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Incorporating Environmental and Social Factors into Decision-making of an Oil and Gas Industry to Improve Sustainability

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Abstract

The energy industry (including the oil and gas industry) is facing unparalleled scrutiny and demands from stakeholders including investors, regulators (industry and environmental), communities, and other stakeholders. Sustainable development is one of the major concerns of the oil and gas industry. Companies are seeking to increase sustainability of their operations by considering environmental and social concerns in addition to economic concerns. Oil and gas companies need to take decisions at different stages of the product life cycle (e.g. planning, design, exploration, production, and clean-up) which have direct or indirect impact on the organization's objectives. Addressing economic, technical, social, and environmental risks and opportunities during decision-making is critical to fulfill stakeholders' and organization's objective and ultimately to the success of a project. This research provides a framework and a model that integrates sustainability into decision-making.

Contents

Table of Figures

Table of Tables

I. Introduction

Over the last few decades, industries have become increasingly aware of the social and environmental concerns and have revised their vision and strategic objectives. Previously, social and environmental concerns were perceived to be peripheral to industrial operations, and their potential impacts were viewed as manageable through "end-of-pipe" solutions (Kathryn & Aidan, 1998). However, these solutions dealt with environmental effects after the operation and not to environmental protection. Since the 'Brundtland Commission Report'[1] of 1987 was published, corporate managers and decision makers have been working on strategies and models that can integrate social and environmental factors along with economic objectives into strategic decision making. According to 'Brundtland Commission Report', the term 'sustainable development' suggested a positive role for organizations to integrate environmental protection concerns with economic performance (Sharma & Verdenberg, 1998). The concept of sustainability, according to World Commission on Environment and Development, 1987, has been defined as "meeting the needs of the present without compromising the ability of the future generations to meet their needs (WCED, 1987)." Although the term 'sustainability' can be defined in many ways, its underlying premise is that improving economic performance along with protecting the environment and well-being of the world's communities and citizens. Figure 1 shows the three important elements of sustainability i.e. economic, social, and environmental.

[1] The '*Brundtland Report*', commonly known as '*Our Common Future*' from the United Nations World Commission on Environment and Development (WCED) was published in 1987. Its targets were multilateralism and interdependence of nations in the search for a sustainable development path. The report sought to recapture the environmental concerns to the formal political development sphere. *Our Common Future* placed environmental issues firmly on the political agenda; it aimed to discuss the environment and development as one single issue.

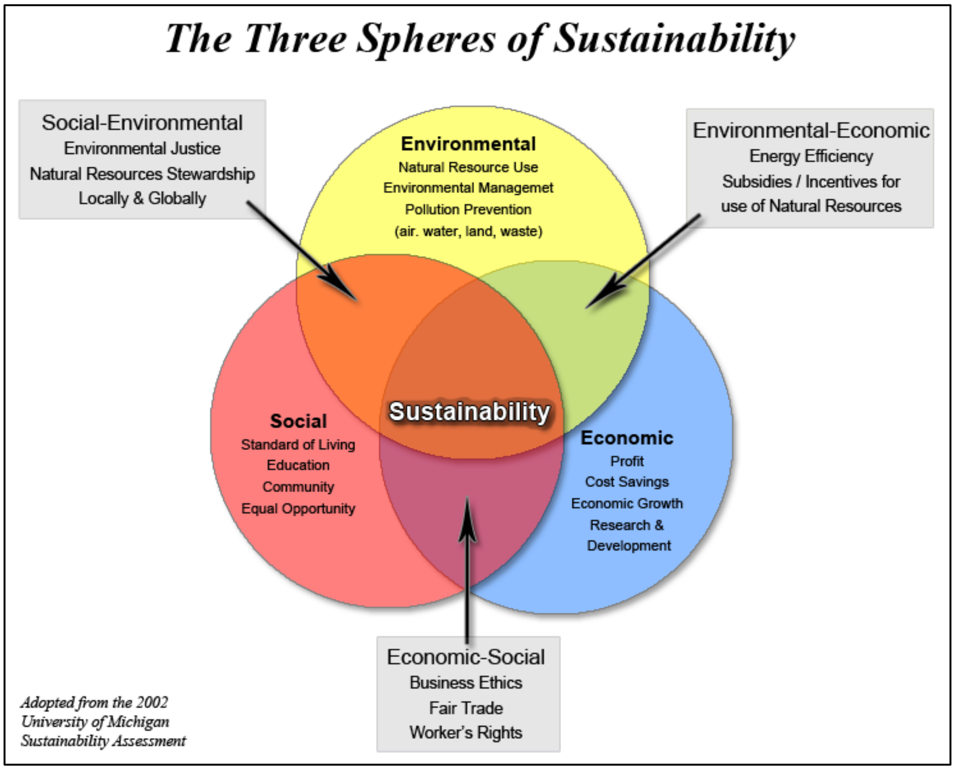

Figure 1 - The Three Spheres of Sustainability

II. Problem Definition

Government, private sector, Non-Government Organizations, and other decision makers are increasingly focusing on 'acting sustainably' and adopt strategies and polices toward 'sustainable development.' However, the private sector has important economic incentives and project evaluation policies and procedures to include economic factors using economic analysis, e.g., net present value with an approved discount rate that reflect profit and risk expectations to meet stakeholder objectives. The challenge is how to alter current organizational policies and procedures to support the sustainability strategy. However, these widely accepted admonitions provide little guidance to decision makers and stakeholders since the term 'sustainability' has not been defined in terms and equations comparable to economic analysis used for project evaluation. Moreover, applications of these concepts are often hindered by disagreements about the effect of human interaction with the environment. In addition, reducing disagreement about sustainable development cannot be accomplished solely through an improvement in scientific knowledge. Hence, including social and environmental concerns with economic concerns during planning and design phase is essential to fulfill stakeholders' and organization's objectives for sustainable projects.

A. Oil and Gas Industry

The oil and gas industry has an important role to play in making decisions that lead to sustainable operations. The oil and gas industry is the critical global energy market as it produces 61.4% of total energy used by countries around the globe (Internation energy agency, 2014). Due to the growth in world population and improved global standard of living, the demand for energy is expected to increase. The transportation sector is the primary consumer of most of the fuel produced by this industry. In addition, this demand will grow since the number of vehicles on the road are expected to increase up to 2 billion by 2050 as compared to approximately 900 million today (Internation Energy Agency, 2014).

B. Oil and Gas Project Lifecycle

The lifecycle of an oil and gas project consists of four phases: exploration, development, production, and decommissioning (Cairn Energy, n.d.). Geological studies, seismic activities, exploration studies are performed during exploration phase (Cairn Energy, n.d.). The development phase consists of detailed engineering, construction, installation, commissioning, and development/production wells (PA Resources, n.d.). The important phase in oil and gas project lifecycle is the production phase which consists of oil and gas production, addition wells, maintenance, and transportation (PA Resources, n.d.). The last phase is the decommissioning phase which consists of activities such as plugging wells, decommissioning, dismantling, and site remediation and restoration (Cairn Energy, n.d.). The life of oil and gas projects is 30-50 years; and decisions have direct or indirect impacts till the end of the project. In addition, economic benefits, social concerns, and environmental concerns come in the later phases of the lifecycle. Hence, it is necessary for decision makers to consider these factors during early stages of the project.

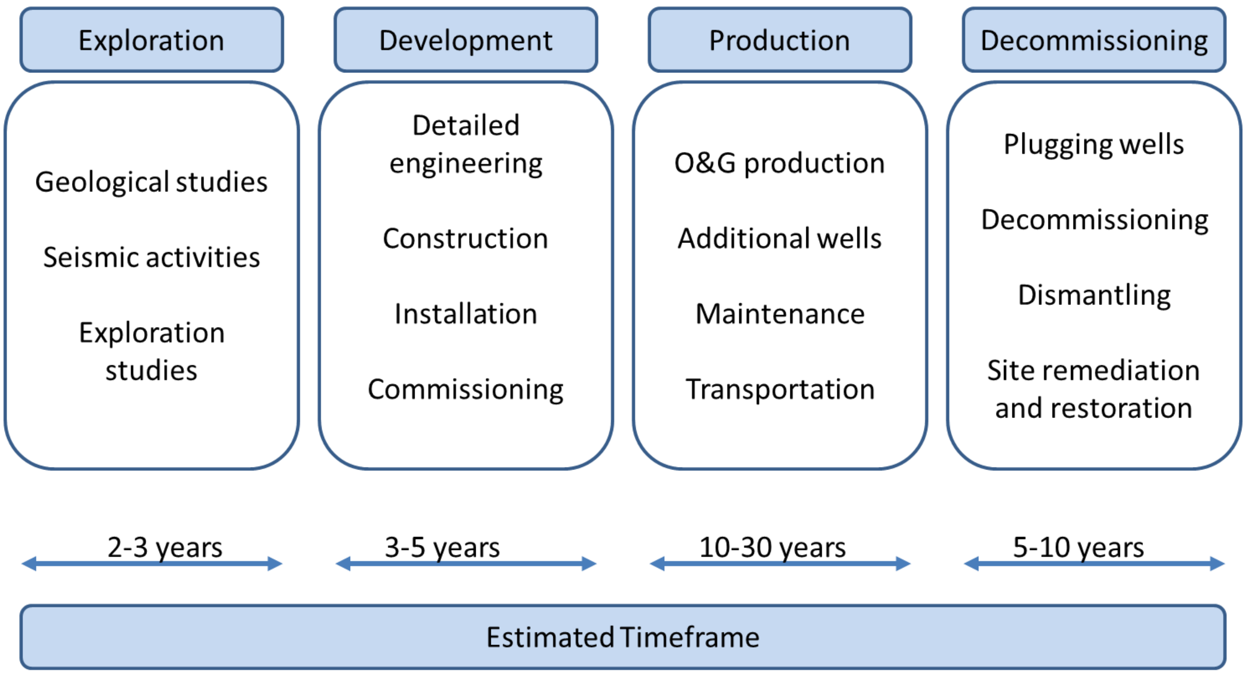

Figure 2 - Oil and gas project lifecycle (Cairn Energy, n.d.)

C. Need for sustainable development in the oil and gas industry

Currently, environmental, health and safety concerns are major challenges faced by the oil and gas industry (Golder Associates, 2014). Stakeholders and decision makers in this industry increasingly recognize that a sustained license to operate requires the management of non-technical risks. There are many benefits for a company which can derive strategic advantage by embracing sustainable development as part of their business policies. These benefits include cost saving by minimizing consumption of natural resources and waste, and new business opportunities through environmentally-friendly product innovations. Moreover, sustainable development aids in operational excellence, better risk management, enhancing business reputation and brand value with partners and customers, and attracting capital from green investors (Friedman, 2012).

