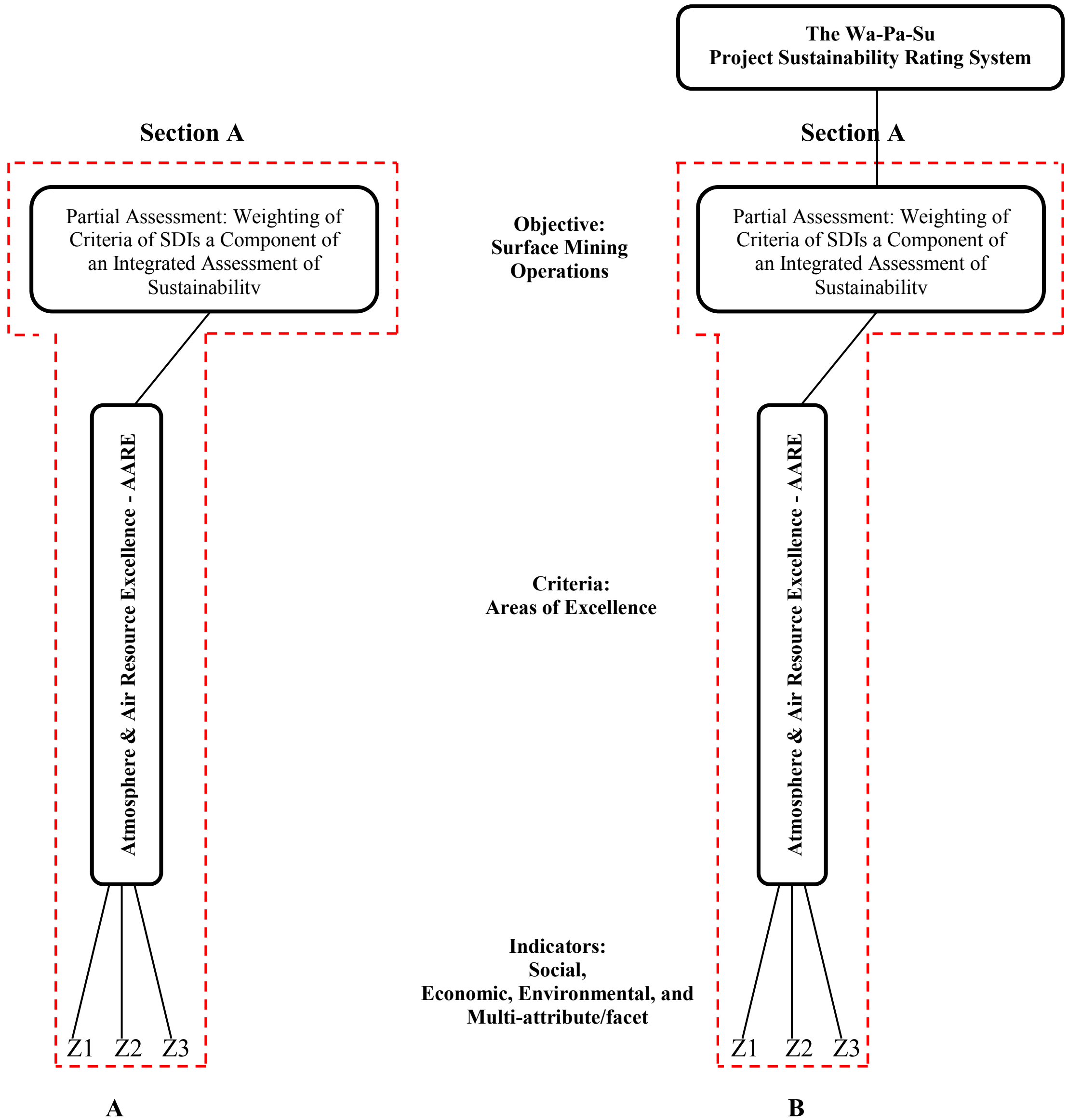


Figure 9.2 Partial and overall graphic representation of the weighting of criteria process for the surface mining operations (A) and oil sands projects (B)

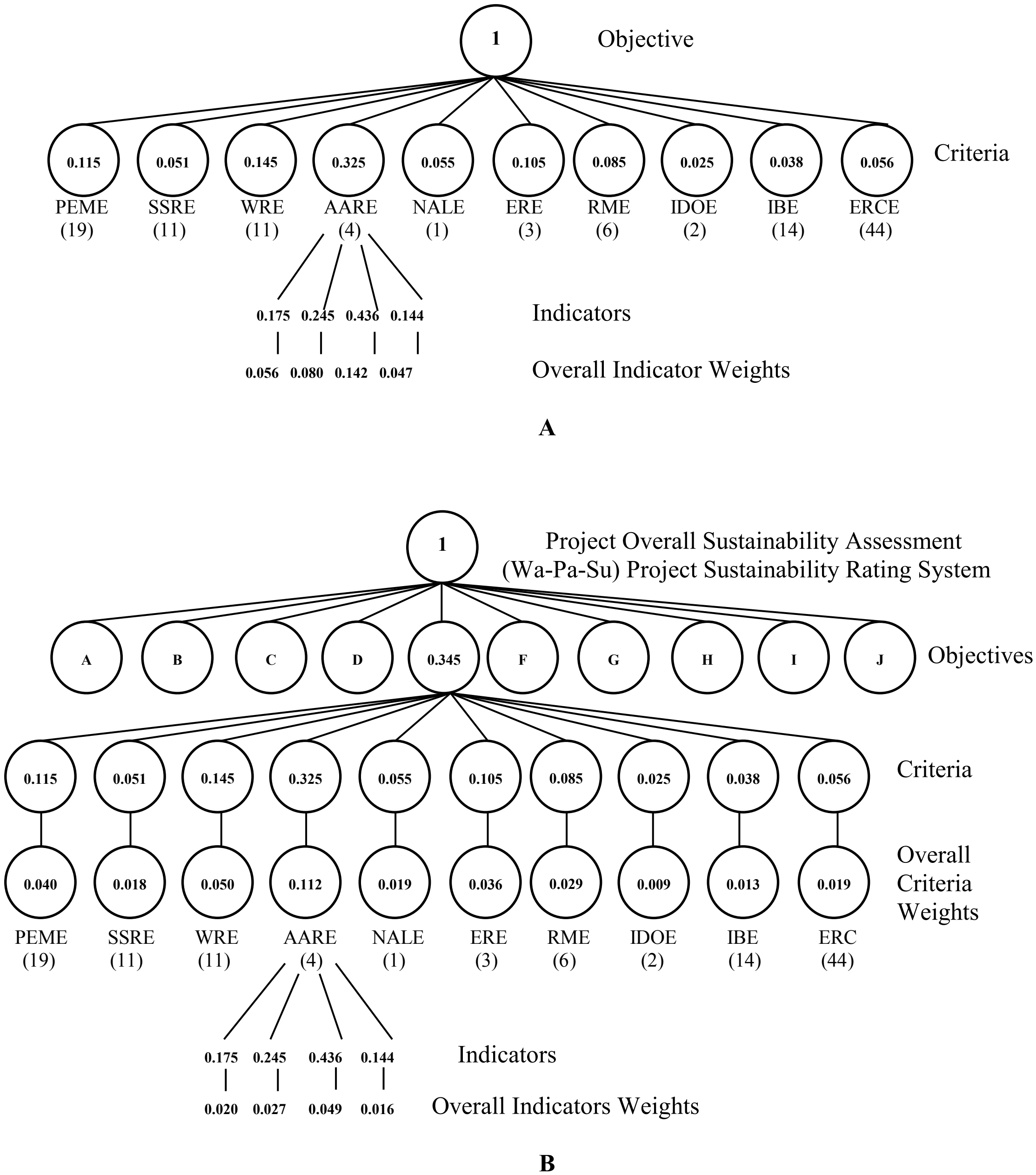


Figure 9.3 Hierarchical structure of the evaluation process of the two hypothetical applications of the AHP methodology to weight SDIs to measure the surface mining operation and oil sands projects' sustainability

accepted responses is not the main aim in the application of the AHP method, the different groups of stakeholders have an opportunity to be heard and express their individual needs through an effective engagement and participatory process that leads to the assessment of the weight of each of the indicators (SDIs), criteria (i.e., areas of excellence), and/or objectives (i.e., sub-divisions). Furthermore, the AHP method, like other MCDM methodologies, helps the DMs face the complex problem of evaluating multiple conflicting and subjective SDIs.

DMs face the challenge of multiple choices in their routine operations or among their list of activities. Therefore, they usually prefer simplistic, rapid, and applicable methodologies to find answers to their queries. The AHP methodology is similar to using the common sense decision-making approach. Consequently, DMs easily understand the approach applied in this methodology. Simplicity in the SDIs assessment becomes a strategic element from the stakeholder's standpoint. In surface mining operations, the numbers of stakeholders varies with their level of education, experience, and seniority level (management position), among other impacting factors in the assessment process. Additionally, the results (weights) of applying the AHP method can be easily communicated and understood by the different decision-making groups. Bahurmoz (2003) noted that using AHP in group settings leads to better communication, clearer understanding, and consensus among members of the decision-making group. Therefore, a greater commitment to choosing the alternative is expected.

9.10 Discussion and Future Research

In addition to the various challenges DMs encounter during the projects conception, planning, execution, and closing phases, the different stakeholders—who often become DMs—are facing the pressure of obtaining the "social license" to operate with the aim of smoothly executing and delivering their projects. Different industries are changing the well-known mentality of "business as usual" for proactive approaches to address the stakeholders' needs. Implementing more environmentally-friendly practices has been not enough. Therefore, organizations are including social and economic performance indicators to demonstrate their commitment to the triple bottom line often addressed in the fundamentals of SD.

The number or selection of SDIs for a determined kind of project or industry is still under debate, not only among stakeholders but also the international scientific community. While selecting specific SDIs for a project, organization, or industry seems to be the preference, the main challenge in applying such criteria becomes the area of benchmarking SD performance. Surface mining operations and the mining industry encounter similar difficulties when determining how to answer not only questions such as [1] what to measure and [2] how to measure the selected set of SDIs, but also finding the level of importance (weight) of each SDI. The application of the AHP method, the design of its hierarchy, and the development of the pairwise comparisons required in the methodology are under the assumption that questions 1 and 2 have been satisfactorily answered and universally accepted. Nevertheless, MCDM methodologies may offer new perspectives, not only in the weighting but also in the selection and design of metrics for SDIs.

While applying the AHP methodology offers a clear representation of the different groups of DMs regarding the level of importance of the various SDIs, criteria (i.e., areas of excellence), and objectives (i.e., sub-divisions), future research must address the validation of the findings (overall indicators' weights) and areas such as the level of importance or relevance of the different DMs (stakeholders), independency of pairwise comparison matrices, and the influence of SDIs among each other. The validation of the findings refers to comparing the values (weights) obtained after applying the AHP methodology with scientific evidence. The weight of an indicator measuring main environmental impacts is expected to be higher than other indicators reflecting an lesser impact, which can be measured through various scientific parameters (e.g., GHG emissions, energy consumption). The weight of each SDI is not only determined by DMs (stakeholders) based on the fact that they represent the three pillars of sustainability (social, economic, and environmental); other factors should be investigated to calculate the final overall indicators' weights; the SDIs' weighting should include the weights of each stakeholder group (e.g., Is the input of a politician and a small business representative equality weighted?); the DM's seniority level (e.g., Is the input of a CEO and a junior manager equally weighted?); and the DM's relevance represented in a combination of years of experience, position, and seniority in a determined position (e.g., Is the input of a Junior Project Manager with 10 years of experience and a Senior Superintendent with 30 years of experience equally weighted?).

Finally, pairwise comparison matrices and SDIs have been treated as independent bodies and the outcomes have been read as such. Future research should question such independency and/or find the interconnection between the different matrices and among the various SDIs in each matrix. For example, an indicator representing the water resources excellence (WRE) area of excellence may be closely linked to another indicator representing the energy resource excellence (ERE) area of excellence. Understanding such dynamism may result in addressing the subjectivity often encountered among SDIs and the metrics used to measure them.

10. Chapter One – An Integrated Approach for Sustainability Assessment: The Wa-Pa-Su Project Sustainability Rating System[9]

10.1 Definition of Sustainability and Objective

"There is no consensus on how to define sustainability" (Alberti, 1996); therefore, reintroducing the author's interpretation and conceptualization of sustainability and departing from all existing definitions, SD can be defined as:

> "the path to balance social, economic, and environmental needs."
> (Poveda & Lipsett, 2011c)

The purpose of this paper derives from this definition and the aim of achieving sustainability and performance excellence as a goal, inspiration, and encouragement for the present and future generations. To that end, an integrated methodology for sustainability assessment is proposed; three distinctive areas of knowledge (i.e., SD, CPI, and MCDA) come together.

10.2 Sustainability Assessment by Indicators and Rating Systems

As per Bebbington, Brown and Frame, (2007), "There is a widely recognized need for individuals, organizations, and societies to find models, metrics, and tools for articulating the extent to which, and the ways in which, current activities are unsustainable"; hence, the need for evaluating SD performance and progress made towards sustainability.

[9] A version of this chapter has been submitted for publication. Poveda & Lipsett 2011. International Journal of Sustainable Development and World Ecology. 21(1):85-98.

Devuyst, Hens and Lannoy (2001) define sustainability assessment as “a tool that can help DMs and policy-makers decide which actions they should or should not take in an attempt to make society more sustainable.” The assessment of sustainability performance allows the evaluation of progress and potential savings when comparing the results against the organization’s SD programme, and/or comparisons between sites or other organizations (Jasch, 2000). Furthermore, Ness, Urbel-Piirsal, Anderberg and Olsson (2007) suggest that the purpose of sustainability assessment is to provide DMs with an evaluation of global to local integrated nature–society systems in short- and long-term perspectives in order to assist them to determine which actions should or should not be taken in an attempt to make society sustainable.

Due not only to the large number of tools, but also the ongoing development and/or evolution of assessment approaches, strategies, models, appraisals, and methodologies for sustainability assessment to overcome their various limitations, it is unrealistic to find a sole document including all of them; however, reviews and state-of-the-art are commonly encountered in the literature in which overviews, classifications, descriptions, and comparisons are included (Ekins & Vanner, 2007; Ness et al., 2007: Haapio & Viitaniemi, 2008; Shen, Ochoa, Shah, & Zhang, 2011; Poveda & Lipsett, 2011c; Singh, Murty, Gupta, & Dikshit, 2012). While some tools focus on assessing sustainable performance, taking into consideration the triple bottom line approach—which focuses on people, planet, and profit—others have been designed to separately evaluate the different pillars of sustainability, primarily focusing on the environmental aspect of sustainability (Kinderytė, 2008). Ness et al. (2007) categorize the assessment tools into three main areas: indicators and indices, product-related assessment, and integrated assessment. The use and development of sustainability indicators and composite indices are increasingly recognized for their importance and gaining notoriety as powerful decision-making and reporting tools (Singh et al., 2012) that measure what counts to people while reflecting key trends in environment, social systems, economy, human well-being, and quality of life (Josza & Brown, 2005).

Amaral (2002) defines indicators and systems of indicators as “a parameter or value derived from parameters that points out or provides information on the state of the phenomenon medium or area with greater extended significance than that obtained directly by observation of the characteristics. A system of indicators is a set of indicators that satisfies certain principles. A system of indicators for SD normally takes into account environmental, economic, and social indicators,” and is a useful mechanism of decision-making for different groups. Furthermore, systems of indicators help to organize the different indicators around specific themes related to the vision and goals of a group of individuals (i.e., stakeholders) or a community (Jeon, Amekudzi, & Guensler, 2013). As a result, the selection of indicators should be done with a clear understanding of the needs where these are going to be applied (Shen et al., 2011), and they should be ethically desirable (Fredericks 2012).

Some of the goals of SDIs are to anticipate and assess conditions and trends; provide early-warning information to prevent economic, societal, and environmental damage; and support decision-making (Singh et al., 2012). Indicators and composite indices are useful for policy-making and public communication in conveying information on countries’ performance in fields such as environment, economy, society, or technological developments (EC, 2005). They are increasingly recognized as useful tools for measuring, tracking, and improving sustainable performance in regard to the specific issues of a company’s development (Tokos, Pintaric, & Krajnc, 2012). In addition, indicators simplify, quantify, analyze, and communicate complex and complicated information, while indices are commonly known to be simple to use and interpret, and have the ability to reduce information overload resulting from individual performance measures (Singh et al., 2012; Lomax, Turner, & Shunk, 1997).

Different attempts to categorize and organize sustainability indicators exist in the academic literature on sustainability. Braat (1991) distinguishes between predictive and retrospective indicators: while predictive indicators offer direct information regarding the future state and development of a determined variable (e.g., socioeconomic, environmental), retrospective indicators offer information regarding the effectiveness of existing policies' autonomous developments. Indicators can also be categorized as either descriptive or normative. While descriptive indicators reflect actual conditions, normative indicators compare or measure the distance between actual and reference conditions (Amaral, 2002). Jeon et al. (2013) identify three frameworks for categorization in the literature: (1) linkages-based frameworks, (2) impacts-based frameworks, and (3) influence-oriented frameworks. Meanwhile, Hart (1998) identifies four frameworks for organizing sustainability indicators: (1) category or issue lists, (2) a goal-indicator matrix, (3) driving-force–state-response tables, and (4) endowment–liability–current result–process tables. Conversely, in the rapid evolution of sustainability assessment—and specifically that of indicator systems—it is relevant to make reference to what the emerging evaluation frameworks are trying to capture, as described by Jeon et al. (2013): (1) the causal relationships that lead to progress towards or deviation away from sustainability; (2) the impacts of decisions on the three important areas that define sustainability, i.e., economic development, environmental integrity, and social well-being or quality of life; and (3) the level of influence or control that the responsible agencies have over the causal factors of sustainability. Finally, Kinderyté (2008, 2010) refers to quantitative and qualitative methodologies to quantify indicators. While DMs and other users of the tools favor the simplicity encountered in objective evaluations, both methodologies—quantitative and qualitative—present advantages and disadvantages (Kinderyté, 2008; 2010).

Consequently, aspects such as time and subjectivity, among others, are to be considered when using either methodology.

While indicators and measures can be integrated into composite indices for each sustainability dimension or the overall sustainability performance, with the aim that the DMs can rapidly and easily identify any deviation from a specific sustainability performance baseline while avoiding making isolated considerations, the use of individual indicators can become troublesome as the number of indicators increases. This is an issue because most DMs favor simplicity. However, composite indices can be understood as generalizations of the theme or dimensions of sustainability, as the vision or goals of a specific group can vary. Furthermore, composite indices offer a rapid snapshot of sustainability, although the continuous improvement process can be jeopardized since it is essential in linking the performance of each indicator with the goal and its further supporting objectives.

Even though the development of indicators addresses a fragment of the issues in sustainability assessment, the applicability and interpretation still present challenges. First, the use of indicators or producing expected results is not guaranteed by following a set of parameters in the design of the indicators (Lyytimäki, Tapio, Varho, & Söderman, 2013). Second, Sadamichi, Kudoh, Sagisaka, Chen, Elauria, Gheewala, Hasanudin, Romero, Shi and Sharma (2012) point out that after identifying and testing different indicators, extensive data collection is required for the use of indicators and interpretation of results. Third, adding to the challenges of identification (i.e., what to measure) and measurement (i.e., how to measure) of indicators in sustainability assessment is the alignment of goals and objectives with the identified indicator; the challenge becomes more difficult when measuring the different dimensions and aggregating their values into a CI (Kuik & Gilbert, 1999). Fourth, not only the number of indicators varies, but differences are also encountered in the parameters to select those that should make the list and their corresponding weights;

these parameters are an interpretation of the actual needs of the social, economic, and environmental contexts in which the indicators are used. Finally, Lancker & Nijkamp (2000) emphasize the target values of indicators, and state that “a given indicator doesn’t say anything about sustainability, unless a reference value such as thresholds is given to it.”

The most common Total Quality Assessment (TQA) systems are the multi-criteria systems known as rating systems (Berardi, 2012). Rating systems evaluate the performance of a variety of parameters (i.e., criteria) to then compare real performances with pre-established thresholds or baselines. Each criterion has a number of available points previously assigned over the total assessment, and the overall sustainability performance score is calculated by summing the results of the assessed criteria. One of the most critical issues in developing a rating system is the distribution of points and weights across the different areas and criteria of the rating system (Trusty, 2008). Ding (2008) recommends weighting criteria derived on a project-by-project basis, which would reflect the objective of any given development since opinions can differ among different groups involved in a project. The weighting of criteria is essential in all systems since it dominates the overall performance score the project is assessed (Lee, Chau, Yik, Burnett, & Tse, 2002); when not specified, the criteria are given equal weights. However, there is not a consensus-based approach or satisfactory method for the assignment of the weight to each criteria in the assessment system (Ding, 2008). The lack of systematic approaches to assign weights may lead to the manipulation of results to improve overall scores (Larsson, 1999; Todd, Crawley, Geissler, & Lindsey, 2001) or the time-consuming task of regularly updating the weighting coefficients (Ding, 2008). Furthermore, Cole (1998) refers to the absence of an agreed-upon theoretical and non-subjective methodology for assigning weights (i.e., weighting factors).

