DEVELOPMENT OF SUSTAINABLE PRODUCTION INDICATORS USING THE ANALYTICAL HIERARCHY PROCESS FOR THE PETROCHEMICAL INDUSTRY IN MALAYSIA

VIJAYALAKSHMI BENJAMIN SAMUEL

THESIS SUBMITTED IN FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

FACULTY OF SCIENCE
UNIVERSITY OF MALAYA
KUALA LUMPUR

2016

UNIVERSITY OF MALAYA
ORIGINAL LITERARY WORK DECLARATION

Name of Candidate: Vijayalakshmi Benjamin Samuel

I.C. No:

Matric No: SHC060028 Doctor

Name of Degree: of Philosophy

Title of Dissertation ("this work"): **Development of Sustainable Production Indicators Using the Analytical Hierarchy Process for the Petrochemical Industry in Malaysia.**

Field of Study: **Environmental Management**

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ABSTRACT

The objectives of this original research was to identify sustainable production indicators (SPIs) for the petrochemical industry in Malaysia, prioritise them in order of importance and establish a methodology for the assessment of sustainable production using the Lowell Centre Indicator Framework developed by the Lowell Centre for Sustainable Production (LCSP) at the University of Massachusetts Lowell, US. The petrochemical industry was selected because it is energy intensive, generates significant impacts and has high dependence on non-renewable fossil fuels. The SPIs were identified and shortlisted from the Global Reporting Initiative (GRI) Guidelines 3.1 by the research respondents comprising EHS managers from 13 petrochemical plants in Malaysia. Out of the 81 indicators listed under six main categories of the guidelines, 19 indicators were shorlisted and prioritised using the Analytical Hierarchy Process (AHP). The commercial PC-based software, Expert Choice™ was used to calculate the weights. The findings of the research indicated that for the six categories evaluated, Environment was ranked as the SPI with the highest priority (0.3777), followed by Labour Practices and Decent Work (0.197), Society (0.133), Economy (0.106), Product Responsibility (0.102) and Human Rights (0.057). For the ranking involving the indicators from all six categories, the top five global sub-criteria are as follows: (1) EN28a: Number of EHS regulatory non-compliance; (2) LA7a: Number of Loss Time Injuries (LTIs); (3): PR1a: Number of environmental, health and safety elements included in the product life cycle assessment; (4) EN6a: Percent of staff hired from local community and (5) HR4: Total number of incidents of discrimination. These indicators were then assessed against the LCSP framework to develop a methodology to understand at which sustainability level they were at and how to progress further.

ABSTRAK

Objektif kajian asal ini adalah untuk mengenal pasti petunjuk pengeluaran mampan (SPIs) bagi industri petrokimia di Malaysia, keutamaan yang mengikut keutamaan dan mewujudkan kaedah untuk penilaian pengeluaran mampan menggunakan rangkakerja Lowell Centre Petunjuk yang dibangunkan oleh Pusat Lowell untuk Pengeluaran mampan (LCSP) di Universiti Massachusetts Lowell, Amerika Syarikat. Industri petrokimia dipilih kerana ia adalah tenaga intensif, menjana kesan yang ketara dan mempunyai pergantungan kepada bahan api fosil yang tidak boleh diperbaharui. SPI telah dikenal pasti dan disenarai pendek daripada Inisiatif Pelaporan Global (GRI) Garis Panduan 3.1 oleh responden kajian yang terdiri daripada pengurus EHS dari 13 loji petrokimia di Malaysia. Daripada 81 petunjuk yang disenaraikan di bawah enam kategori utama garis panduan ini, 19 petunjuk telah disenarai pendek mengikut Proses Analisis Hierarki (AHP) dengan menggunakan perisian yang berasaskan PC komersial, Pakar Choice ™. Hasil kajian menunjukkan bahawa bagi enam kategori dinilai, Alam Sekitar telah disenaraikan sebagai SPI dengan keutamaan yang tertinggi (0,3777), diikuti oleh Amalan Buruh dan Kerja Decent (0.197), Persatuan (0.133), Ekonomi (0.106), Tanggungjawab Produk (0.102) dan Hak Asasi Manusia (0.057). Untuk keutamaan melibatkan petunjuk dari semua enam kategori, lima global sub-kriteria adalah seperti berikut: (1) EN28a: Bilangan EHS peraturan ketidakpatuhan itu; (2) LA7a: Bilangan Kecederaan Kehilangan Masa (LTI); (3): PR1a: Bilangan, unsur-unsur kesihatan dan keselamatan alam sekitar termasuk dalam penilaian produk kitaran hidup; (4) EN6a: Peratus kakitangan di ambil kerja dari masyarakat setempat dan (5) HR4: Jumlah kejadian diskriminasi. Penunjuk ini kemudiannya dinilai terhadap rangka kerja LCSP untuk membangunkan kaedah untuk memahami di mana kemampanan peringkat mereka berada di dan bagaimana untuk terus maju.

ACKNOWLEDGMENTS

The successful completion of this dissertation would not have been possible without the advice and encouragement from so many people in so many ways. Firstly, my deepest appreciation to my main supervisor, Professor Dr. P. Agamuthu, for his guidance on the technical aspects of the research, insightful comments, support and availability. Working on this dissertation whilst holding full time employment was a huge challenge. I am grateful to him for always making time for our discussions even at very short notice and often times at his inconvenience. To my co-supervisor, Professor Dr. Mohd. Ali Hashim, I am appreciative of his comments and input on the research content. I am grateful to the Faculty of Science, University of Malaya for approving the funds used to purchase the Expert Choice® software which was pivotal for this research. A special thanks to my laboratory mates and friends for their enthusiasm in lending me assistance during my study tenure.

This thesis is dedicated to three very important people in my life, my beloved parents, Benjamin and Padma Samuel; and my dearest friend, Dr. Renuka Sathasivam who stood by my side through my darkest hours and never gave up on me. I cherish all that they have done for me. My love and gratitude to the rest of my wonderful family, Vino, Shan, Anandh, Rayna, Rayzel, Uncle Edward and Aunty Ranibai for their prayers and support. And to Alfred - it is indeed a joy to celebrate this achievement with you! And above all, glory, honour and praise to God Almighty for His grace and mercy in my life.

It is of the LORD'S mercies that we are not consumed, because His compassions fail not.
They are new every morning: great is thy faithfulness.
Lamentations 3:22-23
Holy Bible

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LIST OF SYMBOLS AND ABBREVIATIONS

AHP	Analystical Hierarchy Process
API	American Petroleum Institute
DOE	Department of Environment
DOSH	Department of Occupational Safety and Health
EAGC	East Asian Growth Corridor
ECID	East Coast Industrial Development
EHS	Environmental Health and Safety
GHG	Greenhouse Gas Emissions
GOM	Government of Malaysia
GRI	Global Reporting Initiative
ICC	International Chamber of Commerce
ICLEI	International Council for Local Environmental Initiatives
IPIECS	International Petroleum Industry Environmental Conservation Association
IMP	Industrial Master Plan
LCSP	Lowell Centre for Sustainable Production
LCA	Life Cycle Assessment
MCDM	Multi-criteria Decision Making
MIDA	Malaysian Industrial Development Authority
MITI	Ministry of International Trade and Industry
MGCCI	Malaysian German Chambers of Commerce & Industry
PETRONAS	Petroliam Nasional Berhad
RC	Responsible Care®
SPI	Sustainable Production Indicator
TBL	Triple Bottom Line
UN	United Nations
UNCED	UN Conference on Environment and Development
UNEP	United Nations Environment Programme

USD	US Dollars
WCED	World Commission on Environment and Development

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CHAPTER 1: INTRODUCTION

1.1. Background

Malaysia is one of the rapidly growing economies in Asia evolving from an agriculture and mining-based economy to an emerging multi-sector economy spurred by high technology and knowledge-based and capital intensive industries (MGCCI, 2012). The country's rise since the 1970s to become an advanced emerging economy to date is proof that the nation is on track to become a developed economy by the year 2020, a goal embedded in the Malaysian government's Vision 2020. Malaysia's vibrant economy registered a gross domestic product (GDP) of US$312 billion, growing at 4.7 per cent per annum in 2013 (World Economic Forum, 2014). In 2012, the country recorded a per capita income of GDP US$10,400 with a growth rate of 3.9 per cent per annum and a population of 29 million people growing at the rate of 1.8 per cent per annum in 2012 (World Bank, 2014). The growth in the domestic economy was possible due to advancing modern and innovative technologies that have created new production processes. These production processes have in turn contributed to significant growth in the industrial sector. For 2015, the sector was predicted to grow by 5% (The Star, 2015).