Environmental and social factors must be considered in a decision making process of oil and gas industry. Historically, many new oil and gas industries failed to incorporate environmental and social factors in its early decision phase which caused greatest negative economic and political consequence for the government, the company, and society as a whole (United Nations, 2008). Hence, it is necessary for companies to make decisions using Triple bottom line concept (i.e. by considering environmental and social factors with economic gain) to achieve overall sustainability. Sustainable development provides significant advantages. According to Natural Marketing Institute, organizations considering their operational impacts on the environment and society make consumers 58% more likely to buy their products and services, enhancing brand image and increasing competitive advantage (Eco-efficiency, n.d.).

Major advantages of sustainable development are reduced cost of operations, cost of waste treatment, and risks of damage to the environment which results in reduced risks of lawsuits. One of the examples of lawsuit risks can be seen in British Petroleum's non-sustained operations in the Gulf of Mexico which caused deaths of 11 workers and spilled millions of gallons of oil, resulting in lawsuits against BP and costing more than $26 billion on Gulf restoration, response, and clean-up activities (Kay, 2014). Furthermore, this example implies that sustainable operations reduce safety risks and hazards which results in increase employee retention and employee satisfaction. According to Young's 2008 report on 'The Top 10 Business Risks for Business', it is estimated that organizations will be required to cut 25% of carbon emissions by 2020 and 50-80% by 2050 which will be mandated by both state and federal regulations, affecting the availability and costs of energy which are expected to double within the next 10 years (Eco-efficiency, n.d.).

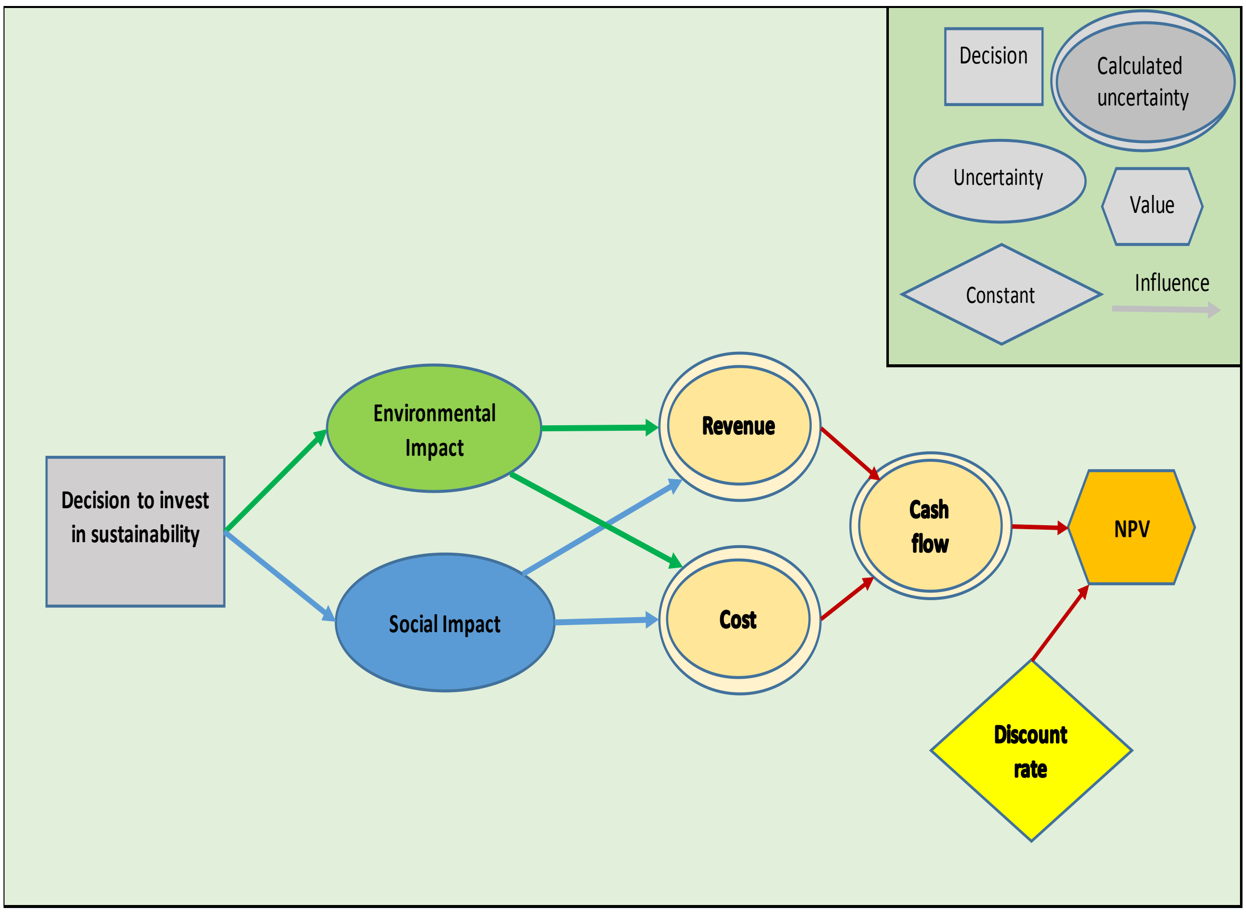

Figure 3 Conceptual influence diagram of investment in sustainability

Figure 3 shows inclusive influence of sustainability investment decision on environmental impact, social impact, revenue, cost, and ultimately the net present value (NPV).

Investing in sustainable development facilitates a company in following aspects:

- The need for companies to satisfy communities' and individuals' right to know about actions that directly affect their health, safety, and local environment by community involvement.
- The drive to improve company performance in the social and environmental arena through workplace safety, stakeholder satisfaction, and reduced environmental impact.
- The demand for new ways of aggregating emissions levels and resource use across companies by using clean energy.
- And the ultimate requirement to add shareholder value by demonstrating a superior ability to manage financial, environmental, and social performance and effects and to communicate this competitive edge to financial analysts.

A general notion of investment in sustainability is that it would increase the revenue and decrease end of the project costs. Investors or decision makers prefer low initial investment than low end of the project costs since discounting high initial investment has more impact on the NPV than high end of the project costs. Hence, increase in revenue or S_B has more impact in justifying high initial investment (additional cost of sustainability) or S_C than decrease in end of the project costs or S_{EC}. Figure 4 shows notional cash flow profile of investment in sustainability and no investment in sustainability.

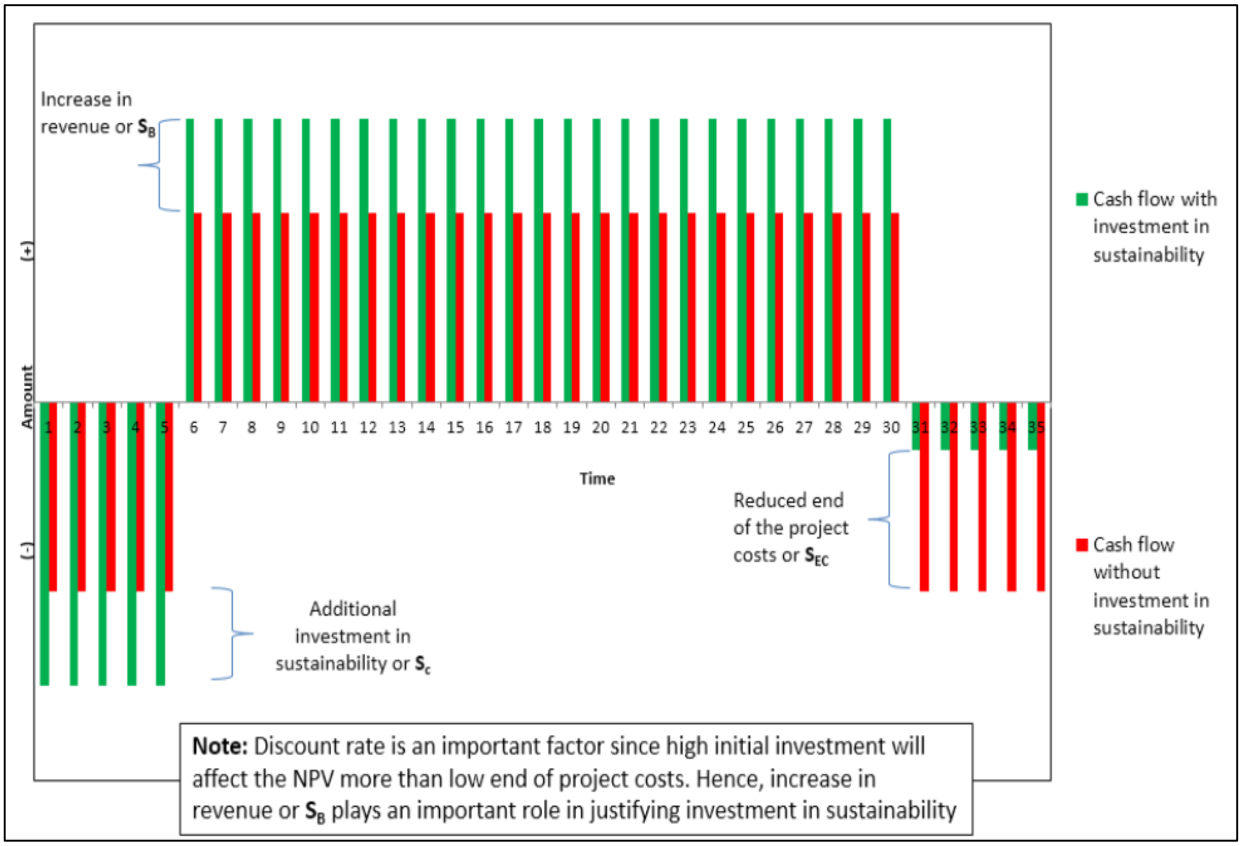

Figure 4 Cash flow profile over the life of the project (notional)

D. International Petroleum Industry Environmental Conservation Association (IPIECA)

The International Petroleum Industry Environmental Conservation Association is the global oil and gas association, formed in 1974, for environmental and social issues. The association's vision is, "An oil and gas industry that successfully improves its operations and products to meet society's expectations for environmental and social performance." IPIECA is the only global organization that focuses on upstream and downstream oil and gas industry on environmental and social issues (IPIECA, 2013).

IPIECA helps the oil and gas industry improve its environmental and social performance by:

- developing, sharing and promoting good practices and solutions
- enhancing and communicating knowledge and understanding
- engaging members and others in the industry
- working in partnership with key stakeholders

E. Research Objective

Our objective is to develop an oil and gas decision model that integrates environmental and social factors with economic objectives in a way that makes business sense to stakeholders and also assesses overall sustainability.