Although the needs of different interest groups have been met by the development of environmental indicators, the development of

BREEAM revolutionized the assessment of the broad range of environmental considerations in buildings during the different phases of their life cycles. Several tools have been developed and implemented around the world since the BRE launched BREEAM in 1990. In fact, Crawley, Aho, Hinks and Cook, (1999) state that BREEAM is the first real attempt to “establish comprehensive means of simultaneously assessing a broad range of environmental considerations in buildings.” Existing environmental building assessment methods were developed to reflect a local vision and limit variations at national or regional levels; however, weighting systems allow a certain level of modification to adjust to a range of needs (Ding, 2008). Modifications are driven by variations in climatic conditions, income level, building materials and techniques, building stock, and appreciation of historic value (Kohler, 1999). While different sets of indicators can be found to assess sustainability and/or environmental performance in different industries, the development of rating systems has mainly focused on the construction building industry, with coverage of a wide type of projects (e.g., new construction and major renovations, healthcare, retail, school, homes, commercial interiors, and core and shell development) including the assessment of communities and neighborhood development. The rating systems have broadened their coverage to other phases of the project life cycle (e.g., LEED for existing buildings’ operation and maintenance) or buildings for industrial use (e.g., BREEAM to assess storage and distribution warehouses, light industrial/factory units, and workshops).

A large number of rating systems exist around the world; currently more than 600 sustainability assessment rating systems are available worldwide (BRE, 2008); however, many are just adaptations of the most well-known systems to a particular region or for specific scopes. The most popular rating systems are BREEAM, LEED, CASBEE, GBTool, SBTool, Green Start, and Green Globes. Other famous rating systems are the Australian Building Greenhouse Rating (ABGR), ATHENA, the Green

Home Evaluation Manual (GHEM), the Hong Kong Building Environmental Assessment Method (HKBEAM), the Chinese Three Star Building Rating System, the Sustainability Tracking, Assessment & Rating System (STARS), and the South African Sustainable Building Assessment Tool (SBAT).

Finally, rating systems often distribute the diverse criteria in different categories. For example, BREEAM contains nine different categories, each with a pre-determined environmental weighting: management (12%), health & wellbeing (15%), energy (19%), transport (8%), water (6%), materials (12.5%), waste (7.5%), land use & ecology (10%), and pollution (10%). LEED initially emphasized six categories: SS, WE, EA, MR, IEQ, and ID, adding the regional priority category in its most recent version. Categories have been developed for specific rating systems; for example, LEED has added one for neighbourhood development. LEED uses a basic weighting equation to determine the value of the credits: the impact categories and their weights are GHG emissions (29%), water use (8%), eutrophication (6%), fossil fuel depletion (10%), ecotoxicity (7%), smog formation (4%), particulates (9%), land use (6%), acidification (3%), human health – cancer (8%), indoor air quality (3%), ozone formation (2%), and human health – non-cancer (5%). Green Star contains nine categories: management, indoor environment quality, energy, transport, water, materials, land use & ecology, emissions, and innovation.

10.3 A Need for Innovation and Diversification

The development and implementation of indicators attempts to address the subject of linking the PPP of SD at macro levels with goals and objectives at the organizational and project levels. Primarily, strategies and goals are defined at the corporate level, which precedes the setting of methodologies for implementation at the project level. Commonly, the strategies for meeting the goals and objectives are set during the planning phase, incorporated in the design process, and then implemented in the construction phase, with the expectation that projects operate as previously planned and designed; consequently, certain processes for monitoring and control during the operation and closing phases of the project are required.

An expected performance can be measured through the implementation of strategies to meet the requirements of a set of indicators. In the case of rating systems, which are tools that present the results of the assessment as a CI, criteria are selected to attain a specific score with the aim of obtaining a "green certification." Since the appearance of the first rating system in the 1990s, these tools have demonstrated their success and applicability based not only on the number of projects certified, but also because of the large variety of tools developed around the world that have adapted the same or similar structures with the aim of measuring the level of "greenness" or sustainability of building projects. In fact, technological innovation and the vision of sustainability led to the emergence of a large number of building assessment systems and tools for the building industry; however, since sustainability is rapidly evolving, there is a need for innovation within the current rating system methodologies. Apart from the fact that a trend for homogenization is emerging, the need for meeting a particular vision has resulted in the continual adaptation of existing, and/or the development of new, assessment systems and tools (Conte & Monno, 2012). Since the assessment systems and tools have demonstrated their usefulness throughout the years (Conte & Monno, 2012; Yudelson, 2008; Reed, Wilkinson, Bilos, & Schulte, 2011; Mateus & Braganca, 2011), this trend of improvement and development must be continuous and encouraged.

Not only do the rating systems used to measure sustainability performance in the building industry require a certain degree of innovation, but there is also a need to explore the adaptation of rating system methodologies to other industrial contexts. In the building industry, meeting a rating system's set of requirements allows the project to be certified, which is interpreted by stakeholders as a guarantee of a certain level of "green" or sustainable functionality. However, once the certification is attained, the requirement of auditing building performance during the operation phase may not be needed to maintain the certification. Other industries are far behind in the green revolution, at least from a rating system implementation standpoint. A new rating system methodology, based on the continual improvement process to award the individual criteria scores, (1) facilitates a re-certification process based on sustainability PeM during the operation phase of buildings, and (2) attracts the attention of potential new rating system users in other industrial contexts due to the flexibility factors that allow organizations and projects to demonstrate their commitment to sustainability through the improvement of performance over time. Since stakeholders and DMs require support throughout the project life cycle, the rating system should be able to adapt its assessment methodology independently of the project phase, which will allow it to assign a new score for each of the criteria, and then calculate the overall performance score. In that sense, rating systems must consider that while building projects typically have a relatively short construction phase, other projects have longer construction or operation phases. In some cases, these phases may overlap (e.g., oil and gas, mining, industrial).

10.4 Areas of Integration

The application of MCDA methods have become increasingly popular in decision-making for sustainability because of the multi-dimensionality of the sustainability goal and the complexity of the different systems included in the assessment (e.g., socio-economic, biophysical) (Wang, Jing, Zhang, & Zhao, 2009). Additionally, the use of MCDA methods offers an opportunity for optimizing stakeholder engagement during the different stages of the assessment of the multiple criteria in the decision-making environment. With the aim of maximizing the benefits of using MCDA methods and filling some gaps in sustainability assessment—which includes, but is not limited to, the use of the sustainability rating system methodology in industrial contexts other than the building industry—the development of the Wa-Pa-Su project sustainability rating system explores two scenarios and proposes a practical solution for (1) the structure of a rating system for oil and gas projects, with application to oil sands and heavy oil projects (Poveda & Lipsett, 2011a; 2011b); and (2) an integrated sustainability assessment methodology, in which a third parameter—the CPI process—is introduced to assist in the selection of SDIs, design of metrics, and calculation of the weight and performance factor for each criterion. As a result, the potential implementation of the assessment methodology is not limited to a specific industry or type of project, demonstrating its applicability and flexibility. Consequently, the Wa-Pa-Su project sustainability rating system presents an integrated approach to sustainability assessment by connecting three distinctive areas of knowledge: (1) SD theory and fundamentals, which supports the rating system's ultimate goal of contributing to sustainability, with the aim of finding a path to balance social, economic, and environmental needs; (2) CPI, which becomes essential due to the duration of the projects, and is critical in assisting organizations or projects to improve performance over time; and (3) MCDA, which assists with the assessment process through stakeholder engagement and participation, and the design and implementation of a criteria weighting system.

10.4.1 Sustainable Development: Defining the Starting Point

SD is an area rapidly developing and constantly evolving. Humans have become highly aware of the different impacts affecting them, and often question the nature of those impacts. While they consider what can be done to mitigate those impacts based on the interests and needs of both current and future generations, they also strive for continuous development and exploitation of resources in the name of prosperity today. Identification and measurement of impacts becomes essential to implement strategies, with the aim of having a balance among the social, environmental, and economic needs of our society. This balance constitutes development that has the aim of being sustainable; however, the integration of environmental, social, and economic aspects is often connected to conflicts between these dimensions (Hansmann, Mieg, & Frischknecht, 2012). Therefore, resolving conflicts, managing synergies, and understanding sustainability dynamism are essential parts of integrating and balancing the three sustainability dimensions.

The origins, fundamentals, definition, and assessment of sustainability are areas of extensive debate, and widely-accepted common grounds are still to be found. To understand where we are going (i.e., our future), we need to understand where we came from (i.e., our past). This often-used quote may explain the difficulties of conceptualization and application that SD is facing as a fairly new area of knowledge. The beginnings of SD are unclear, or at least conflicting, in the literature. While Gibson, Hassan, Holtz, Tansey and Whitelaw (2010) differentiates between the old sustainability as the old wisdom and the second coming of sustainability in the early 1970's as term and rough idea and Rosén, Lindner, Nabuurs Gert-Jan and Paschalis-Jakubowicz (2012) state that "the sustainability concept has been expanded over the centuries and is now widely applied to economic, social and environmental development in the context of all nature–society interactions", Turner (2006) indicates that "sustainable development thinking started in earnest in the 1980s with a rudimentary set of generic guidelines offering no more than signposts in the transition of the contemporary socio economic systems towards a more sustainable development path."

Correspondingly, the fundamentals of sustainability are broad, and several definitions can be encountered. Often, society, economy, and environment are addressed as the pillars of sustainability; a triple bottom line widely known but perhaps not unanimously accepted. However, unless a sort of internationally-accepted standard is developed, the triple bottom line is a recognized starting point to define the components of SD. In that sense, the U.S. National Research Council (1999) highlights three main components of SD: (1) what is to be sustained, which integrates nature, life support, and community; (2) what is to be developed, which brings out people, society, and economy; and (3) the intergenerational component, which addresses the criticality that expresses the time-horizon in which sustainability goals are to be accomplished. Turner (2006) states that "since the sustainable development concept brings together economic prosperity, a better environment, and social justice objectives, it will require an integrated enabling strategy in order to deliver practical measures to achieve a better quality of life for people now and in the future. But, in order to judge whether or not progress is being made towards the desired objectives, one needs to measure, quantitatively and/or qualitatively, movements towards or away from a sustainable development path." The sustainability assessment tools aim to meet the vision and needs of a determined group who do not necessarily have the same interests. In essence, the fundamentals of SD and the interests of the different stakeholders can lead the main objective and goal of the assessment; therefore, assessment methodologies with the aim of standardizing sustainability performance are to be avoided as stakeholders may differ in their particular vision. Instead, appropriate measures capturing a set of diverse interests are encouraged. In fact, designing a methodology to assess sustainability requires an analysis of what is suited for a specific region where different aspects of sustainability (e.g., social, economic, environmental, institutional) are diverse in nature (Sadamichi et al., 2012).

Although in the set of analytical methods for sustainability assessment there is not a standard method, the elements of multidimensionality and interactivity among the different pillars of sustainability are to be considered in the development of a robust assessment methodology (Jeon et al., 2013), and the contextualization of the sustainability vision is made through decision questions that are ultimately evaluated using indicators (Morrison-Saunders & Pope, 2013). Moreover, since the 1990s, when different industrial sectors started to recognize the impact of their activities on the environment, the building industry has moved ahead in the development and implementation of environmental and sustainability assessment tools, allowing for the evaluation and benchmarking of performance (i.e., environmental and sustainability rating systems).

10.4.2 Multi-Criteria Decision Analysis (MCDA): Engaging the Stakeholders

MCDA methods have been widely applied to a variety of systems (e.g., economic, energy, social, agricultural, industrial, biological, and ecological systems, among others) (Wang et al., 2009), and have proven their effectiveness for solving a diversity of multi-criteria evaluation and ranking problems (Dyer, Fishburn, Steuer, Wallenius, & Zionts, 1992; Hwang & Yoon, 1981). MCDM is an operational evaluation and decision support approach that uses structured frameworks to deal with problems facing complex or conflicting multiple objectives, high uncertainty, long-term time horizons, complex value issues, different forms of data and information, and perspectives arising from different interests (Wang et al., 2009; Ananda & Herath, 2009). MCDA problems can be classified into problems of multi-criteria choice, multi-criteria ranking, and multi-criteria sorting. The different methods to solve MCDA problems can be grouped into three categories: the MAUT methods, UTA method, MACBETH method, direct weighting methods, and AHP methods belong to the first category; the outranking methods, PROMETHEE methods, and TACTIC method are included in the second category; and the third category contains the interactive algorithms (VIMDA [Visual Interactive Method for Decision Analysis] method, aspiration level method, InterQuad, LBS [Light Beam Search] method, RNIM method, etc.) (Vassilev et al., 2005).

In terms of sustainability and its evolving environment, the MCDA is a form of integrated sustainability assessment, and MCDM is suitable in the context of complex and evolving biophysical and socio-economic systems (Wang et al., 2009). In addition, DMs from different levels of society require DSSs capable of measuring SD progress (Turner, 2006). The MCDM approach is not particularly new to sustainability assessment, having been used at both the project and planning levels (Jeon et al., 2013; Zietsman, Rilett, & Kim, 2003). As DMs make comparative judgments of each criterion's weight in reference to others in a set of sustainability criteria for representing the relative importance of each criterion (Saaty, 1980), the MCDA methods can weigh the criteria, rank them, and/or present the result as a composite (i.e., integrated) index. Nevertheless, the strengths of MCDA methods rely on the information present in the selected criteria, the weights given to each criterion, and the agreement amongst stakeholders on the weights given to each criterion (Poveda & Lipsett, 2011c). Furthermore, sensitivity analyses are usually used to measure the degree of strength and adjust the weights of the criteria.

Kinderytė (2008) points out that the development of sustainability PeMs is driven by the interest of various stakeholders and the different interrelated forces driving the stakeholder's interests. In MDCA and sustainability assessment, the engagement and participation of different groups of stakeholders become factors in acknowledging and implementing the results of the process. In addition, participatory evaluation approaches (i.e., a simple weighting exercise) enhance stakeholder ownership over the projects, and benefit the project's sustainability (Cosyns, Damme, & Wulf, 2013). Ekins and Vanner (2007) state that "the communication of outputs and their discussion with stakeholders will generally be both easier and more successful if stakeholders have been involved in the process from the beginning and have had an input into some of the framing decisions that determined how the assessment was carried out. Stakeholder engagement in the problem definition stage is crucial to public acceptance of the assessment of the impacts and subsequent measures to address them," while Chen, Tian, Zhang, Feng and Yang (2012) found that public participation is a key factor in ecosystems management for achieving a successful outcome and implementation of methods to operate large projects in a sustainable way; however, public attitudes and perceptions to construction projects are often ignored.

10.4.3 Continual Performance Improvement (CPI): Exploiting Opportunities Over Time

Measuring performance constitutes a key agent of change (Fitzgerald et al., 1991) in which past action are quantified (Neely, 1998) and allows for pursuing strategies that lead to the achievement of overall goals and objectives (Dixon, Nanni, & Vollmann, 1990). Continuous measurement of performance identifies the gaps between established baselines and actual performance with the aim of implementing strategies for improvement. Therefore, the successful implementation of an organization's strategies, goals, and objectives relies on the identification of opportunities and exploitation of risk with the aim of improving performance over time.

After identifying the objectives, indicators, and operational plans, the achieved performance can be measured and monitored. Implementing a continuous improvement measuring system requires a dynamic and flexible monitoring system that identifies agents affecting the performance negatively, monitors the performance in real time, and shows the trend for each contributor agent (Romaniello et al., 2011). As a result, the monitoring system can measure the achievement of targets and identify deviations from the objectives.

Nowadays, implementing performance-monitoring systems to demonstrate improvement in social, economic, and environmental performance is included in most organizations' agendas when discussing the development and implementation of strategies for corporate sustainability. Organizations are expanding the traditional concept of PeM to a wider range of activities to address stakeholders' concerns, and are reporting that performance improvement has become critical in managing stakeholders' expectations. Consequently, adapting continuous improvement strategies is essential to demonstrate flexibility and adapt to changes according to the necessities of stakeholders and demands of each organization's environment.

Sustainability is a process of adaptation, while sustainability assessment is the process of measuring the improvements made over time to adapt. In essence, both concepts are embedded in the definition of continuous improvement. Therefore, the process of CPI for sustainability includes (1) the identification of areas of improvement in the context of social, economic, and environmental performance; (2) diagnosing, analyzing, and understanding the reasons for the existing performance levels; (3) planning strategies for assisting with the improvement process; (4) implementing necessary changes to improve performance; (5) monitoring the results to compare with pre-established baselines; and (6) developing a closed-loop control system with the aim of promoting continuous improvement.

10.5 Integration: Principles and Intersections

A set of ten principles was identified to serve as the core through the development of the assessment methodology utilized in the Wa-Pa-Su project sustainability rating system. The aim of these principles is to strengthen the assessment methodology, enhancing the uniqueness of the integrated approach to sustainability assessment, and serve as objectives and guidelines in internal processes such as identification and selection of criteria, as well as the calculation of criteria weights and scores and the overall sustainability score. The description of the ten principles is summarized as follows:

a. Equality: All three pillars of sustainability are equally relevant in the assessment process; there should be equivalent attention given to social, economic, and environmental impacts.

b. Interconnection/interrelation/intercommunication: Society, economy, and environment are linked and must work in harmony toward finding ways to move forward (development) in a balanced environment (sustainable).

c. Mutually influenced and impacted: Impacts are classified as social, economic, or environmental; however, the fallouts of an occurring impact produce a "domino effect" in which the other two pillars of sustainability are affected.

d. Balance environment: Society, economy, and environment must coexist in a balanced decision-making environment (i.e., a SD environment).

e. Participatory environment: Stakeholders as decisions-makers are critical for the success of the decision-making and sustainability assessment processes.

f. Improvement: Long-term project developers require opportunities for improvement because of the uncertainty and the unknown ahead that upcoming events might intrinsically carry.

g. Fairness: Independently of being qualitatively or quantitatively measured, social, economic, and environmental impacts do not represent the same effects; therefore, criteria should not have the same weights and may vary over time.

h. Continuality: Performance improvement is a continuous process in which organizations and/or projects must engage to promote SD practices.

i. Exploitation: Processes can be improved over time by exploiting opportunities and managing risk.

j. Simplicity and practicability: With the aim of capturing attention from practitioners and facilitating their market penetration, sustainability assessment tools must be easy to use and incorporate straightforward formulas.

As in sustainability, the integration of different areas results in dynamic interactions. The aim of the development of the Wa-Pa-Su project sustainability rating system is to assess sustainability development through the integration of three areas of knowledge, and present the results as a composite index, as graphically represented in Figure 10.1. The various aspects of sustainability are interrelated (Conte & Monno, 2012), and its three pillars are interconnected and influence each other. Similarly, the integration of distinctive areas of knowledge represents a series of dynamic relations defined by the intersection between two or even all three areas of knowledge. The results of the different intersections are explained as follows:

a. A∩B: Integrating SD and CPI principles results in the development of the PIF, which measure the degree of performance achievement of indicators.

b. A∩C: The analysis of different sources results in the pre-selection of SDIs, which are weighted through the application of MCDA.

c. B∩C: MCDA, assisted by the CPI principles, contributes to the integrated assessment approach, and has the ability to adjust criteria weights and design of metrics.

d. A∩B∩C: Criteria and overall sustainability scores are the result of the integration of the three areas of knowledge.

