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Using the Triple Bottom Line to Select Sustainable Suppliers for a Major Oil and Gas Company

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by

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Abstract

Companies have primarily been focusing on the financial bottom line i.e., on increasing profits by increasing revenues and reducing costs. With high energy usage and environmental change posing threats to the environment and business operations, companies are now considering sustainability. Since some global suppliers have low cost labor, social well-being and human development has also emerged as major goals of a company performing global operations. Focusing on these three goals is termed the “Triple Bottom Line” (TBL). We study and explore the TBL benefits that could be realized by an oil and gas company by focusing on sustainable suppliers. A company with a global supply chain cannot be sustainable without sustainable suppliers. This thesis develops the business case for sustainable suppliers using the TBL and presents the benefits of integrating sustainable suppliers into the supply chain. We consider a major oil and gas company and use multi-objective decision analysis to perform the analysis.

Contents

1. Introduction

Over the past couple decades, there has been increasing emphasis on sustainability by U.S companies (Smith, 2014). The word “sustainability” has been used numerous times in the corporate world but seldom with a common definition. Originally, it was used to mean an organization’s ability to have steady and consistent growth in earnings. For some, it also included the environmental aspect of growth and for some it meant philanthropy. The definitions varied with industry types and the goals of organizations. Every company, in order to gain benefits from sustainability, must have a clear definition and their approach needs to align with the organization’s vision and mission. In this thesis, we will study some of the important and widely used definitions of sustainability and “Triple Bottom Line”. The thesis will define sustainability for a major oil and gas company and focus on the benefits of sustainable suppliers early in the life cycle.

This thesis presents the benefits of sustainable suppliers e.g., less energy usage, less water usage, less waste, good working conditions for employees, increased employee productivity, reduced hiring and attrition expenses, growth in revenue, reduction in expenses, effective risk management, brand enhancement, and develops a multi-objective decision analysis framework to evaluate potential suppliers in the exploration stage.

1.1 Brief Introduction to the Oil and Gas Industry

The fossil fuel share of the total energy use accounts for about 80% of the world’s energy needs (Energy Information Administration, 2014) and a predominant share coming from oil and gas. The oil and gas extraction industry is one of the biggest industries in the world generating hundreds of billions of dollars and employing close to 200,000 employees (United States

Department of Labor: Bureau of Labor Statistics, 2015) and it also involves operational, environmental and safety risk factors (Energy Digital, 2012). The industry also produces raw material for chemical products and can range anywhere from small scale companies to government-owned companies such as the national oil corporations owned by Libya and Kenya. A large integrated company usually runs its operations globally and that makes it even more complex to operate because of varied cultures, diverse geographic conditions, governmental and environmental regulations. Despite these challenges, the opportunities to grow are immense (Blackmon, 2014).

Figure 1 shows the major segments of an oil and gas project. The upstream segment explores for and produces crude oil and natural gas. The downstream and chemicals includes refining, fuels and lubricants marketing, and petrochemicals and additives manufacturing and marketing. The gas and oil midstream links upstream and downstream and chemicals to the market and is responsible for providing midstream infrastructure and services (Chevron Corporation, 2013)

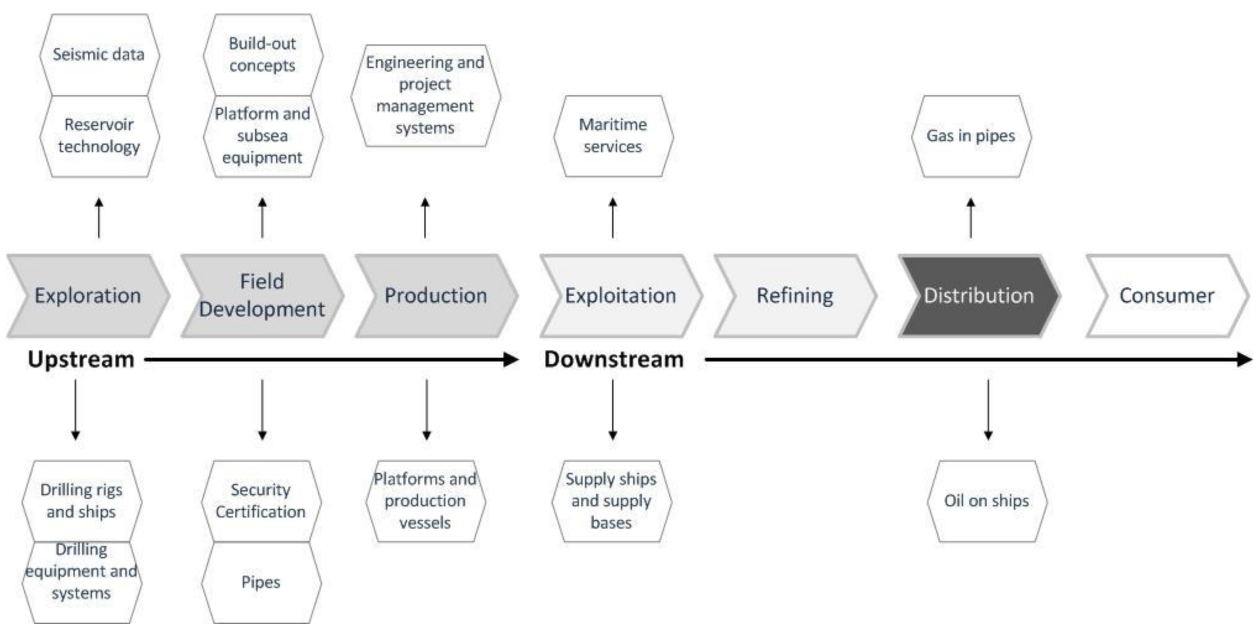

Figure 1: Operations during life cycle stages (Cliq Energy Website, 2015)

During each segment or phase of the oil and gas value chain (**Error! Reference source not ound.**), a company or a supplier performs various operations. For example, using technology to find new oil and gas surfaces and production of oil and gas can be outsourced to specialized companies. The equipment or services required for other operations during the life cycle of an oil and gas project can either be company owned or provided by suppliers. For the operations to be efficient, global companies would need an efficient global supply chain. Specialized suppliers may be more efficient.

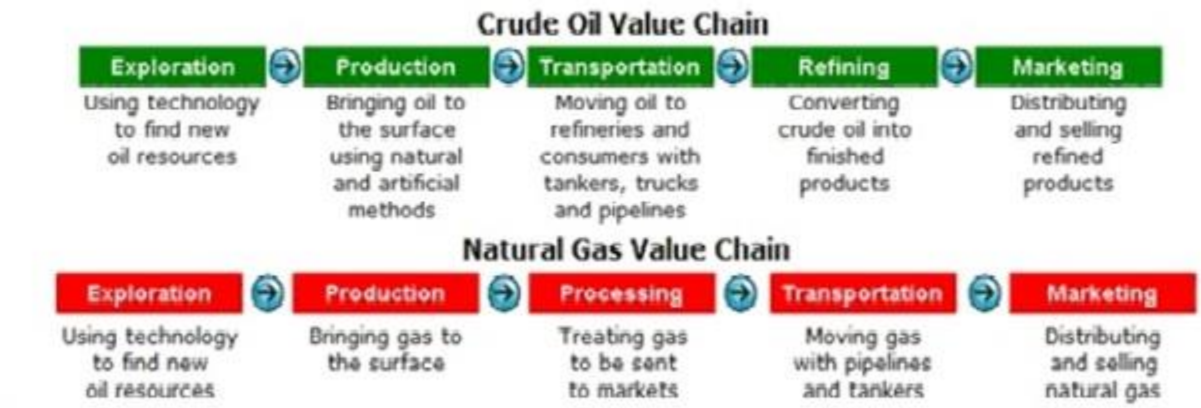

Figure 2: Oil and Gas Value Chain (PetroStrategies Inc., 2015)

Figure 2 shows the operations and services performed during the various stages of the value chain of an oil and gas project. An exploration and production project may have different companies performing each of the activities. The oil and gas industry is very fragmented in terms of the number of critical processes and activities outsourced. Independent oil and national oil companies work together with oilfield services companies to meet exploration and production needs. The equipment and service markets associated with the exploration and production segments of the worldwide petroleum industry are shown in the 2014 edition of the Oilfield Market Report which spans the years 2005-2015 (Table 1). The 32 market segments are:

Table 1: The 32 market segments (Spears & Associates, 2014)

Services	
Artificial lift	Production testing
Casing and tubing services	Unit manufacturing
Cementing	Well servicing
Coiled tubing services	Surface data logging
Completion equipment and services	Wireline logging
Contract compression services	Offshore contract drilling
Directional drilling services	
Solids control and waste management	
Offshore construction services	
Rental and fishing services	
Floating production services	
Geophysical equipment and services	
Hydraulic fracturing	
Inspection and coating	
Land contract drilling	
Logging-while-drilling	
Petroleum Aviation	

Equipment and Supplies
Drill bits
Oil country tubular goods
Drilling and completion fluids
Rig equipment
Downhole drilling tools
Specialty chemicals
Subsea equipment
Supply vessels
Surface equipment

In this thesis, we emphasize the upstream operations of exploration and production and focus on the benefits of having sustainable suppliers during this phase. We have different service providers and suppliers who provide equipment such as General Electric, under a contract for an oil project in West Africa, provides production equipment to Chevron Corporation (Energy Business Review, 2012) and Parker Hannifin Corporation provides instrumentation products to Shell (Quek, 2012) One of the market segments- subsea equipment, has grown from <$6 billion in 2005 to over $21 billion in 2014. See Table 2

Table 2: Subsea Equipment

Subsea Equipment

Subsea Equipment

	Millions									
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
FMC	$1,530	$1,950	$2,332	$2,988	$3,086	$2,712	$3,266	$4,006	$4,726	
Aker Solutions	$650	$930	$1,250	$1,700	$1,650	$1,300	$1,820	$2,565	$2,900	
Technip	$1,080	$1,450	$1,700	$1,941	$2,000	$1,900	$2,100	$2,500	$2,750	
Cameron	$560	$784	$1,137	$1,245	$1,197	$1,637	$1,484	$1,518	$2,097	
GE Oil & Gas	$535	$775	$1,185	$1,392	$1,305	$1,050	$1,175	$1,400	$1,725	
Oceaneering International	$239	$365	$622	$650	$488	$549	$770	$830	$1,028	
Dril-Quip, Inc.	$269	$350	$391	$429	$428	$431	$497	$623	$771	
NOV	$75	$150	$225	$260	$275	$250	$265	$325	$415	
Deep Down, Inc.	$0	$0	$19	$36	$29	$42	$27	$29	$30	
Other	$700	$800	$900	$1,000	$1,050	$900	$1,000	$1,175	$1,300	
Total Market	$5,638	$7,554	$9,761	$11,641	$11,508	$10,771	$12,404	$14,971	$17,742	$21,290
Annual Market Change		**34%**	**29%**	**19%**	**-1%**	**-6%**	**15%**	**21%**	**19%**	**20%**

The global oilfield equipment and service market increased by 7% from 2013 and exceeded $420 billion and is expected to grow by 5-10% and the major segments include offshore contract drilling, offshore construction services and hydraulic fracturing. (Spears & Associates, 2014)

The critical role of the suppliers in the oil and gas supply chain demonstrates the importance that should be given to supplier selection and the value of sustainable suppliers.