III. Literature Search

Researchers have modeled various methods to assess social (IPIECA, 2004) and environmental (GDCL, 2000) impacts of an oil and gas operations. Social Impact Assessment (SIA) has been incorporated into the formal planning and approval processes, in order to categorize and assess how major developments may affect populations, groups, and settlements. SIA is often carried out as part of, or in addition to, environmental impact assessment, but it has not yet been as widely adopted as EIA in formal planning systems, often playing a minor role in combined environmental and social assessments (IPIECA, 2013). In addition SIA and EIA, all three dimensions of Triple bottom line framework have been integrated in supply chain management (Wu & Pagell, 2011), life cycle assessment of oil and gas industry (Matos & Jeremy, 2007), and biodiesel production (Dinh, Guo, & Mannon, 2009).

Eason, Meyer, Curran, & Upadhyayula (2011) developed a guide to facilitate sustainable decision-making in nanotechnology using various methods such as lifecycle assessment, carbon footprint, lifecycle risk assessment, lifecycle costing, and eco-efficiency analysis to assess economic, social, and environmental impacts. Moreover, Abdulai (2013) developed simple, high-level, and practical guidelines to Social and Environmental Impact Assessment using a gap analysis of industry practices in Ghana.

Our model focuses on assessing impacts of investment in sustainability in social and environmental concerns on the overall NPV of the company by analyzing cost reduction, brand enhancement, community engagement, and productivity. Table 1 provides an overview of the literature, research industry, and the method used in that research.

Table 1 - Literature and methods summary

Literature	Industry	Method
A Guide to Social Impact Assessment in the Oil and Gas Industry (IPIECA, 2004).	Oil and Gas	A gap analysis of industry practices to provide simple, high-level and practical guidelines to Social Impact Assessment.
Ways to Achieve Sustainable Development in the Oil and Gas Industry in Ghana (Abdulai, 2013).	Oil and Gas	The content analysis approach to examine subject matter under review and testing its veracity using 'External validity' concept.
Balancing Priorities: Decision-making in sustainable supply chain management (Wu & Pagell, 2011).	Diversified	The grounded theory building approach and principles of theory building based on case studies.
Identification and use of sustainability performance measures in decision-making (Epstein & Widener, 2011)	Oil and Gas	Analyses of archival and interview data along with observations of the field site.
Environmental Impact Assessment (GDCL, 2000)	Diversified	A sequenced approach for impact significance determination considering several levels from a proposed federal action.
Guidance to facilitate decision for sustainable nanotechnology (Eason, Meyer, Curran, & Upadhyayula, 2011)	Nanotechnology	Lifecycle assessment of three sphere of sustainability
Sustainability evaluation of biodiesel production using multicriteria decision-making (Dinh, Guo, & Mannon, 2009)	Biodiesel	Multi objective decision analysis

A. Social impact assessment

SIA is a method that is used to evaluate the most probable impact of organization's operations on the society, regions, and local communities. Social impact assessment is defined as "the process of identifying the future consequences of current or proposed actions, which are related to individuals, organizations and social macro-systems (Becker, 2001)." SIA can be conducted at any stage of a project life cycle. SIA is participative assessment which involves stakeholders including organization's members, local communities, and the government. In oil and gas sector, an effective SIA study helps develop operations to minimize negative social impacts while addressing stakeholders' views throughout the project life cycle (IPIECA, 2004).

Generally, a SIA study addresses issues such as demographics due to new projects, socio-economic concerns, health impacts due to operations, social infrastructure, resource management, psychological and community aspects, and social equity (IPIECA, 2004).

As shown in Figure 4, there are three phases (project conception, design and engineer, and construction/operation/abandonment) involved in SIA process. The initial phase consists of colleting necessary preliminary information to determine the potential area of impact of the project, and identifying the opportunities to be covered by and the required stakeholder engagement level; and gathering of data on baseline conditions which will form the basis for modeling potential impacts of the project (IPIECA, 2004). In the second phase, baseline data is analyzed to provide impact predictions and all significant impacts are evaluated. Findings from this analysis are then disseminated through a continuous process. The third phase consists of implementation plan and monitoring. Implementing the SIA action plan involves the activities of a various company departments with collaboration within the department as well as collaboration with external stakeholders, affected societies, government agencies and contractors. In addition, monitoring mechanisms are established as soon as activities begin at project sites. These mechanisms help identify any deviations from the impacts predicted by the SIA. Monitoring also evaluates the effectiveness of mitigation measures (IPIECA, 2004).

Figure 5 shows a general framework for social impact assessment process

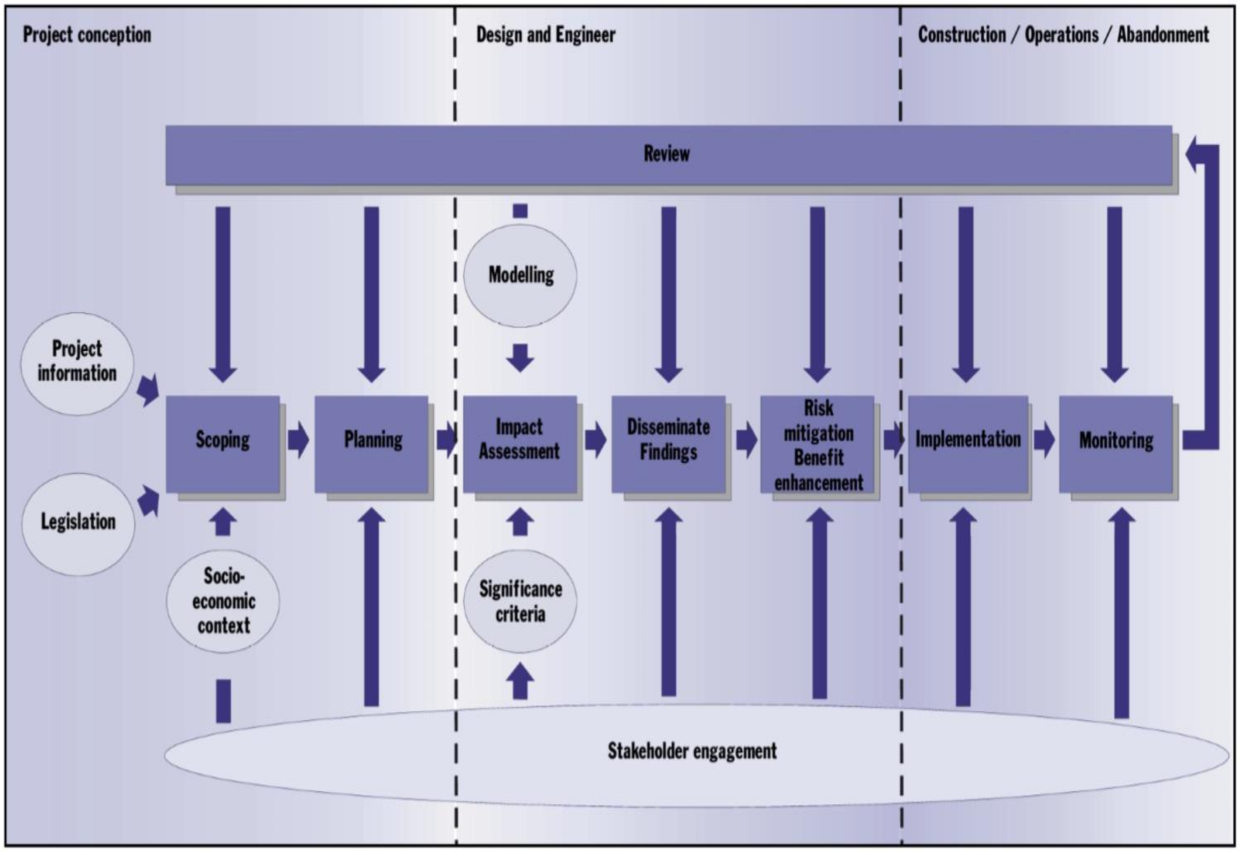

Figure 5 - Social Impact Assessment Process (IPIECA, 2004)

B. Environmental impact assessment

Environmental impact assessment (EIA) is a procedure that must be followed for upstream and downstream projects of an oil and gas industry before they can be given 'development consent'. An EIA is a method of systematically drawing together an assessment of a project's potential significant environmental effects and also helps to ensure that the importance of these predicted effects, and the scope for reducing them are properly understood by the community and the relevant competent authority before they make their decision (GDCL, 2000). The primary purpose of the EIA process is to encourage the consideration of the environment in planning and decision making and to ultimately arrive at actions which are more environmentally compatible.

Environmental impact assessment enables to consider environmental factors, along with social or economic factors, when planning applications are being considered in the development phase of oil and gas project lifecycle. It not only helps to promote a sustainable pattern of physical development, but efficient use of land and property in cities, towns and the countryside. A properly conducted EIA benefits all those involved in the planning process. From the developer's point of view, the preparation of an environmental statement in parallel with project design provides a useful framework within which environmental considerations can inform design development. Environmental analysis may indicate ways in which the project can be modified to avoid possible adverse effects, for example, through considering more environmentally friendly alternatives. The steps taken towards EIA are likely to make the formal planning approval stages run more efficiently (GDCL, 2000).

There are several activities required for EIA, such as an environmental impact study, impact identification, a description of the affected environment, impact prediction and assessment, and selection of the proposed action from a set of alternatives being evaluated to meet identified needs. A general EIA process consists of various steps including defining scope of the assessment, determination of impact significant, interaction matrix development, trade-off analysis, importance weighting for decision factors, ranking of alternatives, and development of a decision matrix (Canter, 1977).

C. Balancing economic and environmental priorities

Environmental issues are considered an integral part of the broad framework of sustainability. Sustainability, as defined by WCED, captures three intrinsically related dimensions (environmental, social, and economic) of the Triple bottom line framework (Elkington, 1998). The triple bottom line framework has gained rapid recognition as evidence by its incorporation in a growing number of third party certification programs such as Leadership in Energy and Environmental Design (LEED) and Forest Stewardship Council (FSC), as well as number of sustainability reporting initiatives such the Climate Action Partnership (2010).

Existing studies find mixed results when examining the relationship between organizations' economic and environmental objectives. Many studies have found a positive connection between firms' environmental actions and financial performance (Pagel, Yang, Krumwiede, & Sheu, 2004). In operations management literature this view is often exemplified by the total quality environmental management (TQEM) perspective that sees a strong positive association between management system and environmental management systems. The same processes that improve quality, reduce waste, cut costs and improve competitiveness can be used to improve environmental outcomes as well, implying that multiple stakeholders can be simultaneously satisfied (Curcovic, Melnyk, Handfield, & Calatone, 2000).