10.6 Assessment Methodology: Rating System and Integrated Assessment

In the different stages of the development process of a CI, various methods, tools, and techniques are involved. This may result in issues of

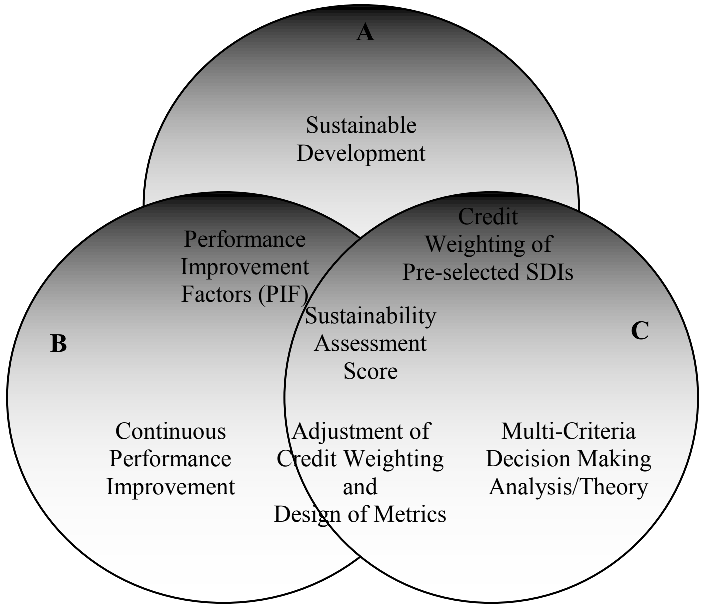


Figure 10.1 Integration of areas of knowledge and intersections

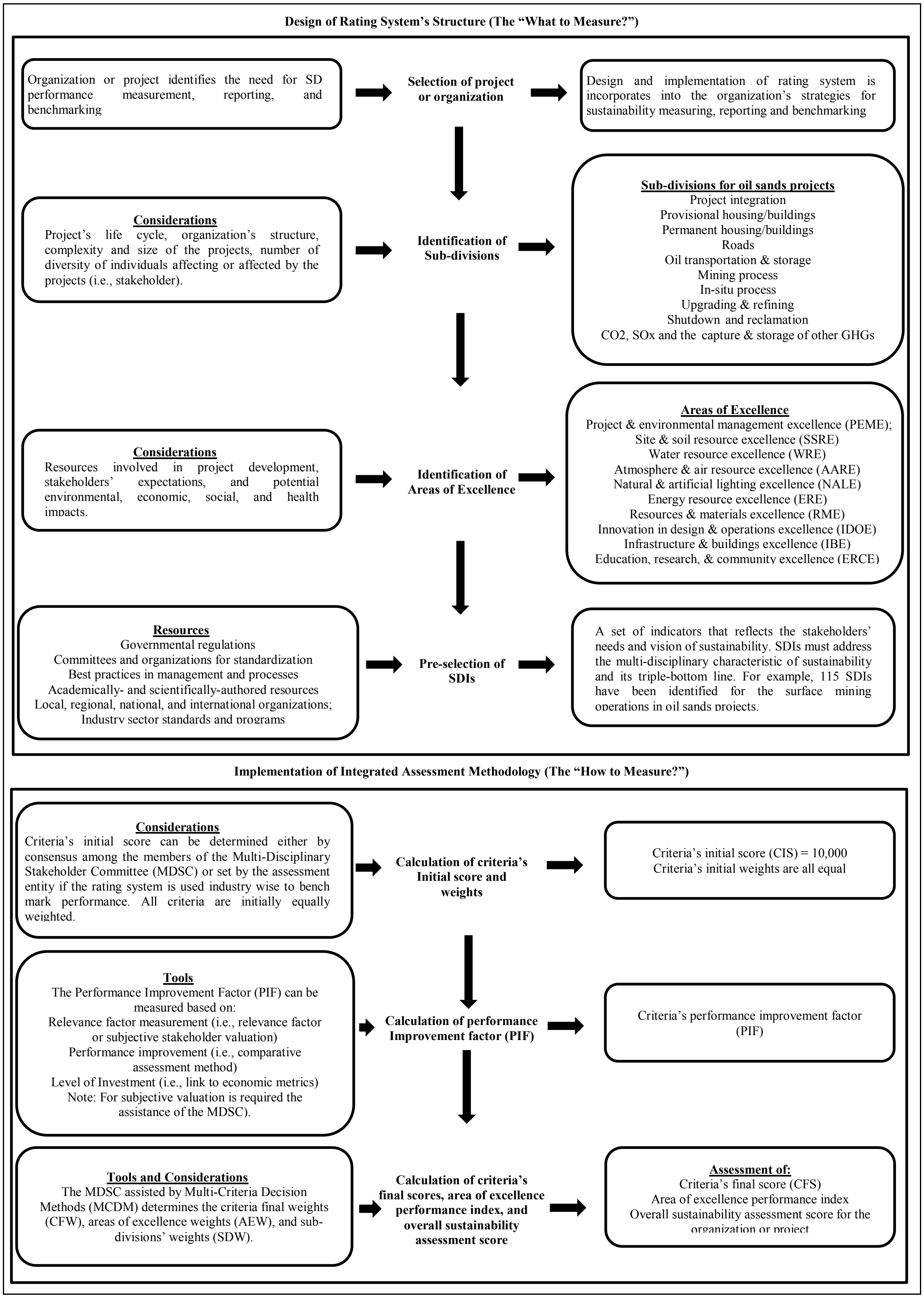
uncertainty due the selection of data, erroneous data, data imputation methods, data normalization, standardization, weighting methods, weights' values, and aggregation methods (Singh et al., 2012). These uncertainty issues and the ten different principles are taken into consideration in the development of the Wa-Pa-Su project sustainability rating system's structure design and integrated assessment methodology, which is graphically represented in Graph 10.1, when implemented for oil sands projects. The first steps (a–d, described below) of the methodology are meant to describe a generic process for the development of a rating system structure, while the following steps (e–g) describe the assessment methodologies for calculating the PIFs, criteria, and subdivisions' weights and scores and the overall sustainability assessment score:

a. Selection of project or organization: The first application of the Wa-Pa-Su project sustainability rating system has focused on an industrial context with an application toward oil sands and heavy oil projects (Poveda & Lipsett, 2011a; 2012); however, the framework of the assessment methodology can be adapted to other scenarios in which the end goal of the users is to measure the continuous progress made toward sustainability.

b. Identification of subdivisions: Organizations and projects can be structured in different areas with commonalities within. Users can identify subdivisions based on functionality, proximity, similar objectives and goals, etc. Grouping the organization or project into subdivisions facilitates breaking the rating system into "pieces" to perform isolated assessments; furthermore, each subdivision assessment can be added to calculate the organization's or project's overall sustainability score. The identification of subdivisions for oil sands and heavy oil projects is based on the project's life cycle; the process takes into consideration the complexity and size of the projects and the number and diversity of individuals affecting or affected by the projects (i.e., stakeholders). The different subdivisions considered in the Wa-Pa-Su project sustainability rating system for oil sands and heavy oil project are (a) project integration; (b) provisional housing/buildings; (c) permanent housing/buildings; (d) roads; (e) oil transportation & storage; (f) mining process; (g) in-situ process; (h) upgrading & refining; (i) shutdown and reclamation; and (j) CO2, SOx and the capture & storage of other GHGs (Poveda & Lipsett, 2011b).

c. Identification of areas of excellence: In other rating systems (e.g., LEED, BREEAM, Green Start), the different criteria fall under specific categories. The Wa-Pa-Su project sustainability rating system re-introduces these categories as areas of excellence. The identification process of the areas of excellence takes into consideration the resources involved in project development, stakeholder expectations, and potential environmental, economic, and social impacts; these areas of excellence are PEME; SSRE; WRE; AARE; NALE; ERE; RME; IDOE; IBE; and ERCE (Poveda & Lipsett 2011b). A difference from the identification of subdivisions process (i.e., step b) is that all areas of excellence are set to be included in every application of the Wa-Pa-Su project sustainability

Graph 10.1 The Wa-Pa-Su project sustainability rating system's structure design & integrated assessment methodology applied to oil sand projects



rating system.

d. Pre-selection of SDIs: The selection of SDIs is an area of SD that is still under debate. The proposed assessment methodology recommended for identifying and selecting SDIs is the analysis of different sources that have engaged a large variety of stakeholders in their internal selection process. These sources include governmental regulations; committees and organizations for standardization; best practices in management and processes; academically- and scientifically-authored resources; local, regional, national, and international organizations; and industry sector standards and programs. While following the guidelines of any of these resources does not guarantee a sustainable performance, they serve as a starting point for pre-selecting SDIs; DMs (i.e., stakeholders) through MCDA determine the final set of SDIs to be included in the assessment.

e. Calculation of criteria initial scores (CIS) and weights: Table 10.1 illustrates the worksheet utilized for the calculations of this and the steps to follow. As a sample, the table contains the PEME and SSRE areas of excellence; however, all ten areas of excellence must be included in the assessment. The different criteria (i.e., environmental, social, economic, and multi-attribute) are classified in ten areas of excellence: PEME, SSRE, WRE, AARE, NALE, ERE, RME, IDOE, IBE, and ERCE. The first step in the weighting process consists of calculating the criterion initial score (CIS) which consists of giving every criterion the same score.

The CIS value equals the rating system total available points. The CIS value of 10,000 is recommended for practicability purposes, as some CFS may be too small; however, once the value is set, consistency is required. Similarly, the all the criteria initial weights are equal. The criteria final weights (CFW) are calculated through applying the MCDA process; criteria with a weighted value of zero are eliminated. Areas of excellence and subdivisions are included in the weighting process, thereby affecting the criteria's final score. Furthermore, the weight of areas of excellence may vary from one subdivision to another; therefore, weights must be independently assessed for each area of excellence in each sub-division. The proposed assessment methodology does not limit its application to a specific MCDA method for the weighting of criteria, areas of excellence, or subdivision.

f. Calculation of performance improvement factors (PIFs): Poveda and Lipsett (2013b) define PIF as “a factor to determine the degree of negative or positive improvement of specific criteria (i.e., indicators) during a specific period of time.” The PIF can be calculated using Formula 10.1 which is described as:

$$PIF = \frac{\mathrm{PA}}{\mathrm{PB}} \quad [10.1]$$

$$PIF = \frac{\mathrm{PB}}{\mathrm{PA}} \quad [10.2]$$

Where,

PA (Pactual) = indicator performance actual value (metric)

PB (Pbaseline) = indicator threshold or baseline value (metric baseline)

Higher PIF values indicate performance improvement; therefore, Formula 10.1 is used for criteria for which an increase of value indicates improvement (e.g., percentage of re-used excavation material). On the contrary, Formula 10.2 is used for criteria for which a decrease in value indicates improvement (e.g., deforestation). Three types of PIFs are identifiable in the methodology, based on which metrics are used to measure indicators: type I is based on relevance factor measurement (i.e., relevance factor or subjective stakeholder valuation), type II is based on performance improvement (i.e., CAMs), and type III is based on level of investment (i.e., link to economic metrics) (Poveda & Lipsett, 2013b).

Table 10.1 Wa-Pa-Su project sustainability rating system score calculation worksheet

Wa-Pa-Su Project Sustainability Rating System

Score Calculation Worksheet

	Criteria Code	Performance Evaluation		Performance Improvement Factor (PIF)	CIS	Weights and CWF				CFS
		PActual	PBaseline			SDW	AEW	CFW	CWF	
PEME	CD_1	PA_1	PB_1	PA_1/PB_1	10,000	SDW_1	AEW_1	CFW_1	CWF_1	10,000 x [CWF_1 x PIF_1]
	CD_2	PA_2	PB_2	PA_2/PB_2	10,000	SDW_2	AEW_2	CFW_2	CWF_2	10,000 x [CWF_2 x PIF_2]
	CD_3	PA_3	PB_3	PA_3/PB_3	10,000	SDW_3	AEW_3	CFW_3	CWF_3	10,000 x [CWF_3 x PIF_3]
	CD_4	PA_4	PB_4	PA_4/PB_4	10,000	SDW_4	AEW_4	CFW_4	CWF_4	10,000 x [CWF_4 x PIF_4]
	CD_5	PA_5	PB_5	PA_5/PB_5	10,000	SDW_5	AEW_5	CFW_5	CWF_5	10,000 x [CWF_5 x PIF_5]
				PEME Performance Index						PEME Score

	Criteria Code	Performance Evaluation		Performance Improvement Factor (PIF)	CIS	Weights and CWF				CFS
		PActual	PBaseline			SDW	AEW	CFW	CWF	
SSRE	CD_6	PA_6	PB_6	PA_6/PB_6	10,000	SDW_6	AEW_6	CFW_6	CWF_6	10,000 x [CWF_6 x PIF_6]
	CD_7	PA_7	PB_7	PA_7/PB_7	10,000	SDW_7	AEW_7	CFW_7	CWF_7	10,000 x [CWF_7 x PIF_7]
	CD_8	PA_8	PB_8	PA_8/PB_8	10,000	SDW_8	AEW_8	CFW_8	CWF_8	10,000 x [CWF_8 x PIF_8]
	CD_9	PA_9	PB_9	PA_9/PB_9	10,000	SDW_9	AEW_9	CFW_9	CWF_9	10,000 x [CWF_9 x PIF_9]
	CD_{10}	PA_{10}	PB_{10}	PA_{10}/PB_{10}	10,000	SDW_{10}	AEW_{10}	CFW_{10}	CWF_1	10,000 x [CWF_{10} x PIF_{10}]
				SSRE Performance Index						SSRE Score

Sustainability Assessment Score: PEME + SSRE + WRE + AARE + NALE + ERE + RME + IDOE + IBE + ERCE

The CPI indicator measurements can be achieved by using three different categories of assessment methodologies, which are linked to PIF factor types I, II, and III respectively: (1) quality and performance audits, (2) performance improvement measurements, and (3) impact vs. investment ratio improvement (Poveda & Lipsett, 2013b). From the CPI point of view, the main focus relies on measuring the improvement of each indicator in a specific period of time; therefore, the CPI measures the improvement of performance in a specific period of time while PIF measures the improvement of performance based on established thresholds or baseline values, and is utilized to calculate the criteria's scores.

g. Calculation of criteria's final scores, area of excellence performance index, and overall sustainability score: The assessment methodology allows monitoring of the performance in four levels: criteria, area of excellence, subdivision, and overall organization or project sustainability. The performance per criterion (score) can be calculated using Formula 10.3 or 10.4 which are described as:

$$CFS = CIS \times [CWF \times PIF] \quad (10.3)$$

Or,

$$CFS = 10{,}000 \times [SDW \times AEW \times CFW \times PIF] \quad (10.4)$$

Where, CIS = criterion initial score

CWF = criterion weight factor

PIF = performance improvement factor

10,000 = rating system total available points

SDW = sub-division weight

AEW = area of excellence weight

CFW = criterion final weight

CFS = criterion final score

Each criterion is assigned a final weight (CFW) after the MCDA process. The CFW is also affected by the weight of the area of excellence (AEW) and the subdivision weight (SDW) under which the criterion falls. Therefore, the criterion weight factor (CWF) is calculated by multiplying the criterion, area of excellence, and SDW; however, the criterion is allowed to claim the entire weight factor and as much CIS as possible only if its performance has met the requirements of its threshold or baseline (i.e., PFI = 1). The continuous improvement process allows each criterion to improve performance in order to claim a higher weight (i.e., PFI > 1); therefore, organizations and projects are encouraged to improve their performance over time. The certification of an organization or project as sustainable depends on the rating scale in which a determined percentage or number of points are required. Figure 10.2 represents the farm of points in which each tree (sub-division) contains branches (areas of excellence) and leafs (criteria). The DMs must decide if all trees, branches, and leafs are equally weighted and the performance (scores) expected from each. Since PIF type I is a subjective stakeholder evaluation, Poveda and Lipsett (2013b) suggest using graphs in which the points are allocated based on linking the relevance factor/category of the criterion (i.e, stakeholder-subjective valuation) with the organization's or project's energy consumption, GHG emissions, or BBL/D (oil and gas industry). Criteria with governmental regulations as the threshold or baseline are meant to obtain a minimum PIF value of 1, as organizations and projects must comply with those guidelines; otherwise, penalties will apply.

The area of excellence, subdivision, and overall organization or project sustainability scores are straightforward calculations that indicate sustainability performance. The scores allow monitoring of the performance at different levels, and can be used for reporting purposes. The area of excellence performance index is calculated by adding every criteria PIF (environmental, social, economic, and multi-attribute) contained within the area of excellence under evaluation, while the sustainability score(s) of the subdivision(s) result(s) can be found by adding every criterion's final score within the subdivision, and the organization or project sustainability scores can be found by adding the sustainability score(s) of the subdivision(s).

10.7 Rules and Restrictions

Potential users of the Wa-Pa-Su project sustainability rating system must take into consideration a series of conditions to optimize the

Organization or Project Environment

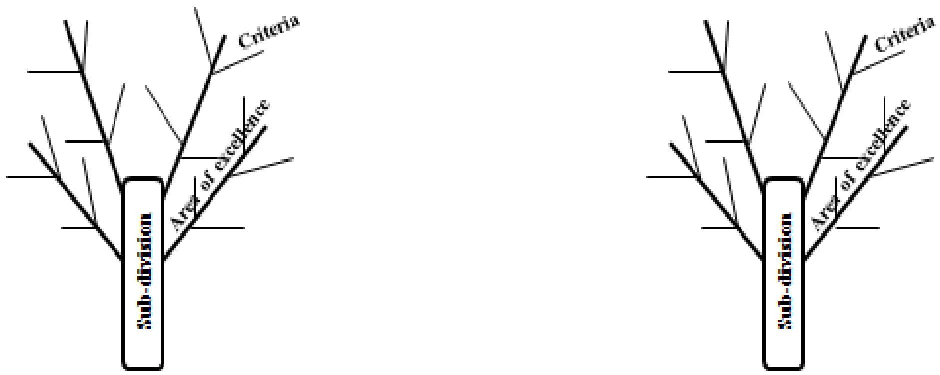


Figure 10.2 Farm of Points

implementation of the assessment tool. There is still not agreement among the international scientific community on the selection of SDIs. In this instance, the assessment methodology suggests that effective engagement of stakeholders and meticulous reviews of the different sources are required for the selection of SDIs (see heading d, section 5). The needs of different stakeholders can be heard in a multi-disciplinary forum, in which members must possess at least one of the three attributes (i.e., power, urgency, legitimacy) that allow them to be identified as a stakeholder. Different factors influence the selection of SDIs. The assessment methodology recommends consistency once the stakeholder consultation process has selected the different SDIs to assess the organization's or project's sustainability performance.

Since different metrics are used to measure the criteria's performance, the PIF was designed to eliminate the different metrics' units among the criteria, thereby allowing a comparative analysis of performance improvement. Nevertheless, PIF type I presents restrictions based on the nature of subjective measurement. Criteria measured using PIF type I are assessed through stakeholder consultation; these are criteria without mathematical models in place to be measured quantitatively. Poveda and Lipsett (2011b) suggest the use of graphs linking quantitative measures to each criteria relevance factor. The PIF value for those criteria under PIF type I can range from 0 to 2. The assessment methodology recommends a periodic re-assessment of those values with the support of stakeholder consultation; however, the re-assessment process of PIF type I values or criteria and/or subdivision weights must be assisted by an external auditor to avoid any manipulation of the credits score.

Some criteria using PIF types II and III for calculation may encounter 1 as the maximum value of PIF. This indicates that those criteria have reached their maximum level of improvement. For example, the optimum value of a criterion measuring the female-to-men wage ratio in an organization or project is 1; declared in the Millennium Summit of the United Nations in 2000, one of the MDGs promotes gender equality and empowering women. Once the ratio of 1 is achieved, the PIF value will reach 1 as well. Additionally, criteria with a regulation as the threshold or baseline are meant to have a minimum PIF value of 1.

Finally, the assessment methodology is based on integrating the continuous improvement process to calculate each criterion’s final score; hence, calculations are based on the actual performance of criteria. The generic model presented in this manuscript shows the level of flexibility in different areas of the assessment methodology, allowing the users decide which MCDA method meets their needs, the subdivisions in which the organization of project is divided, and whether the different areas of excellence and subdivisions are meant to be weighted.

10.8 Conclusions and Future Research

The development of the Wa-Pa-Su project sustainability rating system assessment methodology introduces an integrated assessment approach, and has as its aim the ability to rate performance based on continuous improvement. The internal relationships among the different pillars of sustainability (i.e., social, economic, environmental) and between sustainability and other environments (e.g., areas of management) contains dynamic relationships that are meant to change over time; therefore, assessment methodologies for sustainability must possess a degree of flexibility that allows for the adjustment of the internal parameters of the tool, in order to demonstrate organizations' and projects' degree of performance improvement over time. Assessment methodologies must continue evolving at a similar pace to sustainability; currently, aspects such as impacts, indicators, criteria, and metrics in the environmental pillar of sustainability are far better understood than those in the social and economic pillars. Additionally, the dynamics between pillars are to be considered because of factors explained in principles a, b, c, and d of the integration described in section 5.

The subjectivity factor presents not only challenges but also options for improving the assessment methodology. The selection of SDIs must reflect the vision of sustainability of a particular group, while the design of metrics considers the most accurate measure to capture the real value of the different impacts. Moreover, the design of thresholds and baselines requires a closer examination. Establishing a parameter of comparison may be interpreted as a "set-in-stone" criterion for sustainability; however, it may be a value that should be questioned. It has been suggested that effective stakeholder engagement is required for the success of the MCDA process and sustainability assessment; however, the definition, classification, and selection of stakeholders is another area that is still under debate and of significant impact while exploiting opportunities and managing risk with the aim of improving performance.

Since different MCDA methods can be utilized for weighting criteria, areas of excellence, and subdivisions, the assessment methodology must be tested and validated before implementation occurs. The proposed methodology can be adapted to different scenarios (i.e., organizations and projects), which represents a major advantage; however, since the assessment methodology will evolve, other rules and restrictions will emerge. Simulation and validation methods contribute with the adaptation, and setting the rules and restrictions that may vary with the scenario in which the assessment methodology is intended to be implemented.

11. Chapter One – The Wa-Pa-Su Project Sustainability Rating System: A Simulated Case Study of Implementation and Sustainability Assessment[10]

11.1 Introduction: Sustainability Assessment and Rating Systems

Minimizing the detrimental effects on the natural environment due to construction practices is an existing concern (Cole, 1999; Holmes & Hudson, 2000). Younger generations and society in general are becoming more aware of the different impacts intrinsically carried by organizations and projects in their operations and the need for finding a more sustainable path; the increase in the levels of awareness helps explain the exponential increment in the development of sustainability assessment tools. Sustainability of current operations and possible future improvements to meet goals and objectives are the main target for the development of approaches, strategies, models, appraisals, and methodologies for sustainability assessment; however, the development of efficient and reliable assessment methods and their respective tools is a challenge for both academia and the scientific community (Ness, Urbel-Piirsalu, Anderberg, & Olsson, 2007; Mateus & Braganca, 2011).

Sustainability is a multi-disciplinary area in permanent evolution; therefore, assessment tools evolve in parallel to meet new requirements and overcome existing and emerging limitations. Social, economic, and environmental aspects require balanced and integrated approaches for implementation and measurement. While most current sustainability

[10] A version of this chapter has been submitted for publication. Poveda & Lipsett 2014. Environmental Management and Sustainable Development. 3(1):1-24.

assessment tools focus on one aspect of sustainability, which often refers to the environmental pillar, very few present an integral approach that considers the interlinkages and dynamics of all three pillars of sustainability (Singh et al., 2012). In fact, the assessment of economic and social aspects has emerged to contribute defining the progress towards SD in developing countries (Gibberd, 2005); therefore, integrated assessment systems require not only the identification of dynamics among the social, economic, and environmental parameters, but also the collection and analysis of much more detailed information.

Sustainability assessment tools gather information for decision-making; therefore, the systems can be designed targeting a specific aspect or various aspects of sustainability. Hasting and Wall (2007) group these systems in cumulative energy demand (CED) systems, which focus on energy consumption; life cycle analysis (LCA) systems, which focus on environmental aspects; and TQA systems, which evaluate ecological, economic, and social aspects. The multi-criteria systems are the most common type of TQA systems, and aim at including the three pillars of sustainability (Berardi, 2012). Multi-criteria systems compare the real performance of different parameters with predetermined baselines or thresholds. In environmental or sustainability rating systems each criterion included in the multi-criteria system has a certain number of points, and the overall organization or project sustainability score comes out by summing the results of the assessed criteria.