1.2 Definition of Sustainability

Sustainability has been defined in different ways. The United States Environmental Protection Agency has defined sustainability as “Sustainability is based on a simple principle: Everything that we need for our survival and well-being depends, either directly or indirectly, on our natural environment. Sustainability creates and maintains the conditions under which humans and nature can exist in productive harmony; that permit fulfilling the social, economic and other requirements of present and future generations.” (SustainAbility, 2010)

Business development is one of the primary objectives of any company but sustainable development is very important for organizations. Sustainable development is defined by the Brundtland commission's report as "development which meets the needs of current generations without compromising the ability of future generations to meet their own needs." (Brundtland Commission Report, 1987) Corporate Sustainability is defined by Robecosam and Dow Jones Sustainability Indices as "a business approach that creates long-term shareholder value by embracing opportunities and managing risks deriving from economic, environmental and social developments." (Dow Jones Sustainability Indices, 2014) This type of sustainable development that takes into account social and environmental factors along with financial factors in designing the organization's business model is used as the foundation for decision making.

1.3 Triple Bottom Line (TBL)

The triple bottom line, a term coined by John Elkington (SustainAbility, 2010), is a framework that measures corporate performance taking into account not just the traditional measure of profits but also to include the social and environmental dimensions of performance measurement. This framework focuses on comprehensive investment results, i.e, to consider profit, planet, and people can be a very important tool to support sustainability goals of an organization. These three dimensions are also called the three Ps. The measurement of these three dimensions has one major challenge, i.e., the units of measurement are not consistent across dimensions and some aspects are difficult to quantify. But, the flexibility of TBL allows organizations to apply the concept in a manner suitable to their specific needs. (Slaper & Hall, 2011)

Figure 3 portrays sustainability in the form of a three legged stool where all the three legs need to be stable for the business to grow sustainably. The three legs being, profit, planet, and people in the business context.

Figure 3: The three legged stool of sustainability (Willard, Sustainability models: Sustainability Advantage, 2010)

The benefits and costs associated with these three dimensions are shown in Figure 4. The overall value of an organization is dependent on: the economic value, social value, environmental value, achieved from the stability of the three legs of the stool. There are many uncertainties in TBL.

To illustrate this, we use the influence diagram which is "a compact graphical representation of conditioning relationships among uncertainties and decisions in a perspective on a decision situation." (Parnell, Bresnick, Tani, & Johnson, 2013)

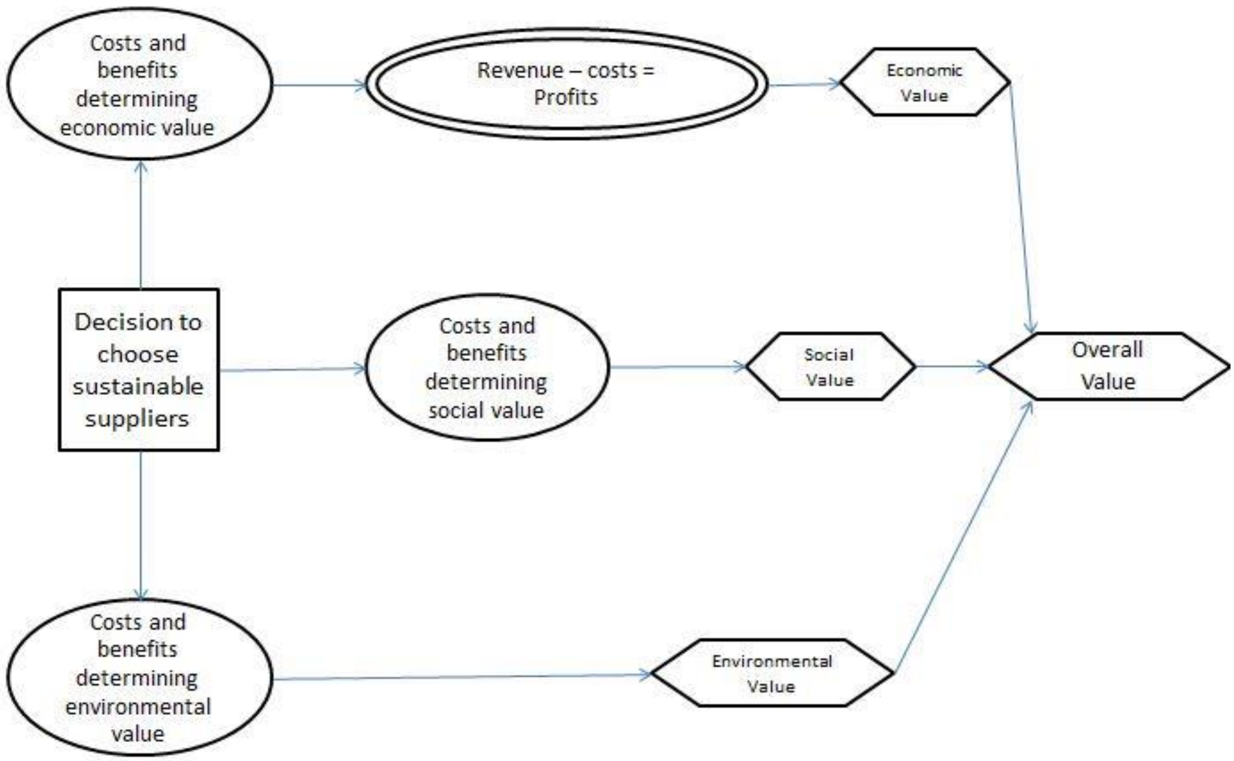

Figure 4: Influence Diagram

In Figure 4, a rectangle represents a decision, which is specified by a set of alternatives. An oval represents an uncertainty. The costs and benefits associated with a supplier are the uncertainties we want to determine with this model (Parnell, Bresnick, Tani, & Johnson, 2013)

A double oval represents a calculated uncertainty. The profits can be calculated by determining the revenues and costs associated with a particular supplier and these profits can be used to estimate the economic value provided by that supplier.

The benefits of sustainability and the value chain of a typical manufacturing company are shown in Figure 5. The pursuit of sustainability and the alignment of sustainability-related benefits with the value chain framework show how each benefit strengthens each link in the supply chain.

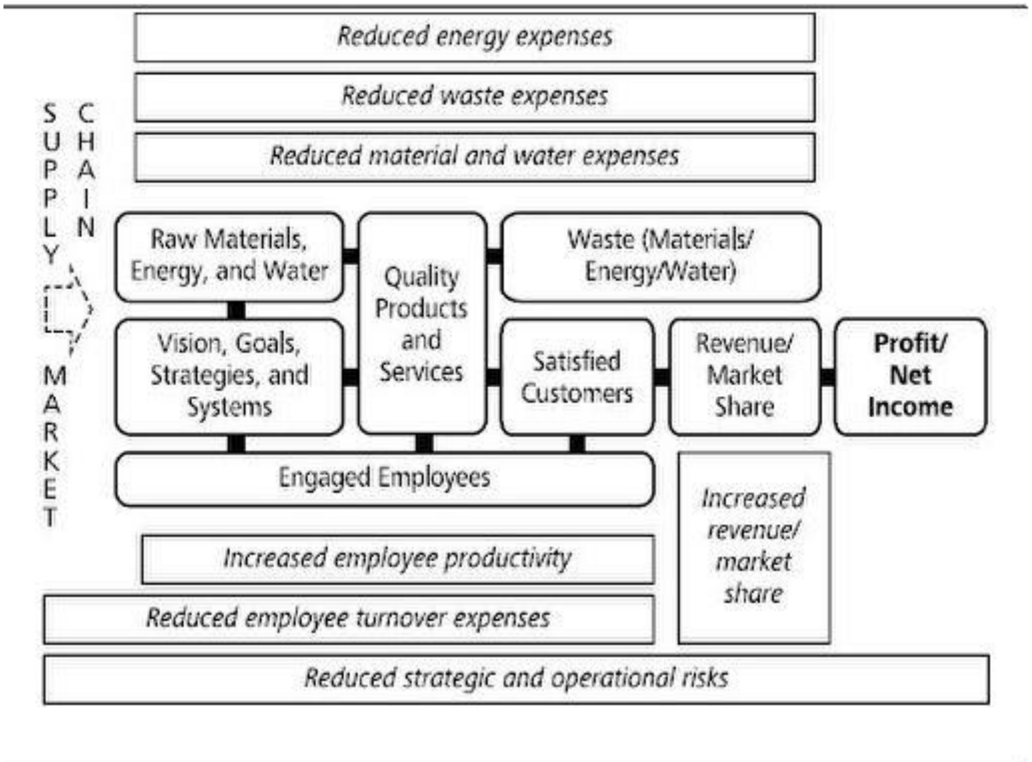

Figure 5: Value chain and sustainability benefits (Willard, Value chain and sustainability benefits, 2010)

Some benefits such as reduced energy, waste, material, and water expenses can be quantified financially- but the financial benefits accrued due to increased employee productivity, employee engagement, customer satisfaction, and reduced strategic and operational risks are more difficult to quantify.

1.4 Risk Management and Sustainability Benefits

Risk management is an integral part of day-to-day activities in the energy industry. Many risks plague the oil and gas industry such as volatile commodity prices, increased health, safety, and environmental pressures resulting from past and recent major accidents negatively impacting environment, industry image, and its social lease. The major risks faced by the oil and gas industry operations other than the above mentioned risks are related to asset damage, business interruption, pollution, injuries to people, and damage to properties. There are also risks of noncompliance and major cost overruns for large construction projects in the oil and gas industry. Yet human and environment safety and health protection remains the number one priority for the oil and gas industry. The Environment, Health, and Safety regulations are not only stringent but also constantly revised to take into consideration technological development and the more extreme conditions in which oil and gas companies operate (Bigliani, 2013).

Willard in his book “The New Sustainability Advantage: Seven Business Case Benefits of a Triple Bottom Line” has categorized risk into four major risks- strategic risks, operational risks, compliance risks, and financial risk. Strategic risks threaten a company’s reputation and may grow to be the most important risk for businesses. A few companies such as General Electric are becoming more aggressive with their suppliers and demanding transparency on the energy, carbon, water, material, and social footprints of not only purchased products but also the supplier’s whole company. Wal-Mart, Proctor and Gamble are leading the way in sustainable supplier selection. The poor reputation of suppliers and customers has turned out to be one major risk to revenue. Willard estimates 5% of company’s annual revenue could be jeopardized by its suppliers’ or customers’ socially and/or environmentally irresponsible behaviors. (Willard, 2012)

Ernst and Young in their “The Ernst & Young Business Risk Report 2010” ranked the top 10 risks for the oil and gas industry (Ernst & Young, 2010). See Figure 6.