However, there is research that suggests that not all stakeholders are satisfied at the same time. Strategic decisions with ambitious environmental goals can come with real economic costs (Hoffman, et al., 1999). More importantly, as companies begin to confront global competition for resources and tighter environmental regulations, the debate has moved beyond the consideration of whether or not it pays to be green to focus on how to address environmental challenges while maintaining competitiveness (King & Linox, 2002).

D. Sustainable decision-making: some challenges

Sustainable decision making generally involves a range of environmental, economic, political, social, ethical, and other factors and requires a mixture of quantitative and qualitative, precise and imprecise, and subjective and objective data. It requires a change of temporal and spatial scale from short to long term and local to global, as well as the possibility of a multi-scale approach that would allow consideration of impacts and consequences over a range of different time scales and regions. Sustainable decision problems may be unstructured and characterized by shifting, ill-defined, or competing goals, action feedback loops, time stress, high stakes, multiple stakeholders, uncertain dynamic environments, and particular organizational goals and norms which are often omitted from decision-making process (Hersh, 1999). Uncertainty and risk are also important. In addition to the uncertainty from measurement error and poor quality data, incomplete understanding of some of the underlying issues may lead to controversy about what is and is not sustainable. For instance, the causal relationship between anthropogenic emissions and global climate change has gained general acceptance only recently. Although considerable progress has been made toward understanding the mechanisms involved, there are still many open questions in this area. Thus, the “precautionary principle” of avoiding action which might have unforeseen and poorly understood effects on parts of the complex, interacting environmental system should be an important part of sustainable decision making. For instance, according to this principle, nuclear power stations should not have been built until the effects of radiation on the environment were better understood and the problem of disposal of radioactive waste had been resolved.

Sustainable decision making frequently involves uncertainty and inadequate information. In some cases, full understanding of the situation would require data on environmental effects possibly over an extended period of several hundred years, but decisions have to be made within the limitations of existing data and time constraints (Hersh, 1999). However, the use of imperfect or uncertain information is preferable to the exclusion of ecological considerations. Since much of the available information is uncertain, sensitivity analysis should be used to investigate the dependence of decisions on particular parameters, weights, and models.

IV. Methodology

An economic decision analysis approach, illustrated in Handbook of Decision Analysis by Parnell, Bresnick, Tani, & Johnson, 2013, was used to assess impacts of investment in sustainability on the overall NPV. Following steps were used in this research:

Problem statement: Incorporating social and environmental factors into decision-making in a way that makes business sense to stakeholders and also assesses overall sustainability.

Vision statement: We will decide how to incorporate environmental and social factors in decision making process in a way that makes legitimate business sense. We need to do this to establish a decision making process to foresee environmental and social impact on firm's objectives. We will know that we have succeeded if all decision makers and stakeholders are satisfied that we have chosen the right path forward

Influence diagram: An influence diagram was created to determine influence of decision to invest in sustainability on the NPV.

Excel model: A model was created in Excel based on influence diagram to analyze various decision alternatives and their impact on the NPV.

Deterministic analysis: Deterministic analysis was performed to assess various parameters scenarios and decision alternatives, and to determine sensitive parameters.

Probabilistic analysis: Probabilistic analysis was performed using Monte Carlo simulation on sensitive parameters to incorporate uncertainty.

Comparing alternatives: The three decision alternatives were compared using value risk profile or cumulative probability chart.

Figure 6 shows the methodology used in this research.

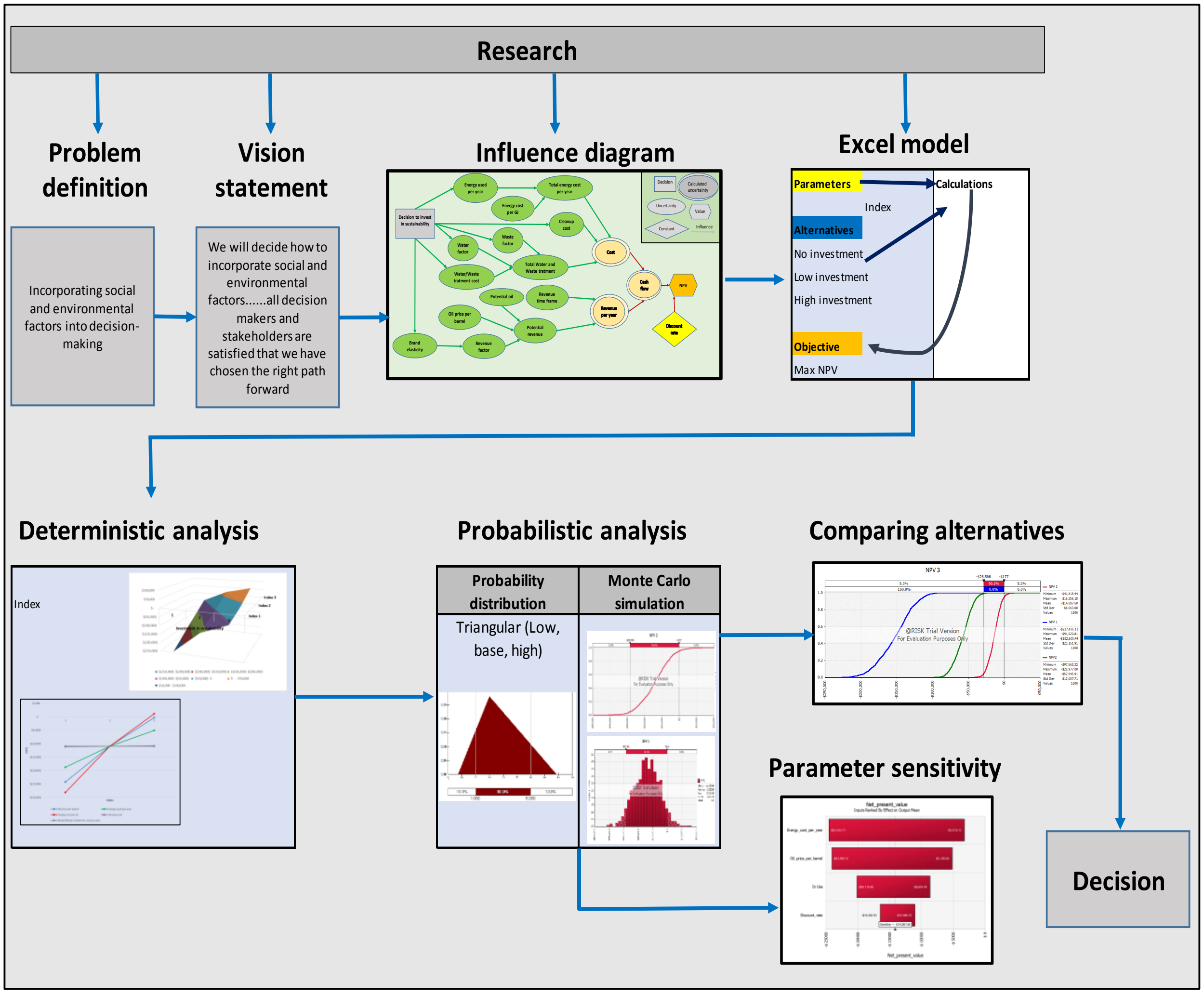

Figure 6 Methodology

V. Modelling steps

The decision analysis modelling steps, as illustrated in illustrated in Handbook of Decision Analysis by Parnell, Bresnick, Tani, & Johnson, 2013, were used in this reseach.

A. Issues

During this study, possible issues were identified through research and inputs from chevron executives.

Issue list

- Decide how much to invest in sustainability
- Water factor
- Waste factor
- Water/Waste treatment cost
- Energy cost per GJ
- Total energy cost per year
- Cleanup cost
- Potential oil
- Oil price per barrel
- Revenue factor
- Potential revenue
- Revenue time frame
- Brand elasticity
- Total cost
- Revenue per year
- Net present value

Categorization of issues

These issues were then categorized into four types:

Decision: how much to invest in sustainability (No investment, low investment, or high investment).

Value: Net present value.

Uncertainty: Water factor, waste factor, water/waste treatment cost, energy cost per GJ, total energy cost per year, cleanup cost, potential oil, oil price per barrel, revenue factor, potential revenue, and revenue time frame.

Other: Total cost and brand elasticity.

B. Influence Diagram

An influence diagram was created to determine relevancy of the decision to various uncertainties and to the final value, i.e. NPV. There were six uncertainties directly influenced by the decision: energy used per year, waste factor, water factor, waste/water treatment cost, cleanup cost, and brand elasticity.

In an oil and gas industry, the discount rate changes due to the market's expectations and various factors such as inflation rate, risk-free component, general risk premium, and property-specific risk premium (Susan Combs, Texas Comptroller of Public Accounts, 2012), but a calculated value of the discount rate is used to determine the NPV after analyzing these factor. In most analyses, the discount rate is used as a constant in determining the NPV of a particular scenario. However, three levels (worst, base, and best) of discount rate were used in this study to accommodate uncertainties related to discount rate components and market's expectation.

As shown in Figure 7, the influence diagram shows the interrelationship of the decision and the key variables. The decision has direct influence on uncertainties energy used per year, waste factor, water factor, water/waste treatment cost, cleanup cost, and brand elasticity which impact cost and revenue per year. The cost, revenue per year, and cash flow are calculated uncertainties since while assessing these factors, we will have information of their related uncertainties. The cost and revenue per year contribute to cash flow which was used to calculate the final value, NPV, using discount rate.