Although environmental or sustainability rating systems are widely used, the development and application of the tools have been concentrated in the building industry (Poveda & Lipsett, 2011a). In the 1990s, the building industry not only recognized the impact of its activities, but also the need for mitigating the environmental impact of the building sector driven by public policy and market demand for environmentally-sound products and services (Haapio & Viitaniemi, 2008). Ding (2008) groups the different tools for sustainability assessment of buildings into assessment and rating tools. Assessment tools provide a qualitative understanding of the building performance, which is used for design purposes, while rating tools determine building performance level with starts or points being awarded based on the criteria met within a specific certification process. Although each rating system and certification tool presents a specific structure, commonalities are found in categories of building design and life cycle performance: water, materials, energy, site, and indoor environment (Braganca, Mateus, & Koukkari, 2010).

BREEAM was the first real attempt to develop a comprehensive building performance assessment method to meet the different needs of relevant interest groups (Crawley et al., 1999; Ding, 2008). Currently, more than 600 sustainability assessment rating systems are available and used worldwide (BRE, 2008) with the only exceptions being Africa (except South Africa) and Latin America (except Brazil) (Berardi, 2012). If the success of environmental and sustainability rating systems is measured by the numbers of projects or square meters certified, then Bloom and Wheelock (2010) indicate that 650 million square meters obtained a sustainability certification in 2010 with projections of 1100 and 4600 million square meters for 2012 and 2020, respectively.

Environmental and sustainability rating systems target different performance aspects of the building in different stages of the life cycle. The aim of the assessment tools is to promote sustainable practices in the building industry during design, construction, operation, maintenance, disassembly or deconstruction, and disposal while integrating social, economic, and environmental needs and the concerns of the different stakeholders. Therefore, the purpose of sustainability assessment is to gather information to support decision-making during the project’s life cycle (Mateus & Braganca, 2011).

Rating systems are easy to understand, and they enable performance assessment of the building in several stages (Berardi, 2012). Currently, rating systems strongly support the design process of a building

(Braganca et al., 2010), but there is a trend for covering the construction, operation, and dismantling phases with a whole-life-perspective analysis; consequently, the evolution of any rating system must continue to cover the multidimensionality of sustainability while improving the triple bottom line of buildings (Berardi, 2012).

11.2 The Wa-Pa-Su Project Sustainability Rating System and Its Applicability to Oil Sands Projects

The Wa-Pa-Su project sustainability rating system is a verification process to assist in demonstrating compliance in SD performance during a project's life cycle through the implementation of enhanced strategies to mitigate environmental, social, health, and economic impacts. The rating system proposes a framework for measuring—in a consistent manner—the sustainability of the development of oil sands and heavy oil projects. While the original intent was to target the oil sands and heavy oil projects (Poveda & Lipsett, 2011a), the methodology for determining the rating structure and the assessment methodology to calculate the criteria weights and final sustainability scores can be used for designing rating systems with applicability across different industry contexts.

The name of the rating system addresses three facets: history, Aboriginal heritage, and SD. The first non-indeigenous man to see bitumen from the largest oil deposit in Canada was Henry Kelsey, manager of the Hudson's Bay Company (HBC) at York Factory, when a Cree man named Wa-Pa-Su brought him a sample in 1719. In the Plains Cree language, wâpisiw (pronounced and commonly Anglicized as wa-pa-su) means "white swan." Finally, considering the goals and objectives of SD, the acronym denotes World And People Align for SUstainability.

Figure 11.1 shows the logo adopted to represent the rating system. The logo's colour symbolizes the "green," sustainable path that must be the aim of developers, government, local communities, and stakeholders in general. The drop of oil and the maple leaf represent the resource and its country of origin, respectively. The maple leaf also suggests the country in which the first sustainability rating system for industrial projects with application to oil sands and heavy oil was developed. Additionally, the immersion of the maple leaf in the drop of oil is a reminder that the resource extracted is part of a larger world market for oil.

Figure 11.1 Wa-Pa-Su project sustainability rating system's logo

The steps to determine the structure of the rating system can be summarized as follows: (1) select project or organization to be assessed, (2) identify sub-divisions (if applicable), (3) identify areas of excellence, and (4) pre-select SDIs. Large projects or organizations may require grouping their activities in easily-identifiable areas or sub-divisions with the intent of effectively managing the different SDIs; therefore, the different activities in the oil sands and heavy oil projects are categorized in ten sub-divisions: (1) project integration; (2) provisional housing/buildings; (3) permanent housing/buildings; (4) roads; (5) oil transportation & storage; (6) mining process; (7) in-situ process; (8) upgrading & refining; (9) shutdown and reclamation; and (10) CO2, SOx, and other GHGs capture & storage (Poveda & Lipsett, 2011b). The Wa-Pa-Su project sustainability rating system takes into consideration the different resources utilized during development, stakeholder expectations, and potential environmental, economic, social, and health impacts to determine the areas of excellence. These consist of PEME; SSRE; WRE; AARE; NALE; ERE; RME; IDOE; IBE; and ERCE.

The rating system, in its structure development methodology, proposes to analyze different sources to pre-select the SDIs to then submit the set of pre-selected SDIs to a multi-disciplinary stakeholder participatory process to weight and select the final set of SDIs. These sources can be grouped into three categories: (1) indicators agreed upon by public or governmental representatives through consensus, which include governmental regulations and committees, as well as organizations for standardization; (2) indicators identified by academics and practitioners, which include best practices in management and processes as well as academically- and scientifically-authored resources; and (3) indicators established by organizations, including local, regional, national, and international organizations and industry sector standards and programs. Finally, each criterion under the different areas of excellence uses an acronym for simplification and identification purposes; the acronym for each criterion identifies the sub-division, area of excellence, and project phase where it belongs, accompanied by a numeric identifier. For example, PEMEID&BC06019 refers to criterion 019 that belongs to sub-division 06 (surface mining process) for the PEME area of excellence during the initial development & business case phase (ID&BC).

11.2.1 Assessment Methodology

The Wa-Pa-Su project sustainability rating system introduces a new assessment methodology to calculate each criterion's final sustainability score. The sustainability assessment methodology is based on an integrated approach that includes three distinctive areas of knowledge: CPI, MCDM, and SD. The assessment methodology can be described in the following steps: (1) calculation of each CIS and weights; (2) calculation of the PIF; and (3) calculation of each criterion's final score, area of excellence performance index, and overall sustainability score. The rating system and its assessment methodology award the final scores and an eventual certification based on actual performance, rewarding the implementation of strategies for improvement, which is reflected in the PIF value.

The assessment methodology utilizes the same CIS for each criterion; it is a start value which is impacted by the CWF and the PIF. A multi-disciplinary stakeholder participatory process defines the CFW, SDW, and AEW weights through MCDA. The PIF is defined as "a factor to determine the degree of negative or positive improvement of each specific criterion (i.e., indicators) during a specific period of time" (Poveda & Lipsett, 2013b), and can be calculated using Formula 10.1 or 10.2.

Higher PIF values indicate performance improvement; therefore, Formula 10.1 is used for criteria for which an increase of value indicates improvement (e.g., percentage of re-used excavation material). On the contrary, Formula 10.2 is used for criteria for which a decrease in value indicates improvement (e.g., deforestation). PIFs can be categorized into three types: (1) those based on relevance factor measurement (i.e., relevance factor or subjective stakeholder valuation), (2) those based on performance improvement (i.e., CAMs), and (3) those based on level of investment (i.e., link to economic metrics). Since PIF type I is a subjective valuation, Poveda and Lipsett (2013b) propose the use of graphs in which the stakeholder valuation is linked to objective metrics (e.g., energy consumption, GHG emissions, or BBL/D [oil and gas industry]).

Finally, the final score for each criterion is calculated using Formula 10.3 or 10.4. As noted, each criterion starts with the same score (CIS); however, different weights and the actual organization's or project's performance determines the final score of the criteria. Since the different weights' values range from 0 to 1, the CIS value of 10,000 is recommended for practicability purposes, as some CFS may be too small.

11.3 The Canadian Oil Sands Projects: Surface Mining Operations

The Canadian oil sands are located in three main deposits in the northern half of the province of Alberta: the Athabasca, Peace River, and Cold Lake. After the Venezuelan heavy oil and Saudi Arabian conventional oil deposits, the Canadian oil sands rank third in the world, with 168.7 billion barrels of proven oil reserves (Alberta Energy, 2013). Different in-situ (Latin, meaning "in place") methodologies can be utilized to potentially recover up to 80% of the oil sands, while the remaining 20% are recoverable through open-pit mining (i.e., surface mining) operations. The surface mining process involves using electric and hydraulic shovels with a capacity of up to 45 m3 to extract those oil sands that are within 75 m of the surface. The extracted material is scooped into trucks with a carrying capacity of up to 400 tons, and transported to crushers where the material (i.e., large clumps of earth) is broken down. The mixture of sand, clay or other minerals, water, and bitumen is known as oil sands, and is diluted using water and diluent (naphthenic and paraffinic), to then be transported to a plant in which the bitumen is separated from the other components (i.e., the clay or other minerals, sand, water, and chemicals). At this point, the recovered bitumen continues its course for upgrading and refining in order to become synthetic oil, while the other components are sent to the tailings ponds areas after maximizing the water recycling process.

Surface mining operations currently cover about 500 km2 of the 140,000 km2 of oil sands deposits resulting in a variety of social, economic, health, and environmental impacts (Poveda & Lipsett, 2013c). While GHG emissions, land use, water use, and tailings ponds are among the most common environmental impacts from the oil sands (CAPP, 2013), different stakeholders are increasingly raising concerns regarding the non-environmental impacts resulting from the various oil sands operations; therefore, there is the need not only for developing but also implementing a tool to measure—in a consistent manner—the sustainability of the oil sands operations.

11.3.1 Current Sustainable Development Performance Reporting

Different Canadian oil sands developers and operators present the sustainability performance results of their operations in a non-compulsory report. The different metrics, indicators, and/or KPIs are shown in Table 11.1 for a handful of the developers and operators currently exploiting the oil sands resource. The areas and KPIs included in each report varies from one company to another, and this affects any attempt to benchmark performance. Moreover, the available reports present a variety of communalities: (1) the different metrics or indicators are arbitrarily selected by the reporting organization; (2) the reporting data shows the organization's overall performance instead of the specific area (i.e., sub-division) in which the task was performed; (3) differentiation between different levels of performance cannot be made, as baselines or thresholds are not part of the reporting data; (4) there is no indication of the relevance or importance (i.e., weight) of each metric or indicator in comparison to others; and (5) the reports present the performance data for each metric or indicator but do not assign scores, leaving the results open to interpretation.

Oil sands developers and operators use metrics, indicators, and/or

Table 11.1 Metrics, indicators and/or KPIs for sustainability performance reporting by oil sands developers and operators

CONOCOPHILLIPS		
Air Emissions	**Greenhouse Gases**	**Land Management and Biodiversity**
Flared gas volumes (E^3m^3) Vented gas volumes (E^3m^3) Benzene emitted from glycol dehydrators (kT) Oxides of nitrogen (NOx) emitted (kT) Sulphur oxides (SOx) emitted (kT) Particulate matter (PM) emitted (kT) Volatile Organic Compounds (VOCs) emitted (excludes methane and benzene) (kT) Natural gas fuel usage (10^3m^3) **Water Use (Pilot and Phase I)** Non-saline groundwater used (m^3) Saline groundwater used (m^3) Produced water used (m^3) Steam injected (m^3) Produced water disposed (m^3) Water used per barrel of oil produced (bbls water/BOE) Water used for drilling, completions & abandonment (m^3) Water recycle rate (%) * **Water Use (Pilot and Phase 1)** Groundwater used (fresh) (m^3) Ground used (fresh) (m^3) Produced water disposed (m^3) Steam injected (m^3) Water used per barrel of oil produced (bbls water/BOE) Water used for drilling completions & abandonment (m^3) **Waste** Hazardous waste disposed (tonnes) Non-hazardous waste disposed (tonnes) Waste recycled (tonnes)	Direct carbon dioxide (CO_2) emitted (kT) Directed methane emitted expressed as CO_2e (kT) Direct nitrous oxide emitted expressed as CO_2e (kT) Direct carbon dioxide equivalent emissions (kT) Indirect carbon dioxide equivalent emissions (kT) Direct carbon dioxide (CO_2e) intensity (kT/E^3m^3OE) **Leaks and Spills** Number of produced water spills to land (>1 bbl) Total volume produced water spilled to land (>1 bbl) (m^3) Total volume of produced recovered (m^3) Portion of produced water recovered (%) Volume of produced water spilled intensity ($m^3/10^3m^3OE$) Hydrocarbon spills Volume hydrocarbon spilled (m^3) Volume hydrocarbon recovered (m^3) Portion of hydrocarbon recovered (%) Volume of hydrocarbon spilled intensity ($m^3/10^3m^3OE$) Number of pipeline incidents Number of pipeline leaks Leaks per 1,000 km of pipeline **Stakeholder Engagement** Staff/consultants devoted to stakeholder engagement Groups/initiatives in which the organization collaborates with other companies or take a leading roles	New linear features requiring new cut (km) New footprint (delineation wells) (ha) Current disturbed land for Surmont Phase I and Pilot Plant (ha) Current disturbed land for Phase 2 2009 only (ha) Research support for species of management concern ($) Valued Ecosystem Components (VECs) that are species of management concern (%) Low impact (km) Report size of seismic lines (m) Low seismic impact overall (ha) Reclamation certificate received (RCR) Abandoned and un-reclaimed wells Number of hectares reforested Total number of reclaimed and abandoned wells in Alberta **Regulatory Compliance** Number of times ConocoPhillips Canada was placed on the ERCB heightened level (persistence) **Community Investment** Community investment expenditure ($) Community benefits expenditure ($) Community investment expenditure – Join Venture ($) Local workers that participated in safety training Local contracts Community investment to nearby Aboriginal communities ($) Training and capacity building programs ($)

SUNCOR		
Environmental	**Social**	**Economic**
Air emissions (tonnes/year) M^3 of river water and groundwater to produce one m3 of oil (mining) Water withdrawal and consumption (m^3) Land use at oil sands (cumulative hectares) Installed wind capacity (megawatts) Hectares disturbed by mining operations Hectares reclaimed Number of trees planted on oil sands site GHG emissions (tonnes CO_2 equivalents CO_2e) GHG emissions intensity (tonnes CO_2e/m^3OE)	Lost time injury frequency (injuries per 200,000 hours worked) Support for excellence in indigenous education ($) Number of charitable & non-profit organizations supported by employees Spent on goods and services from Aboriginal business ($)	Net production (boe/day) Net earnings ($) Cash flow from operations ($) Royalties paid by Suncor ($) Suncor paid income taxes ($) Capital spending ($) Suncor spent on good and services ($)

CNRL		
Safety	**Environment**	**Employment**
Recordable injury frequency (employees and contractors) (per 200,000 hours worked) Fatalities (employees) Fatalities (contractors)	**Land** Well abandonment and reclamation • Number of active operated wells • Number of inactive operated wells • Number of wells abandoned • Number of reclamation certificated submitted **Water** Total water withdrawal from source (m^3) • Fresh water • Brackish Total water discharge by quality (tonnes) **Spills** Number of reportable spills Volume spilled (m^3) Number of spills and leaks/production (MMBOE) Volume spilled or leaked/production (m^3/MMBOE) Number of leaks/1,000 km pipeline **Waste** Weight of waste by type and disposal method (tonnes) • Hazardous waste • Non-hazardous waste **Air and GHG Emissions** • Direct GHG emissions from fuel consumption (tonnes CO_2e) • Indirect GHG Emissions (tonnes CO_2e) (Electricity Consumption (TWh) and Indirect GHG emissions) Direct GHG emissions (tonnes) **Emissions Intensity** Direct GHG emissions intensity (tonnes CO_2e/BOE) **Flaring and Venting** Total gas flared (10^3m^3)	Distribution of Canadian Natural Employees • Numbers of employees • Exposure hours (millions)

Table 11.1 Metrics, indicators and/or KPIs for sustainability performance reporting by oil sands developers and operators (cont'd)

	Total gas vented (10^3m^3) NOx emissions (tonnes) SOx emissions (tonnes)	
Note: CNRL includes a series of indicators as part of the Global Reporting Initiative (GRI) index; however, performance values are not indicated in the Stewardship Report to Stakeholders.		
SYNCRUDE		
Air Quality Ozone-depleting substances (kg of chlorofluorocarbon (CFC) equivalent/yr) Sulphur dioxide (tonnes/yr) Sulphur dioxide emission intensity (kg/m^3 production or tonnes/KBbls) Nitrogen oxides (tonnes/yr) Nitrogen oxides emission intensity (kg/m^3 production or tonnes/KBbls) Volatile organic compounds (VOCs) (tonnes/yr) VOCs emission intensity (kg/m^3 production or tonnes/KBbls) NPRI on-site releases (tonnes/yr) Sour gas diverting (tonnes per day SO_2)	**Biodiversity** No metric, indicator or KPI reported **Climate Change** **Energy Conservation** Total energy consumption (BTUs) Energy intensity (BTUs per barrel) Energy intensity improvement (% as compared to year prior) Energy return ration (BTUs of SCO product BTUs of energy consumed) **Greenhouse Gas Emissions** GHGs-millions of tonnes (as per Environment Canada quantification guidelines) GHGs-millions of tonnes (as per Specified Gas Emitters Regulation) GHGs-tonnes CO_2e per barrel produced	**Land Reclamation** Total land disturbed (cumulative hectares) Soils placed-land available for revegetation (hectares) Temporary reclamation (hectares) Permanent land reclaimed (hectares per year) Permanent land reclaimed (cumulative hectares) Tree and shrub seeding planted (annual) **Tailings Management** No metric, indicator or KPI reported
Waste Management Major waste recycled or reused-solid (tonnes) Minor waste recycled or reused-solid (tonnes) Major waste recycled or reused-liquid (m^3) Waste-solid hazardous or potential hazardous material sent for off-site treatment or destruction (m^3) Waste-liquid hazardous or potential hazardous material sent for off-site treatment or destruction (m^3) Waste disposal-onsite industrial, non-hazardous (tonnes) Waste disposal-on-site sanitary non-hazardous (tonnes) Waste disposal-off-site sanitary non-hazardous (tonnes)	**Community Involvement** Corporate giving ($ millions) **People** See online report for details. **Labour Relations, Stakeholder Relations-Non Aboriginal, Aboriginal Relations** No metric, indicator or KPI reported. See online report for activities and investments.	**Water Management** Imported from Athabasca River (m^3) Imported from Athabasca River (m^3/m^3 production) Water returned to the Athabasca River-treated sanitary (m^3) Water returned to the Athabasca River-other (Aurora diversion) (m^3) Process water recycled (m^3 and % of total water used) Water discharge quality exceedances (treated sanitary) (# of incidents) Water discharge quality exceedances (industrial process) (# of incidents) Reportable spills to natural water bodies (m^3)
Health and Safety See online report for company's statistics **Research and Investment** No metric, indicator or KPI reported. See online report for activities and investments.	**Economic Contribution** Royalties, payroll & municipal taxes ($) Purchased energy ($) Employees (net) ($) Materials and supplies ($) Contracted services ($) Other expenditures ($)	**Finance and Operations** Total crude oil production (various units) Realized SCO selling price $ per barrel) Total operating costs (various units) Capital expenditures ($) Revenues ($) Retained earning Bitumen produced (barrels) Bitumen recovery (%) Upgrading yield (%) Environmental fines ($) Environmental protection orders (#)
CENOVUS		
Financial Net land position (hectares) Common shares outstanding ($) Market capitalization ($) Gross sales ($) Cash flow ($) Annual capital investment ($) Operating expenses ($) Dividends per common share Dividend yield (%) Current taxes ($) Royalties ($) Total assets ($) Debt to capitalization ratio (%)	**Operating** Net production, before royalties – oil sands (Mbbls/d) Net production, before royalties – other oil and NGLs (Mbbls/d) Net production, before royalties – natural gas (MMCF/d) Total proved reserves (MMBOE) Bitumen proved reserves (MMbbls) Gross production, before royalties (MBOE/d) Gross production, before royalties (Mbbls/d) – oil sands **Air** SO_2 emissions (tonnes) NOx emissions (tonnes) Total gas flared (m^3) Total gas vented (m^3)	**Health and Safety** Total recordable injury frequency (employees and contractors and separately) Lost time injury frequency (employees and contractors and separately) Fatalities (employees and contractors) **Leadership and Corporate Governance and Business** Business conduct investigations Total incidents of violations involving rights of indigenous people Monetary value of significant fines and total non-monetary sanctions for non-compliance with laws and regulations ($) Integrity helpline intakes Political donations ($)
Health and Wellness Field employee health assessments Global Corporate Challenge (GCC)-Team fitness participation rate Workstation Ergonomics Program (% of discomfort improvement post assessment) Short Term Disability (% of employees returning to work) **Workforce** Total workforce (employees and contractors) Voluntary employee turnover (%) Gender breakdown of employees Age (employees) Average age (employees) Generational profile Location of employees Employees with completed development plans (%)	**Greenhouse Gases** Direct GHG emissions (tonnes CO2e) Direct GHG emissions –oil sands (tonnes CO2e) Indirect GHG emissions (tonnes CO2e) Indirect GHG emissions –oil sands (tonnes CO2e) Direct GHG emissions intensity (tonnes CO2e) Direct GHG emissions intensity –oil sands (tonnes CO2e) Bitumen production GHG emissions intensity (% decline from 2004) Cumulative mass CO_2 sequestered (kT CO_2) Net mass of CO_2 stored annually(absolute, kT CO_2) **Energy Efficiency and R & D** Cenovus Environmental Opportunity Fund Ltd. Planned spend ($) Cenovus Environmental Opportunity Fund Ltd. Planned spend ($) Energy efficiency fund planned spend ($) Energy efficiency fund actual spend ($) Employee Energy Efficiency Rebate Program	**Energy** Energy use (GJ) Energy use (GJ) – oil sands Energy intensity (GJ/m3OE) Energy intensity-oil sands (GJ/m3OE) **Land** Total area under reclamation (hectares) Well site reclamation certificates received Total wells undergoing active reclamation Total reclaimed land (hectares) Reportable spills (oil sands and pipelines) Estimated reportable volume spilled (bbls) (oil sands and pipelines) **Waste** Hazardous (tonnes) Non-Hazardous (tonnes) Total waste (tonnes)