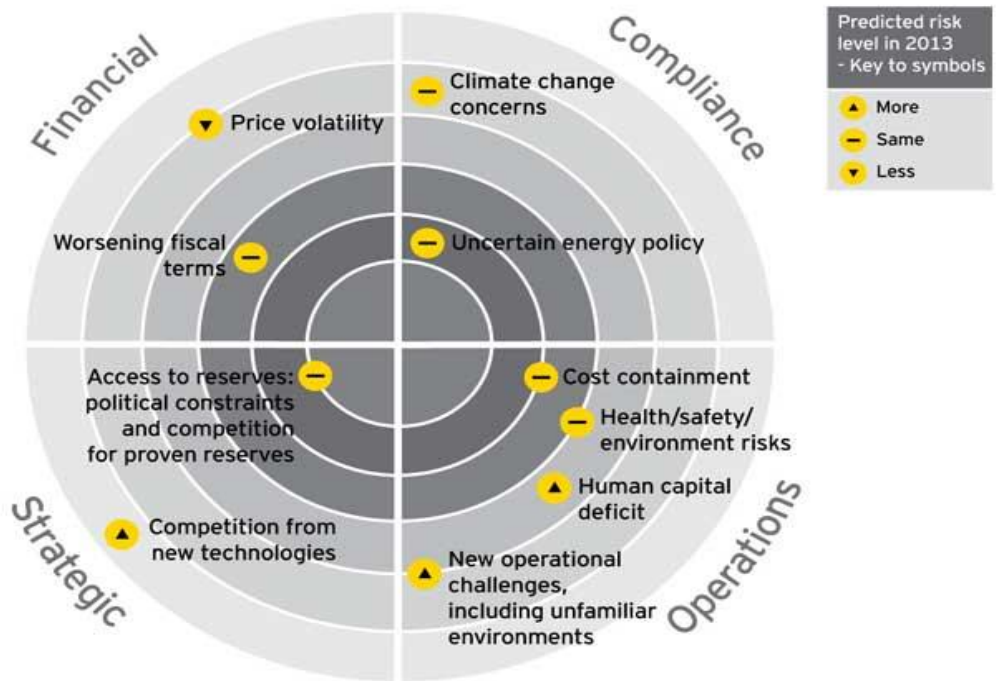

Figure 6: Top Ten Business Risks

2. Problem Definition

We now focus on one of the most effective ways to become sustainable. For a company to be sustainable, it is very important to have a sustainable supply chain. By purchasing products and services from suppliers who use sustainable processes, products, and services, a company can reap significant benefits. Sustainable purchasing is a management process used to acquire goods and services ("products") in a way that gives preference to suppliers that generate positive social and environmental outcomes and that integrates sustainability considerations into product selection so that impacts on society and the environment are minimized throughout the full life cycle of the product. (Sustainability Purchasing Network, BuySmart network, 2007). The benefits of sustainable suppliers include financial, environmental, management, and socio-economic benefits. There are also costs associated with sustainability purchasing such as labor and research to determine which environmental, ethical, and social attributes are most important to that particular industry and life cycle stage, cost and effort of stakeholder engagement, initial higher cost of some products/services, educating external suppliers, educating internal purchasers, cost of conflicting and confusing information among others (Sustainability Purchasing Network, BuySmart network, 2007).

The benefits can be difficult to quantify with a single value metric which is usually some unit of currency. In order to effectively quantify these benefits we use the multi objective decision analysis.

3. Literature Survey

A literature survey was conducted to study existing research on the benefits of sustainability; both quantitative and qualitative. These papers are not specific to the oil and gas industry and have been studied as the benefits are applicable to all kinds of industries including equipment providers and service providers. A literature survey was also conducted to assess the business case benefits of sustainability purchasing and why to choose sustainable suppliers. This research helped us outline the benefits of choosing sustainable suppliers. Papers related to the discussion of problems of integrating sustainable development were also studied to provide a better idea on the construction of the model. Lastly, papers related to decision analysis pertaining to the oil and gas industry were studied to provide better insight into decision making for oil and gas industry. These papers also include supplier selection using a multiple-criteria indicator for sustainable rating for suppliers and studies on different types of sustainability assessment methodologies. See Table 3.

Table 3: Literature Survey

Author	Industry	Focus	Methodology
(Gullo & Haygood, 2010)	All	Business case for benefits of sustainability	Examination of business case with quantifiable measures and less easily measurable assets. Based primarily on qualitative, anecdotal data and interviews, a review of company reports and web sites as well as media articles, books and recent reports from Green Impact, ICF International, and MIT Sloan Management Review
(Sustainability Purchasing Network, BuySmart network, 2007)	All	Business case benefits for sustainability purchasing Outlines financial, management, environmental, and socio-economic benefits of sustainability purchasing Outlines costs and barriers to sustainability purchasing	International literature review of sustainability purchasing business case tools and guides Case study interviews with Canadian sustainability purchasing practitioners and suppliers Feedback from eleven sustainability purchasing practitioners and experts.
(Matos & Jeremy, 2007)	Oil and Gas, and Agricultural Biotechnology	Discussion of problems of integrating sustainable development concerns in the supply chain Framework that addresses deficiencies and implications for practitioners and management theory	Grounded theory approach to explore issues about integrating sustainable development in the supply chain Interview subjects identified through snowball technique Analyzed complexity theory, risk management, and innovation dynamics literature to understand lifecycle assessment applicability

(Sabanov, Pastarus, & Shommet, 2011)	Oil and Gas, Mining	Aim of the study: To elaborate sustainability assessment methodologies suitable for mine closure life cycle stage which allows defining hazardous influences on environment, society, and economic dimensions, and helps solve existing problems	Life cycle assessment, Closure impact assessment, Financial assessment, technological risk assessment, economic viability
(Barata, Quelhas, Costa, Gutierrez, Lameira, & Meirino, 2014)	Oil and Gas	A multiple-criteria based approach to classifying the degree of organizational sustainability to evaluate suppliers of the Brazilian petroleum industry	Elimination Et Choix Traidusaint la Réalité (ELECTRE TRI method)

4. Single and Multi Objective Decision Analysis

Decision analysis is an operations research/management science (OR/MS) technique that is appropriate for modeling decisions with preferences (value, time, and risk), uncertainties about future consequences, and complex alternatives (Parnell, Bresnick, Tani, & Johnson, 2013). A decision is described as irrevocable allocation of resources and the decision analysis practice could either address one or more objectives and the choice of whether to use single or multiple objective decision analysis needs to be taken by the decision maker. If a common value metric can be used to measure all values sought by the decision maker, then single objective decision analysis could be used. In this case, multiple objective decision analysis is more appropriate because not all values can be easily quantified in monetary terms.

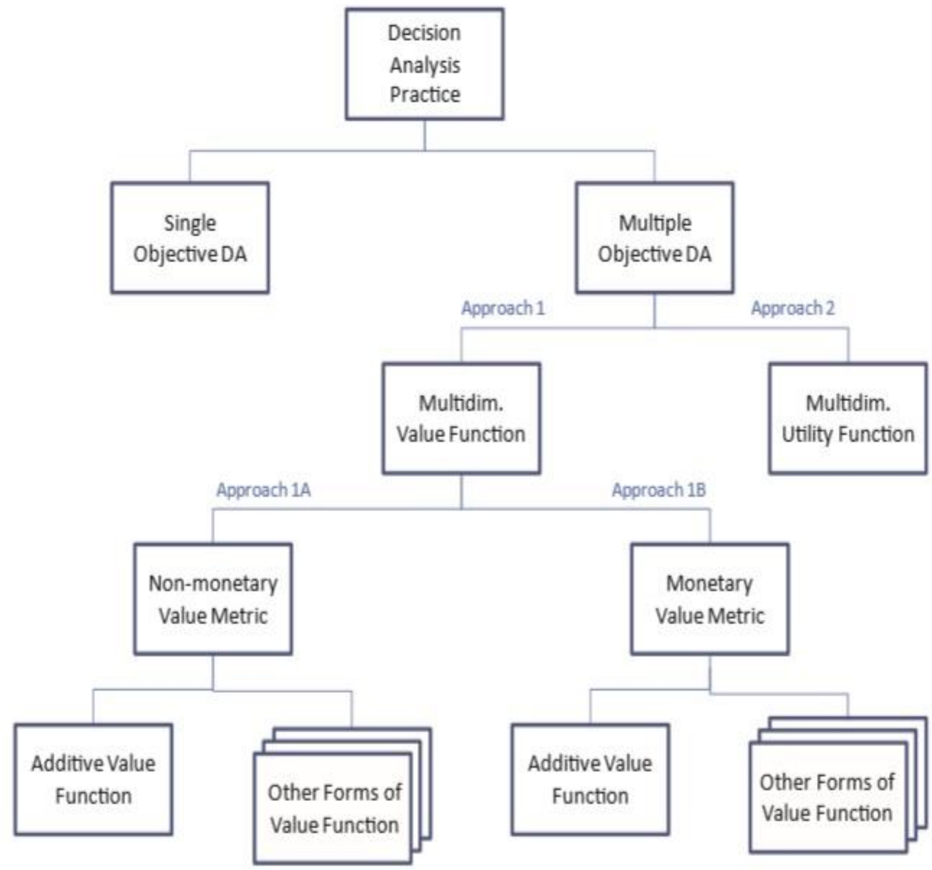

Figure 7: The Taxonomy of Decision Analysis (Parnell, Bresnick, Tani, & Johnson, 2013)

Figure 7 shows the taxonomy of decision analysis and the approach we would take is the multidimensional value function with both monetary and non-monetary value metrics.

4.1 Introduction of Value Hierarchy Model and Supplier Selection Criteria

In order to assess the three components of the triple bottom line, we break them up into three different value hierarchies (environmental, social, and economic) for profit, planet, and people respectively. Functional value hierarchies have been found to be very useful, especially for complex decisions, in identifying functions that create value that the solution must perform.

Then objectives to be achieved for those functions are identified and value measures form the final tier which help measure the objectives.

In order to achieve the purpose of increasing overall value by incorporating sustainability into supplier selection, one of the functions we need to focus on is increasing the environmental value. The value measures selected to achieve the objectives have been chosen from prior research on sustainability criteria.

Table 4 shows the research of different organizations and the environmental factors that improve environmental value and could result in cost savings for the organization. After finalizing the objectives and value measures, we then assigned weights to individual value measures. The last row shows the value measures selected for our model.