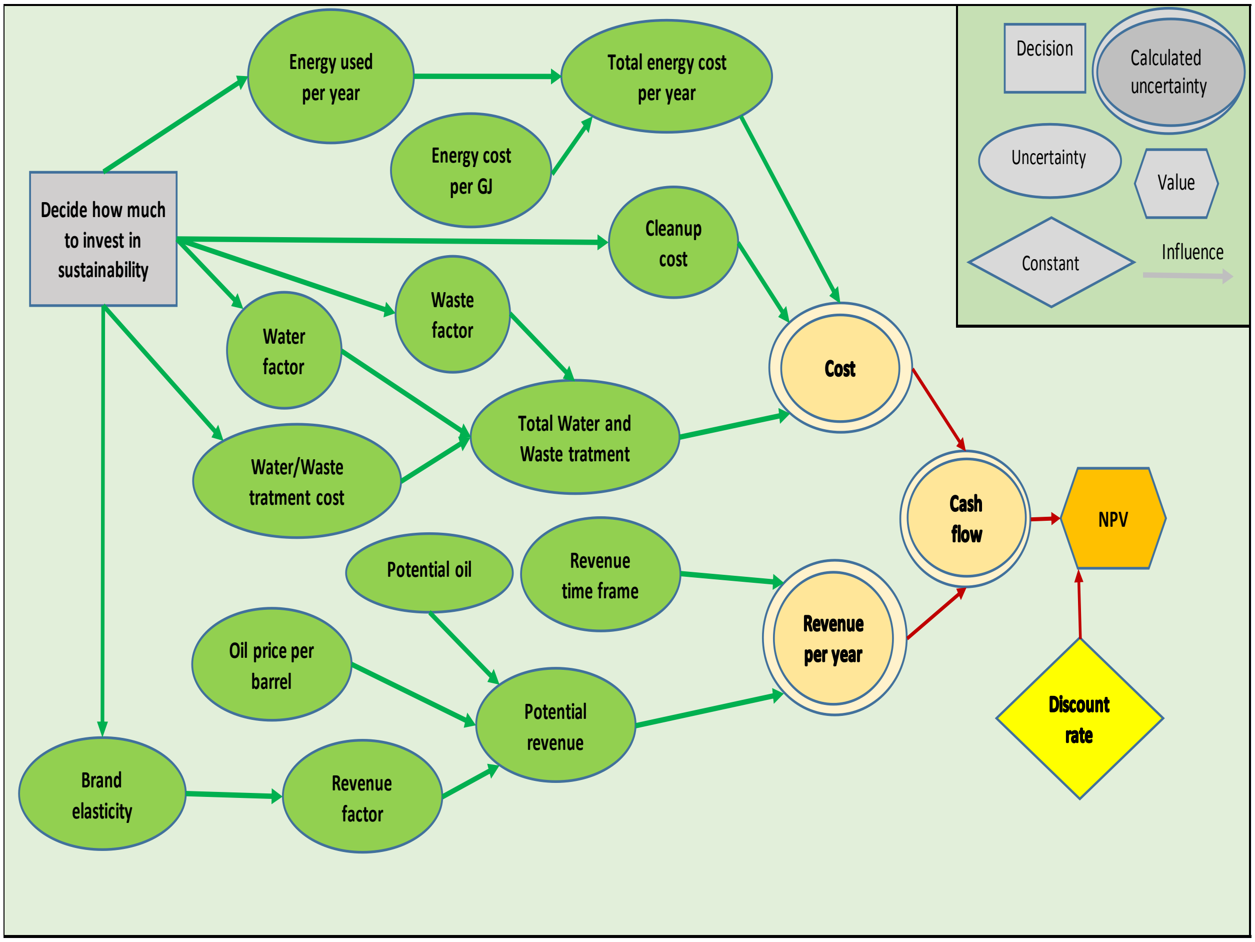

Figure 7 Influence diagram

C. Parameters

To analyze the impact of the decision to invest in sustainability, a model was created in Excel using uncertainties and their influence on the NPV. These uncertainties were categorized into two types: independent parameters and decision dependent parameters. Table 2 shows independent parameters used in this research.

Table 2 Independent parameters

Parameter	Unit	Worst	Base	Best	Data source
Discount rate	%	22%	19%	16%	2014 Property Value Study (Combs, 2014)
Potential oil	Billion barrels	4.5	6.0	8.0	US Oil and Gas Reserve Study 2014 (EY, 2014); The Telegraph (Critchlow, 2014)
Oil price per barrel	$	50	75	90	Nasdaq (Nasdaq, 2015)
Energy cost per GJ	$	22	18	15	Energy Cost Calculator
Revenue time frame	Year	26			Cairn Energy (Cairn Energy, n.d.); US Oil and Gas Reserve Study 2014 (EY, 2014)

Decision alternatives:

The investment amount depends on the size of the company as well as the area of investment under consideration. In addition to this, various investment alternatives may vary from company to company based on their definition of what is sustainable. For instance, for a small scale organization, e.g. supplier of a large organization, a particular value of investment amount may fall under high investment alternative considering its level of sustainability or sustainability evaluation criteria to account for the needs of its customers, but for a large organization the same investment amount may fall under low investment alternative which plans to achieve industry wide sustainability levels. As shown in table 3, there were three decision alternatives considered in this research. Although the investment amount was notional, the basic idea was to capture three different levels, i.e., no investment, low investment, and high investment.

Table 3 Decision alternatives

Alternative	Investment ($ million)
No investment	0
Low investment	1,000
High investment	2,000

Decision dependent parameters:

Investment in sustainability results in approximately a 9% increase in revenue, a 2% increase in employee productivity/innovation, a 75% decrease in energy expenses, a 20% decrease in waste expenses, a 10% decrease in material and water expenses, and a 25% decrease in employee turnover expenses (Willard, 2012).

Table 4 shows decision dependent parameters used in this research. Values of parameters such as energy used per year, water factor, and waste factor were determined from data published in Chevron's 2013 Corporate Responsibility Report: Performance Data (Chevron, 2014) and impact of investment in sustainability on those parameters using business case studies of benefits of Triple bottom line (Willard, 2012).

Table 4 Decision dependent parameters

Parameter	Unit	Investment	Worst	Base	Best	Data source
Energy used per year	Million GJ	No	1300	1100	950	Chevron CR Report: Performance Data (Chevron, 2014)
		Low	650	550	475	
		High	325	275	238	
Water factor	-	No	0.90	0.80	0.70	The New Sustainability Advantage (Willard, 2012); Chevron CR Report: Performance Data (Chevron, 2014)
		Low	0.81	0.72	0.63	
		High	0.73	0.65	0.57	
Waste factor	-	No	0.90	0.80	0.70	
		Low	0.72	0.64	0.56	
		High	0.58	0.51	0.45	
Waste/water treatment cost per year	$ Million	No	250	200	150	US Oil and Gas Reserve Study 2014 (EY, 2014); The New Sustainability Advantage (Willard, 2012)
		Low	150	100	75	
		High	100	70	50	
Cleanup cost	$ Million	No	700	550	400	
		Low	500	300	200	
		High	200	120	60	
Brand elasticity	-	No	0.7	0.9	1.2	The New Sustainability Advantage (Willard, 2012)
		Low	1.3	1.4	1.5	
		High	1.5	1.6	1.7	

Calculations

There were five factors used to calculate the profit profile over the life of an oil and gas project: revenue, investment in sustainability, energy cost per year, total water and waste treatment cost, and cleanup cost. The amount to invest in sustainability was determined from the decision alternatives, while the cleanup cost was determined using decision-index array of parameters. In addition, the brand elasticity is an important term which determines a multiplying factor, calculated revenue factor, of the potential revenue. In the Excel model, various notional values of brand elasticity ranging from 0.7 to 2.4 were considered; and their corresponding calculated revenue factors were determined using an increasing function (considering a 9% increase in overall revenue (Willard, 2012)) as shown in Table 5. The values of remaining factors were calculated as below:

Potential revenue[2] =

((Potential_oil*1000*Oil_price_per_barrel)/Revenue_time_frame)*Calculated_revenue_factor

Energy cost per year =

Energy_used_per_year*Energy_cost_per_year

Total waste and water treatment cost =

Waste_factor*Waste_water_treatment_cost+Water_factor*Waste_water_treatment_cost

[2] - In calculating potential revenue, potential oil is multiplied by 1,000 to convert billion barrels to millions barrels to get the final value in $ million.

Table 5 Brand elasticity and revenue factor

Brand elasticity	Revenue factor
0.70	0.69
0.80	0.73
0.90	0.77
1.00	0.81
1.10	0.85
1.20	0.89
1.30	0.93
1.40	0.97
1.50	1.01
1.60	1.05
1.70	1.09
1.80	1.13
1.90	1.17
2.00	1.21
2.10	1.25
2.20	1.29
2.30	1.33
2.40	1.37

Table 6 shows a cash flow profile of alternative 3 (high investment in sustainability).

Table 6 Cash flow profile

Time	Revenue	Investment in sustainability	Energy cost per year	Water & waste treatment cost	Cleanup cost	Total Cost	Profit
0	$ -	$ (2,000)	$ (4,950)	$ (81)	$ -	$ (7,031)	$ (7,031)
1	$ -	$ (2,000)	$ (4,950)	$ (81)	$ -	$ (7,031)	$ (7,031)
2	$ -	$ (2,000)	$ (4,950)	$ (81)	$ -	$ (7,031)	$ (7,031)
3	$ -	$ (2,000)	$ (4,950)	$ (81)	$ -	$ (7,031)	$ (7,031)
4	$ -	$ (2,000)	$ (4,950)	$ (81)	$ -	$ (7,031)	$ (7,031)
5	$ 15,242	$ -	$ (4,950)	$ (81)	$ -	$ (5,031)	$ 10,211
6	$ 15,242	$ -	$ (4,950)	$ (81)	$ -	$ (5,031)	$ 10,211
7	$ 15,242	$ -	$ (4,950)	$ (81)	$ -	$ (5,031)	$ 10,211
8	$ 15,242	$ -	$ (4,950)	$ (81)	$ -	$ (5,031)	$ 10,211
9	$ 15,242	$ -	$ (4,950)	$ (81)	$ -	$ (5,031)	$ 10,211
10	$ 15,242	$ -	$ (4,950)	$ (81)	$ -	$ (5,031)	$ 10,211
11	$ 15,242	$ -	$ (4,950)	$ (81)	$ -	$ (5,031)	$ 10,211
12	$ 15,242	$ -	$ (4,950)	$ (81)	$ -	$ (5,031)	$ 10,211
13	$ 15,242	$ -	$ (4,950)	$ (81)	$ -	$ (5,031)	$ 10,211
14	$ 15,242	$ -	$ (4,950)	$ (81)	$ -	$ (5,031)	$ 10,211
15	$ 15,242	$ -	$ (4,950)	$ (81)	$ -	$ (5,031)	$ 10,211
16	$ 15,242	$ -	$ (4,950)	$ (81)	$ -	$ (5,031)	$ 10,211
17	$ 15,242	$ -	$ (4,950)	$ (81)	$ -	$ (5,031)	$ 10,211
18	$ 15,242	$ -	$ (4,950)	$ (81)	$ -	$ (5,031)	$ 10,211
19	$ 15,242	$ -	$ (4,950)	$ (81)	$ -	$ (5,031)	$ 10,211
20	$ 15,242	$ -	$ (4,950)	$ (81)	$ -	$ (5,031)	$ 10,211
21	$ 15,242	$ -	$ (4,950)	$ (81)	$ -	$ (5,031)	$ 10,211
22	$ 15,242	$ -	$ (4,950)	$ (81)	$ -	$ (5,031)	$ 10,211
23	$ 15,242	$ -	$ (4,950)	$ (81)	$ -	$ (5,031)	$ 10,211
24	$ 15,242	$ -	$ (4,950)	$ (81)	$ -	$ (5,031)	$ 10,211
25	$ 15,242	$ -	$ (4,950)	$ (81)	$ -	$ (5,031)	$ 10,211
26	$ 15,242	$ -	$ (4,950)	$ (81)	$ -	$ (5,031)	$ 10,211
27	$ 15,242	$ -	$ (4,950)	$ (81)	$ -	$ (5,031)	$ 10,211
28	$ 15,242	$ -	$ (4,950)	$ (81)	$ -	$ (5,031)	$ 10,211
29	$ 15,242	$ -	$ (4,950)	$ (81)	$ -	$ (5,031)	$ 10,211
30	$ 15,242	$ -	$ (4,950)	$ (81)	$ (120)	$ (5,151)	$ 10,091
31	$ 15,242	$ -	$ (4,950)	$ (81)	$ (120)	$ (5,151)	$ 10,091
32	$ 15,242	$ -	$ (4,950)	$ (81)	$ (120)	$ (5,151)	$ 10,091
33	$ 15,242	$ -	$ (4,950)	$ (81)	$ (120)	$ (5,151)	$ 10,091
34	$ 15,242	$ -	$ (4,950)	$ (81)	$ (120)	$ (5,151)	$ 10,091
35	$ 15,242	$ -	$ (4,950)	$ (81)	$ (120)	$ (5,151)	$ 10,091