Table 11.1 Metrics, indicators and/or KPIs for sustainability performance reporting by oil sands developers and operators (cont'd)

Development sessions attended by supervisors (%) Females in management positions (% at VP level and above) Scholarships provided to dependents of employees **Stakeholder and Aboriginal Engagement** Aboriginal business spending Percent of total company spend	participation (rebates issued) Employee Energy Efficiency Rebate Program participation (employees) Employees Energy Efficiency Rebate Program – Eco Kits issued R&D capital spend ($) Steam to oil ratio (Foster Creek) Steam to oil ratio 9Christina Lake) Industry average steam to oil ratio	**Community Involvement and Investment** Community funding ($) Community funding-Organizations supported (#) LBG corporate giving in Canada
SHELL		
Safety	**CO_2**	**Water**
Exposure hours Total recordable cases Total recordable case frequency Lost time injuries Lost time injury frequency **Tailings** Total volume of liquid discharged to external tailings facility & in-pit (m^3) **Land and Reclamation** Total active footprint –mine + plant size (ha) Permanent reclamation (ha) Temporary reclamation (ha) **Community** Social investment spend ($) Aboriginal spend ($)	Total direct emissions (Mt CO2e) Total indirect emissions (Mt CO2e) Total emissions (Mt CO2e) Total CO_2e intensity (kg CO2e/bbl) Total CO_2e intensity (kg CO2e/bbl) – Excluding construction emissions Total CO_2e intensity including offsets (kg/bbl) Total CO_2e intensity including offsets (kg/bbl) – Excluding construction emissions Total direct emissions (Mt CO_2e) – In Situ Total indirect emissions (Mt CO_2e) – In Situ Total direct emissions (Mt CO_2e) – Scotford Upgrader Total indirect emissions (Mt CO_2e) – Scotford Upgrader Total direct emissions (Mt CO_2e) – Musket River and Jackpine mines Total indirect emissions (Mt CO_2e) – Muskeg River and Jackpine mines	**Scotford Upgrader** Total water use (m^3) Net fresh water consumption (m^3) Total effluent treated and returned to the river (m^3) % net fresh water consumption % total effluent treated and returned to the river Fresh water intensity (bbl water consumed/bbl MRM and JPM bitumen) **Musket River Mine and Jackpine Mine** Total water use (m^3) Mine recycle water use (m^3) Net Athabasca River freshwater consumption (m^3) Net freshwater from other sources consumption – surface runoff and ground (m^3) % recycled pond water % freshwater (Athabasca River) %freshwater from other sources (surface runoff and ground) Freshwater intensity – Athabasca River (bbl freshwater/bbl bitumen) **In –Situ** Total freshwater consumption (m^3) Fresh water intensity (bbl water consumed/bbl in situ bitumen)

* Metric used only in Phase 1

KPIs to measure progress towards SD; however, certain areas of performance lack a similar set of reporting tools, which can be attributed to the characteristics being intrinsically subjective.

ConocoPhillips reports their performance in seven areas: air quality, GHGs, land management and biodiversity, water use and quality, stakeholder engagement and aboriginal peoples, community investment, and waste (ConocoPhillips, 2013). Although ConocoPhillips presents the results using objective metrics that help facilitate the interpretation of data, there is a lack of consistency in their reporting, as some metrics' last available performance data dates back to 2009, while for others, the most up-to-date available data dates back to 2011.

Suncor reports environmental, social, and economic performance results and goals to stakeholders using objective and subjective metrics.

The environmental areas of focus include water, land and biodiversity, energy efficiency and GHG emissions, air, renewable energy, and tailings. Suncor has clear environmental performance goals, with the aim to reduce fresh water consumption by 12%, increase reclamation of disturbed land area by 10%, improve energy efficiency by 10%, and reduce air emission by 10% by the year 2015 (Suncor, 2013). With the exception of some highlighted areas of performance, Suncor's report does not include a tabulated yearly comparison of every metric included in each area; Table 1 includes only objectives metrics and indicators extracted from Suncor's Report on Sustainability 2013 (Suncor, 2013).

Canadian Natural Resources Limited (CNRL) presents the performance results in its annual Stewardship Report to Stakeholders; the last available report dates back to 2011, in which the results are grouped into the areas of safety, environment (land, water, spills, waste, air and GHG emissions, emissions intensity, and flaring and venting), and employment. Additionally, CNRL includes in its report a list of indicators as part of the GRI index; however, the report does not show the performance results (i.e., actual values), but instead sends the reader to four sources where the information can be found: the annual information form, annual report, stewardship report to stakeholders, and the management information circular (CNRL, 2013).

The 2010–11 Sustainability Report is the latest document to provide information on Syncrude's performance in the areas of finance and economic contribution, stakeholder and employee engagement, community investment, health and safety, and environmental stewardship (Syncrude, 2013). Performance is grouped into the areas of environmental, social, and economic. The environmental section includes air quality, biodiversity, climate change, land reclamation, tailings management, water management, and waste management. The social section includes community involvement, people, labour relations, stakeholder relations (non-aboriginal), aboriginal relations, and safety &

health. Finance and operations, economic contribution, and research and development are included in the economic area of performance.

Cenovus identifies 39 corporate responsibility issues of key concern to internal and external stakeholders; the report focuses on environmental, social, and governance issues grouped as follows: economic (financial and operating), leadership and corporate governance and business practices, people (health and safety, workforce, and health and wellness), environmental performance (air, GHGs, energy, land, water, waste, energy efficiency, and R&D), stakeholder and aboriginal engagement, and community involvement and investment (Cenovus, 2013).

Finally, Shell Canada reports performance focusing in three main areas: environment, community, and reclamation. Within those three areas, the oil sands performance report data contains information regarding safety, CO2, water, tailings, land and reclamation, and community (Shell Canada, 2012).

11.4 Data Required and Stakeholder Involvement

Since the rating system, in its application to oil sands, is divided into ten sub-divisions aligned with a project's life cycle, the implementation of a sustainability rating system in the oil sands projects facilitates benchmarking performance among projects (i.e., sub-divisions) with similar characteristics. Although not all of the sub-divisions are part of every oil sands project, the "Lego" methodology adopted in the structure the Wa-Pa-Su project sustainability rating system facilitates the assessment of one, several, or all of the sub-divisions included in the rating system's structure. Moreover, the application toward complex and diversified projects such as the oil sands demonstrates the flexibility and adaptability of the structure design, and integrated assessment methodology used in the rating system.

The project or organization sustainability assessment plan requires the development and implementation of data collection, analysis, and reporting processes. Once the implementation of the rating system has been determined, the status of the current data collection must be determined. Currently, most oil sands developers and operators report their performance through different metrics, indicators, and/or KPIs for sustainability. Through comparing current data collection practices with the Wa-Pa-Su project sustainability rating system requirements, users can evaluate the additional needs and standards for evaluating sustainability performance and assessing the organization or project's sustainability score.

Effective stakeholder engagement and consensus-building increases the chances for the success of the assessment process while favouring the acceptability of the results. The creation of a Multi-Disciplinary Stakeholder Committee (MDSC) assists in the development and implementation of the rating system on several fronts. At this stage, the MDSC has already collaborated with oil sands developers and operators to determine which SDIs and metrics are to be used in the assessment of the project's and/or organization's sustainability. The MDSC comprises individuals who are directly and indirectly impacted by the oil sands operations; hence, members of the MDSC represent organizations or individuals who are affected by or affect the project's operations in one way or another. Moreover, decisions in different phases of the project's life cycle or sub-divisions may require the presence of specific members of the MDSC; therefore, stakeholder management policies within the organization or project determine the participation of each MDSC member as required.

The assessment methodology also requires the input of the MDSC members in the weighting process. The Wa-Pa-Su project sustainability rating system bases the score calculation for each criterion on relevance (i.e., importance) and performance. While metrics and performance are independently designed and calculated for each criterion, the relevance is calculated through comparisons among different criteria, sub-divisions, and/or areas of excellence. Each activity in the oil sands operations represents a different degree of impact; hence, the MDSC must indicate the weight of criteria depending on the area of excellence and sub-division to which each criterion belongs. Similarly, areas of excellence and sub-divisions are to be weighted. Dividing the project or organization into sub-divisions does not imply equality in relevance (i.e., weights) among them; for example, the degree of impact of surface mining operations in the oil sands is expected to be higher than those carried in the sub-division relating to roads Additionally, the design of areas of excellence is based on the different resources involved in the project's and organization's operations, areas of concern for internal and external stakeholders, and sustainability fundamentals, the latter indicating the inclusion and balance of social, environmental, and economic parameters. Therefore, the MDSC must indicate through a weighting process the level of relevance of each area of excellence.

Finally, input from the MDSC is required to determine the PIF for those criteria having a PIF type I. Criteria having a PIF type I can be found in any area of excellence and sub-division. Criteria with PIF type I are those calculated through stakeholder valuation, which implies a high degree of subjectivity. The MDSC must determine the relevance factor (RF) for each criterion on a 9-point scale presented in numeric and linguistic terms; the results are compared with objective measures to determine each criterion's PIF (Poveda & Lipsett, 2013b). Criteria having a PIF type II or III, the PIF is calculated using objectives measures. While criteria having a PIF type II use CAM, criteria having a PIF type III are linked to economic metrics to determined performance (Poveda & Lipsett, 2013b).

11.5 Assessment of Sustainability Using the Wa-Pa-Su Project Sustainability Rating System

The surface mining process is one of the major projects undertaken in the

Canadian oil sands operations; hence, a set of criteria have been selected to demonstrate how the assessment methodology utilized in the Wa-Pa-Su project sustainability rating system is implemented in practice.

After the criteria selection process, each criterion receives a code. The MDSC weights the sub-divisions, areas of excellence, and criteria through the MCDM process. The sum of the weights must equal one within each group of assessment. Tables 11.2, 11.3, and 11.4 show the different weights required in the assessment process, while Figure 11.2 shows the summary of calculation for assessing the sustainability of Project A. To demonstrate the applicability of the assessment methodology, two sets of data have been selected, and three possible scenarios are discussed: actual performance assessment, potential minimum performance, and potential maximum performance. Additionally, criteria having a PIF type I, II, or III are included in the simulated case study to show the application of each calculation methodology.

The first step consists of measuring the performance actual (Pactual) and setting the performance baseline (Pbaseline). Criterion PEMEP&D06015 (Development of EMS) is in the group of criteria having a PIF type I. The performance of these groups of criteria is measured in a subjective manner; therefore, the PIF calculation is proposed through linking the relevance category to which the criteria belongs with the objectives measures. In this case, the relevance category for the criteria with PIF type I is linked to the organization's or project's oil production as shown in Graph 8.2. Criterion PEMEP&D06015's assessment indicates a relevance category of low-high; with the organization's or project's oil production higher than 50,000 BBL/D, the PIF equals 1.33. The value used to represent oil production is the average for the immediate previous year at the time of the performance assessment. Similarly, the PIF type I for other criteria are calculated. The MDSC through consensus indicates the relevance category of the set of criteria having a PIF type I. The relevance category can be linked to various objective measures (Poveda

& Lipsett, 2013b); therefore, the lowest of the different PIF values is to be selected.

Table 11.2 Sub-division's weights projects A and B

	Weights	
Sub-Division	**Project A**	**Project B**
Project integration	0.08	0.06
Provision housing/buildings	0.05	0.04
Permanent housing/buildings	0.07	0.06
Roads	0.10	0.11
Oil transportation & Storage	0.12	0.09
Mining Process	0.16	0.21
In-situ Process	0.10	0.12
Upgrading & refining	0.13	0.15
Shutdown and reclamation	0.11	0.09
CO2, SO2 and capture & storage of other GHGs	0.08	0.07

Criterion SSREO06025 (Percentage of Re-used Excavation Material) belongs to the group of criteria having a PIF type II. The performance of this set of criteria is measured based on CAMs; therefore, a baseline or threshold is set to compare actual performance with pre-established guidelines. Criteria with baselines or thresholds based on regulatory requirements are found in this group. Formula 10.1 is used to calculate the PIF for each criterion; hence, the PIF for criterion SSREO06025 is:

$$PIF = \frac{0.92}{0.90} = 1.02$$

Similarly, the type II PIFs can be calculated for other criteria. For those criteria whose baseline or threshold has been designed based on regulatory requirements, the PIF value must be 1 or higher. The MDSC will indicate the value of other baselines and thresholds. The PIF formula is designed to grant higher PIF values as performance improves;

Table 11.3 Areas of excellence's weights project A and B

Areas of Excellence		Weights	
Code	**Name**	**Project A**	**Project B**
PEME	Project & environmental management excellence	0.02	0.04
SSRE	Site & soil resource excellence	0.08	0.10
WRE	Water resource excellence	0.12	0.14
AARE	Atmosphere & air resource excellence	0.11	0.09
NALE	Natural & artificial lighting excellence	0.01	0.03
ERE	Energy resource excellence	0.09	0.11
RME	Resources & materials excellence	0.13	0.08
IDOE	Innovation in design & operations excellence	0.08	0.11
IBE	Infrastructure & buildings excellence	0.05	0.03
ERCE	Education, research, & community excellence	0.31	0.27

therefore, the PIF formula must be inverted for those criteria for which the Pactual value decreases to indicate an improvement in the PIF value. For example, criterion SSREO06032's (Deforestation) performance baseline is set at a maximum of 900 ha/year, and the actual performance is 950 ha/year. Using Formula 10.2, the PIF value is calculated as:

$$PIF = \frac{900}{950} = 0.95$$

As noted, the Pactual is the denominator while the Pbaseline is the numerator; consequently, deforestation must decrease in order to improve performance.

Criterion IDOEO06058 (Investment in Innovation) integrates the group of criteria that have type III PIFs. The performance of this group of criteria is measured based on the organization's or project's level of investment. Linking organizations' or projects' performance to economic metrics (e.g., level of investment) demonstrates, to some degree, the level of commitment to SD and performance improvement. The MDSC sets up the different baseline or thresholds for this group of criteria, and they must be indicated as a percentage of an economic metric, such as net income or ROI. The baseline or threshold for criterion IDOEO06058 is set at 0.5% of the organization’s net income for the immediate previous year at the time of the performance assessment. With a Pactual value of 0.65%, the PIF for criterion IDOEO06058 can be is calculated using Formula 10.1 as:

$$PIF = \frac{0.65}{0.50} = 1.30$$

The score (i.e., number of points) for each criterion (i.e., CFS) is calculated using Formula 10.3 or 10.4. Using criterion PEMEP&D06015 (Development of EMS) as an example, the CFS is calculated as follows:

8.5 = 10,000 x [0.16 x 0.02 x 0.20 x 1.33]

Where, 10,000 = criterion initial score

[0.16 x 0.02 x 0.20] = criterion weight factor

1.33 = performance improvement factor

10,000 = rating system total available points

0.16 = sub-division weight

0.20 = area of excellence weight

0.20 = criterion final weight

8.5 = criterion final score

The sustainability assessment score for the mining process sub-division can be calculated by adding each CFS or the score for each area of excellence that fall within the sub-division. The sustainability assessment score for Project A is 1632 points, as indicated in Figure 11.2. Another indicator can be extracted from the score calculation worksheet:

the performance index for each area of excellence, which can be calculated by adding each criterion's PIF value within the area of excellence.

To calculate the sustainability assessment score for Project B, the weights for sub-divisions, areas of excellence, and criteria are replaced as indicated in Tables 11.2, 11.3, and 11.4. Pactual and Pbaselines for each criterion are kept as they are in Project A to be able to compare the impact of the CWF in the final sustainability assessment score between the two projects. Replacing the different weights, the sustainability assessment score for Project B is 2220 points. The weights within each group of assessment are normalized; that is, they sum to one, but the weights have been redistributed. The redistribution of weights within the sub-divisions, areas of excellence, and criteria affect the overall results for both Project A and Project B assessments. This demonstrates not only the critical importance of input by the MDSC in the assessment of weights and establishing the different criteria baselines or thresholds and PIF values, but also the relevance in the relationship between the project's or organization's performance and the weighting process.

11.5.1 Potential Minimum and Maximum Performance Scores

The minimum and maximum potential sustainability assessment scores can be calculated for Projects A and B. Since the performance of a criterion can be linked to PIF type I, II, or III, the minimum and maximum potential scores must be analyzed independently. Using Graph 8.2, the minimum value of PIF type I for Project A is 1; the relevance category is low-low for all criteria, and the oil production is kept at 65,000 barrels per day (BBLD). For other criteria with PIF type II or III, the performance has been reduced by 50% of the Pbaseline (PIF = 0.5). Since performance is the variable under analysis, the weights for sub-divisions, areas of excellence, and criteria are still the same as in the actual performance

Table 11.4 Criteria weight for project A and B

Area of Excellence	Criteria Name	Criteria Code	PIF Type	Project A CFW	Project B CFW
PEME	Cumulative Environmental Impact Assessment (CEIA)	PEMEP&D06003	I	0.25	0.20
PEME	Development of Environmental Management Systems	PEMEP&D06015	I	0.20	0.15
PEME	Implementation of Environmental Management Systems	PEMEC06016	I	0.30	0.35
PEME	Regulatory Compliance	PEMEID&BC06019	I	0.25	0.30
SSRE	Percentage of Re-used excavation material	SSREO06025	II	0.35	0.20
SSRE	Deforestation	SSREO06032	II	0.30	0.38
SSRE	Proportion of non-previously developed land used	SSREO06035	II	0.35	0.42
WRE	Percentage of recycled water	WREO06037	II	0.85	0.78
WRE	Acid drainage monitoring	WREO06039	I	0.15	0.22
AARE	Dust control	AAREO06043	I	0.68	0.55
AARE	Noise & vibration monitoring	AAREO06045	I	0.32	0.45
NALE	Provision and monitoring of adequate luminosity	NALEO0648	I	1	1
ERE	Internal production of energy consumed	EREO06051	II	1	1
RME	Improvement in machine application efficiency	RMEO06054	II	0.15	0.27
RME	Distance of materials suppliers	RMEO06056	II	0.85	0.73
IDOE	Investment in innovation	IDOEO06058	III	1	1
IBE	Monitoring of wildlife	IBEO06061	I	0.15	0.10
IBE	Protection of vegetation	IBEO06063	III	0.20	0.35
IBE	Reduction of land area used for tailing ponds operations	IBEO06071	II	0.65	0.55
ERCE	Community awareness programs	ERCEO06082	III	0.10	0.15
ERCE	Work satisfaction	ERCEO06087	II	0.18	0.25
ERCE	Percentage of hours of training	ERCEO06095	II	0.25	0.38
ERCE	Female-to-male wage ratio	ERCEO06107	II	0.47	0.22

assessment scenario previously discussed. The sustainability assessment under the minimum potential score scenario for Project A is 935 points. In comparison with the actual performance (1632 points), the variance is a 57.3% reduction in points. Under similar assumptions of PIF types I, II, and III, the minimum potential sustainability assessment score for project B is 1254 points, which represents a 56.5% decrease in comparison with the actual performance score of 2220 points.

The maximum potential sustainability assessment for Projects A and B are calculated under the assumption that the performance has improved 100% from the previous measurement. For criteria with PIF type

I, the relevance factor is described as high-high, while the oil production is still set at 65,000 BBLD; therefore, the PIF value is 2, as indicated in Graph 1. For other criteria with PIF type II or III, the increase in performance sets the PIF value at 2. The sustainability assessment under the maximum potential score scenario for Project A is 3200 points. In comparison with the actual performance (1632 points), the variance is a 96.1% increase in points. Under similar assumptions for PIF types I, II, and III, the maximum potential sustainability assessment score for project B is 4196 points, which represents an increase of 89% in comparison with the actual performance score of 2220 points.

11.6 Restrictions and Frequency of Measurements

Currently, oil sands developers and operators report sustainability performance on an annual basis to not only stockholders and internal and external stakeholders, but also to the public in general, as their sustainability reports are intended for public access. The application of the Wa-Pa-Su project sustainability ratings system with the current set of data collected for each project becomes a challenge. Although the development and implementation of environmental and sustainability rating system carries a series of benefits already demonstrated in the building industry, other industry contexts require an initial investment for transforming the current planning, construction, and operation practices to consequently impact performance auditing and reporting.

With the aim of avoiding mismanagement of data collection and performance auditing and reporting, sustainability measurement, through the utilization of the Wa-Pa-Su project sustainability rating system, requires setting guidelines in the use of its integrated assessment methodology. Since sustainability is undergoing continuous evolution and projects' and organizations' conditions may change, it is possible to introduce changes to the set of parameters (SDIs) for sustainability assessment; however, there is a series of ramifications when introducing

Figure 11.2 Wa-Pa-Su project sustainability rating system score calculation worksheet.