One of the key industrial sectors in Malaysia is the petrochemical sector. Petrochemicals are defined as chemicals derived from petroleum and natural gas by direct manufacture or indirect manufacture as by-products from distillation or catalytic cracking processses (Speight, 2007; Naderpour, 2006). Supported by Petroliam National Berhad (PETRONAS), Malaysia's national oil company, this sector has made Malaysia a regional hub for petrochemicals. The industry produces a wide range of products that are raw materials or feedstock for downstream industries, e.g. plastics, polymers, packaging, electrical and electronics, medical devices, automotive, construction and agriculture (fertilizer) (MGCCI, 2012).

The petrochemical industry in Malaysia has shown significant growth in the past decade. Under the Third Industrial Master Plan (IMP3) (2006-2020), the key strategic thrusts for the petrochemical sector under the IMP3 include the following fiscal and non-fiscal incentives: (1) expand existing capacities and broadening the range of petrochemicals produced; (2) diversify into manufacturing related services and support industries; (3) enhance linkages with downstream industries, in particular plastics and oleochemicals; (4) improve chemical process technologies and the application of catalysts to increase yields; (5) undertake the full integration of existing petrochemical zones in Kertih (Terengganu), Gebeng (Pahang), Pasir Gudang-Tanjung Langsat (Johor), (6) establish new petrochemical zones in Bintulu, Sarawak; Gurun, Kedah; Tanjung Pelepas, Johor; and Labuan and (7) ensure feedstocks are available at competitive prices (MITI, 2005).

In the past, under the Second Industrial Master Plan (IMP2) (1996-2005), the total investment for petrochemicals and petroleum products totalled RM 31.2 billion (USD 7.6 billion)[1] of which 89.1% was for petrochemicals (MITI, 1995). At the end of 2005, the total investment from the sector was USD 9.5 billion. With regards to workforce, an estimated 10,000 employees were engaged in the petrochemical sector and the capital investment per employee ratio recorded during the IMP2 period was RM 4.1 million (USD 976,200) higher than the average ratio of RM 0.4 million (USD 95,240) in the manufacturing sector (MITI, 2005). Subsequently, in the coming years (2006-2011), the total investment exhibited an increasing trend. The total investment for the period between 2006 and 2011 is provided in Table 1.1. The quantum of the

[1] Based on the exchange rate of 1 US Dollar (USD) = 4.2 Ringgit Malaysia (RM) as of 1 February 2016

investment and its increasing trend over the past years are evidence that this sector contributes significantly to the Malaysian economy.

Table 1.1: Financial Contribution of the Petrochemical Industry to the Domestic Economy

Year	Total Investment (USD)
2006	11.6 billion
2007	18.9 billion
2008	19 billion
2009	10.7 billion
2010	19.1 billion
2011	20 billion

Source: Malaysian Investment Development Authority, 2015 Retrieved from http://www.mida.gov.my/env3; Malaysian-German Chamber of Commerce and Industry (2011, 2012)

1.2. Industrialisation and Sustainable Development

The industrial revolution propelled urbanization and industrialization as the predominant channels toward modernization. Although industrial growth is pivotal for progress and development, it is recognised as a significant source of environmental pollution and resource depletion. Some of the critical issues highlighted by the Global Environmental Outlook's Summary for Decision Makers (2007) under the United Nations Environmental Programme (UNEP) include global warming, air pollution, depletion of the ozone layer as a result of carbon dioxide (CO_2) and other greenhouse gas (GHG) emissions, unsustainable land use, decreased per capita of freshwater availability, uncontrolled exploitation of aquatic resources and loss of biodiversity (UNEP, 2007; Li & Lin, 2015).

Realising that uncontrolled environmental and human-health impacts would culminate in unsustainable development, the Government of Malaysia has given due cognizance to the principles of sustainable development and has developed national policies and guidelines aimed at the protection of the environment and human health (MITI, 2005). These measures are important for a country rich in biodiversity and natural resources where the government is often times critised for unsustainable development practices and neglecting human rights in pursuit of industrial and large scale agriculture development (Varkkey, 2013; Hezri & Hassan, 2006).

Sumiani *et al.* (2006) list the following as some of the environmental issues plaguing Malaysia as a result of industralisation and rapid urbanisation: deforestation to make way for large-scale land development, mining, dam construction and logging which have resulted in the loss of biodiversity, erosion, wildlife extinction, siltation of rivers, water pollution caused by untreated sewage and air emissions from industrial and vehicular sources. In a rapidly evolving world where the resources are finite and where there is marked deterioration in the quality of the natural environment as well as social concerns, the principles of sustainability needs to take centre place in every facet of development including industrialisation.

The concept of sustainable development was first coined and defined in 1987 in a report published by the World Commission on Environment and Development (WCED). The report entitled "Our Common Future" (also known as the Brundtland Report) was a result of research by the WCED which was set-up in response to the General Assembly of the United Nations. The mandate of the WCED was to identify and develop strategies to achieve global sustainable development by the year 2000 and beyond (GRI, 1997). In the Brundtland Report, the concept of sustainable development is summarised as development that is adept to satisfy the necessaties of the present generation without compromising the ability of future generations to fulfill their own needs; a process in which the employment of resources, the direction of investments and the orientation of technological advancement and institutional change are synchronised to meet human needs (WCED, 1987). The concept encompasses all impacted stakeholders and is built on a triad which comprises economic, social and environmental aspects (Figure 1.1).

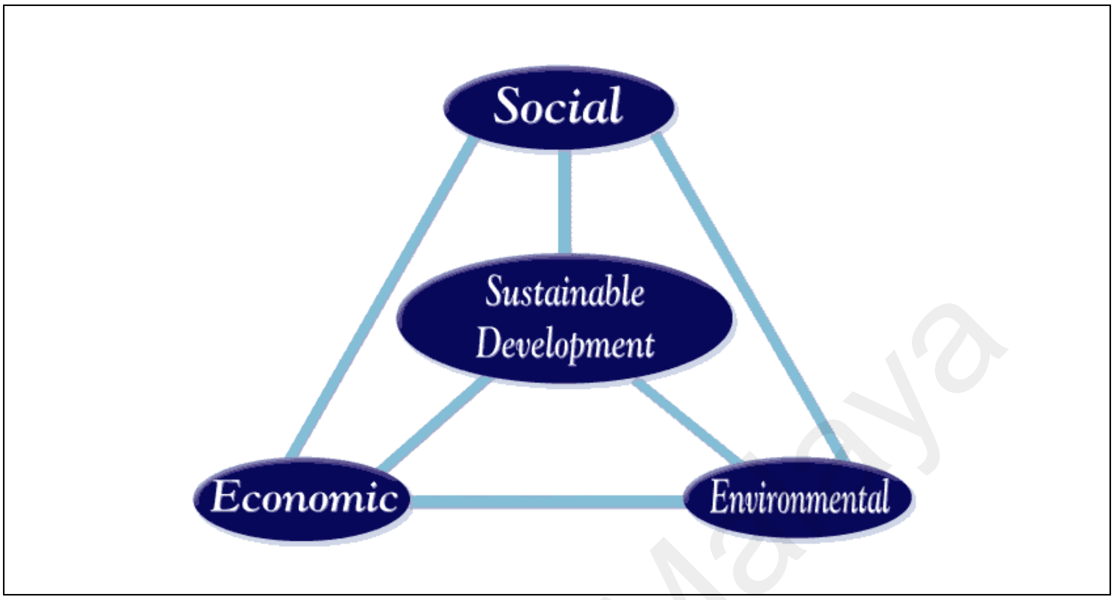


Figure 1.1: The fundamentals of sustainable development
Adapted from Hunkeler, 2006; Brundtland, 1987.