Table 4: Environmental criteria selection

Authors	Energy	Resources	Waste	Rating
(International Finance Corporation: World Bank Group, 2012)	Reduce GHG emissions and adverse impacts on environment.	Promote sustainable management of living natural resources.	Reduce generation of hazardous and non-hazardous waste. -Recover and reuse as much waste as possible.	
(Global Reporting Initiative, 2011)	Total direct and indirect GHG emissions by weight	Percentage and total volume of water recycled and reused	Percentage of materials used that can be recycled. Total weight of waste and disposal method.	

(Willard, The New Sustainability Advantage: Seven business case benefits of sustainability, 2012)	Energy used and energy produced.	Ratio of wastewater generated to water treated and reused.	Amount of waste generated to waste recycled.	
(Wal-Mart Stores, Inc., 2015)	Total greenhouse gas emissions in the most recent year measured.	Total water use from facilities that produce products for the buyer company.	Total amount of solid waste generated from facilities that produce products for the buyer.	Certifications for products that are sold to the buyer company. Environmental compliance.
(Barata, Quelhas, Costa, Gutierrez, Lameira, & Meirino, 2014)	Energy efficiency and energy saved	Water treated and reused	Percentage of waste recycles, reused	
Our model	Energy Intensity	Percentage of wastewater generated that can be recycled.	Ratio of waste recycled/reused to waste generated.	Environmental rating

Figure 9 shows the value hierarchy for environmental value where the function "Focus on Environmental Health" is achieved by the four objectives shown in the second tier and the value is measured by the value metrics shown in the third tier.

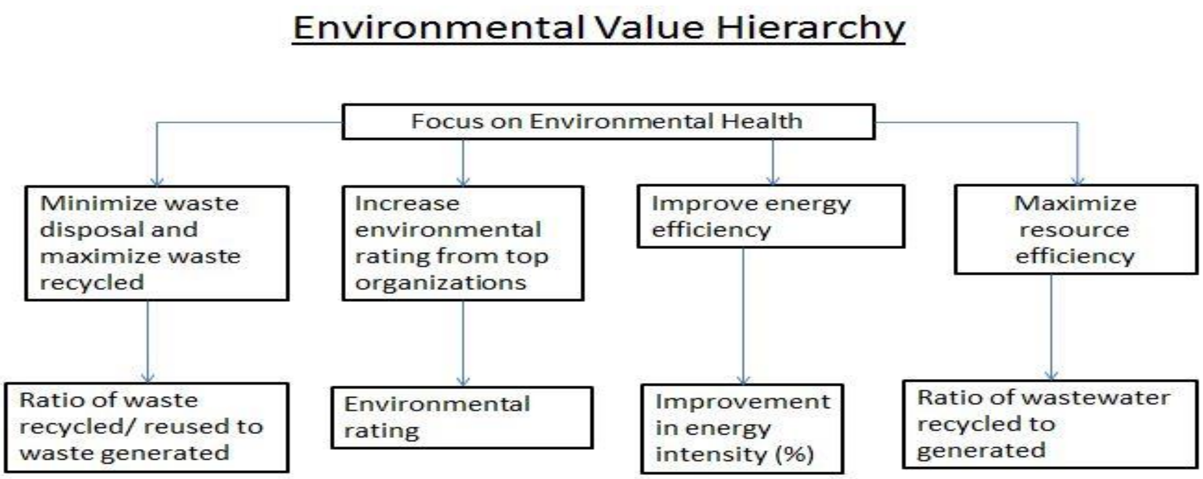

Figure 8: Environmental Value Hierarchy

Table 5 shows the research on social factors that improve social health and we selected four of these that we believe can be measured before the supplier is selected and the ones that are vital in cost savings and in increased social value.

Table 5: Social criteria selection

Authors	Employee health and satisfaction	Service to local community and community health & safety	Contribution to local community	Rating
(Fontes, 2014)	Average rate of health related incidents during the reporting period. Percentage of employees satisfied with job.	Number of adverse impacts on community health and safety identified during the reporting period.	Number of people in community benefiting from capacity building programs during reporting period.	

(International Finance Corporation: World Bank Group, 2012)	Fair treatment, non-discrimination, and promotion of equal opportunity to workers. Identify and evaluate social risks and impacts to workers.	Identify and evaluate social risks and impacts to local communities of project.	Promotion of sustainable development benefits and opportunities for indigenous people	
(United Nations Environment Programme, 2009)	Equal opportunities and social benefits/social security. Number of working hours and fair salary.	Public commitments to sustainability issues.	Contribution to local economic development Community engagement and local employment.	
(Wal-Mart Stores, Inc., 2015)	Social compliance evaluations and documentation of specific corrections and improvements.			Social compliance evaluations and documentation of specific corrections and improvements.
(Barata, Quelhas, Costa, Gutierrez, Lameira, & Meirino, 2014)	Employee satisfaction, health and safety at work, remuneration performance variable	Number of employees involved in programs of support to the society	Ratio of taxes paid by company to city budget	Employee satisfaction
Our model	Percentage of health related absence	Ratio of volunteer hours to number of employees	Total contributions as a percentage of net income	Social rating

Figure 9 shows the social value hierarchy which focuses on improving social health. The value measures to achieve the objectives were selected after studying papers and reports on social guidelines and criteria. We use four value measures that can be known at the time of supplier selection and those which could reduce costs for the organization.

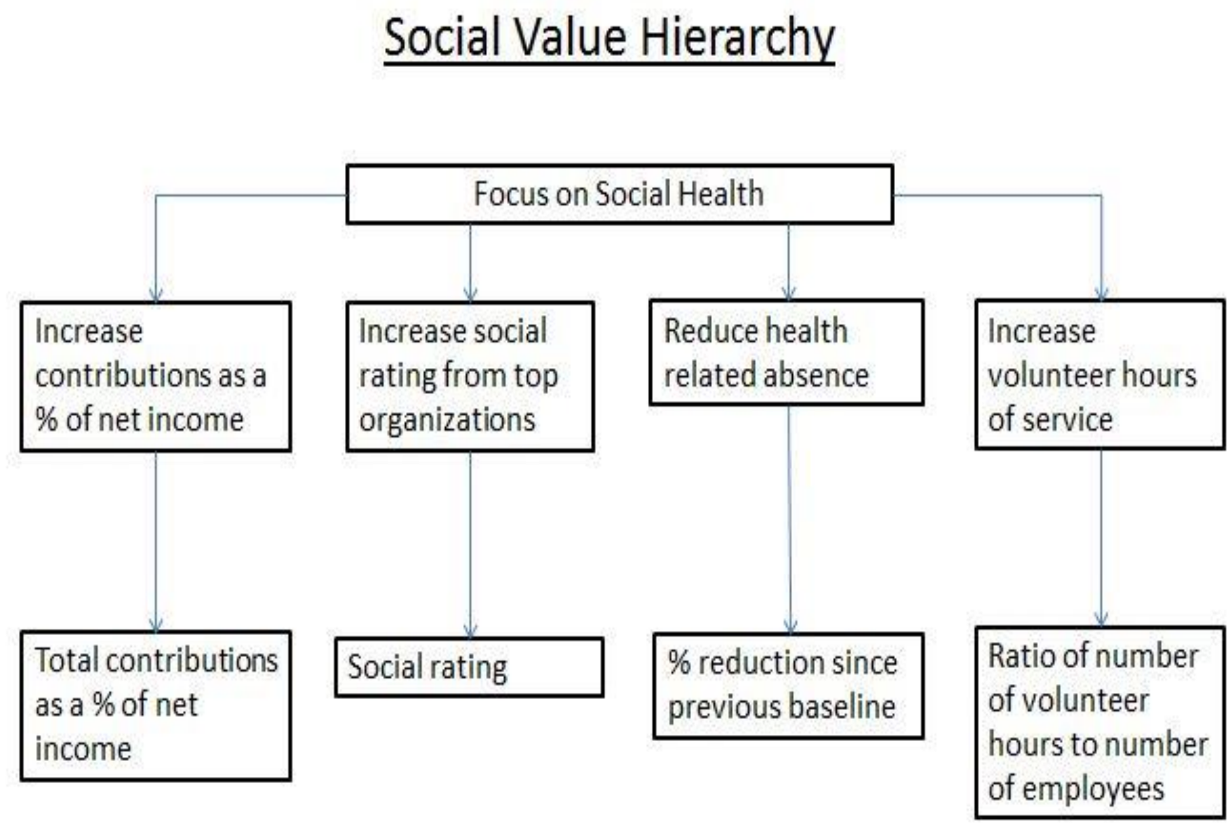

Figure 9: Social Value Hierarchy

4.2 Types of suppliers

To show the difference between a sustainable supplier who focuses on all three bottom lines, i.e, financial, environmental, and social, and other suppliers who focus on one particular bottom line, we chose 5 different suppliers as described in the sections below.

4.2.1 Sustainable supplier

A sustainable supplier is the one who focuses on all three bottom lines instead of just emphasizing the financial bottom line. The purpose of the sustainable supplier is to provide socially responsible products and services that are not only good for the environment but also are beneficial to the buyer for long-term profitability and cost reduction. In the oil and gas industry, especially during the upstream operations of a project lifecycle, reliability is crucial for a supplier, both in terms of quality and timing. A sustainable supplier thrives to manage waste effectively and to reduce the company's carbon footprint and who take their responsibilities towards environmental impact seriously. Such supplier is one of our alternatives that we are comparing with other alternatives.

4.2.2 Social value focused supplier

We defined a social value focused supplier as the one who emphasizes increasing social value and has less focus on environmental and economic bottom lines. The scores of this kind of supplier are high on the social value measures but fall short on the other value measures.

4.2.3 Environmental value focused supplier

An environmental focused supplier is the one who emphasizes increasing environmental value and has less focus on social and economic values. This kind of supplier thrives to be environment friendly and scores high on the environmental value measures compared to the other value measures.

4.2.4 Economic value focused supplier

This kind of a supplier focuses on reduction of costs initially and may provide lower quality products and services at a lower cost compared to the other suppliers. The focus on environmental value and social value are less compared to the other suppliers. In our case, the equipment lease costs are lower for this supplier.

4.2.5 Ideal supplier

We included this supplier to show the ideal supplier a buyer would want to have in the supply chain, one that provides the best value possible on all three bottom lines. This kind of supplier is usually hypothetical and it may not be possible to have such a supplier in the supply chain.

Table 6: Type of Suppliers

Type of Supplier	Social value	Environmental value	Economic value
Sustainable supplier	High	High	High
Social value focused supplier	High	Low	Low
Environmental value focused supplier	Low	High	Low
Economic value focused supplier	Low	Low	High
Ideal supplier	Ideal	Ideal	Ideal

Low and high are comparative to other suppliers and may not be low or high in absolute values.

5. Decision Model and Calculations

Since there are three bottom lines in the TBL, we measure them independently by calculating economic, environmental, and social values independently. The environmental and social values are difficult to quantify using dollars as the unit of measurement. But the cost savings and costs of working with the supplier are measurable in dollars. Hence, we measure the qualitative aspect of environmental and social values using multi objective decision analysis in two different models and the quantitative component of these values such as cost savings, equipment lease costs, and operating costs in a separate economic model.