Wa-Pa-Su Project Sustainability Rating System

Score Calculation Worksheet

Sub-division: Mining Process – Project A

Sub-division weight (SDW) : 0.16

	Criteria Code	Performance Evaluation		Performance Improvement Factor (PIF)	CIS	Weights and CWF				CFS
		PActual	PBaseline			SDW	AEW	CFW	CWF	
PEME	PEMEP&D06003	N/A	N/A	1.67	10,000	0.16	0.02	0.25	0.0008	13.36
PEME	PEMEP&D06015	N/A	N/A	1.33	10,000	0.16	0.02	0.20	0.00064	8.512
PEME	PEMEC06016	N/A	N/A	1.11	10,000	0.16	0.02	0.30	0.00096	10.656
PEME	PEMEID&BC06019	N/A	N/A	1.78	10,000	0.16	0.02	0.25	0.0008	14.24
				5.89						46.768

	Criteria Code	Performance Evaluation		Performance Improvement Factor (PIF)	CIS	Weights and CWF				CFS
		PActual	PBaseline			SDW	AEW	CFW	CWF	
SSRE	SSREO06025	0.92	0.90	1.02	10,000	0.16	0.08	0.35	0.00448	45.696
SSRE	SSREO06032	950 ha/yr	900 ha/yr	0.95	10,000	0.16	0.08	0.30	0.00384	36.48
SSRE	SSREO06035	450 ha/yr	500 ha/yr	1.11	10,000	0.16	0.08	0.35	0.00448	49.728
				3.08						131.904

	Criteria Code	Performance Evaluation		Performance Improvement Factor (PIF)	CIS	Weights and CWF				CFS
		PActual	PBaseline			SDW	AEW	CFW	CWF	
WRE	WREO06037	90	95	0.95	10,000	0.16	0.12	0.85	0.01632	155.04
WRE	WREO06039	N/A	N/A	1.11	10,000	0.16	0.12	0.15	0.00288	31.968
				2.06						187.008

	Criteria Code	Performance Evaluation		Performance Improvement Factor (PIF)	CIS	Weights and CWF				CFS
		PActual	PBaseline			SDW	AEW	CFW	CWF	
AARE	AAREO06043	N/A	N/A	1.67	10,000	0.16	0.11	0.68	0.011968	199.8656
AARE	AAREO06045	N/A	N/A	1.78	10,000	0.16	0.11	0.32	0.005632	100.2496
				3.42						300.1152

	Criteria Code	Performance Evaluation		Performance Improvement Factor (PIF)	CIS	Weights and CWF				CFS
		PActual	PBaseline			SDW	AEW	CFW	CWF	
NALE	NALEO0648	N/A	N/A	1.78	10,000	0.16	0.01	1	0.0016	28.48
				1.78						28.48

Figure 11.2 Wa-Pa-Su project sustainability rating system score calculation worksheet (cont'd)

Wa-Pa-Su Project Sustainability Rating System

Score Calculation Worksheet

Sub-division: Mining Process – Project A

Sub-division weight (SDW) : 0.16

	Criteria Code	Performance Evaluation		Performance Improvement Factor (PIF)	CIS	Weights and CWF				CFS
		PActual	PBaseline			SDW	AEW	CFW	CWF	
ERE	EREO06051	25	100	0.25	10,000	0.16	0.09	1	0.0144	36
				0.25						36

	Criteria Code	Performance Evaluation		Performance Improvement Factor (PIF)	CIS	Weights and CWF				CFS
		PActual	PBaseline			SDW	AEW	CFW	CWF	
RME	RMEO06054	65	50	.1.30	10,000	0.16	0.13	0.15	0.00312	40.56
	RMEO06056	75	90	0.83	10,000	0.16	0.13	0.85	0.01768	146.744
				2.13						187.304

	Criteria Code	Performance Evaluation		Performance Improvement Factor (PIF)	CIS	Weights and CWF				CFS
		PActual	PBaseline			SDW	AEW	CFW	CWF	
IDOE	IDOEO06058	0.65	0.50	1.30	10,000	0.16	0.08	1	0.0128	166.4
				1.30						166.4

	Criteria Code	Performance Evaluation		Performance Improvement Factor (PIF)	CIS	Weights and CWF				CFS
		PActual	PBaseline			SDW	AEW	CFW	CWF	
IBE	IBEO06061	N/A	N/A	2.0	10,000	0.16	0.05	0.15	0.0012	24
	IBEO06063	0.25	0.30	0.83	10,000	0.16	0.05	0.20	0.0016	13.28
	IBEO06071	20	100	0.20	10,000	0.16	0.05	0.65	0.0052	10.4
				3.03						47.68

	Criteria Code	Performance Evaluation		Performance Improvement Factor (PIF)	CIS	Weights and CWF				CFS
		PActual	PBaseline			SDW	AEW	CFW	CWF	
ERCE	ERCEO06082	0.20	0.10	2	10,000	0.16	0.31	0.10	0.00496	99.2
	ERCEO06087	84	100	0.84	10,000	0.16	0.31	0.18	0.008928	74.9952
	ERCEO06095	45 hr/yr	50 hr/yr	0.90	10,000	0.16	0.31	0.25	0.01240	111.6
	ERCEO06107	0.92	1	0.92	10,000	0.16	0.31	0.47	0.023312	214.4704
				4.66						500.2656

Sustainability Assessment Score: 1631.9248 = 1632 points

new parameters. New assessment parameters must be set by the rating system design body instead of the company or organization, as performance benchmarking requires uniformity of data collection, auditing, and reporting. The weight of each criterion is expected to change as the result of introducing new parameters of assessment. Once the sub-division, areas of excellence, and criteria weights are set, the MDSC is to serve as auditor of the assessment process. A change in the set of SDIs or weights must be explained and justified by the MDSC on behalf of the change originator, and then approved by the rating system design body, which acts as the governing body. In the event that the assessment methodology proposed in the Wa-Pa-Su project sustainability rating system has not been adopted industry-wide, but instead a project or organization decides to utilize it for internal performance reporting, the MDSC can make changes to the set of SDIs, considering that sub-divisions, areas of excellence, and criteria weights must be re-assessed.

As demonstrated in the simulated case of implementation in which the sustainability assessment scores for Projects A and B were calculated in different scenarios, the weighting process for sub-divisions, areas of excellence, and criteria resulted in the most sensitive factor followed by performance assessment; therefore, the MCDA methodology selected in the weighting process will directly impact the results of the different scores. The MDSC uses the MCDA methodology to determine the weights, including those for the set of criteria in the rating system; therefore, stakeholder identification and selection becomes an additional critical factor in the sustainability assessment process.

Finally, the PIFs for criteria in the rating system can be classified into types I, II, and III (Poveda & Lipsett, 2013b). PIFs type II and III are calculated through objectives metrics, while PIF type I possesses a certain degree of subjectivity; therefore, the MDSC evaluates the relevance of this group of criteria to then link them to objective measurements. The Wa-Pa-Su project sustainability rating system proposes three objective measurements: energy consumption, GHGs, and BBLD (Poveda & Lipsett, 2013b). While some organizations or projects collect data for all three parameters, others require the implementation of processes and procedures for such a purpose. Although the PIF type I can be calculated linking the criteria relevance (i.e., relevance category) to each objective measurement, the criteria score uses the lowest PIF value with the aim of encouraging performance improvement. While advances in some areas of SD have been made, other areas still require further development in order to implement objectives metrics to assess performance; hence, the design of the PIF type I. As a result, for criteria whose performance is subjective in nature or for which doubts surround the design of metrics, the MDSC input will decide the relevance of the criteria and the final impact (weight) in the overall rating system score.

11.7 Discussion

The different life cycle stages of projects and organizations vary in duration; therefore, sustainability PeM must include a degree of dynamism brought by the different factors. Stakeholders, SDIs, and project conditions (e.g., economic, socio-economic, political, scope changes) are among those factors that may vary overtime; these various dynamic factors influence not only the success of sustainability assessment tools, but also the design of the assessment methodology itself. During development and implementation sustainability assessment tools must consider characteristics such as applicability, flexibility, and practicability in order to link the dynamism of the different factors with the goals and vision of sustainability held by a specific group of individuals (e.g., a particular project, organization, or industry).

The integrated sustainability assessment methodology used in the Wa-Pa-Su project sustainability rating system considers a variety of factors found in the three areas of knowledge: SD, MCDA, and CPI. The continuous evolution and factors within make every area of knowledge intrinsically dynamic. The integrated assessment methodology takes those dynamic factors into consideration to rate sustainability performance based on improvement over time, while stakeholders accompany the process along the way through weights assessment, SDI selection, and auditing and monitoring the process.

The degree of success in decision-making and sustainability assessment processes measures the effectiveness of stakeholder management. While sustainability assessment tools continue in the search for the most accurate system to measure the advance toward SD, inquiries surround the basis of the different assessment methodologies, stakeholder theory addresses stakeholder definition, identification, and classification; SD attempts to identify what should be measured (i.e., SDIs) and how it should be measured (i.e., metrics), while still trying to find the proper answer regarding what constitutes SD or what makes a project, organization, city, etc. sustainable; and (3) MCDA uses subjective input in mathematical models to bring a degree of rationale and present objective outcome(s).

12. Chapter Twelve – General Discussion and Conclusion

12.1 Summary and General Discussion[11]

This chapter provides a general discussion of different aspects included in this research and a series of conclusions are outlined.

12.1.1 The Oil Sands and Its Path to Sustainability

The development of the Alberta's oil sands has been extensively documented (Breen, 1993; Chastko, 2004; Alberta Energy, 2012e; Kelly, 2009). Ancient civilizations used the bitumen for construction of buildings and water proofing of reed boats, in North America, fur traders from Europe found Canadian First Nations using bitumen to waterproof their birch bark canoes. Henry Kelsey, manager of the HBC at York Factory saw the first sample of bitumen from the largest oil deposit in Canada in 1719 (Kelly, 2009). The bitumen mixes with sand, clay or other minerals, and water to form a heavy and extremely viscous oil that must be treated before it can be used by refineries to produce usable fuels (Alberta Energy, 2012f). Canada and Venezuela have the two largest deposits of oil sands, however they can be found around the world in small scale (e.g., United States, Russia, Middle East), conversely; the first document oil sands mining operation was set up in northeastern France in 1745, adding refining capacities in 1857.

The 1800s was a period of exploration. In 1842, Geological survey of Canada established to explore for coal and other minerals, but not until 1875 decides to investigate the Athabasca oil sands with drilling beginning in 1894. Additionally, natural gas is discovered in different parts of Canada, New Brunswick in 1859, south-western Ontario in 1866, and 55

[11] A version of section 12.1 of this chapter has been published. Poveda & Lipsett 2012. Environmental Impact. 115-127.

kilometers northwest of Medicine Hat in 1883.

In the early 1900s, a period of independency; Medicine Hat develops its own gas utility, Edmonton electric Lighting and Power Company is purchased by Edmonton becoming the first municipally-owned electric utility in Canada, Alberta becomes a province, and Calgary Power is formed which later is renamed TransAlta. Later, with the First Wolrd War oil was recognized as key strategic commodity. The first regulatory agency in Alberta was funded in 1915, the Public Utilities Board (PUB), its jurisdiction included but not limited to cancelation of subdivisions plans, approval of utility franchise agreements, regulation of the sale of shares and securities within the province, approval of tariffs for provincial railways, ad approval of highway crossings by railway branch lines (Alberta Energy, 2012e). In 1922 the International Bitumen Company is formed and built a small plant near Bitumount, 80 kilometers north of Fort McMurray to produce bitumen for roofing and road surfacing, a year later Edmonton adopts natural gas for heating, lighting and cooking.

In the 1930s, the government establishes its presence. Minerals rights are transferred from the federal government to Canada's western provinces in 1930, and the Alberta Department of Land and Mines is established. In 1931, the first Alberta "Royalty Regulation on petroleum and natural gas produced on provincial lands was set at 5% of well output or value to January 1935, thereafter 10%" (Breen, 1993). Later in 1932, the Turner Valley Conservation Board and the Petroleum and Natural Gas conservation Board now the ERCB were established. In 1936, Alberta's 1000 fuel dealers were required to obtain a license from PUB under the Fuel Oil Licensing Act.

In the 1940's the royalty rates drastically went up. In 1941, royalty rates from oil went from a flat rate of 10 per cent to a choice of a 12.5 per cent flat rate or a five to 15 per cent royalty based production levels, later Alberta royalty rate is capped at 16 and two thirds per cent. In the 1950s, the oil takes over, oil replaces coal as Canada's largest single source of energy. Pipelines are now transporting natural gas to Vancouver, Winnipeg, Toronto, and Montreal. The federal government created the NEB to oversee interprovincial and international energy trade. The Gas Utilities Act is introduced in 1960, and Alberta establishes air quality standards in 1961 which include limits for industrial emissions of hydrogen sulphide and sulphur dioxide.

In 1980, the Constitution Act gives each province the exclusive right to make laws in relation to the development, conversation and management of natural gas in the province. Three provinces, Alberta, British Columbia, and Saskatchewan, and the federal government signed the Agreement on Natural gas Markets and Prices, this will start the process of natural gas price deregulation in Canada in 1985, furthermore, in 1986 the provincial government allowed the Natural gas Protection Plan to expire. In 1992, with Canada and more than 160 other nations presence, the UNCED in Ro de Janeiro adopted a philosophy of SD and agreed to begin limiting emissions of GHGs that may contribute to global climate change. Later in 1997, the Kyoto Protocol treaty was negotiated and came into effect on February 16th, 2005.

In the latest 1990s, encouraging development the Oil Sands Generic Regime set rates and established the federal accelerated capital cost allowance for oil sands projects. In the early 2000s, the Government of Alberta implements the energy Tax Refund, and from 2003 to 2009, implemented the Natural Gas Rebate Program to protect Alberta consumers from high natural gas prices. Approximately 6 years ago, in 2005, “Alberta’s Mineable Oil Sands Strategy (MOSS), was produced by a steering group that included representatives from environmental organizations, First Nations, industry and government. They revised plans for consulting on policy principles the draft for discussion document, Mineable Oil sands Strategy and Fort Mc Murray Mineable Oil Sands Integrated Resources Management Plan” (Alberta Energy, 2012e).

The development of the oil sands has become a priority. In 2006 the Oil Sands Ministerial Strategy Committee developed a short term action plan to address the social, environmental and economic impacts of oil sands developments. The Oil Sands Consultations Multi-Stakeholder Committee (MSC) held information meetings throughout the province and allowed Albertans to raise their opinion on how the oils sands should be developed. In 2007, the Oil Sands Sustainable Development Secretariat was created to address the different issues related to the rapid growth of the oil sands in Alberta, a 20 years plan is released in 2009: Responsible Actions: A Plan for Alberta's Oil Sands (Government of Alberta, 2009b).

Currently, governmental and private organizations work together in different fronts to development a more sustainable path to the development and operations of the oil sands projects while addressing the needs of the different stakeholders. Nevertheless, oil sands developers and operators are still independently reporting sustainability performance as previously discussed in chapter elven; therefore, there is the need for the development of tool (i.e., sustainability rating system) to not only measure –in a consistent manner- but also benchmark SD performance.

12.1.2 The case for Sustainability

The demand for better integrated and more anticipatory decision making signals the transition from environmental to sustainability assessment. The success for sustainability relays on understanding the fundamentals of what sustainability is, or at least what the search of sustainability requires (Gibson, Hassan, Holtz, Tansey, & Whitelaw, 2010). The Brundtland Commission formally known as the World Commission on Environment and Development (WCED) defines SD as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs. It contains within it two key concepts: 1) the concept of 'needs', in particular the essential needs of the world's poor, to which overriding priority should be given; and 2) the idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs" (United National General Assembly, 1987). The fundamental relationship between human cultures and biospheres is represented with concentric circles. This relationship has been graphically represented; ‘the egg of well-being’ adopted by the Word Conservation Union represents an egg in which the yolk of people is immersed in the white of ecosystems (Guijt et al., 2001), another version immerses the circle of economy inside the circle of society, which is in turn inside the circle of ecology. These two versions are considered the old sustainability. The new sustainability is commonly represented by three pillars or circles (i.e., triple bottom line) that intersect –ecology, society and economy – suggesting interdependency and mutually support among the three principles.

Gibson et al. (2010) describe the essentials of the concept. Sustainability is: 1) a challenge to conventional thinking and practice, 2) about long – as well as short term well-being, 3) comprehensive, covering all the core issues of decision making, 4) a recognition of links and interdependencies, especially between human and the biophysical foundation for life, 5) embedded in a world of complexity and surprise, in which precautionary approaches are necessary, 6) a recognition of both inviolable limits and endless opportunities for creative innovation, 7) about an open-ended process, not a state, 8) about intertwined means and ends – culture and governance as well as ecology, society and economy, and 9) both universal and context dependent. The essentials of sustainability carry a set of benefits to economics, society, and environment when applied to PPP of any organization.

Nobody denies that the oil sands are an economic opportunity for Alberta and Canada, but how this resource is exploited has substantial ramifications in different areas. The projects have economic, social, and environmental impact for present and future generations therefore sustainability essentials and principles must be considered. Recognizing the importance of developing the oil sands in a sustainable manner the government of Alberta releases in 2009 the document “Responsible Action: A Plan for Alberta’s Oil Sands, which outlines an integrated approach for all levels of government, for industry, and for communities to address the economic, social and environmental challenges and opportunities in the oil sands regions” (Alberta Energy, 2012f). The document highlights six strategies: 1) develop Alberta’s oil sands in an environmentally responsible way, 2) promote healthy communities and quality of life that attract and retains individuals, families, and business, 3) maximize long-term value for all Albertans through economic growth, stability, and resource optimization, 4) strengthen our proactive approach to Aboriginal consultation with a view to reconciling interests, 5) maximize research and innovation to further support SD and unlock the deposit’s potential, and 6) increase available information, develop measurement systems, and enhance accountability in the management of the oil sands.

Working with stakeholders facilitates to accomplish the goals of sustainability. Most believe that sustainability is guaranteed by imposing environmental regulations, however; other factors are to be considered (i.e., social, economic). Municipalities, Aboriginal communities, industry, researchers, and other public and private organizations are among the parties that impact or are impacted by the projects. Each one of them has particular interests and concerns when it comes to the oil sands projects and how to guarantee their SD. Government sets standards and regulations; legal requirements that must be met by developing companies, but the strictest is imposed by society and environment, a social license that do not required a signature. Government, oil sands developing companies and stakeholders are working together towards SD, but one question remains; how the SD of the oil sands projects is being measured?.

12.1.3 Sustainability Assessment and Environmental/Sustainability Rating Systems as Decision Making Tools

Among other fundamentals functions, sustainability assessments and sustainable rating systems are tools to direct and support the planning and decision making process for projects toward accomplishing their sustainability goals. In the decision making process a person and/or organization try to make the best decision weighting the positives and negatives of each option available while considering all the alternatives, process that gets intricate based on the number of variables to be considered. The oil sands and heavy oil projects must include in the analysis economic, social, and environmental factors.

Gibson et al. (2010) explain, sustainability includes the core issues of decision making. To the contrary sustainability is not one item in a list of considerations instead is a framework and set of relevant values integrated to comply with those considerations, however the term is still used narrowly to describe specific areas (e.g., environmental sustainability). EIA and SEA are the foundation for sustainable assessment. While EIA are more closely related to project level, the SEA applies to policies, plans and programs. It is valid to differentiate between external and internal sustainability; while external sustainability assessment is performed by regulatory bodies, and the internal sustainability assessment is performed by planning and project proponents as part of the process of developing a proposal. External and internal sustainability assessment are both important if a shift towards more sustainable decision making is going to take place (Post, 2007).

Sustainable rating systems have been designed to measure environmental performance of buildings. The term “building performance” is complex, since each stakeholder has particular interest and requirements (Cole, 1998). Tenants are interested in comfort and health while economic performance is the interest of investor (Haapio & Viitaniemi, 2008). The building industry counts with a wide variety of sustainable ratings systems to choose from. ATHENA, BEAT 2002, BREEAM, LEED, Green Globes, CASBEE, Green Start are some of the existing sustainable rating systems. LEED, for example, addresses all building type and emphasizes initially in six categories: sustainable site, WE, EA, MR, IEQ, and ID, adding the regional priority in its last version (USGBC, 2009e). As LEED has been a success in North America and LEED certified projects are in more than 100 countries, BREEAM has demonstrated its applicability in Europe, developed in the United Kingdom by the BRE. BRE has more than 100.000 buildings certified and operates in dozens of countries. BREEAM uses nine categories: management, health and wellbeing, energy, transport, water, materials, waste, land use and ecology, and pollution. These categories facilitate practitioners to make effective and efficient decisions in the use and operation of the resources involve the development of projects.

Sustainable rating systems support the decision making process throughout the project life cycle or certain(s) phase of it. In common practice the designer does not have much interaction with the constructor; however, accomplishing the sustainability goals requires an integrated effort between the parties involved regardless of the project delivery method used (e.g., design-bid-build, design-build, integrated project delivery, etc). This integrated approach assists the decision making process and minimize design and building errors among other benefits.

While a variety of sustainability assessment tools are available for practitioners, a sustainable rating system to measure the overall environmental performance in a consistent manner of oil sands and heavy oil projects has not been yet developed. Critical decisions are made in all projects to accomplish the goals of SD; consequently the use of tools design based on the sustainable principles should be considered the best and primary option (Poveda & Lipsett, 2011c).