More than two decades ago Elkington (1993) coined the concept of Triple Bottom Line or commonly known as TBL as described in Figure 1.2 to described sustainability. He put forward the theory that in ensuring success in business, an organization's holistic success should be based on its social development, environmental protection and economic growth.

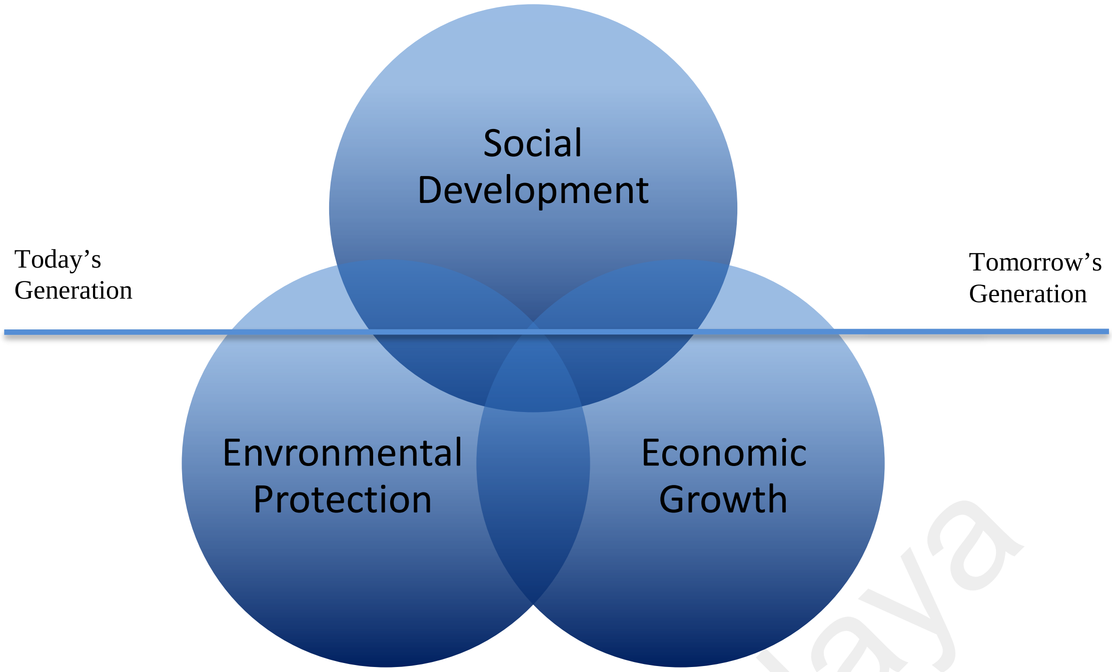


Figure 1.2: The three main dimensions and interactive process in sustainability (Manzi et al., 2009)

In other words, economic advancement which is integrated with environmental preservation and social responsibility is necessary to achieve sustainable development (Bello, 2006; Dahl, 2012). Chaabane et al., (2012) & Shen et al. (2013) frame sustainable development as the interdependence of three dimensions, namely, the economic, the environmental and the social performance of an organization. This is reinforced by findings from a study by Gomes et al. (2015) where it was noted that society and stakeholders are increasingly valuing companies based on their position with respect to initiatives towards susainable development. This is turn increases the value of companies that have a clear focus towards growing sustainably.

1.3. The Petrochemical Industry and Sustainability

As much as the petrochemical industries contribute significantly to the economy of the nation, the sector has been identified to be one of the polluting industries by the Department of Environment (DOE) Malaysia. The sector is classified under the category of heavy industry which generates significant air emissions, wastewater, noise pollution and toxic and hazardous wastes (DOE, 1996). Heavy industries are defined by DOE as industries with the following characteristics: (1) significant environmental pollution and risk due to fire, explosion, radiation, and/or highly hazardous chemicals; (2) significant air pollution risk (including odour) from residual pollutants in air emissions (fugitive and source emissions); (3) significant potential for contribution to greenhouse gas emissions and/or ozone depleting substances; (4) generate excessive noise and/or vibration exceeding safe limits; (5) discharge significant volumes of wastewater containing levels of residual contaminants exceeding the discharge criteria; (6) utilise large quantities of raw material(s) with potential to cause significant fugitive emissions during handling, transfer and storage; and (7) generate signficant quantities of scheduled wastes some of which have recalcitrant characteristics making it difficult to treat, recover or recycle and requiring disposal within a secure landfill. In terms of safety and risk, petrochemical facilities in Malaysia are categorized as major hazardous installations by the Department of Occupational Safety and Health (DOSH) as enforced under the Occupational, Safety and Health Act, 1996. Hazardous installations are defined as industrial facilities that store and process large quantities of flammable and/or toxic materials above a set of threshold values which have the potential to cause adverse consequences to the surrounding population, property and environment (GOM, 1996).

Globally, it is reported that the chemical and petrochemical industy consumes approximately 35 EJ (Exajoules) of final energy (sum of fuel demand (for fuel and feedstock purposes), steam and elecricity use) (Saygin et al., 2010). Studies by Duce and Hoffman (1976) and, Hope (1997) have shown that petrochemical industries have been identified as key contributors of inorganic and organic pollutants including elements such as vanadium (V), arsenic(As) and chromium (Cr). Organic contaminants such as volatile organic compounds (VOCs), polycyclic aromatic hydrocarbons (PAHs) and polychlorinated biphenyls (PCBs) have been also been detected in environments surrounding oil refineries which produce products that form the feedstock for the petrochemical industries (Tsai *et al*., 1995; Kuo *et al*., 1996; Lee *et al*., 1996; Lin *et al*., 2001; Cetin *et al*., 2003; Pandya *et. al*., 2006; Rao *et al*., 2008). In a study by Nadal *et. al* (2007), soil samples collected near a petrochemical zone were found to have high concentrations of Cd and Pb. Further, selected epidemiological studies have revealed the possibility that the existence of these types of facilities could induce an excess of health concerns involving leukemia, as well as bone, brain, and bladder cancers (Pan *et al*., 1994; Knox & Gilman, 1997). Yang et al., (2002) reported evidence of a positive correlation between petrochemical air pollution and adverse pregnancy outcome (preterm delivery). Therefore, sustainable production processes in this sector is vital for the protection and conservation of natural resources and, human life in an era where global economies are driven predominantly by industry and technology.

Given the rapid industrialisation in Malaysia with a significant thrust in the petrochemical sector, there is a clear need to operationalise the concept of sustainable development within this industry, i.e. with the implementation of sustainable production processes at a facility or plant level. This research was conceived out of the need for a suitable assessment tool to enable the petrochemical industry in Malaysia to track their progress towards operating in line with the principles of sustainable development.

1.4. Problem Statement

In Malaysia, over the last two decades, there has been a clear paradigm shift amongst organisations from only focusing on economic progress to ensuring that a balance is achieved between business excellence and environmental and social sustainability. Presently, although there are many guidelines, frameworks and management systems in the country which organisation can employ to monitor, evaluate and benchmark sustainable development in urban planning and agriculture production (Sham Sani, 2001; Hezri & Hasan, 2006), there is no assessment tool which specifically adddresses sustainable production in the context of industrial operations/production. Most of the sustainable development initiatives which have been implemented in Malaysia are with resepct to the sustainability of urban areas as these areas are seen to be the main receptors of the impacts of industrialisation. Sustainable development initiatives such as Healthy Cities, Sustainable Cities and Local Area Agenda 21 which are all aimed at improving the quality of life of local residents (Peterson, 2002) have been implemented largely by Government agencies in Malaysia.