D. Deterministic analysis

A deterministic analysis was performed in Excel to determine the best alternative by considering all three index levels: worst, base, and high. As shown in Figure 8, alternative 3, i.e., high investment in sustainability yields maximum value in all three index levels. Table 8 shows NPV values of all alternatives.

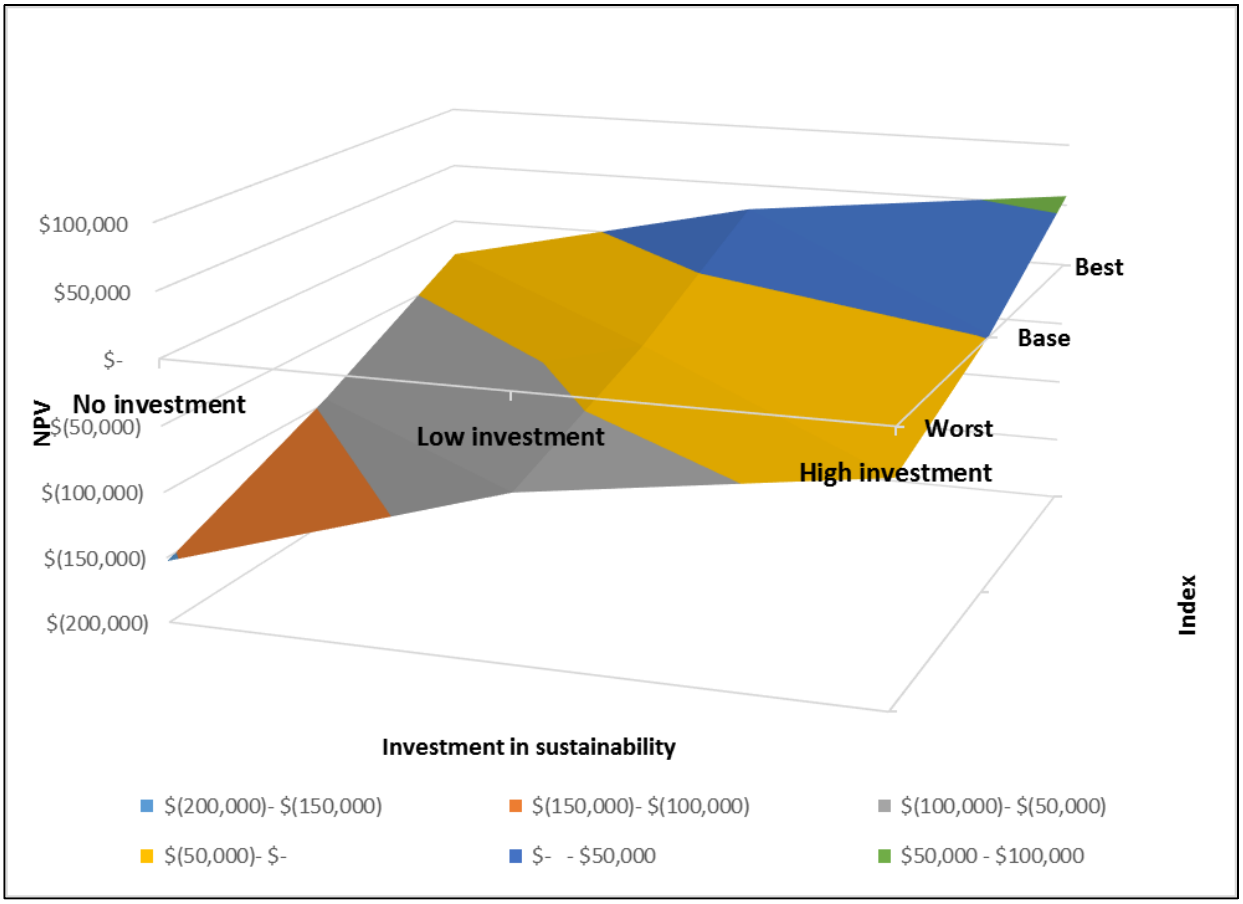

Figure 8 Deterministic analysis result

Table 7 Deterministic analysis results

Investment alternatives	Index		
	1	2	3
1	$ (152,774)	$ (96,584)	$ (29,794)
2	$ (72,952)	$ (29,595)	$ 28,752
3	$ (35,324)	$ 1,091	$ 57,645

The deterministic analysis yielded alternative 3 as the best alternative in all index levels. However, the analysis was perfomed considering all parameters would take values in either index worst, base, or best. Hence, sensitivity analysis was perfomed to assess uncertainties related to each parameter varied one at a time. In this analysis, NPV values were calculated for all parameters by chaning every parameter's value from worst to best and keeping remaing parameters to the base level. After analysing all paramters, it was determined that paramters oil price per barrel, discount rate, energy cost per GJ, and energy used per year are most sensitive. Figure 9 shows the one way sensitivity analysis chart.

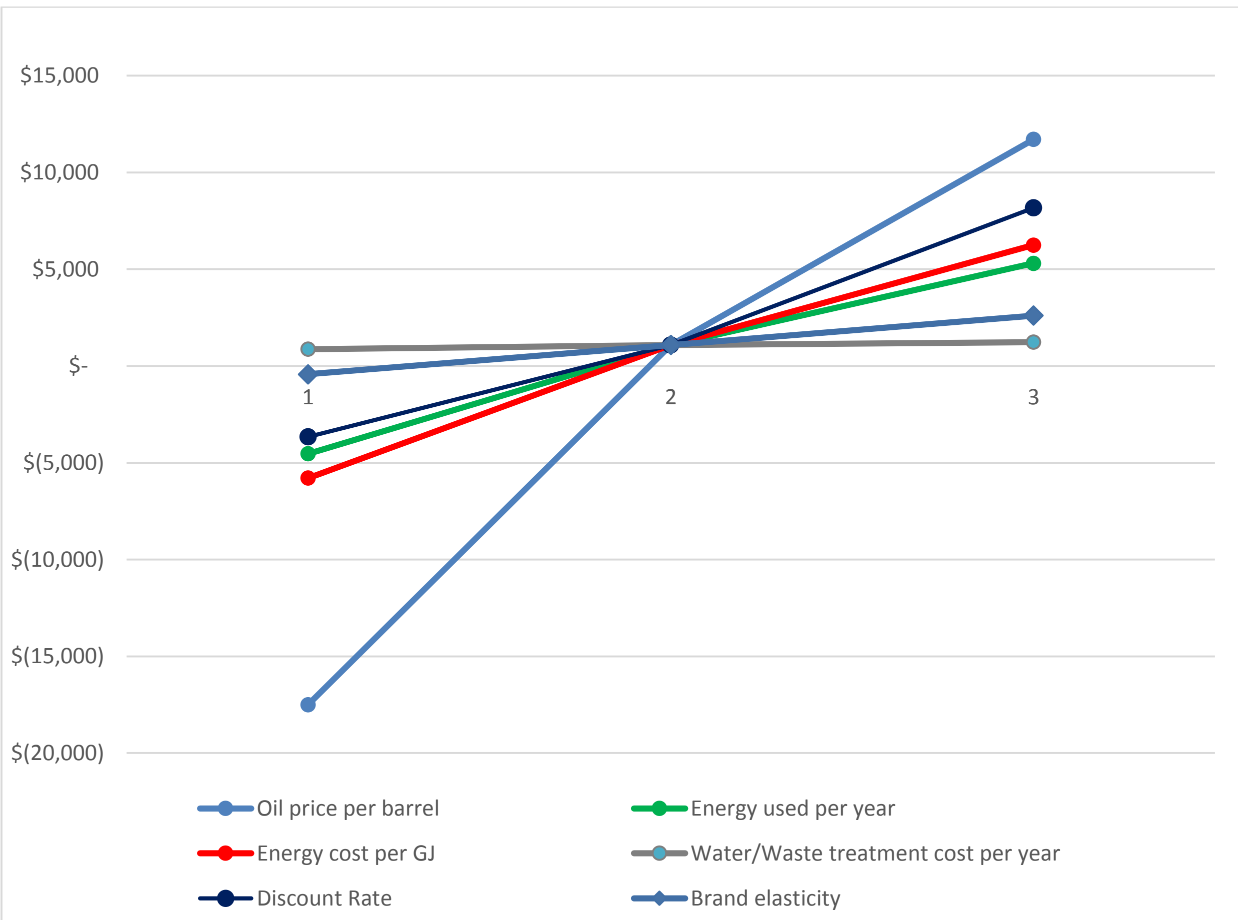

Figure 9 One way sensitivity analysis

E. Probabilistic analysis

A Monte Carlo probabilistic analysis was performed on sensitive parameter to accommodate uncertainties related to their values. In addition to these parameters, discount rate was also considered as a source of uncertainty since it varies due to fluctuations in market expectation and its determining factors (Susan Combs, Texas Comptroller of Public Accounts, 2012). Following formulae were used to determine values of these parameters:

Discount rate = RiskTriang(16%, 19%, 22%)