12.1.4 Are Environmental Regulations Enough?

Regulations can take shape in different forms: legal, social, self-regulation, co-regulation and market regulation. For the exploration and exploitation (construction, operation and maintenance) of the oil sands and heavy oil projects a serie of approvals, licenses, dispositions, permits and registrations are required. AENV, the ERCB and ASRD are part of the provincial agencies, and Environmental Canada, the Department of Oceans and Fisheries and Transport Canada operates at the federal level (OSDG, 2012a; 2012b).

The set of regulations, approvals, licenses, permits and registrations have a crucial role throughout the projects life cycle, however a question remains to be answered; are regulations enough to demonstrate environmental and SD performance?. Technically, regulations demonstrate that companies have met the restrictions impose by government authorities, however accomplishing the goals of regulations does not imply that the projects have an overall successful performance. In the case of the oil sands and heavy oil projects specifically the projects certainly meet regulations impose by the different regulatory agencies yet the developing companies do not poses a sustainable rating system to demonstrate overall environmental and SD compliance.

Table 12.1 shows some of the main difference between regulations and sustainable rating system. Under the principle of not only the goal is essential but the path how to get there, the main objective of sustainable rating system is to assist constructors, regulatory agencies, developers, stakeholders, etc. in the decision making process.

12.1.5 The Wa-Pa-Su Project Sustainability Rating System and Its Potential Benefits

Following the trends of environmental and SD PeMs it is appropriate to

Table 12.1 Differences between regulations and sustainable rating systems

Regulations	Sustainable Rating Systems
Compulsory	Non-Compulsory
Limited decision making support	Decision making support throughout project life cycle.
Reactive Approach	Pro-Active Approach
Development Stage Primarily environmental and legal factors are regulated. Other sustainable criteria are not included (e.g., social economic, etc.)	**Development Stage** Sustainable principles included additional to environmental and legal factors (e.g., management, research, community, etc.).
Operational Stage Selected criteria are measured.	**Operational Stage** Large variety of criteria are measured: regulated and non-regulated
Accomplishment measure by specific criteria.	Gives overall score of project sustainability.
No-flexible.	Users decide which criteria to meet to obtain the desire score. However, criteria based on regulates factors must be met.

consider the development of a sustainable rating system for industrial projects with application to oil sands and heavy oil projects. The rating system combines the structure of oil sands and heavy oil projects, the concepts of sustainable rating systems, and includes legal requirements (e.g., regulations) as part of the CWT.

The Wa-Pa-Su project sustainability rating system is a verification process to assist demonstrating compliance in SD performance during project life cycle through the implementation of enhanced strategies to mitigate environmental, social, health and economic impact.

The development of a sustainable rating system for oil sands and heavy oil projects is expected to contribute to a variety of areas including SD, research, environmental science, finance and economy, social, productivity, construction, management (e.g., risk management, performance evaluation, decision making, etc), design, health, public relations, and employee retention. The design and implementation of a sustainable rating impacts developers, constructors, stakeholders and society in general since construction practices are modified to meet the requirements of the tool.

Sustainable rating systems carry a number of benefits when are implemented (Yudelson, 2008). The existing sustainable rating systems have demonstrated that their implementation favored the planet and humanity in environmental, economic and social grounds. Some benefits that the Wa-Pa-Su project sustainability rating system are but not limited to: 1) contributes with a tool to implement green and sustainable performance excellence during difference phases of the project life cycle, 2) helps organizations to meet environmental, social and economic objectives, 3) provides productive positive publicity, 4) assists in expressing civic leadership, 5) facilitates to improve morale and engagement of employees and stakeholders, 6) supports strong local economies, 7) facilitates markets transformation, 8) helps reduce environmental impact due to project construction and operations, 9) stimulates the increment of energy efficient processes, 10) supports the decision making process throughout the project life cycle, 11) shows companies as pioneers and leaders of the way in the oil and gas industry, and 12) demonstrate companies continual improvement and innovation vision (Poveda & Lipsett, 2011a; 2011b).

12.1.6 The Wa-Pa-Su Project Sustainability Rating System: Structure and Assessment Methodology

The structure of the Wa-Pa-Su project sustainability rating system was designed taking into consideration two essential functions: 1) meeting the requirements of the oil sands projects, for which the projects' life cycle assists in the sub-divisions selection and 2) serving the objectives of sustainability by considering the measurement of the development of each pillar (economy, social and environmental), which supports the areas of excellence and criteria selections. Furthermore, since the Wa-Pa-Su project sustainability rating system attempts to break into the well-structured oil and gas industry, the main concern, expressed by different stakeholders, relays on its implementation, then three different factors were included in the analysis of the structure design: applicability, functionality and user friendly.

Due to the complexity and size of the projects and the number and diversity of individuals affecting and affected by the projects (stakeholders) in each different phase, the selection process of the sub-divisions of the rating system took into consideration the projects' life cycle. As every oil sands project does not contain each sub-division, the structure of the rating system allows to break it into different "pieces" which can be used as lego to then calculate the project sustainability overall score reinforcing the functionality characteristic of the rating system. Additionally, the integrated sustainability assessment approach supports and aligns with "breaking into pieces" methodology intended.

The analysis of three different aspects contributed to the selection of the different areas of excellence: resources involved in the projects development, stakeholders expectations, and potential environmental, economic and social impacts. The word excellence added to the name of the sub-divisions is with the aim of reminding the different users of the rating system the ultimate goal of the tool, the stakeholders' objectives and the purpose of striving for a more SD of the projects.

Similarly, each area of excellence combines a serie of unique and specific criteria. The criteria are selected considering the three principles of sustainability, therefore with the continuous thought of minimizing the social, economic and environmental impacts created by the development of the projects.

The assessment methodology adopted in the Wa-Pa-Su project sustainability rating systems consists of three fundamental steps: the SDIs pre-selection process, the CWT, and the credit and overall sustainability assessment score allocation methodology. All three steps are recommended to not only be accompanied but also led by the MDSC.

The six resources for the pre-selection of SDIs are organized in three distinctive groups: (1) indicators agreed on by public or governmental representatives groups through consensus, consisting of governmental regulations and committees and organizations for standardization; (2) indicators identified by academics and practitioners, comprising management and processes best practices and academically- and scientifically-authored resources; and (3) indicators established by organizations, containing the resources from local, regional, national, and international organizations and surface mining industry standards and programs.

The weighting assessment tool uses MCDA. With the aim of demonstrating the flexibility and applicability of the assessment methodology adopted in the Wa-Pa-Su project sustainability rating system, the analysis of the CWT was carried using the AHP; however, different MCDA methodologies have been used to solve problems on multi-criteria in decision-making environments. In this instance the proposed assessment methodology cannot conclude that specific MCDA methodology presents the optimal solution for assessing the relevance of criteria. As a result, future research is recommended in this area.

Finally, the proposed credit and overall sustainability assessment score allocation methodology integrates three distinctive areas of knowledge:1) SD theory and fundamentals supports the ultimate goal of the rating system of contributing to sustainability, with the aim of finding a path to balance social, economic and environmental needs, 2) CPI becomes primordial due to the duration of the projects, it is critical to allow organizations or projects to improve performance over time, and 3) MCDA assists the assessment process through stakeholder engagement and participation, and the design and implementation of a criteria weighting system. In this integrated approach the sustainability performance assessment contains two main factors: score allocation based on actual performance and stakeholder engagement and participation for the duration of the development (i.e., pre-selection and weighting of SDIs) and implementation of the rating system and monitoring and control during performance assessment and reporting.

12.2 Conclusions

Sustainable assessment tools and the sustainable rating system assists practitioners, researchers, and projects' stakeholders and DMs in accomplishing the goals of sustainability in the social, economic, and environmental groups. The results of the assessment process must facilitate the implementation of the requirements to meet sustainability objectives. Gibson et al. (2010) explain: "ideally, every undertaking that emerges from an assessment process would help meet every one of the requirements for sustainability. Every new project, program, policy and plan would assist in the building of socio-ecosystem integrity, provide good jobs and other opportunities for a decent life, reduce inequities, cut overall energy and material use, strengthen democratic practice, foster habitual respect for people and nature avoid risks and prepare for adaptation. These are the qualities we need for sustainability."

Since the oil sands and heavy oil projects continue with a rapid development pace, it is crucial for the parties involved in the exploration, construction, and operation processes (e.g., oil companies, stakeholders, government, subcontractors, etc.) to find a tool to measure, in a consistent manner, the environmental and SD performance of the projects. Even though measuring the performance of the projects is relevant for continual improvement practices, the appropriate assessment tool must support the decision-making process. Assessing sustainability in projects includes finding the right balance among social, environmental, and economic grounds as part of the fundamental pillars of SD.

DMs often find themselves in difficult, uncomfortable, and compromising situations when choices are to be made among trade-offs. Deciding if social and economic benefits prevail instead of potential environmental impacts usually leads to conflicts and compromise among the different parties involved in the project. The concept of sustainability implies finding the balance between social, economic, and environmental needs, and in order to do so, two main characteristics must be highlighted: the development of the right process to find the balance, and definition of "needs."

The development of the framework for sustainability assessment of industrial projects with application to oil sands and heavy oil projects—known as the Wa-Pa-Su project sustainability rating system—intended in this research study has led to a diversity of conclusions in a range of areas of knowledge related in one way or another to different topics in SD and sustainability assessment:

- Not only the origins of sustainability are still under debate, but also its definition. While for some, the idea of SD and its intended objective (i.e., sustainability) have been around since the beginning of time, for others, the concepts go back to only a few decades ago. Independent of the time frame in history in which researchers and practitioners can reference sustainability, one of the challenges encountered in the study of the subject is its definition. The well-known triple bottom line represented by three equally-sized circles indicating the inter-relationship between society, economy, and environment is broadly known; however, it is not universally accepted. Hundreds of definitions for sustainability can be found in the literature, and each offers the vision of a determined group of stakeholders. Nevertheless, most definitions are categorized as too broad. As a result, based on the fundamentals of SD, this research offers a new definition of sustainability, and establishes ten principles that serve as the basis for the development of an integrated sustainability assessment methodology.
- The premise "If we cannot define what we want to measure, how

we can measure what we want to become or the progress towards to it?” summarizes another challenge encountered in sustainability assessment and the development of assessment methodologies. SDIs and criteria are designed with the aim of measuring progress towards sustainability; however, researchers, practitioners and stakeholders in general often face the questions of what to measure (i.e., SDIs and criteria) and how to measure (i.e., metrics) those SDIs and criteria, which includes determining the baseline in order to measure progress. In this instance, a methodology for pre-selecting SDIs has been proposed, and development of metrics for SDIs has been designed based on the concept of CPI, which resulted in the proposal for the use of PIFs.

- SD and sustainability assessment are multi-disciplinary subjects that require the engagement and participation of stakeholders. Yet, the concepts of stakeholders and stakeholder management add to the complexity of the subject matter. While stakeholder theory emphasizes the management of stakeholders, there is not a definitive set of rules for the definition, identification, classification, and management of stakeholders for large projects in complex environments.
- Stakeholders are a decision-making force that determines the outcome in the implementation of MCDM methodologies and the success of development and implementation of SD PPP and assessment methodologies. However, organizations and projects typically face difficulties not only identifying but also engaging and managing those decision-makers in the different phases of the project’s life cycle. While stakeholder theory calls for the effective engagement and participation of stakeholders, different factors make stakeholders a dynamic force. Factors influencing a change in attributes in stakeholders include: changes in project phase or time, change in issue, manager’s perception, and triggered

situations. Furthermore, triggered situations may occur because of the mismanagement of a certain issue or stakeholder, the undermining of stakeholder attributes (especially power) or issue relevance, and the misinterpretation of stakeholders' attributes (i.e., identification of) or issues (e.g., due to complexity).

- Concerns with construction practices in the building industry led to the development of different environmental and sustainability assessment approaches, strategies, models, appraisals, and methodologies. Among those tools, a number of these sustainable rating systems have been developed around the world and used extensively, impacting the building industry in a positive manner. The development and implementation of rating systems aims to address the concerns and needs of stakeholders while implementing innovative processes and technologies to reduce social, economic, and environmental impacts during the construction and operation of the projects. Rating systems have greatly contributed to the green revolution of the building industry; however, other industries are far behind in their development and implementation of similar tools. The implementation of the green revolution in the oil and gas industry faces difficulties in areas of market transformation; cultural change; the development and adoption of processes and procedures aligned with innovation and the dynamism of a transforming market; and new design, construction, and operation methodologies. Moreover, the development of the Wa-Pa-Su project sustainability rating system demonstrates that while the development of a rating system faces challenges on its own, the truth test comes in the implementation of the tool.
- Current developed and implemented rating systems must not only be diversified for their implementation to other industry contexts, but also have their intended goals re-examined by revisiting the

fundamentals and theory of SD. The term “sustainability” is often lousily used in some instances in which measurement tools—including rating systems—mostly use environmental criteria to determine sustainability performance. It is often found that rating systems with a substantial environmental component leave behind the premise of balancing the social, economic, and environmental needs of the stakeholders. Nevertheless, the systems previously known as “environmental rating systems” are now including more social and economic aspects in the assessment process in an effort to address increasing stakeholders’ concerns and become tools with multi-faceted or inter-disciplinary assessment characteristics instead of using an isolated pillar to define sustainability.

- The “green” certification process of projects usually occurs during the planning and/or construction phase, instead of rewarding the criteria and overall sustainability performance scores based on actual performance. Score allocation methodologies are meant to demonstrate the level of performance through the given number of points or stars; however, if the certification process occurs based on the design and/or implementation of certain processes and technologies during the design or construction phase of the project, there is not a guarantee for the stakeholders that the project will perform accordingly and the previously-given number of points or stars are accurately deserved. As a result, rating systems must implement criteria and overall sustainability performance scores methodologies based on actual PeMs during the operation phase of the project—and points or stars are to be allocated there—without forgetting the efforts made by developers and operators in the planning and construction phases.
- The Canadian oil sands development and operation projects are required to meet a set of governmental regulations. However, different groups of stakeholders argue that the set of regulations

are neither meeting their needs, nor addressing the various impacts (e.g., social, economic, environmental, health) the projects carry throughout their life cycles. Additionally, most—if not all—of the regulations presently used mainly address environmental aspects of the projects. In fact, the SDIs pre-selection process for surface mining operations resulted in less than 5% of the SDIs designed based on governmental regulations requirements.

- Current oil sands developers and operators are collecting data with the aim of evaluating "sustainability" performance. The data is collected in an independent manner; each organization or project evaluates performance based on internal sustainability performance reporting requirements. Although performance evaluation and reporting are meant to address the needs of internal and external stakeholders, the independent nature of the reporting process results in the impossibility of benchmarking performance among organizations or projects within the same industry performing similar activities. As a result, the design of the structure of the Wa-Pa-Su project sustainability rating system presents ten sub-divisions, and its integrated assessment methodology allows users to break it into different "pieces" that can be used as building blocks to then calculate the project sustainability overall score, reinforcing the functionality characteristic of the rating system.
- SDIs and criteria usually are treated as isolated sustainability performance subjects. Nevertheless, the pre-selection process of SDIs addresses—in fact, *must* address—the different pillars of sustainability (e.g., social, economic, environmental) while meticulously examining the different impacts. Meanwhile, the MCDA process correlates—or at least attempts to correlate—the relevance between SDIs or criteria. However, the synergies and dynamism among SDIs and criteria and other internal and external factors are neither measured nor considered in the assessment

process. The development of the Wa-Pa-Su project sustainability rating system concluded that SDIs and criteria are not isolated: the "behavior" of one element impacts others, which creates a dynamic environment with similarities similitudes to the dynamic environment encountered in stakeholder management in which internal and external factors make the elements dynamic forces that are constantly changing, adapting, and/or interacting.

- The environmental pillar of sustainability has been extensively studied and is currently ahead of the social and economic components of sustainability. Since environmental impacts and performance are measurable, the different stakeholders and the public in general can easily correlate objective measures. Additionally, the public in general correlates sustainability with environmental issues and/or performance; governmental regulations mainly address environmental issues; and sustainability reports primarily integrate environmental performance. On the other hand, economic sustainability is understood—and often interpreted—as how well an organization or project does financially; however, the economic impacts of an organization or project on external environments is poorly studied. Since healthy economic performance usually indicates to internal and external stakeholders that the organization or project is still in business and, as a result, bringing economic wealth to society, the interpretation of the economic pillar of sustainability faces the challenge of demonstrating that economic wealth does not necessarily translate to a balanced sustainable path. The social pillar of sustainability is intrinsically subjective; therefore, researchers and practitioners encounter difficulties in designing the metrics to measure performance. Although the most common interpretation of SD, graphically represented by three inter-related, equally-sized circles, implies balance, the current PeM and reporting reflect otherwise.

- Due to the subjectivity encountered in some areas of sustainability assessment, the Wa-Pa-Su project sustainability rating system proposes the use of three types of criteria based on which metrics are used to measure performance and establish baselines or thresholds. Two types of criteria possess objective measures: the first use CAMs and the second are linked to economic metrics. The group of criteria using CAMs are linked to measurable aspects of the organization or projects (e.g., CO_2 per ton for bitumen produced) and baselines or thresholds are designed based on common goals or governmental regulations. Links to economic metrics are proposed to link performance to existing and recognizable economic metrics (e.g., level of investment per ROI). Finally, there is a set of criteria requiring future research to use either of the above PeM methodologies; therefore, subjective performance methodologies are to be used in the meantime and until there is better understanding of the subject (i.e., criteria). As a result, the Wa-Pa-Su project sustainability rating system proposes the use of the relevance factor (RF) or subjective stakeholder valuation, which involves linking the stakeholders' subjective evaluation of the relevance of criteria with objective measures (e.g., energy consumption, GHGs generated, BBL/D).
- The integrated sustainability assessment methodology proposed in the Wa-Pa-Su project sustainability rating system allocates criteria and overall sustainability assessment scores based on two factors: weights and actual performance. The simulated case study of implementation and sustainability assessment demonstrated the impact of both factors (e.g., weights and actual performance). The different sustainability scores that can be calculated are highly sensitive to the weight factor, which can be seen as weights are redistributed within the same set of elements. In other words, the weights within each group of assessment are normalized; that is,

they sum to one, but the weights have been redistributed. The impact of the weight factor demonstrates not only the critical importance of input by the MDSC in the assessment of weights and establishing the different criteria baselines or thresholds and PIF values, but also the relevance in the relationship between the project's or organization's performance and the weighting process.

- Although the initial intent with the development of the Wa-Pa-Su project sustainability rating systems focused on a specific industry (i.e., oil and gas), there is a high degree of flexibility and applicability of the sustainability assessment methodology and the rating system structure design methodology developed; therefore, the both methodologies can be applied to organizations or projects in other industry contexts.

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Appendix

Appendix A: Sustainable Development Indicators (SDIs) Description

A. Project and Environmental Management Excellence – PEME

- **Biophysical Impact Assessment (BIA)** assesses the baseline conditions of a determined environment and evaluates the biophysical impacts of a project on a particular region.

- **Cumulative Environmental Impact Assessment (CEIA) (as per cumulative impact threshold requirements for Alberta oil sands)** evaluates the changes to the environment caused by an action in combination with other past, present and future human actions, regardless who undertakes such actions.

- **Economic Impact Assessment (EcIA)** appraises the effects, both positive and negative, on the economy of a determined policy, program, activity, project, or event.

- **Emergency Response Management Plan** describes the measures, procedures, and processes that should take place in the event of an emergency in the project. "Emergency" refers to any situation or impending situation that constitutes danger that could result in harm to persons or substantial damage to property or the environment.

- **Environmental Impact Assessment (EIA)** refers to possible impacts and effects—either positive or negative—that a proposed development or project may have on the environment.

- **Environmental Management Systems (EMS)** are systems commonly supported by a database in which a set of management procedures and processes are documented, allowing an organization to identify, evaluate, and reduce the environmental impact of its activities. The set of documents are used for training personnel, monitoring, and reporting environmental performance to internal and external stakeholders of the organization.

- **Environmental Protection Management Plan** outlines the environmental management approach and protection measures that will be considered in each phase of the project's life cycle. The plan describes the measures to be applied throughout the project, while highlighting the measures to be considered in specific construction phases and project components.

- **Environmental Risk Management Plan** is a set of actions and measures to be undertaken to reduce potential risks arising from any activity performed during the project life cycle. Actions and measures are meant to focus on protecting the environment and reducing the diverse impact due to project development.

- **Erosion and Sediment Control Plan** describes the appropriate actions and practices for protecting the ecosystem from erosion and sedimentation occurring as a result of mining activities.

- **Hazard Management Plan (which includes assessments, inspections, and procedures)** refers to measures, processes, and procedures to manage the different hazards that may arise during the project life cycle, including, but not limited to, physical, chemical, biological, psychological, and radiation hazards.

- **Independent Verified Auditing and Reporting Plans** describe the different audit and reporting activities to undertake during the project life cycle. Independent audits and reports refer to third-party verification systems that examine data, statements, records, operations, and performances, with the aim of comparing the baseline with actuals.

- **Project Lifecycle Assessment (PLA)** is also known as life-cycle analysis, eco-balance, or cradle-to-grave analysis. Project Lifecycle Assessment (PLA) is a technique used to evaluate the different environmental impacts associated with all the phases of a product's life cycle, starting from raw material extraction to the final stages of disposal or recycling.

- **Regulatory Compliance (approvals, licenses, and permits)** is a verification process of approvals, licenses and permits to operate.

- **Safety Management Plan (which includes safety training, reporting, and prevention of incidents)** is a formal document that highlights the processes and procedures to manage the area of safety in the project. The plan includes, but is not limited to, safety training programs, reporting, PeM, goal setting, and incidents prevention.

- **Social Impact Assessment (SIA)** is a methodological review of the intended and unintended social impacts, effects, and consequences—both negative and positive—of project or development interventions.