At an industry level, most of the petrochemical facilities in Malaysia typically implement environmental management systems and occupational safety and health management systems such as the ISO 14001 and OHSAS 18000 whilst others have derived specific key environmental performance indicators as an assessment tool. Further, the petrochemical industries also subscribe to the principles of Responsible Care® (RC). RC is a global initiative that drives continuous improvement in health, safety and environmental performance, together with open and transparent communication with stakeholders, and embraces the development and application of sustainable chemistry thereby contributing towards sustainable development. Other indicators systems include those developed under the International Organization for

Standardization of Environmental Performance Evaluation Guidelines ISO 14031, the Global Reporting Initiative, or the World Business Council for Sustainable Development. Whilst some of these are very specific to the environmental component of sustainable development, i.e. the ISO 14031 or the ISO 14001, others are general guidance documents which enable industries to select aspects which are relevant to them (Azapagic & Perdan, 2000).

Applying the Brundtland definition of sustainable development at an industrial level, sustainable production was defined by Ron (1998) as industrial production processes that manufacture goods meeting the needs and aspirations of the present society without compromising the ability of future generations to meet their own needs and aspirations. The sustainability of the product should be considered throughout its lifecycle.

To this end, there is a definite need to develop sustainability criteria and identify indicators which can be used to assess the performance of industries and for continous tracking of their progress towards sustainability (Krajnc & Glavic, 2003); and for decision making and policy formulation (Chess *et. al.*, 2005). Sustainability indicators are essential tools for the appraisal of an industry's performance towards sustainable development. With the accessibility of varying types of indicators with different levels of complexity, industries can benchmark their performance and improve their operations (Al-Sharrah et al, 2010; Tseng, 2013).

1.5. Selection of an Indicator System and an Assessment Framework

Irrespective of the development sector, there is global consensus that in order to achieve the sustainability objectives, the development of appropriate indicators is fundamental (Narula and Reddy, 2015; Ault et al., 2014, Lahtinen et al., 2014). In

Malaysia, research efforts on sustainable development indicators commenced in 1995 with involvement from the academia, Federal and State government agencies and non-governmental organisations. These initiatives involve the development of indicators for urban planning (Hezri & Hasan, 2004) and most recently, research by Ilias Said et al., (2010) for the construction industry and, identification of indicators for a sustainable rating system for building design and construction (Ibrahim et al., 2013). To date, no indicator system has been developed to measure sustainable production in the context of industrial processes in Malaysia.

The indicators shortlisted for use in this research were selected from the pool of indicators identified in the Global Reporting Initiative (GRI) 3.1 which was developed by an organization of the same name that works towards a sustainable global economy by providing sustainability reporting guidance. GRI has pioneered and established a comprehensive Sustainability Reporting Framework for voluntary use. The framework is the world's most widely used sustainability reporting tool and the performance indicators listed therein are used to measure and report their economic, environmental, and social performance (GRI, 2012). As these indicators have been well established and recognised by governments, institutions, businesses, non-governmental organisation and other stakeholders and, because the majority of the petrochemical companies in Malaysia are already voluntarily reporting selected GRI 3.1 indicators, this pool of indicators was deemed to be a technically sound and socially accepted for purposes of this research.

From this pool, a set of suitable indicators was selected (in the original form or as a modified form to suit the local context of the research) for use as sustainable production indicators (SPIs). The SPIs were the further prioritised using the Analytical Hierarchy Process (AHP), one of the well-known multi criteria decision-support tool, to understand their respective importance to the petrochemical industry. The indicators were ranked in order of priority as decided by the research respondents who comprises solely of environment, health and safety (EHS) managers employed at petrochemical plants in Malaysia. Prioritisation allows the industry to focus on the indicators based on their importance especially during economic downturn when financial resources are not readily available and funds are approved only for critical expenditure. During such times, the industry can then allocate budget for the more important indicators to ensure that data tracking towards sustainability is still carried out. The selection of SPIs using the hierarchical approach has been established (Tseng, 2013)

Developed by Saaty (1980), the AHP is a multi-criteria decision making (MCDM) method that prioritizes groups of alternatives or assumptions or any set of scenarios being compared (Khamkanya et al., 2012; Ishizaka & Labib, 2009; Saaty, 1980). For purposes of this research, the Expert Choice® software was used for the AHP calculations.

In developing an assessment framework, the SPIs tailored for the petrochemical industry were used in conjunction with the Lowell Centre Indicator Framework developed by the Lowell Centre for Sustainable Production (LCSP) at the University of Massachusetts Lowell. The LCSP framework was established to promote industrial production practices that are safe, healthy, environmentally sound, socially responsible and economically viable over the long term (Veleva et al., 2003). The LSCP defines sustainable production as (1) the production of goods and services via processes and systems that do not pollute the environment, (2) the conservation of energy and natural resources, (3) the operation of businesses that are economic viable, (4) protecting the safety of employees and creating a living environment that has minimal risk to human health (LCSP, 1998).

The LSCP definition is consistent with the current understanding of sustainable development which addresses all three aspects of environmental, social and economic aspects. The Lowell Centre Indicator Framework uses a five-level model for the assessment of sustainable production and to date, the framework has been tested and used to evaluate sustainable production activities in numerous businesses including the pharmaceutical industry (Fernandez-Sanchez and Rodriguez-Lopez, 2010).

1.6. Purpose and Objectives of the Research

As there is presently no specific tool for the assessment of sustainable production in the petrochemical industry in Malaysia, the objectives of this research are to:

1. Identify a set of SPIs representing the three pillars of sustainble development, i.e. economics, environment and social issues that the industry can use to assess sustainable production processes;
2. Prioritise the SPIs using the Expert Choice® software which is based on AHP to rank the SPIs in order of priority and to understand the importance of each of the respective indicators to the petrochemical industry;
3. Identify a suitable assessment framework for the integration of the SPIs in a manner that can be used by the petrochemical industry to track their progress in operating in a sustainable manner; and
4. Develop a clear and transparent process for the selection of SPIs to enable the industry to continue to track its progress towards sustainability. This is to enable its duplication in the future should there be changes in the external factors that would influence the type of SPIs as well as their ranking. For example, with time and advancement of scientific research, changes in petrochemical production processes will occur to create more efficient processes. Further, with the introduction of new local and international regulatory requirements, the

focus on sustainability will change. To keep abreast with these changes, the assessment process needs to be dynamic with the identification and use of new SPIs. Therefore, as part of continous improvement towards sustainability, the industry must adapt to sustain their competitive advantage. A clear assessment process will serve as a solid foundation on which the industry can repeat the assessment with or without modification.

CHAPTER 2: LITERATURE REVIEW

2.1. Introduction

Sustainability has been the subject of extensive debates and discussions, drawing attention of both academia, which has been involved in the research and theoretical analysis of the concept. Organisations and institutions also play a role by primarily being involved in developing tools and frameworks for government policies as well as best practices for industries (Hourneaux Jr., 2014; Comoglio & Botta, 2012). For the industry sector, specifically, sustainability has become the focal point, as industries are the drivers of economies and therefore they are responsible for the manner in which they operate (Singh et al., 2009).

Based on 2010 data, Malaysia is one of the 20 largest trading nations globally and is ranked 30th out of 125 countries by the Global Enabling Trade Report by the World Economic Forum (MGCCI, 2012). Economic growth averaged at 7.7% and 5.8% during the periods 1970 to 1980 and 1980 to 1990 respectively. For the period 1990-2005, the growth averaged at 6.5% before falling to 4.3% and 5.9% in 2008 and 2009 respectively due to the Global Financial Crisis (Hui et al., 2014). The growth rate subsequently moved upwards in 2010, 2011 and 2012 at 6.7%, 5.1% and 5.6% respectively. The growth rate for 2013 is between 4.5 – 5.0 % with 2014 recording a growth rate of between 5.0 – 5.5 %. For 2015, Malaysia's projected growth rate of 4.5% - 5.5% remains one of the world's top growth forecast which is largely supported by strong fundamentals, robust trade and prudent fiscal policies (Lim, 2015). This projection is aligned with the ASEAN-5 economies consisting of Malaysia, Indonesia, Thailand, Singapore and the Philippines, which is expected to expand by 5.2% in 2015 as claimed by the International Monetary Fund (Lim, 2015).