Oil price per barrel = RiskTriang(50, 75, 95)

Energy used per year = RiskTriang(238, 275, 325)

Energy cost per GJ = RiskTriang(3, 5, 8)

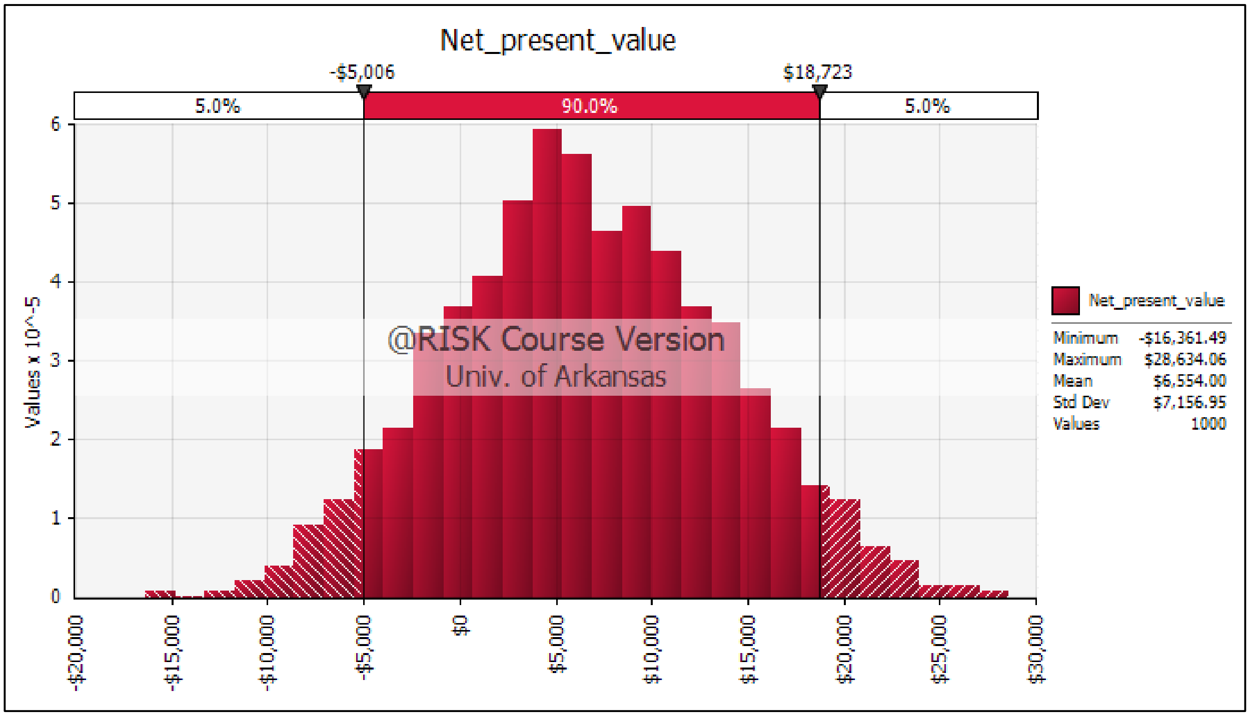

Figure 10 Individual probability chart of alternative 3

A probabilistic analysis was performed on sensitive parameters using Monte Carlo simulation with 1000 iteration and keeping remaining parameters at base level to determine the best alternative. Figure 10 and 11 show individual probability chart and cumulative probability chart of net present value respectively.

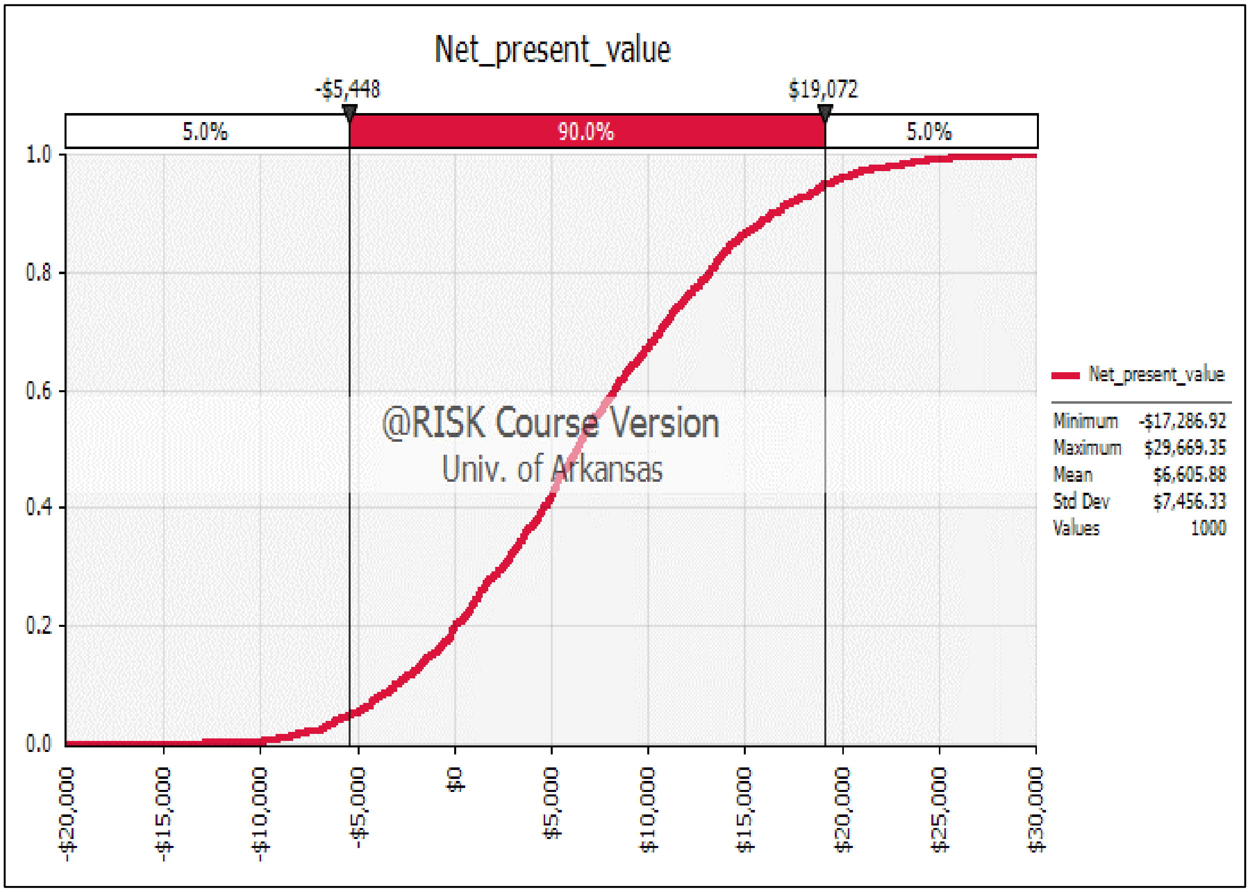

Figure 11 Cumulative probability chart of alternative 3

F. Comparison of alternatives

All three alternatives were compared using a combined cumulative probability chart or cumulative risk profile. Although there is no stochastic or deterministic dominance between alternatives, alternative 3 yields maximum NPV most of the time as shown in Figure 12.

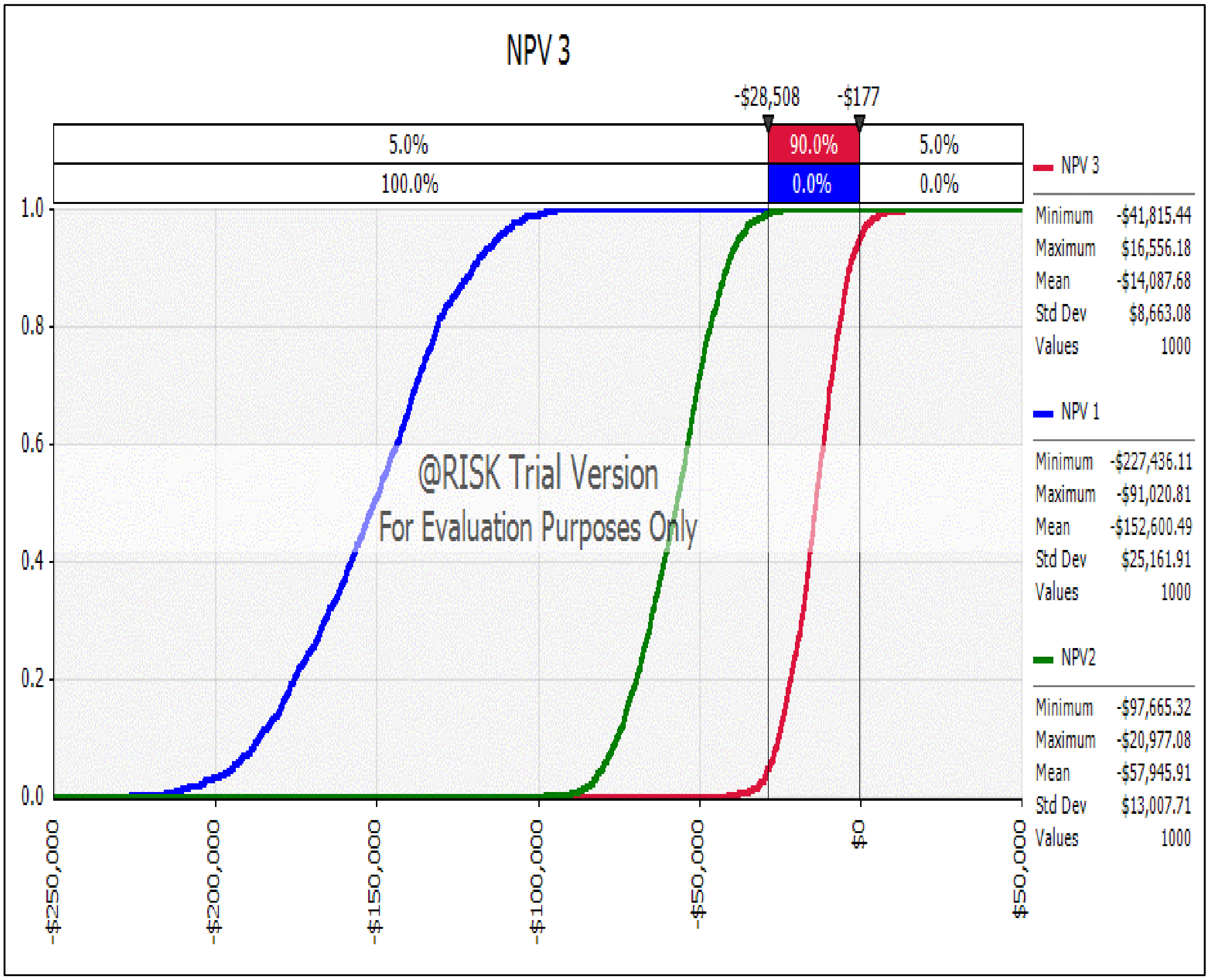

Figure 12 Cumulative probability chart of all three alternatives

Figure 13 shows comparision of cash flow profile over the life of the project for alternative 1(no investment in sustainabilty) and alternative 3 (high investment in sustainability). This comparision is similar to the notional comparision between these two alternatives as shown in Figure 4. Increase in revenue plays an important role in justifying investment in sustainability since discounting intial investment has more impact on the NPV than discounting end of project costs. Therefore, investing in sustainable operations makes business sense due to increase in revenue as shown in Figure 4.