We then combined the three values onto a chart to enable the decision maker to take better decisions based on his/her preferences and company policies.

5.1 The Three Models

In this thesis, we build a quantitative value model to evaluate the alternatives (suppliers). The quantitative value model is a mathematical model that includes value functions, weights, and mathematical equation to evaluate the alternatives (Parnell, Bresnick, Tani, & Johnson, 2013). For this decision analysis, the mathematical equation we use is the additive value model. We develop a multi objective decision analysis for both environmental value and social value as the objectives we use may not have a common value metric. The objectives to achieve the purpose of higher environmental value are- minimize waste disposal and maximize waste recycled, increase environmental rating from top organizations, improve energy efficiency, maximize resource efficiency. In order to measure these and compare different suppliers we use four value measures- ratio of waste recycled/reused to waste generated, environmental rating, percentage of improvement in energy intensity, percentage of materials used that can be recycled.

We then provide a ‘common currency’ across all measures by assigning a value to scores ranging from 0 to 100. For example, a ratio of 0 for waste recycled/reused to waste generated is given the value 0 which is represented by v(x) and the latter is represented by x. Each company based on its performance can assign these values to different scores. We plot these values on a value function with the values of x on the x-axis and their corresponding v(x) values on the y-axis. These value functions are usually scaled from 0 to 1, 0 to 10, or 0 to 100. We use the scale 0 to 100 for all value measures. Most companies usually have a minimum acceptable level or score and the most desirable score which can then be assigned to different value scores on the y-axis. As the value functions are piecewise linear functions and we used a value function macro, the ‘valuePL’ macro, to return the interpolated value result given an array of x values, denoted by x_i, and corresponding value array, v_i. Each of these value measures and objectives may not hold equal importance for all companies and for all stages of the life cycle. These are denoted by swing weights and the more important a particular value measure is during that stage of the lifecycle, the more weight is assigned to that value measure in distinguishing and selecting a supplier from a set of suppliers. Weights are our relative preference for value measures. (Parnell, Bresnick, Tani, & Johnson, 2013)

We assessed the swing weights using the swing weight matrix after the range has been determined for each value measure. A swing weight is assigned to a value measure and it depends on the measure's range. The swing weights define the trade-offs that the decision maker will make between objectives. These swing weights can be assessed by swinging the score on each value measure from its least preferred level to its most preferred level. The more variation there is among outcomes of a particular objective, the more weight the objective is assigned. In our case, an objective that has high variation among the top rated supplier and the least preferred supplier is given more weight in the supplier selection decision.

These swing weights are non-normalized and denoted by f_i. The weights can be input into the model by the decision maker depending on his preference for the variation and importance of that particular value measure. We then normalize these swing weights and arrive at w_i- the normalized swing weight obtained by:

$$\boxed{w_i = \frac{f_i}{\sum_{i=1}^{n} f_i}}$$

The sum of these normalized swing weights for all value measures must sum up to 1. The normalized swing weights are then multiplied with their respective scores and we obtain the normalized values for each value measure. The sum of all such normalized values is the alterative value for that particular supplier. Hence, we obtained the final alterative environmental values for all suppliers.

$$\boxed{v(x) = \sum_{i=1}^{n} w_i v_i (x_i)}$$

A similar calculation was done to obtain alterative social values for individual suppliers by normalizing values for all value measures. The social and environmental values are later plotted on a chart with economic value on the x-axis and environmental value on the y-axis and the area of the bubble representing the social value.

5.2 The Net Present Cost of the Supplier

We took the five illustrative suppliers mentioned in the previous section to show the difference between suppliers who specialize in sustainability and focus on triple bottom and compare with suppliers who focus on just one triple bottom line. We calculated the net present cost (NPC) to work with a supplier and plotted the values and NPC onto a chart.

The operating costs are assumed to increase at approximately 2-3% per year. This is a notional number taken from statistics by the U.S. Energy Information Administration (U.S. Department of Energy, 2010). The equipment lease costs, operating costs have all been taken from the same source. The notional costs for leasing equipment during the production phase of the upstream operations of oil and gas in 2000, 4000, 8000, and 12000 foot wells have been used for calculation in the model. These costs have been aggregated for all depths, areas, and production rates within the United States. The average operating costs per year have been assumed for 10 wells.

The savings in energy and waste cleanup costs during and after the upstream operations have also been considered as important parameters and subtracted from the lease equipment and operating costs to give the total costs for an average oil and gas project lifecycle which is assumed to be 30 years. These waste cleanup savings have been taken at approximately 3-5%, a number close to the reduced waste expenses percentage from a section of Willard’s book

(Willard, Benefit 3: Reduced Waste Expenses, 2012). The net present costs have been calculated using the discount rate of 20% which is in the range of discount rates typically used for oil and gas properties (Texas Comptroller of Public Accounts, 2014) often used for oil and gas industry. These values have all been entered into an input table (Parnell, Bresnick, Tani, & Johnson, 2013). The ranges of uncertainties in the input variables are specified by entries in the three columns labeled “Low”, ”Base”, and “High”, usually meaning 10th, 50th, and 90th percentile. We have used the data from U.S. Energy Information Administration (U.S. Department of Energy, 2010) as “Base” and used 90% of that value for “Low” and 110% of the “Base” for “High”. These three values of “Low”, “Base”, and “High” have been denoted by an Index with “1 for low”, “2 for base” and “3 for high”. The column “In use” shows the value that is currently being used for calculations. This structure for the input table has been used to perform “what if” calculations easily by changing the index number of an input variable.

The tables below show the input table we created to perform calculations of net present costs for suppliers: sustainable supplier, social value focused supplier, environmental value focused supplier, economic value focused supplier, and ideal supplier, and with the entering of data in the base column of the parameters, we obtained the net present costs of all 5 suppliers.

Table 7: Example of Input Table

Parameters	Units	Name	In use	Index	Low	Base	High
Equipment lease costs	Dollars	Sustainable supplier	$16,602,200	2	$14,941,980	$16,602,200	$18,262,420

Table 7 shows an example of one of the parameters used to calculate the net present cost for low base and high. The setting of the input variable used in the model calculations can be used from low, base, or high and is shown in the column labeled “In use” and this can be changed by changing the number in the index from 1, 2, or 3.

Table 8: Example of Total Cost Calculations

Year	Costs with sustainable supplier	Savings in energy and waste disposal costs	Total costs for sustainable supplier
1	$ 16,602,200	$ 0	$ 16,602,200
2	$ 4,000,000	$ 1,000,000	$ 3,000,000

Table 8 shows an example of the total cost calculations for the sustainable supplier. The first column is the year and we assumed a typical oil and gas project lifecycle, i.e., 30 years. The first row of the second column shows the equipment lease costs for the first year and the second row shows the operating costs beginning in the second year and running through the 30th year. The third column shows the savings in energy and waste disposal/cleanup costs which begin after the operations begin. The difference of the costs incurred and costs saved is the total cost of the supplier for that year.

Table 9 shows the net present costs for all suppliers calculated using the NPV function and using a discount rate usually used for oil and gas properties (Texas Comptroller of Public Accounts, 2014) which we assumed ranges from 18% to 22% with 18% being low, 20% base, and 22% being high. In Table 9 we used index 2, i.e., a discount rate of 20%.

Table 9: Net Present Costs for all Suppliers

Net Present Cost of sustainable supplier	$ 33,080,773
Net Present Cost of social value focused supplier	$ 40,929,963
Net Present Cost of environmental value focused supplier	$ 36,714,846

Net Present Cost of economic value focused supplier	$ 38,552,693
Net Present Cost of ideal supplier	$ 22,947,813

With the bases entered for all parameters we obtained the net present costs. We then performed sensitivity analyses for different parameters to see how a company's willingness to focus on sustainability could change.

Figure 10 shows the sensitivity to discount rate and we found that with increase in discount rate, the willingness to focus on performing sustainable actions increases as the difference between a sustainable supplier and the other suppliers reduces and at a discount rate of close to 40% we can see that the social value focused and the environmental value focused suppliers which are less sustainable compared to the sustainable supplier have almost equal net present costs.

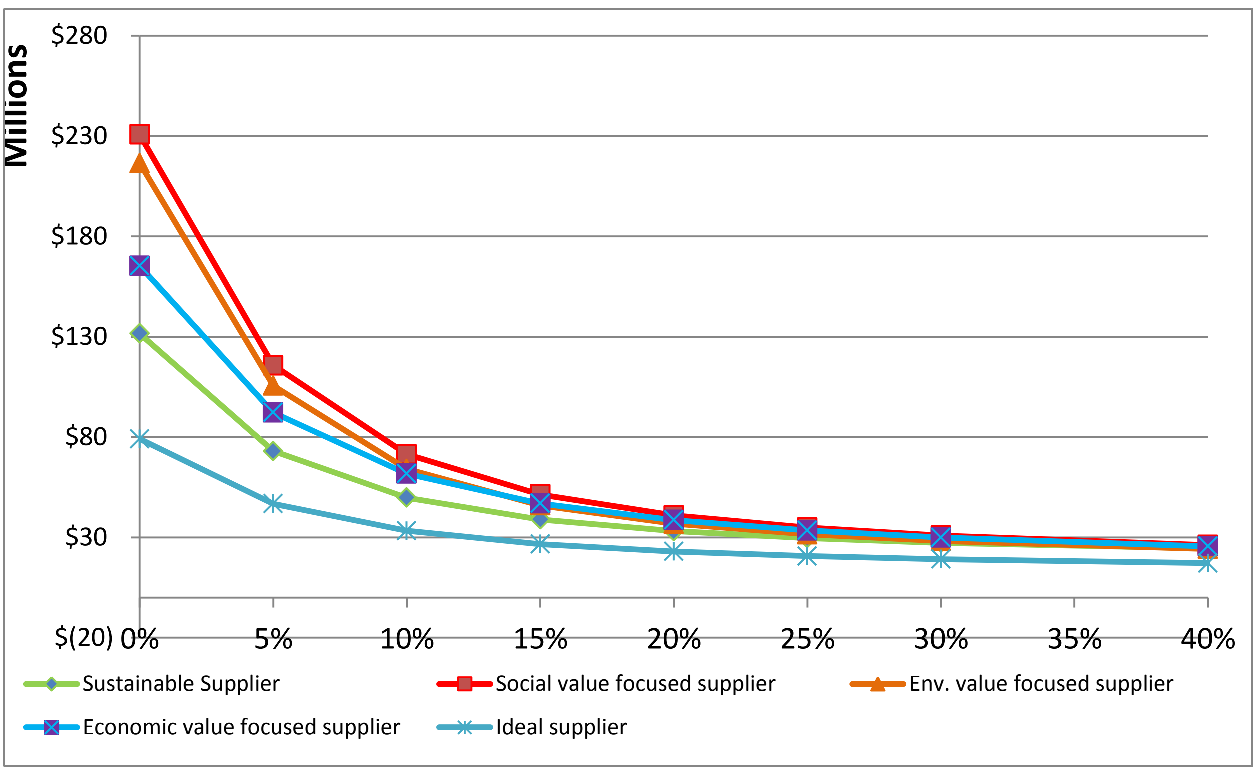

Figure 10: Sensitivity to Discount Rate

Figure 11 shows the total costs for all suppliers for a 30 year project lifecycle. We can see that the initial costs for the sustainable supplier are high compared to the other suppliers but over the time period of 30 years we see that the savings increase for the sustainable supplier and total costs decrease, which is expected as with a good quality supplier energy efficiency increases and less waste is produced and most of the waste is recycled resulting in lesser operating costs.