Malaysia's per capita income has doubled in less than a generation by transforming itself from an economy reliant on agriculture and mining to an industrialised economy. It is undeniable that whilst industrial growth is pivotal for the progress and development of any country around the globe, it is also recognised as a significant source of pollution and resource depletion leading to environmental degradation (Herva, et al., 2011). Some of the critical issues highlighted by the Global Environmental Outlook's Summary for Decision Makers (2007) under the United Nations Environmental Programme (UNEP) include global warming, air pollution, depletion of the ozone layer, unsustainable land use, decrease in agriculture production per capita and availability of freshwater, heavy and uncontrolled exploitation of aquatic resources and loss of biodiversity (UNEP, 2007). Dahl (2012) observed that the precipitous increase in food and energy prices point to the vulnerability of global sustainability and Bebbington et al. (2009) emphasized that there is an inherent need for model, metrics and tools to convey the extent to which anthropogenic activities are unsustainable. As a result, the on-going debate on sustainability and the development of tools to measure its progress have taken a new urgency.

Similarly, in Malaysia since the past three decades, there has been an increased awareness in environmental and social sustainability with numerous policies and strategic national sustainability objectives being formulated by the Government of Malaysia (EPU, 2010). These include sustainable development frameworks and indicator systems that have been developed at policy levels (Hezri, 2003). Whilst there is an urgent need to design and construct for sustainability, the process of translating these into concrete action at a micro-level, i.e. at an operational level is often not straightforward (Ugwu *et al.*, 2006).

In Malaysia, although indicator systems have been developed for elements of sustainable development, there remains a gap for tools to assess sustainable production at an industry (operational) level. In designing such a tool, there needs to be a clear understanding of the indicators that influence sustainability at an operational level and their interaction. A sound understanding of the relevant sub-indicators and their cumulative impacts is also necessary. In this research, the development of a set of indicators and a suitable framework for the assessment of sustainable production specifically for the petrochemical industry are investigated.

This chapter begins with a description on the evolution of sustainable development leading into a discussion on the concept of sustainable production and its relevance to the petrochemical industry. Following this, a review is presented on the available assessment methodologies, as well as, existing indicator systems. The discussion then continues on the sustainable development initiatives in Malaysia, followed by the petrochemical industry and why the sector was selected for the study. The last part of the chapter describes the research framework employed for this research and the Analytical Hierarchy Process, a mathematical model developed by Saaty (1980) used for the prioritisation of suitable indicators.

2.2. Evoluation of the concept of sustainable development

Since its inception in 1987, the concept of sustainable development and its evolution has gained marked prominence with governments, research institutions and corporations (Ugwu *et al.,* 2006). The premise of sustainable development comprises two concepts: development (to improve) and sustainability (to maintain) (Bell and Morse, 2003). The term 'sustainable' does not imply preservation of a static state of affairs (Walter & Wilkerson, 1998) but rather an evolving process that is based on continuous development.

The Brundtland Report (1987) defines sustainable development as development that caters for the needs of the current generation without compromising the ability for future generations to satisfy their own needs. In 2002, using the definition provided by the Brundtland Report at the World Summit on Sustainable Development, sustainable development was described as comprising three pillars, i.e. social, environmental and economic as symbolised by the summit motto “People, Planet, Prosperity” (Moldan et al., 2012). More importantly, these three pillars are to be integrated and not treated as mutually exclusive in order to achieve the objectives of sustainable development (Goodland, 1997; Kuhtz, 2007; Ding, 2008).

Prior to the Brundtland Report, and before the concept of sustainable development was coined, elements of sustainability was discussed by the International Union for Conservation of Nature in their publication entitled the World Conservation Strategy in the year 1975. The concept was used in the context of social equity, encouraging the redistribution of resources to the poorer countries (Stern, 1997). The strategy discussed sustainable development as being represented by three key pillars or approaches, namely, (1) changes are necessary in the development and use of technologies to ensure that they are in harmony with the conservation and preservation of natural resources (2) developing nations should be able to independently meet their needs by means of ensuring a sustainable population level and finally, (3) developing countries should be given opportunities for equal growth with developed countries (Hanley & Buchdahl, 2002).

The relationship between society, environment and the economy as subsets of sustainable development is depicted in Figure 2.1**.** Although the concept originally emerged in the context of global development, governments, institutions and businesses have applied it at a corporate or business level (Atkinson, 2000; Bansal, 2005; and Ehrenfeld, 2005).

In the context of a corporation or organization, Hund *et al.*, (2004) describes corporate sustainable development as the ability of a business to predict as well as satisfy the needs of both the present and future generations of stakeholders. Although the general concept of sustainable development has been developed, researchers have been debating on what the concept means in practice (Beloff *et al*., 2004). Some of the general requirements as summarised by Gibson (2004) include '*social and environmental integrity, sufficiency and opportunity, equity, efficiency and throughput reduction, democracy and civility, precaution and adaptation and immediate and long-term integration*'. Elkington (1997) defines these three dimensions as the 'triple bottom line' of organisational performance. An expanded model of sustainable development which is an example of corporate sustainability in the context of industrial operations is provided by ConocoPhilips (Esquer-Peralta, 2007) in **Figure 2.2.**

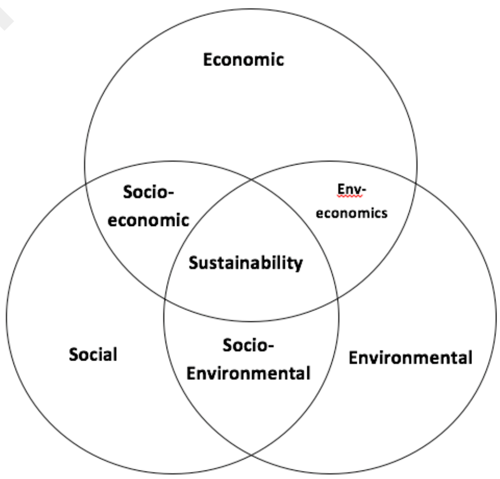


Figure 2.1: Conventional Model for Sustainable Development
Source: Adapted from WCED (1987)