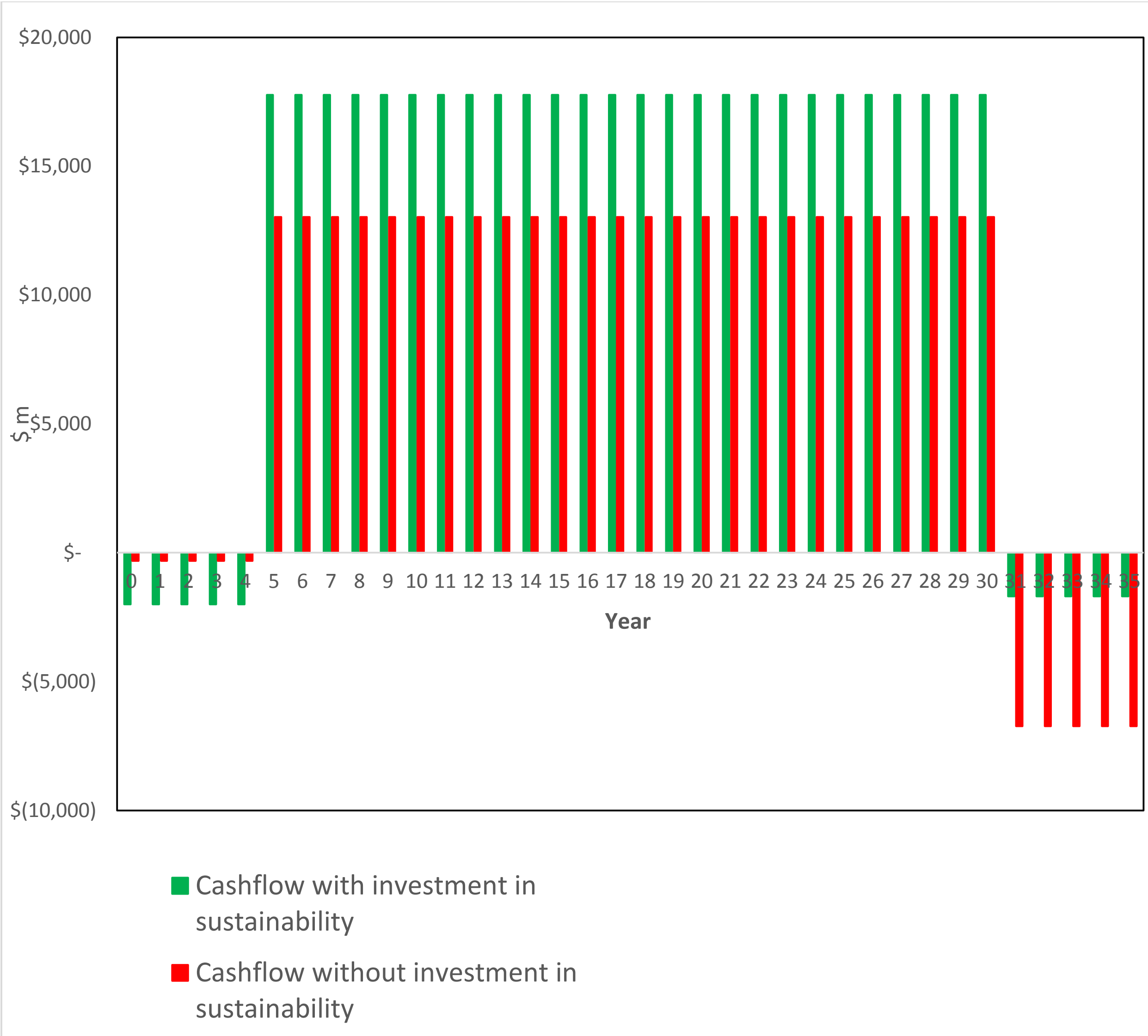

Figure 13 Cash flow profile over the life of the project (from results)

Sensitivity analysis was performed in Excel using Palisade @Risk and tornado diagram on uncertain parameters to determine the most sensitive factor. Figure 14 shows the tornado diagram of four parameters and it can be seen that 'oil price per barrel' is the most sensitive parameter.

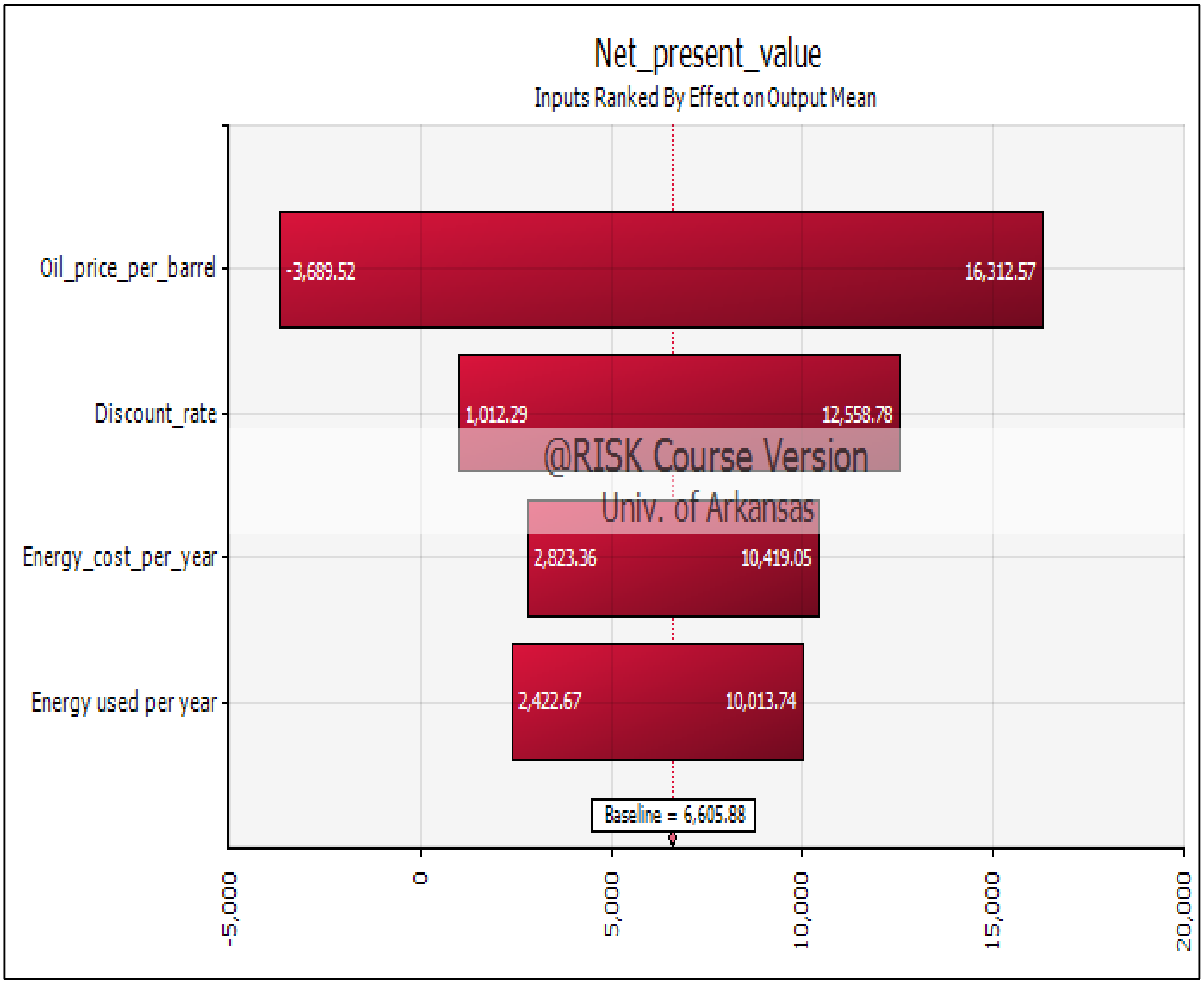

Figure 14 Tornado diagram of sensitive parameters

VI. Future research

In this research, we attempted to justify investment in sustainability using an economic decision analysis approach and performing deterministic and probabilistic analyses. The data used in this study reflect research in sustainable development in diversified sector. In addition to this, the three segments of the cash profile (investment, revenue, and cost) were assumed to be constant during their time frame. However, more precise results can be obtained by using industry specific data of the oil and gas sector and incorporating investment, revenue, and cost patterns in calculation of the NPV.

This research can be extended in the area of risk assessment by incorporating uncertainties related to environmental outcome and future regulation. Environmental regulations are changing every year to minimize impacts of on the environment and to deal with uncertainties related to outcomes of operations. Hence, adding these factors would help validate the model and also increase reliability.

The primary objective of this study was to justify investment in sustainability using a NPV model (single objective decision analysis). This model can be converted into multi objective decision analysis (using multi-attribute utility theory, and outranking (Eason, Meyer, Curran, & Upadhyayula, 2011)) by integrating it with social impact assessment and environmental impact assessment and parameters that cannot be converted into dollars into decision making. Another area for future research would be to extend this study to accommodate impacts of sustainable development at various stages of project lifecycle. This would align the model with all aspects of triple bottom line framework and it would help decision makers to analyze project decision to meet all aspects of sustainability.

VII. Conclusion

By focusing on sustainable development, the oil and gas industry can improve/increase potential benefits to society, environment, and economic objectives without jeopardizing the well-being of humans or the environment in this current generation and beyond. There are many aspects, both quantifiable and unquantifiable, of sustainability which can help oil and gas industry to meet their objectives. The model presented in this research should aid in better organizing and understanding the economic impact of sustainable development and also provide an approach that can be extended to accommodate various other factors. This research is intended to offer a preliminary framework required for integrating social and environmental factors into economic decision making using decision analysis.

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