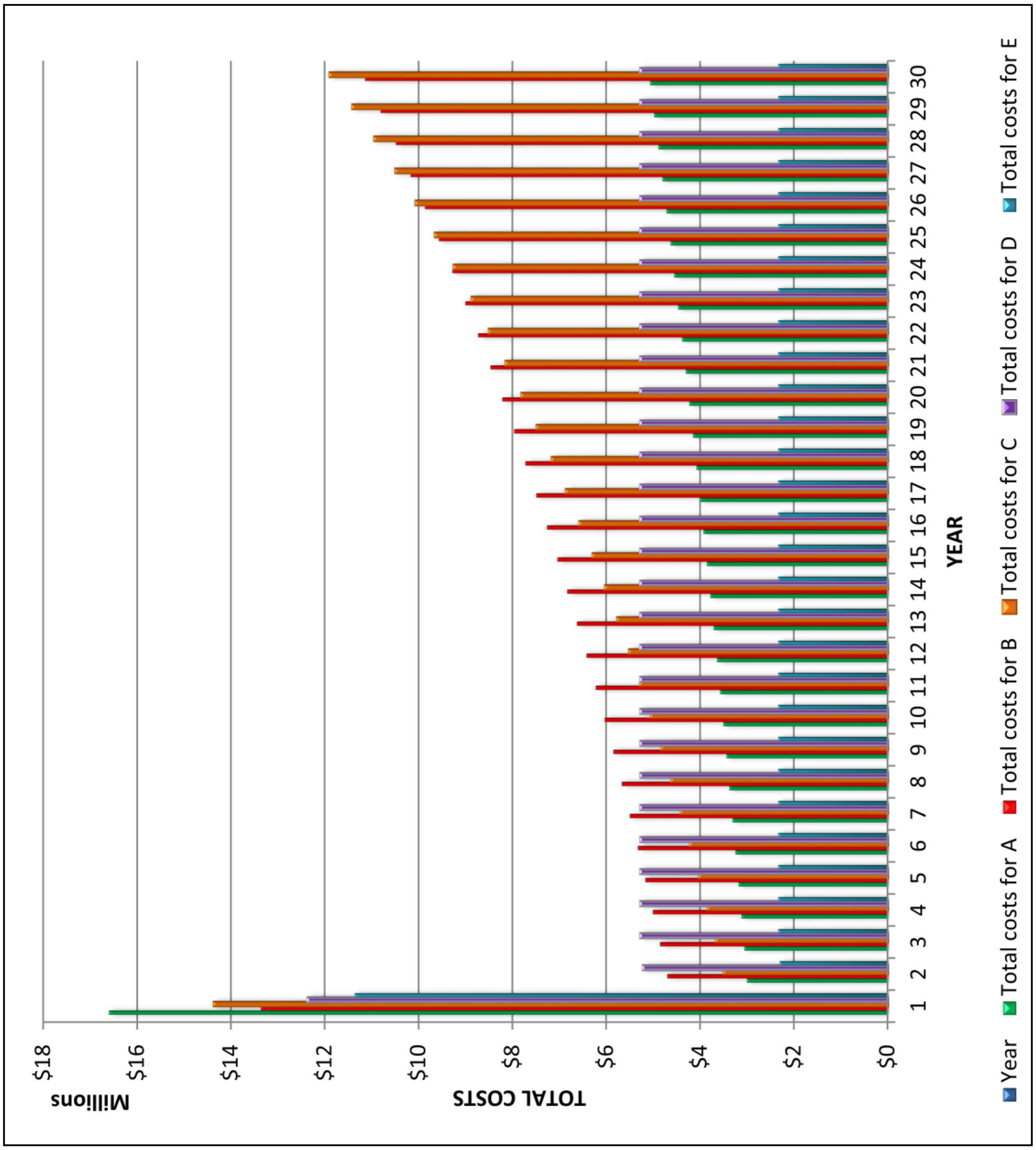

Figure 11: Total costs for 30 years

In Figure 11 Total costs for A, B, C, D, and E refer to total costs for the sustainable supplier, social value focused supplier, environmental value focused supplier, economic value focused supplier, ideal supplier.

5.3 Environmental Value

Table 10 shows the function, objectives, value measures, and value functions used for calculating environmental value. The objectives of minimizing waste disposal and maximize waste recycled, and improve energy efficiency are qualitative measures of the waste recycled and energy saved and the costs associated with it are used to compute the net present cost of the supplier.

Table 10: Environmental value single-dimensional value functions

Function	Objectives	Value measure	Minimum acceptable level	Ideal Level	Curve shape	Rationale
Focus on Environmental Value	Minimize waste disposal and maximize waste recycled	Ratio of waste recycled to waste generated	0.2	1	S-shape curve	Value is likely to increase with more than half waste being recycled
	Increase environmental rating from top organizations	Environmental rating	40	100	S-shape curve	Minimum rating desired is likely to start from 40
	Improve energy efficiency	Improvement in energy intensity (%)	0%	100%	Concave	Improvement in energy intensity has good value starting from about 30%
	Maximize resource efficiency	Ratio of wastewater recycled to generated	0	1	Linear	Value is likely to increase

A high value for the ratio of waste recycled/reused to waste generated would mean less waste cleanup costs at the end of the project lifecycle and is characteristic of a sustainable supplier. This cost reduction also reflects in the purchasing cycle of the material. The objective “improve energy efficiency” was used as a criterion as it means better usage of energy and cost reduction as a result. The value measure improvement in energy intensity shows the energy efficiency of the company and the units for energy intensity are MMBtu/Revenue. The lower the energy intensity, the higher the energy efficiency (U.S. Department of Energy, 2015)

The objective “ratio of wastewater recycled to wastewater generated” is an indicator of efficient use of resources and that leads to cost savings as well as conserving natural resources. The objective “increase environmental rating” was chosen as the value measure “environmental rating” encompasses all factors considered while rating a company. These ratings could be taken from any top organization and one of the sources used to obtain such ratings is www.climatecounts.org. This is scored on a scale of 100 and an example of the rating is 80 for General Electric which is one of the suppliers of equipment for oil and gas companies (Climatecounts, 2015)

Table 11: Scores on each Environmental Value Measure

Supplier	Ratio of waste recycled to waste generated	Environmental rating	Improvement in energy intensity (%)	Ratio of wastewater recycled to generated
Sustainable supplier	0.79	90	60	0.62
Social value focused supplier	0.6	60	40	0.30
Environmental value focused supplier	0.75	80	55	0.60

Economic value focused supplier	0.65	65	50	0.50
Ideal supplier	1	100	100	1

Table 11 shows the scores entered for all suppliers and we can see that the environmental value focused supplier has higher scores compared to the social value focused and economic value focused suppliers. The environmental value focused supplier thrives to reduce waste as much as possible and of the waste generated the supplier tries to recycle/reuse as much waste as possible. In order to reduce GHG emissions, the supplier shows a significant improvement in energy efficiency and reduces energy intensity.

Table 12: Single-Dimensional Value Calculations for each Value Measure

Supplier	Ratio of waste recycled to waste generated	Environmental rating	Improvement in energy intensity (%)	Ratio of wastewater recycled to generated
Sustainable supplier	89	90	86	63
Social value focused supplier	50	50	73	25
Environmental value focused supplier	80	80	84	60
Economic value focused supplier	60	55	82	50
Ideal supplier	100	100	100	100

Table 12 shows the values of the scores entered and using a “common currency” for all value measures. These values were then normalized with the weights attached to each value measure as shown in the swing weight matrix Table 13. The column f_i is the weight assigned to that particular value measure and w_i is the column that shows the normalized weights. The top row defines the value measure importance scale and the left side defines the impact of the range of value measure (Parnell, Bresnick, Tani, & Johnson, 2013)

Table 13: Swing Weight Matrix for Environmental Value

	Significant impact on supplier selection	f_i	w_i	Less impact on overall value when ignored	f_i	w_i
Major variation in suppliers	Improve energy efficiency	100	0.37	Minimize waste disposal and maximize waste recycled	70	0.26
Minor variation in suppliers	Maximize resource efficiency	60	0.22	Increase environmental rating from top organizations	40	0.15

Table 14 shows the normalized swing weight calculated using the formula mentioned in earlier section. Energy efficiency can save more costs and we believe it is of highest importance as the energy savings run throughout the project lifecycle and significant cost savings in energy can reduce overall costs to a large extent. Hence, it is placed in the top left corner of the swing weight matrix. It also can have a large variation between the best supplier and the least preferred supplier. Environmental rating is placed in the bottom right corner of the matrix as it includes all other factors which may or may not reflect in direct cost savings and the variation among suppliers is usually not high.

Table 14: Normalized Swing Weight for Environmental Value

	Ratio of waste recycled to waste generated	Environmental rating	Improvement in energy intensity (%)	Ratio of wastewater recycled to generated	Total
Normalized swing weight, wi	0.26	0.15	0.37	0.22	1

Table 15 shows the normalized scores and total value calculations used for the model. We can see that the sustainable supplier scores more than the other suppliers and the environmental value focused supplier's score is closer to the sustainable supplier. First, the swing weight is multiplied by each measure score and then these weighted values for the four value measures are added to obtain the total value for each alternative.

Table 15: Normalized Weighted Values for Environmental Value

Supplier	Ratio of waste recycled to waste generated	Environmental rating	Improvement in energy intensity (%)	Ratio of wastewater recycled to generated	Total value
Sustainable supplier	23	13	32	14	82
Social value focused supplier	13	7	27	6	53
Environmental value focused supplier	21	12	31	13	77
Economic value focused supplier	16	8	30	11	65
Ideal supplier	26	15	37	22	100

The calculations have been done as mentioned earlier in this section. The value component chart shown in Figure 12 was obtained after entering notional data for the value measures and after normalized scores were calculated.

The value component chart was generated after entering values for all parameters and for all suppliers. We showed the difference between the four kinds of suppliers and the sustainable supplier. In Figure 12 we can see that the environmental value focused supplier performs better compared to the social value focused and economic value focused suppliers and this could help the decision maker take better decisions on which kind of supplier to choose depending on the policies of the company and/or the lifecycle stage of the project.