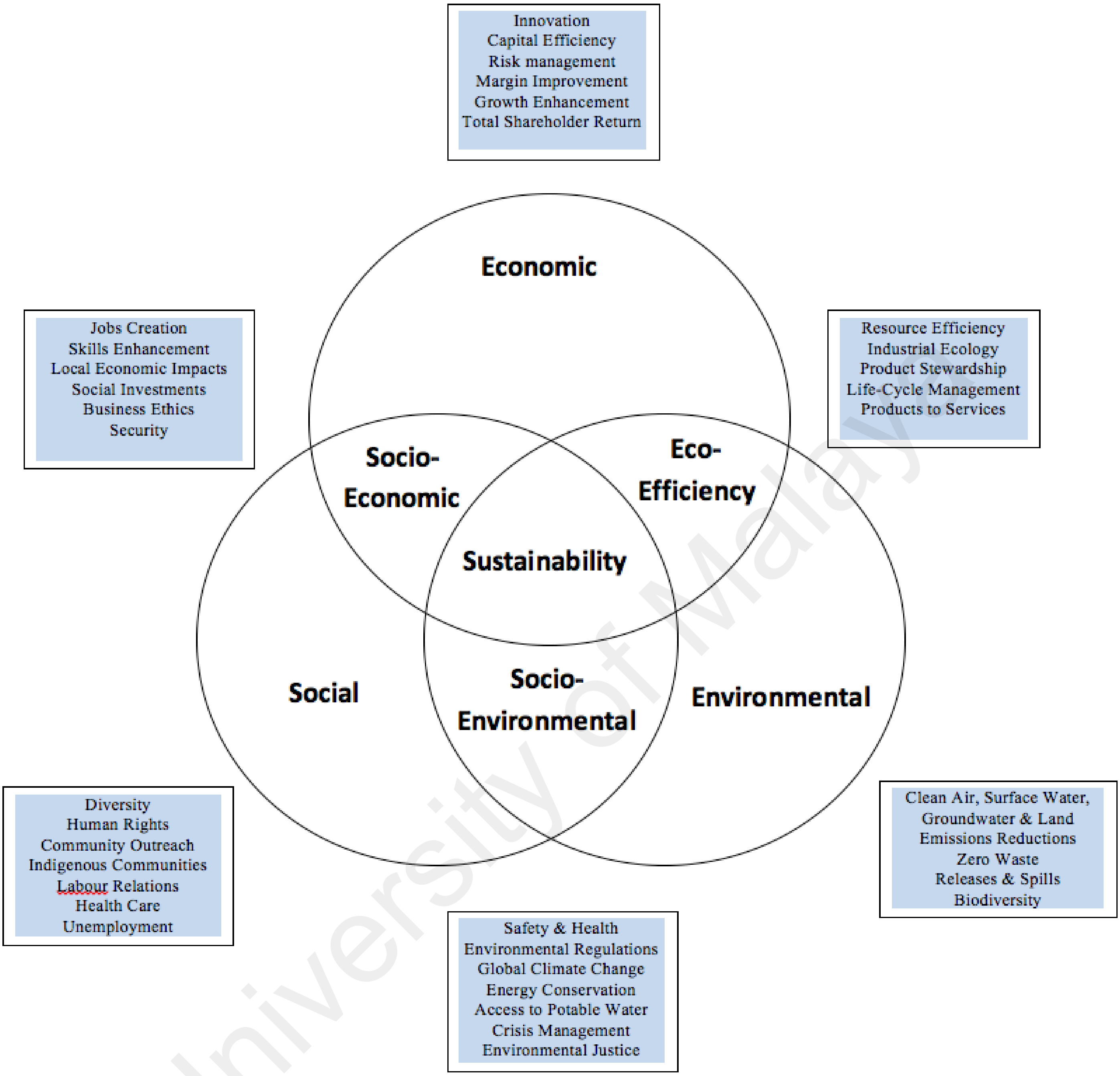


Figure 2.2: Expanded Model of Sustainable Development

Source: Modified from Esquer-Peralta (2007).

The following sub-sections describe examples of key international initiatives on sustainable development which essentially formed the foundation for much of the efforts undertaken by both academia as well as governments, institutions and private sector ogranisations/businesses in progressing and operationalising the concept.

2.2.1. The Brundtland Report

Environmental matters first took global prominence in the year 1972 when the United Nations Environmental Programme (UNEP) was formed during the very first world conference on the environment. The impetus to hold this conference was the result of the findings of a book entitled “The Limits to Growth” which was published by the Club of Rome in the same year. The findings painted a bleak picture, i.e. the earth would reach her limits if the growth rate of the population, food production and natural resource extraction continued in an uncontrolled manner (Pezzoli, 1997). In 1983, to further address the issues pertaining to environmental degradation, the United Nations Commission on Environment and Development (UNCED) was founded. The primary objective of the commission was to scrutinize critical environmental issues and development in order to devise suitable mitigation or action plans to circumvent the impacts; to reinforce and foster international coorporation on environment and development; and to educate populations across the world on these issues (Hanley & Buchdahl, 2002; Redclift, 1992). In 1987, the commission produced a land mark report entitled “Our Common Future” which used and defined the concept of sustainable development. The report was also called “The Brundtland Report” in honour of the former Norwegian Prime Minister Gro Harlem Bruntland who headed the commission at that time. The report was a product of research by the commission with a mandate to identify and develop strategies for implementation that would enable global sustainable development by the year 2000 and beyond (GRI, 1997).

Sustainable development as originally defined in the Brundtland Report is as follows:

…."Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs... sustainable development is not a fixed state of harmony, but rather a process of change in which the exploitation of resources, the direction of investments, the orientation of technological development, and institutional change are made consistent with future as well as present needs." (Brundtland, 1987, p.46)

This progression of change requires inter alia:

…an economic system that is able to generate surpluses and technical knowledge on a self-reliant and sustained basis…..a production system that respects the obligation to preserve the ecological base for development [and] a technological system that can search continuously for new solutions (Brundtland, 1987, 52).

The report essentially highlighted that the main cause for progressive degeneration of our common environment is the unsustainable mode of consumption and production, especially in industrialised countries.

2.2.2. Agenda 21

Initiatives to develop sustainability indicators by both government and private sector have been rapidly on the rise since the beginning of the 1990s (Pulzl *et al.*, 2007). In 1992, the Rio Earth Summit under the auspices of the UNCED was convened by the United Nations General Assembly and this conference became one of the largest environmental conference in history. The conference noted that there was a rise in inappropriate pattern of utilisation of resources and production, especially in industrialized countries (United Nations, 1996) and therefore a need for sustainable consumption and production practices was established. The distinction between sustainable consumption and sustainable production is that the former targets consumers whilst the latter is related to businesses that make products or offer services (Veleva and Ellenbecker, 2001a). This led to the birth of Agenda 21, an international blueprint that outlines actions and initiatives to be undertaken by governments, international organisations, industries and the community to achieve sustainability. These actions acknowledge the impacts of human behaviour on the environment and on the sustainability of systems of production. Agenda 21 was put forward as a means for the alleviation of poverty, hunger, sickness and illiteracy worldwide while halting the deterioration of ecosystems which sustain life.

Agenda 21 was formulated and launched by the International Council for Local Environmental Initiatives (ICLEI) in 1991 for the implementation of programmes by the United Nations Conference on Environment and Development. The primary objective of Agenda 21 is to reformulate the structure of economic success by forcing governments to consider natural resources as an integral part of economic success (Llamas-Sanchez, 2013). Hence, the costs associated with environmental degradation should be taken into account when conducting economic assessments. In addition, developed nations are called to assist under-developed countries to become more sustainable and thereby reduce their impact to the environment. The treaty provides a detailed plan of action including roles, responsibilities and targets and is to be used by local governments as a blueprint towards achieving sustainable development. Agenda 21 is divided into four sections (UNEP, 1992):

- **Social and Economic Dimensions**: This section examines the causal human factors and problems of development, along with the key issues of trade and integrated decision-making;
- **Conservation and Management of Resources for Development**: As the largest section of Agenda 21, this part presents the range of resources, ecosystems and other issues, all of which must be examined in detail if sustainable development is to be achieved at global, national and local levels;
- **Strengthening the Role of Major Groups**: This section examines the role of social partnerships if sustainable development is to be a reality. The discussion

presented herein recognises that Government and international agencies on their own are unable to attain sustainable development unless the community, through representative and industry organisations, becomes a key player in the development of policy and in achieving the necessary changes.

The proceedings of this conference also became the basis for the development of major treaties including the Convention on Biological Diversity; the Framework Convention on Climate Change; Principles of Forest Management; and the Rio Declaration on Environment and Development (Hanley & Buchdahl, 2002; Harger & Meyer, 1996).

Malaysia has been signatory to Agenda 21 since 1992. Funded by the United Nations Development Programme, the Government of Malaysia implemented its pilot programme between 2000-2002 which involved four cities, namely, Petaling Jaya, Kuantan, Miri and Kerian with the intention of including other cities in the future. For these four cities, initiatives were put in place to enable the cities to achieve the status of sustainable cities. These initiatives encourage private sector participation and cooperation (Ngah et al., 2011).