- **Solid Waste Management Plan** is developed with the aim of identifying an effective and efficient manner to collect, transport, process/dispose, manage, and monitor solid waste material.

- **Sustainable Public Procurement Strategies** highlight the acquisition of material and equipment, with the aim of supporting the green and sustainable goals of the project. For example, this may include material that comes from certified sustainable production activities (e.g., wood) or equipment with lower rates of GHG emissions or energy consumption.

- **Strategic Environmental Assessment (SEA)** serves as a tool in the decision support process. The main objective of the assessment is to ensure that informed decisions regarding sustainable development are made by effectively incorporating environmental aspects into plan, policies, and programs.

- **Water Management Plan** identifies the different strategies for water consumption and usage. The plan must effectively set water conservation goals and identify water conservation opportunities.

B. Site and Soil Resource Excellence – SSRE

- **Biological Monitoring Studies and Reports** are used to describe the existence of biological impairments. The health of biological systems is identified through biological monitoring, in which a description of the consequences of human activities on the systems are presented, and a distinction is made between naturally-occurring variations and human-induced changes.

- **Deforestation** indicates the permanent removal or destruction of a forest or area of trees in order to make the land available for other uses, which implies the land is thereafter converted to a non-forest use.

- **Mining Effluents: Monitoring, Control, and Reduction** refers to measures undertaken to minimize impacts, control emissions, and improve the overall performance of the operations related to the emanation of certain substances that includes, but is not limited to, arsenic, copper, cyanide, lead, nickel, zinc, TSS, and radium. Monitoring, control, and reduction activities also refer to levels of pH.

- **Overburden Management** indicates the different steps that are taken toward dealing with the material that lies above the mining area of interest. In surface mining operations of oil sands, the overburden may include rock, soil, and ecosystems. Overburden is also known as waste or spoil.

- **Percentage of Resource Extracted Relative to the Total Amount of the Permitted Reserves of that Resource** identifies the operational ratio of a determined area in volume (quantity extracted) and time (rate in time).

- **Proportion of Non-previously-developed Land** Used measures the length of a new developed area (i.e., mining area) in reference to the non-previously-developed land area, but with a high probability of being developed in a determined region, area, or legal jurisdiction.

- **Proportion of Protected Land Used** is the ratio of area under development in relation to the protected land in a determined region, area, or legal jurisdiction.

- **Re-used Excavation Material** proportionally quantifies the percentage of excavated material that is being re-used (e.g., overburden) or effectively extracted to meet the end goals of the operations (e.g., the ratio of oil per ton of extracted oil sand).

- **Structures to Prevent Erosion and Soil Runoff: Implementation and Monitoring** examines all the construction, control, and monitoring of structures designed to prevent erosion and soil runoff in the mining area and its vicinities.

- **Total Waste Extracted (non-saleable, including overburden)** measures the material extracted from the mining area, which includes material that is not being re-used through the overburden management plans, as well as strategies and the waste material (non-saleable or recyclable) extracted during the operational phase of the mine.

- **Tree Harvest Management** identifies the strategies for efficiently and effectively harvesting trees in the area of the operations. It also refers to the total area (i.e., number) of trees harvested in reference to the total area of the mining operations.

C. Water Resource Excellence – WRE

- **Acid Drainage: Monitoring, Control, and Reduction** indicates strategies to manage the acid drainage that results from mining activities. Although acid drainage is usually referred to as the outflow of acid water from metal or coal mines, the surface mining operations for oil sands projects must monitor the existence of acid drainage, and, if required, put in place control and reduction strategies. Acid drainage is also referred to as acid mine drainage, acid and metalliferous drainage (AMD), or acid rock drainage (ARD).

- **Aquatic Life: Protection and Monitoring** refers to measures that must be put in place to preserve the aquatic ecosystems in the area of operations.

- **Construction of Water Management Systems and Structures** entails the construction of different infrastructure systems to control bodies of water resulting from mining operations. Additionally, rain water and other external water effluents are to be considered. The structures for water management after processing the oil sands are to be included as well; however, the indicator does not refer to water management during the processing of the oil sands.

- **Control of Formation Dewatering** measures the procedures in place for dewatering and deposition strategies applicable for each mining site. Usually, each site needs to be considered separately when applying the best dewatering technology. Dewatering technologies include thickening, in-line flocculation, centrifuge, and co-mingling, among others, and deposition strategies include thick lift, thin lift, deposition cells, single-point discharge, and multiple-spigot discharge, among others.

- **Ground Water Resources: Protection and Monitoring** refers to existing and naturally-formed water resources, and the different strategies that must be put in place to protect the natural state. The management of ground water resources must include a permanent monitoring system.

- **Mining Effluents: Monitoring, Control, and Reduction** refers to measures undertaken to minimize impacts, control emissions, and improve the overall performance of the operations in relation to the emanation of certain substances into any body of water. The different substances include, but are not limited to, arsenic, copper, cyanide, lead, nickel, zinc, TSS, and radium. Monitoring, control, and reduction activities also refer to levels of pH.

- **Muskeg Drainage: Monitoring, Control, and Reduction** indicates the different measures used to prevent and minimize the presence of muskeg drainage in the mining areas of the project.

- **Seepage Prevention (from ponds, pits, and landfills)** refers to measures taken to prevent the seepage or leakage of fluids from ponds, pits, and landfills. The different measures are meant to prevent any source of contamination from bodies of water.

- **Usage of Recycled Water** measures the percentage of water re-used in the mining process, with the aim of minimizing the water intake from naturally-formed bodies of water such as rivers or lakes.

- **Wastewater Management** refers to the different strategies to manage the water used in the mining process. In this indicator, not only is wastewater from sanitary sewage and stormwater sources included, but so too is contaminated water resulting from the processing of the mining material.

- **Water Supply and Consumption** includes the quantities of water consumed during the mining process and other activities (e.g., human consumption).

D. Atmosphere and Air Resource Excellence – AARE

- **Dust Control** indicates the measures taken to minimize the amount of particles in the atmosphere originating from different sources, including soil dust lifted by either weather or pollution.

- **Fugitive Emissions: Monitoring, Control, and Reduction** refers to the management of the emission of gases or vapors from pressurized equipment during the surface mining process. The fugitive emissions usually refer to leaks and other unintended or irregular releases of gases.

- **GHGs: Monitoring, Control, and Reduction** refers to measures undertaken to minimize impacts, control emissions, and improve the overall performance of the operations related to the emanation of certain substances into the air. The different substances include, but are not limited to, sulphur dioxide (SO_2), ozone (O_3), nitrogen dioxide (NO_2), particulate matter ($PM_{2.5}$), carbon monoxide (CO), oxides of nitrogen (NO_x), volatile organic compounds (VOCs), and hydrogen sulphide (H_2S).

- **Noise and Vibration Management** refers to management strategies to monitor, control, and reduce the noise and vibrations from transportation and processing equipment during the surface mining process.

E. Natural and Artificial Lighting Excellence – NALE

- **Luminosity: Control and Regulatory Compliance** includes any luminosity required by law to perform mining activities in a safe manner. In the event any luminosity activity is not mandatory by law, a minimum level of luminosity is required to perform any activity in the surface mining area.

F. Energy Resource Excellence – ERE

- **Consumption of Secondary Energy (electricity and heat)** indicates the levels of secondary energy consumption during the operations related to surface mining activities. Secondary energy refers to electricity and heat. Secondary energy is also defined as any form of energy generated by the conversion of primary energies; for example, electricity is transformed from primary sources such as coal, raw oil, fuel oil, natural gas, wind, sun, streaming water, nuclear power, gasoline, etc. Secondary energy also refers to refined fuels such as gasoline or synthetic fuels such as hydrogen fuels.

- **Consumption of Primary Energy (natural gas, LPG [liquefied petroleum gas], petrol, and other fuels)** indicates the levels of primary energy consumption during the operations related to surface mining activities. Primary energy refers to energy found in nature that has not been exposed to any transformation process. Some examples of primary energy are crude oil, hard coal, NGLs, natural gas, nuclear, waste, biomass, wind, hydro, and tides, among others.

- **Internal Production of Energy Consumed (renewable energy use)** measures the level of energy produced internally for the project to become self-sufficient. It implies the minimum consumption of energy from external sources.

G. Resource and Materials Excellence – RME

- **Distance (proximity) of Materials Suppliers** is designed with the aim of minimizing the transportation of materials for the mining process from far distances. Local and nearby businesses should be the first providers of the mining developers and operators.

- **Hazardous Materials Management, Storage, and Disposal** refers to the implementation of strategies for the management, storage, and disposal of those materials that present a risk to health or the environment. Hazardous materials can be radioactive, explosive, gaseous, flammable, leachable, corrosive, combustible, or toxic.

- **Improvement in Machine Application Efficiency** measures the level of optimization (i.e., comparison analysis between design and operation indicators) in the use of the machines and equipment utilized during the mining process. It also includes transportation and mining equipment such as shovels and trucks.

- **Machines Material Re-use** indicates the re-utilization of machinery, with the aim of minimizing the purchase of brand new parts to fix or for maintenance purposes of machines or equipment currently in use to maintain their operability and extend their usable lifespan.

- **Solid Waste Management (non-renewable resources): Reduction, Reuse, and Recycling** refers not only to solid material but also liquid, gaseous, and radioactive waste. A set of management strategies for the collection, transport, processing or disposal, management, and monitoring of waste material as a result of human activity during the different mining activities.

- **Usage of Chemical Substances** indicates the level of use of toxic substances during the process. The aim is to control and minimize the use of substances that present potential risks to the environment and humans. Contaminants can potentially affect air, soil, and water resources and ecosystems in the areas surrounding a mining project.

H. Innovation in Design and Operations Excellence – IDOE

- **Clean Technology Innovations: Testing and Implementation of New Technologies** refers to the effective and efficient implementation of new technology, with the aim of improving performance and minimizing the impacts generated due to oil sands operations. The level of success of certain technology is measured using parameters such as reduction of emissions of GHG and energy consumption.

- **Investment in Innovation** measures the levels of investment of developing organizations toward technology innovation, with the aim of improving performance and minimizing the impacts generated due to oil sands operations.

I. Infrastructure and Buildings Excellence – IBE

- **Affected Species: Animal and Vegetal** measures the number of species affected and the level of the impact on each. The potential impacts on each species must be evaluated before starting mining operations; thereafter, the impacts must be monitored, controlled, and reduced by implementing the appropriate measures.

- **Area of Habitat Created/Destroyed (i.e., area disturbed by oil sands development)** indicates the percentages of (1) the area created, with the aim of compensating for the impacts resulting from mining operations; and (2) the area destroyed or disturbed by oil sands development.

- **Biodiversity and Habitat (includes biological studies and reports): Monitoring and Protection** evaluates the management strategies put in place to monitor and protect the biodiversity and habitat of the area of the mining operations.

- **Communication and Transportation Facilities** evaluates the effectiveness of the road and transportation system in the area of the mining project, and the impacts on fuel consumption and travel times.

- **Ecological Footprint** assesses the total amount of land and resources used. The assessment includes the carbon footprint of the mining operations. In other terms, the ecological footprint evaluates how much biocapacity there is in contrast with how much biocapacity people use.

- **Mining Location Within or Proximal to Water Bodies** is evaluated with the aim of reducing the mining operations within a minimal distance of bodies of water. Minimizing impacts on any bodies of water (including groundwater) should be a priority of mining projects developers; therefore, the location of bodies of water must be taken into consideration when evaluating the location of surface mining projects.

- **Proximity of Mining Operations to Mining Material Processing and Tailing Ponds** is designed with the aim of minimizing distances between extraction areas and material processing facilities and tailing ponds. Intrinsically, this indicator evaluates the effectiveness of the road and transportation systems, but with a focus on the transportation of raw and processed mining material.

- **Reduction of Land Area Used for Tailings Ponds Operations** indicates improvements made by mining projects developers toward reducing the use of areas of land for tailings pond operations. Reducing land use for tailings pond operations probably represents, among other things, the reduction of water use and the implementation of newer technology or methods in the oil sands processing to better the current rates of water consumption.

- **Tailings Ponds Location and Impacts Study** evaluates the location of tailings ponds in reference to other locations in which the impacts might be potentially lower. Implications of locating the tailings ponds in other areas (farther) must be evaluated. The assessment includes, but is not limited to, impacts on energy consumption, travel distances, and productivity.

- **Total Area of Permitted Developments** examines the rates at which the development is occurring; the percentage does not refer to projects under construction or in the operation stages, but instead, to projects in the permitting and approval stage. The total area of permitted development must be compared against the total area of potential development.

- **Total Land Area Newly Opened for Extraction Activities (including area for overburden storage and tailings)** refers to the percentage of areas used for new developments compared against the total area of potential development; it includes mining operations, overburden, and tailings ponds, among others.

- **Transportation Distance of Customers, Business Travel, Workforce, and Community for Fly-in and Fly-out Operations** is designed with the aim of reducing travel distances; among other factors considered in this indicator are the encouragement of reduction of fuel consumption and development of local communities.

- **Vegetation: Monitoring and Control** refers to management strategies to monitor and control the different impacts on vegetation in the area of the mining operations.

- **Wildlife: Monitoring and Protection** refers to management strategies to monitor and control the different impacts on wildlife in the area of the mining operations.

J. Education, Research, and Community Excellence – ERCE

- **Community and Stakeholder Consultation and Involvement** indicates the management strategies for the effective and efficient involvement of the different stakeholders in each phase of the project life cycle. A process for the identification and classification of stakeholders must occur before the subsequent engagement phase takes place.

- **Community Awareness Programs** measures the different awareness programs implemented during the project life cycle, the rate of participation, and the programs' effectiveness. Among others, the set of programs includes aspects such as safety and environmental, social, health, and economic impacts, among others. The programs are directed toward community members impacted by the surface mining projects development.

- **Contribution to Economic and Institutional Development of Communities** demonstrates the degree to which surface mining developers are involved with the economic and institutional development of the communities nearby and affected by the project's operations.

- **Contribution to GDP (gross domestic product)** assesses the level of impact (or percentage of contribution) that a determined surface mining project may have on the gross domestic product (GDP).

- **Contribution to Social Development of Communities** demonstrates the degree to which surface mining developers are involved with the social development of the communities nearby and affected by the project's operations.

- **Employment, Unemployment, and Underemployment Rates** indicates the percentage of these three measures in the areas nearby and affected by the surface mining project's operations; the indicator is designed with the aim of incentivizing high rates of employment and lower rates of unemployment and underemployment in these regions.

- **Employee Turnover** refers to the rate at which employers (i.e., surface mining projects developers) gain and lose employees, or the ratio of the number of employees that had to be replaced in a given period of time to the average number of employees; therefore, the objective of the employers is to have lower turnover rates in their projects.

- Environmental Liabilities measures the type of insurance and the quality of its coverage acquired by surface mining projects developers toward protecting (i.e., preventing and remediating) the environment in the event of any damage occurring because of their operations.

- **Ethical Investment is also known as socially responsible investing (SRI).** It refers to those investment strategies that consider both financial return and social good. The indicator measures the percentage of the total investments made by the surface mining projects developers that can be classified under the ethical investment status.

- **Expenditure on Environmental Protection** refers to the rate of investment made toward environmental causes. For example, this may include investments made into training and prevention programs on environmental protection that are directed toward employees and communities nearby and affected by the surface mining project's operations.

- **Expenditure on Health and Safety** refers to the rate of investment made toward health and safety causes. For example, this may include investments made into training and prevention programs on health and safety that are directed toward employees and communities nearby and affected by the surface mining project's operations.

- **Fatalities at Work** indicates the number of lives lost in the workplace (i.e., surface mining area) in a given period of time. The main objective of the indicator is to provide motivation for the implementation of high safety standards and procedures in order to have zero fatalities at work, and no time lost due to injuries and incidents.

- **Female-to-Male Wage Ratio** provides motivation for gender equality. The ratio measures the difference in income between genders that perform the same job duties and have similar responsibilities in the work place.

- **Health Care Management/First Aid Facilities** refers to management strategies that guarantee proper health care coverage for employees. The indicator also reflects the adequate service and location of first aid facilities in the workplace. For example, a minimum number of health care professionals must be available in the work facilities at all time (ratio of employees to health care professionals).

- **Health, Pension, and Other Benefits and Redundancy Packages Provided to Employees as Percentage of Total Employment Cost** measures the investment made by the organizations (i.e., surface mining projects developers) for each employee in areas such as health, pension, and shares, among other benefits.

- **Housing Development for Local Communities** refers to the degree of involvement of the developing companies in the housing development of communities nearby and affected by the surface mining projects development.

- **Housing Provision for Workforce** indicates the percentage of that workforce that has been provided with housing nearby or in the project's facilities.

- **Inflation Rate** assesses the level—if any—of impact that a determined surface mining project may have on the inflation rate.

- **Internal Return Ratio is also known as internal rate of return (IRR), economic rate of return (ERR), discounted cash flow rate of return (DCFROR), or rate of return (ROR).** The indicator measures the profitability of investments. A surface mining project with a higher IR is more desirable for the developers to undertake the project.

- **Investment in Employee Training and Education** measures the level of investments that an organization has made toward the career development of its employees.

- **Investment in Research** indicates the percentage of resources invested in research with the aim of improving performance toward minimizing social, economic, health, and environmental impacts as a result of the surface mining operations.

- **Lost-Time Injuries** measures the length of time lost due to injuries in the workplace. The measurement is an indicator of the effectiveness of the safety programs put in place during the operations of the surface mining projects.

- **Lost-Time Injuries Frequency** is designed to indicate the number of injuries with lost-time in the workplace, and the frequency of their occurrence.

- **Net Employment Creation** measures the number of new employees in a surface mining company in a determined period of time. The indicator must take into consideration the number of employees leaving the organization indifferently of the motive for the termination of the employment.

- **Net Migration Rate to Project Areas** measures the levels of people moving into the areas near the project. The indicator must specifically measure those individuals migrating because of a determined project.

The migration rate must count only those individuals directly employed by the project, and differentiate between those migrating with the aim of finding employment.

- **Number of Direct and Indirect Employees** determines the employment created in a specific period of time. Direct employees are those permanently employed by the surface mining company, while indirect employment refers to when businesses that supply or produce goods and services generate employment, or when the surface mining company contracts some work to an individual.

- **Number of Local Contractors Relative to the Total Number of Contractors** measures the number of local contractors hired by the surface mining company during the project's operations. The indicator encourages the utilization of local business instead of contracting the services from contractors outside the region or area of operations.

- **Number of Local Suppliers Relative to the Total Number of Suppliers** measures the number of local suppliers utilized by the surface mining company with the aim of providing their goods and services during the project's operations. The indicator encourages the utilization of local suppliers instead of importing goods and services from suppliers outside the region or area of operations.

- **On-going Health Monitoring (workers and local communities)** measures the different management strategies and their effectiveness in monitoring the health of workers and local communities nearby and impacted by the operations of the surface mining project.

- **Participation in Regional Co-operative Efforts** indicates the level of involvement of the surface mining company in regional co-operative efforts toward the mitigation of social, economic, and environmental impacts, not only in the project area, but also in the region in which the project is located.

- **Payback Period** measures the length of time required for the return or repayment of the total amount of the original investment. This economic indicator is an important factor in determining whether the investors will undertake the project or not. Investors typically do not proceed with developments with long payback periods.

- **Percentage of Employees Sourced from Local Communities Relative to the Total Number of Employees** measures the number (percentage) of employees in the surface mining project hired from nearby or local communities in comparison with the total number of employees in the project. The indicator does not include employees who have migrated with the aim of working on the surface mining project.

- **Percentage of Employees that are Stakeholders in the Company** indicates the number of employees that own any amount of share of stocks in the surface mining company. The indicators must take into consideration those employees that choose to not own any shares even though the developing company has offered them to the employee.

- **Percentage of Ethnic Minorities Employed Relative to the Total Number of Employees** refers to the number of employees from visible minorities in relation to the total number of employees in a determined surface mining project.

- **Percentage of Hours of Training** measures the number of hours of training employees have received from their employers in a determined period of time. The training may include areas such as safety, environmental, social, and economic impacts awareness, and technical training to improve employees' work performance and build upon career development.

- **Poverty Alleviation of Affected Areas** assesses the contribution of surface mining developers toward the alleviation of poverty in nearby or local communities affected by the project's development.

- **Project's Acceptability** indicates the level of acceptance the surface mining project has among nearby communities and those directly impacted by the development.

- **Ratio of Lowest Wage to National Legal Minimum** identifies the lower wage paid among the different jobs in the surface mining project, and then compares it to the national legal minimum wage that applies in the region (province) in which the surface mining project is located.

- **Return of Investment** considers the profits in relation to the capital invested. The indicator is used to measure the efficiency of the investment (i.e., the surface mining project), or, in the case of having various investment options, the indicator compares the efficiency among them.

- **Total Number of Health and Safety Complaints from Local Communities** monitors and measures the number of complaints from the residents of nearby and local communities impacted by the surface mining projects. Issues of health and safety are among the areas to be included in the monitoring system.

- **Wealth Distribution** measures the gap between the different social classes (i.e., groups in a society) in the regions or areas nearby and impacted by the surface mining project development.

- **Women/men Employment Ratio** encourages gender equality by comparing the number of women and men employed by the surface mining company.

- **Workforce Awareness and Training Programs (safety, and environmental, social, economic, and health impacts)** measures the different awareness and training programs implemented during the project life cycle, the rate of participation, and the effectiveness of those programs. Among others, the set of programs includes aspects such as safety and environmental, social, health, and economic impacts, among others. The programs are directed towards projects' workforce participants.

- **Work Satisfaction** indicates the level of conformity of employees in their current job and with their employers. The indicator includes the areas of affective and cognitive job satisfaction.