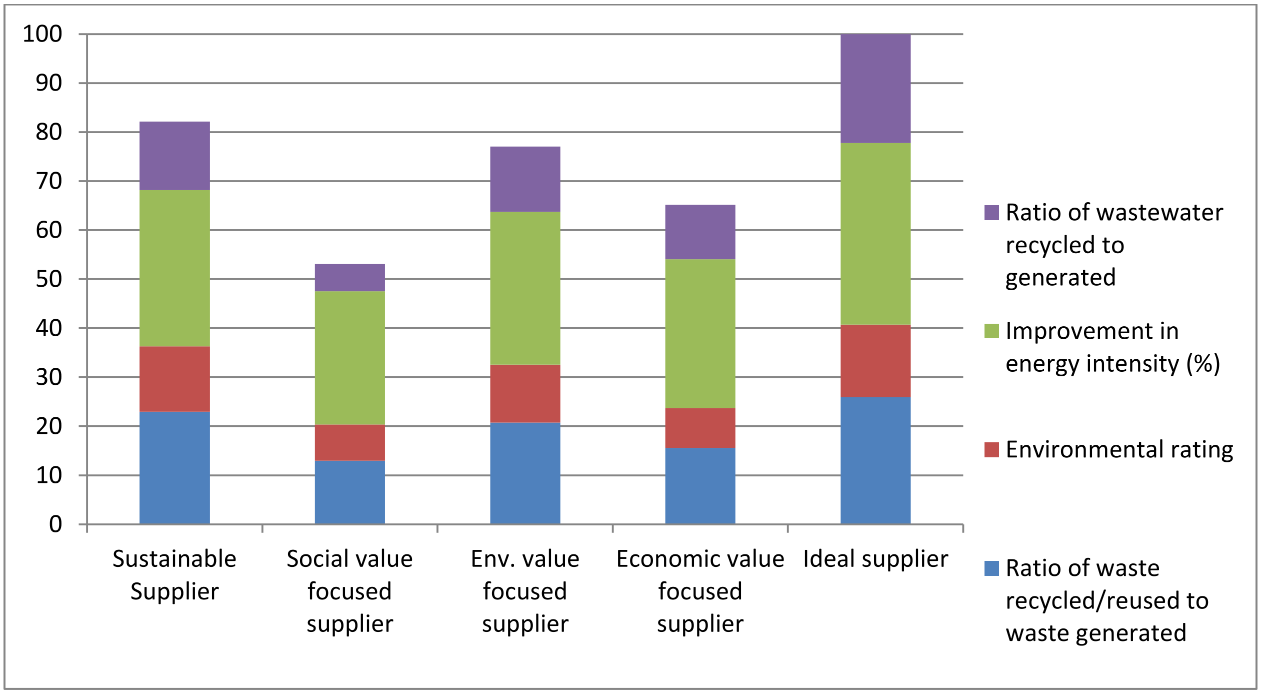

Figure 12: Value Component Chart for Environmental Value

5.4 Social Value

Table 16 shows the function, objectives, value measure, and rationale for the curve shape used for the value functions. The value functions were developed after considering the average low for each value measure and using that as minimum acceptable level and the best possible score for the ideal level. For example, the social rating value function has an S-shape curve as the minimum acceptable score is usually upwards of 40 and achieving scores of around 60 requires less effort on improving social value.

Table 16: Social value single dimensional value functions

Function	Objectives	Value measure	Minimum acceptable level	Ideal Level	Curve shape	Rationale
Focus on Social Value	Increase contributions as a percentage of net income	Total contributions as a percentage of net income	0	3%	Linear	Value is likely to increase linearly
	Increase social rating from top organizations	Social rating	40	100	S-shape curve	Minimum rating desired is likely to start from 40
	Reduce health related absence	Percentage of health related absence (%)	20%	0%	Concave	Less health related absence is more likely to be preferred
	Ratio of volunteer hours to number of employees	Ratio of volunteer hours to number of employees	0	10	Linear	Value is likely to increase linearly

The value function for the first value measure is likely to increase linearly as even a 0.5% contribution has good value and the value increases linearly. The value function for health related absence is likely to have a concave shape as the lower the score the better it is for the supplier and the buyer as it directly relates to the productivity of the company. The fourth value measure corresponds to the service to the local community and it is more likely to increase linearly.

Table 17: Scores for Social Value Measures

Supplier	Total contributions as a % of net income	Social rating	Percentage of health related absence	Ratio of volunteer hours to number of employees
Sustainable supplier	1.64%	90	5%	3.9
Social value focused supplier	1.5%	80	8%	4.0
Environmental value focused supplier	0.80%	67	12%	3.0
Economic value focused supplier	0.50%	65	10%	3.5
Ideal supplier	3%	100	0%	10.0

Table 17 shows the scores for each supplier and we can see that the social value focused supplier performs better in fulfilling its social objectives compared to the other suppliers except the sustainable supplier.

Table 18: Single-Dimensional Value Calculations for Social Value Measures

Supplier	Total contributions as a % of net income	Social rating	Percentage of health related absence	Ratio of volunteer hours to number of employees
Sustainable supplier	83	90	90	68
Social value focused supplier	80	80	78	70
Environmental value focused supplier	52	48	50	50
Economic value focused supplier	40	40	70	60
Ideal supplier	100	100	100	100

Table 18 shows the single dimensional value calculations for each value measure.

Table 19: Swing Weight Matrix for Social Value

	Significant impact on supplier selection	f_i	w_i	Less impact on overall value when ignored	f_i	w_i
Major variation in suppliers	Reduce health related absence	100	0.45	Increase contributions as a percentage of net income	40	0.18
Minor variation in suppliers	Increase service to community	50	0.23	Increase social rating from top organizations	30	0.14

The column f_i in Table 19 shows the weights for each value measure and the column w_i shows the weighted or normalized weights which sum to 1 as shown in Table 20.

Table 20: Normalized Swing Weights for Social Value

	Total contributions as a % of net income	Social rating	Percentage of health related absence	Ratio of volunteer hours to number of employees	Total
Normalized swing weight, wi	0.18	0.14	0.45	0.23	1

Table 21 shows the normalized or weighted values and total value calculations used for the model calculated using the additive value model and we can see that the social value focused supplier has a score of 77 compared to the sustainable supplier which has a score of 84 and the other lower scoring alternatives are also shown.

Table 21: Weighted Value Calculations and for Social Value

Supplier	Total contributions as a % of net income	Social rating	Percentage of health related absence	Ratio of volunteer hours to number of employees	Total value
Sustainable supplier	15	12	41	15	84

Social value focused supplier	15	11	35	16	77
Environmental value focused supplier	9	7	23	11	50
Economic value focused supplier	7	5	32	14	58
Ideal supplier	18	14	45	23	100

Figure 13 shows the social value component chart with the ideal alternative always shown for reference. This chart shows the contribution of each value measure which makes it easier for the decision maker.

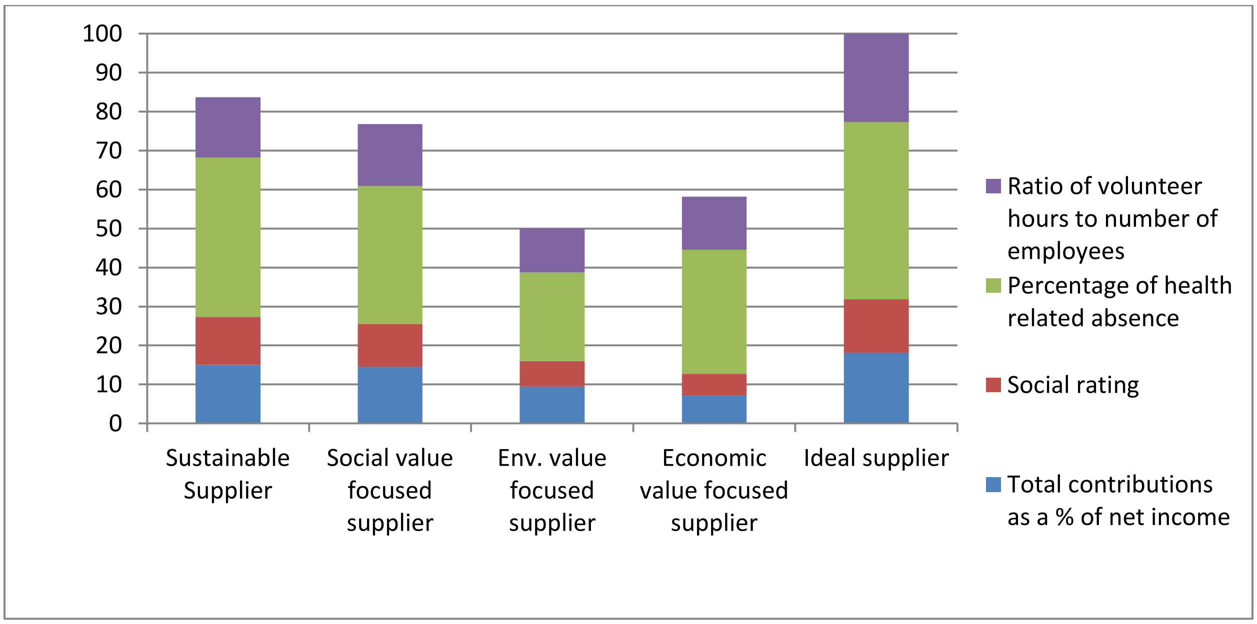

Figure 13: Social Value Component Chart

5.5 Total Value

Figure 14 shows the total value plotted against the net present costs of each supplier. The costs are plotted on the X-axis and the environmental value on the Y-axis. The size of the bubble represents the social value. From the chart, we can see that the green bubble represents the sustainable supplier and is of higher value for a lower net present cost and is obviously the better choice compared to the red, orange, and purple bubbles which represent social, environmental, and economic value focused suppliers.