The role industries can assume in meeting environmental, social and economic challenges has been recognised and highlighted in Agenda 21. Chapter 35 (Science for Technology Development) and 40 (Information for Decision-Making) of Agenda 21 provide the foundation to develop and implement indicators of sustainable development (UNEP, 1992). Chapter 35 which addresses the role of science in development, advocates that science is a tool for decision-making in the process of formulating environmental and development policies. More importantly, the chapter implies that there must be enhanced scientific knowledge, improved long-term scientific appraisals, reinforce scientific capacities and ensure that the sciences are receptive to the burgeoning needs of the nation. The chapter goes on to propose that countries who are assisted by international organizations should develop and institute the necessary tools for sustainable development such as the development of quality-of-life indicators which encompass aspects such as health, education, social welfare, state of the environment and the economy (UNEP, 1992).

2.2.3. Business Charter for Sustainable Development

The International Chamber of Commerce (ICC), in response to the UNCED, developed a Business Charter for Sustainable Development in 1991 which sets out sixteen (16) principles for environmental management. The ICC is a non-governmental organization serving the global business community and has members from more than 130 countries including thousands of business organizations and enterprises with international interests (Fortuński, 2008). As an international association representing the concern of business entities from all sectors, the ICC helps promote world trade and investment. The ICC Charter encompasses environmentally relevant aspects, namely health, safety and product stewardship. Its objective is to provide a fundamental framework to be used as a tool to assist business in improving their environmental performance in line with the principles of the Charter and to establish management practices that would enable the measurement of their progress towards sustainability (Barkemeyer 2014). The 16 principles set out in the charter are presented in **Table 2.1** below.

Table 2.1: Principles of the Business Charter for Sustainable Development

1. Corporate priority	9. Research
2. Integrated management	10. Precautionary approach
3. Process of improvement	11. Contractors and suppliers
4. Employee education	12. Emergency preparedness
5. Prior assessment	13. Transfer of technology
6. Products and services	14. Contributing to the common effort
7. Customer advice	15. Openness to concerns
8. Facilities and operations	16. Compliance and reporting

Source: (Barkemeyer, 2014)

The ICC Charter has been endorsed by more than 2,300 companies including large multinational corporations such as Norsk Hydro, Deloitte & Touche, Akzo Nobel, and Xerox and, numerous industry associations use the Charter to formulate their sustainability programmes (Platje et al., 2008). The endorsement of the Charter is voluntary and by embracing it, organisations are committing themselves to comply with the 16 principles for environmental management. The ICC is currently in the midst of evaluating how organizations are applying the principles of the Charter, and what their experiences were with implementation (ICC, 2015)

2.3. Sustainability, sustainable development and sustainable production

Over the years, there have been numerous conceptualizations of sustainable development literature with businesses becoming more aware and give prominence to sustainability (Govindan et al., 2013; Shen et al., 2013). With the introduction of the term sustainable development, other related terms which have been introduced include sustainability (or corporate sustainability) and sustainable production. In order to understand these terms, it is important to discern their similarities and subtle differences. For the purpose of this research, the terms sustainable development and sustainability are used interchangeably with sustainable production used specifically for sustainability in the context of industrial production processes.

2.3.1. Sustainability

Sustainability is defined by Harris (2007) as business activities and operations that are implemented in a way that does not lead to permanent and long term destruction of the environment including consideration of permanent, irreversible, cumulative and severe temporary effects. Another definition provided by Brand (1997) defines sustainability as the reworking of technological, scientific, environmental, economical and social resources in a manner that does not compromise the temporal and spatial equilibrium. This is a more applied definition which takes into account the three pillars of sustainable development.

Historically, in the context of industries and businesses, corporate sustainability has evolved as a result of economic growth, environmental regulation-stewardship and an emphasis for social justice and equity. Corporate sustainability is largely defined in the context of the ‘triple bottom line’ which covers environmental performance, social responsibility and economic contribution. In 1992, the Rio de Janeiro Conference on Environment and Development played a key role in endorsing the concept that corporate sustainability is a result of three pillars: economic growth, ecological balance and social responsibility (DESA, 1992). Wilson (2003) described corporate sustainability as a new and evolving corporate management paradigm as this concept constitutes a replacement of the traditional growth and profit-maximization. His description states the following:

> […] while corporate sustainability recognised that corporate growth and profitability are important, it also requires the corporation to pursue societal goals, specifically those relating to sustainable development – environmental protection, social justice and equity, and economic development (p. 54)

The essence of sustainability was further propagated in the Brundtland Report where the report challenged the world to envision a future where the threats of environmental degradation be reduced for economic stability and social equity for present and future generations. The report recognised that mankind is dependent on the environment to meet their needs, and that there is a linkage between ecology and economic growth. There needs to be a balance between exploitation of resources and, environmental protection and conservation (Hopwood et al., 2005). Based on these definitions, it can be concluded that the underlying principles of sustainable development and sustainability are essentially similar. Hence, these terms are used interchangeably in this research to describe a process which is dynamic and evolutionary that requires a focus on continuous improvement.

2.3.2. Sustainable Production

Applying the Brundtland definition of sustainable development at an industrial level, sustainable production was defined by Ron (1998) as an industrial production process that manufactures products to satisfy the needs of the present generation without compromising the ability for future generations to meet their needs. This definition is applicable to the entire lifecycle of the product.

As previously discussed, the concept of sustainable production was highlighted in the Rio Summit and described in the context of sustainable consumption and production. Whilst sustainable consumption pertains to consumers, sustainable production relates to organisations that make products or offer services using processes and systems developed on the principles of non-polluting, conservation of energy and natural resources whilst being economically viability, not affecting the health and safety of employees, communities and consumers, and socially and creatively rewarding for employees (Veleva and Ellenbecker, 2001a). O'Brien (1999) defined sustainable production as the industry's ability to "underpin society's need not only to create wealth but to do so in a way which will support sustainable economic development". Industries are challenged to produce products which are sustainable and hence they require decision-making tools that address the impacts associated with environmental, economic and social issues.

2.4. Why industries pursue sustainable production

Incidents of environmental pollution as a result of the industralised era and the unearthing of toxic waste dumps such as Love Canal and Times Beach in the 1970s; the Union Carbide gas leak in Bhopal, India and the Chernobyl nuclear power plant explosion in Russia, the Kuwait oil-well fires during the Gulf War, Exxon Valdez oil spill, and the recent Deepwater Horizon oil spill in the Gulf of Mexico have created greater awaress and the emergence of global interest among industry, governments, and non-government on environmental protection. Organisations including the industries combine resources and work together to develop methods for sharing responsibility and complying with legal provisions that preserve and maintain the environment and its natural resources. Today, most businesses have voluntarily adopted initiatives to extend the traditional economic objective which leads to shareholder wealth maximization to include environmental and social elements (Christofi et al., 2012). Government regulators and policy makers recognise that corporate sustainability is pivotal to investors and the public at wide, and are increasingly concerned with potential consequences of environmental and social degradation.

Schwarz *et al.* (2002) note that implementing the concept of sustainable development in an operational context entails the use of practical and economically feasible methods to evaluate sustainability performance and measure its progres over time. Organisations have developed numerous types of policies, plans and programmes in an effort to operationalise sustainable development within their organisation (Beloff *et al.*, 2004). In the past decade, numerous non-specific tools have been developed for some aspects (if not all) of the assessment and monitoring of sustainable development. Notable tools amongst others include the ISO 14001 - Environmental Management System and ISO 14031 - Environmental Performance Evaluation Guidelines, the Life Cycle Assessment or commonly known as LCA, Ecological Footprinting, Environmental Accounting, Design for Environment and Eco-Design. Similarly, due to increased awareness on process and product sustainability, the concept of eco-labelling has become a fundamental benchmarking system for organisation's to assess their sustainability performance and, to steer consumer choice to environmental-friendly products (Herva et al., 2011). In 2005, the International Petroleum Industry Environmental Conservation Association (IPIECA) in cooperation with the American Petroleum Institute (API) published a voluntary framework entitled IPIECA-API specifically for the oil and gas sector (Proto, et. al., 2007). To date, the oil and gas industry players have begun to implement the IPIECA-API and the Global Reporting Initiatives (GRI) reporting guidelines to benchmark their performance in sustainable exploration, production and refining processes (Dittrick, 2007).