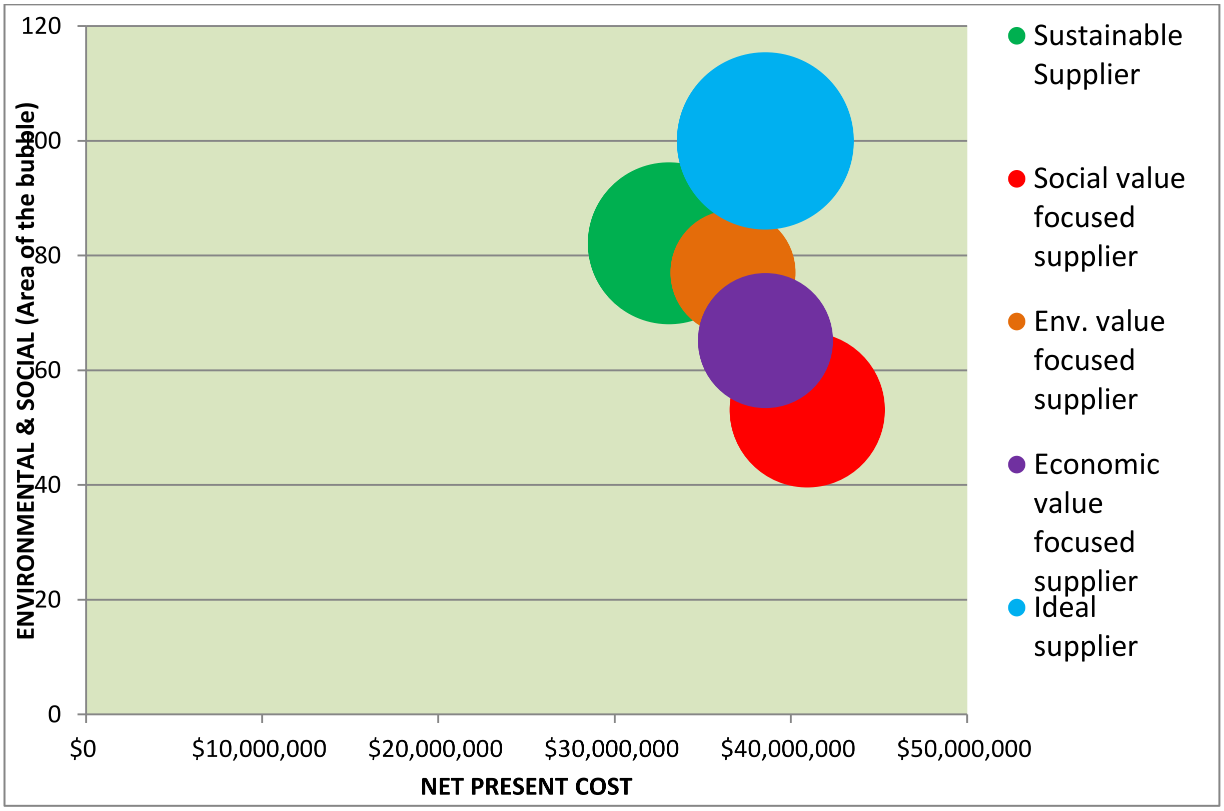

Figure 14: Total Value Bubble Chart

The total value chart brings together the quantitative and qualitative aspects of environmental value as the easily quantifiable dollar figure for the savings in energy costs and waste cleanup costs are embedded into the net present cost and the qualitative value which is not easily quantifiable is represented on the y-axis.

6. Conclusions and Future Research

The bubble chart shows that the sustainable supplier who focuses on all three bottom lines performs better over the life of an oil and gas project. Other benefits of higher social value might include increased productivity of the employees which could reduce costs of services for the company and provide additional benefits. Additional benefits specific to the equipment or services could also be added to the model to make it suit the needs of the organization using it or the decision maker. Few of the benefits include reliability, reduced cost of risk of lost productivity in case of malfunctioning equipment, time of delivery for spare parts and so on. The costs can be assessed with proper risk assessment and cost analysis for such scenarios and depends on the decision maker. This decision model requires the involvement of the decision maker to assess the importance and value of each parameter in order to assign weights in the swing weight matrix. This decision is based on the discretion of the decision maker and can vary from company to company and person to person. There is scope for future research in the selection of criteria specific to the needs of the company and other criteria could be more relevant to suit the vision of the organization. This model could also be used to assess existing suppliers and assess their environmental and social values.

Other social and environmental benefits such as reduction in hiring expenses and increased productivity due to low health related absence could be added to the economic value calculations in the model. The social and environmental value measures could be tailored to the decision model and stakeholder preferences. This model could be enhanced to incorporate other stages of the project lifecycle including midstream and downstream operations. The model could be extended to include benefits of sustainability from the supplier's perspective which could transform into a "shared-benefits" model.

Bibliography

Brundtland Commission Report. (1987). *Our Common Future.* Oxford University Press.

Bigliani, R. (2013). *Reducing Risk in Oil and Gas Operations.* IDC Energy Insights.

Blackmon, D. (2014, February 20). *Energy: Forbes*. Retrieved March 3, 2015, from Forbes website: http://www.forbes.com/sites/davidblackmon/2014/02/20/oil-gas-boom-2014-jobs-economic-growth-and-security/

Chevron Corporation. (2013). *Annual Report.* San Ramon, US: Chevron Corporation.

Climatecounts. (2015). *Climatecounts: Company scorecard*. Retrieved April 5, 2015, from Climatecounts Web site: http://www.climatecounts.org/scorecard_score.php?co=22

Cliq Energy Website. (2015). *FAQ Sheets: Cliq Energy*. Retrieved March 6, 2015, from Cliq Energy Website: http://www.cliqenergy.com/faq_sheets.php

Dow Jones Sustainability Indices. (2014). *Corporate Sustainability*. Retrieved January 26, 2015, from Sustainability Indices Web site: http://www.sustainability-indices.com/sustainability-assessment/corporate-sustainability.jsp

Energy Business Review. (2012, November 1). *Drilling and Production, Energy Business Review*. Retrieved February 25, 2015, from Energy Business Review Web site: http://drillingandproduction.energy-business-review.com/news/chevron-selects-ge-for-165m-production-equipments-contract-011112

Energy Digital. (2012). Top Risks Facing the Oil & Gas Industry. *Energy Digital*.

Energy Information Administration. (2014). *Annual Energy Outlook 2014.* Washington, DC: Office of Integrated and International Energy Analysis.

Ernst & Young. (2010). *The Ernst & Young Business Risk Report 2010.* Ernst & Young.

Ernst & Young. (2010). *Turn risk and opportunities into results: Oil and Gas - Top 10 risks.* Ernst & Young.

Fontes, J. (2014). *Handbook for Product Social Impact Assessment: Roundtable for Product Social Metrics.* Amersfoort: PRe Sustainability.

Global Reporting Initiative. (2011). *Sustainability Reporting Guidelines.* Amsterdam: Global Reporting Initiative.

Gullo, K., & Haygood, L. (2010). *The Business case for Environmental and Sustainability Employee Education.* Washington, DC: National Environmental Education Foundation.

International Finance Corporation: World Bank Group. (2012, January 1). *Performance Standards on Environmental and Social Sustainability.* Retrieved March 22, 2015, from International Finance Corporation Website: http://www.ifc.org/wps/wcm/connect/115482804a0255db96fbffd1a5d13d27/PS_English_2012_Full-Document.pdf?MOD=AJPERES

Matos, S., & Jeremy, H. (2007). Integrating Sustainable Development in the Supply Chain: The case of life cycle assessment in oil and gas and agricultural biotechnology. *Journal of Operations Management*.

Oladunjoye, S., Price, R., Rahman, N., & Wells, J. (2012). Transfer pricing: Transfer pricing in the oil and gas sector: A primer. *International Tax Review*.

Parnell, G., Bresnick, T., Tani, S., & Johnson, E. (2013). *Handbook of Decision Analysis.* New Jersey: John Wiley & Sons Inc.

PetroStrategies Inc. (2015, February 19). *Learning Center: Oil and Gas Value Chains.* Retrieved March 3, 2015, from PetroStrategies Website: http://www.petrostrategies.org/Learning_Center/oil_and_gas_value_chains.htm

Quek, A. (2012, January 6). Shell Chooses Parker Hannifin as a Supplier of Instrumentation Products. *Control Engineering Asia*.

Sabanov, S., Pastarus, J.-R., & Shommet, J. (2011). Sustainability Assessment Methods in Oil Shale Mine Closure. *8th International Scientific and Practical Conference, Volume 1.* Tallinn: 8th International Scientific and Practical Conference.

Slaper, T. F., & Hall, T. J. (2011). The Triple Bottom Line: What Is It and How Does It Work? *Indiana Business Review*, pp. 1-5.

Smith, J. (2014, January 22). *Leadership: The World's Most Sustainable Companies of 2014*. Retrieved March 10, 2015, from Forbes Website: http://www.forbes.com/sites/jacquelynsmith/2014/01/22/the-worlds-most-sustainable-companies-of-2014/

Spears & Associates. (2014). *Oilfield Market Report.* Tulsa: Spears & Associates.

Spears & Associates. (2014). *Oilfield Market Report.* Tulsa: Spears & Associates.

SustainAbility. (2010). *History: Sustainability*. Retrieved March 4, 2015, from Sustainability Website: http://www.sustainability.com/history

SustainAbility. (2010). *sustainability*. Retrieved January 26, 2015, from sustainability: http://www.sustainability.com/sustainability

Sustainability Purchasing Network, BuySmart network. (2007). *Guide to the Business Case and Benefits of Sustainability Purchasing.* Vacouver: Sustainability Purchasing Network.

Texas Comptroller of Public Accounts. (2014). *2014 Property Value Study: Discount Rate Range for Oil and Gas Properties.* Austin: Texas Comptroller of Public Accounts: Publication #96-1166.

U.S. Department of Energy. (2010). *Oil and Gas Lease Equipment and Operating Costs 1994 Through 2009.* Washington, DC: U.S. Energy Information Administration.

U.S. Department of Energy. (2015, March 3). *Efficiency vs Intensity*. Retrieved April 5, 2015, from U.S. Department of Energy: Energy Efficiency and Renewable Energy: http://www1.eere.energy.gov/analysis/eii_efficiency_intensity.html

United Nations Environment Programme. (2009). *Guidelines for Social Life Cycle Assessment of Products.* Druk in de weer: United Nations Environment Programme.

United States Department of Labor: Bureau of Labor Statistics. (2015). *Industries at a Glance: Oil and Gas Extraction: NAICS 211.* Washington, DC: Bureau of Labor Statistics.

Wal-Mart Stores, Inc. (2015). Supplier Sustainability Assessment. *Supplier Sustainability Assessment*. Bentonville, Arkansas, United States of America: Wal-Mart.

Willard, B. (2010, July 20). *Sustainability models: Sustainability Advantage*. Retrieved March 6, 2015, from Sustainability Advantage Website: http://sustainabilityadvantage.com/2010/07/20/3-sustainability-models/

Willard, B. (2010). *Value chain and sustainability benefits.* Gabriola Island: New Society Publishers.

Willard, B. (2012). Benefit 3: Reduced Waste Expenses. In B. Willard, *The New Sustainability Advantage: Seven Business Case Benefits of Triple Bottom Line* (pp. 65-75). Gabriola Island: New Society Publishers.

Willard, B. (2012). *The New Sustainability Advantage: Seven Business Case Benefits of a Triple Bottom Line.* Gabriola Island: New Society Publishers.

Willard, B. (2012). *The New Sustainability Advantage: Seven Business Case Benefits of a Triple Bottom Line.* Gabriola Island: New Society Publishers.

Willard, B. (2012). *The New Sustainability Advantage: Seven business case benefits of sustainability.* Gabriola Island: New Society Publishers.