The Dow Jones Sustainability Index (DJSI) was launched in 1999 to measure and monitor the financial performance of leading sustainability-driven corporations. The main emphasis of the DJ Indexes is to develop performance indicators from investable concepts and report on their financial performance. The view that corporate sustainability leading businesses attain long-term stakeholder value by developing strategies to harness the market's potential for sustainability products and services while concurrently reducing and avoiding sustainability risks is considered to be economically profitable and can be targeted for investment decisions. The selection of index components adheres to a rule-based process described in the DJSI Guidebooks and is based on a systematic assessment of general and industry-specific sustainability criteria. The index has three dimensions, i.e. economic, environmental and social aspects with equal weights each. With respect to criteria, 43 percent are classified as general criteria and 57 percent as industry criteria (DJSI, 2009).

Although numerous tools exits for various uses, researchers conclude the majority of these tools are not able to assist decision makers in industries to assess and evaluate their operations in terms of the internal and external impacts of sustainable development as proper decisions can only be made when the economic, social and environmental consequences are taken into consideration collectively (Hockerts, 1999). Hak et al. (2012) point out that there is no agreement on a common set of criteria for evaluating them although numerous frameworks and indicators have been developed to assess sustainability. Further, most of these methodologies are also not able to fully operationalise the concept of sustainable development and sustainable production (Veleva, 2001). Systems and frameworks employing the use of indicators of sustainable production in industrial processes should not only include aspects of production but also measure the relationship between the production and all the economic, social and environmental systems within which it exists.

Shriberg (2002) summarised three main reasons that organisation should consider to begin their journey toward sustainability: (1) Morality and intergenerational equity: the concept that present generation should only live on what is available without borrowing from future generations is desirable; (2) Survival: the current stress on the environment and ecosystem is excessive for the continued survival of any organism. Therefore, for the existence of a future, sustainable development is a prerequisite to survival and properity on this planet; and (3) Organisational benefits and risks: By not embracing sustainability, an organisations' economic, environmental and social liability increases.

2.5. Sustainability Assessment Methodologies

The principles of sustainable development can be applied at different levels of development ranging from global policies, government frameworks to industrial production processes or at a project level. These levels can be categorized as 'micro level' or 'macro level' as depicted in **Figures 2.3a** and **2.3b** (Rosa, 2009). Assessment methodologies presently available are largely being applied for each sub-set described under micro and macro levels as described in **Table 2.2**.

Table 2.2: Example of sustainability assessment frameworks and their level of application

	Macro Level			Micro Level	
	I	II	III	IV	V
	Global Objectives	System or Strategy	Business/Industry Targets	Actions & Projects	Auditing & Reporting
Balance Scorecard					
Brundtland					
Corporate Sustainability					
Decision Analysis					
Earth Summit (Rio)					
BRS Framework Measures					
Global Reporting Initiative					
Industrial Ecology					

Table 2.3: Continued

Life Cycle Analysis					
Life Cycle Inventory					
On Common Ground					
Sustainability Footprints					
I Chem E Metrics					
World Resource Institute					

Adapted from Batterham (2006)

In the research by Batterham (2006), the assessment frameworks were categories into five levels which was selected as the minimum number required to connect the global and individual activities:

Level 1: Global objectives

Level 2: Industry strategy

Level 3: Enterprise targets

Level 4: Specific projects

Level 5: Individual actions/measured outcomes

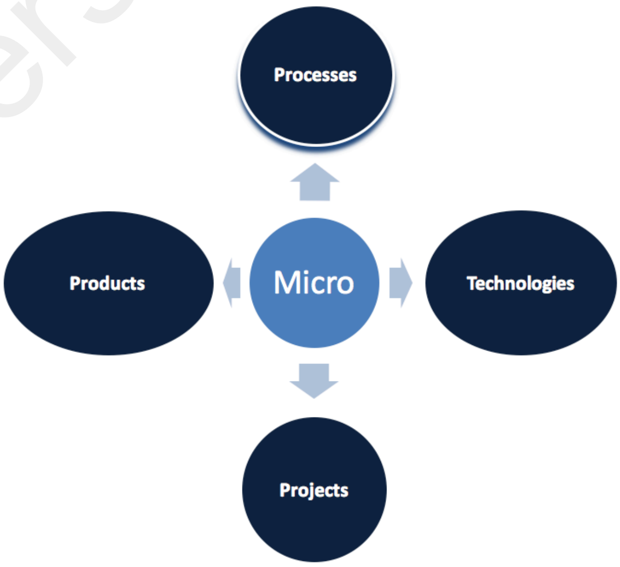


Figure 2.3a: Sustainability Methodologies Application Levels (Micro Category) (Rosa, 2009)

Figure 2.3b: Sustainability Methodologies Application Levels (Macro Category) (Rosa, 2009)

This research's focus is at the micro level encompassing all the sub-sets of the micro category which is at the factory/industrial facility level. One of the objectives of this research is to develop an assessment methodology that can be used by the petrochemical industry in Malaysia to assess their sustainability, namely, with respect to sustainable production.

2.5.1. Sustainability Indicator Systems

Summarising from related literature (Lundin, 2003; Singh et al., 2009) sustainable production indicators (SPIs) can be used to predict and evaluate economic, environmental and social aspects of business operations and, when properly defined and applied, are effective in operationalizing sustainability (Mascarenhas et al, 2010). The fundamental role of the SPI is to be able to convert complex inter-linked information into a form which is manageable, easily assimilated and understood by all stakeholders (Veleva and Ellenbecker, 2001b). Once indictors have been identified and defined, they need to be measured qualitatively and quantitatively, and appropriately interpreted and used as indicators (Molden et al., 2012).

Existing literature indicates that businesses are employing selected sets of indicators to measure the sustainability performance of an organisation (Krajnc and Glavic, 2005). These indicators interpret sustainability issues into quantifiable measures of economic, environmental and social performance with the primary objective of benchmarking their performance and contribution towards sustainable development (Azapagic and Perdan, 2000). Numerous indicators sets have been developed for such purposes, including determining improvements to be made to chemical processes and manufacturing facilities as well as business enterprises (Sikdar, 2003).

One of the challenges when evaluating sustainability is the identification and selection of an appropriate suite of indicators (Fernandez-Sanchez and Rodriguez-

Lopez, 2010). Similarly, Lin et al. (2012) conclude that the bottleneck is the lack of clear process for the selection of indicators. Selection of ideal indicators is based on numerous criteria, for example, easy to measure and interpret, broadly applicable, timely integrative, anticipatory, non-destructive, recognizable to the public, cost effective and relevant to environmental management and policy makers. While there is much research on the proposed framework for the development of indicators, there is a lack of a common methodology (Weilhoefer, 2011).

In order to comprehend sustainable production, measure it and manage it, indicators or sets of indicators are required. Indicators are tools that measure, simplify and communicate key issues and trends regarding a specific subject (Walker, et. al, 2000) and are used throughout society in a multitude of ways. Indicators can be used to translate and communicate complex information into manageable and easily understood units which allow decision making at all levels and, can be measured over time (Darby and Jenkins, 2006). According to Meadows (1998), indicators are developed for activities that are of value to businesses and once the indicators are in use they in turn enhance the value of the businesss. Indicators are beneficial because they can be used to encapsulate and concentrate the complexity of our surroundings to a manageable amount of important information (Godfrey &Todd, 2001).

Current research indicates that the use of indicators for the assessment of sustainable development (including sustainable production) is the most comprehensive, reliable and explanatory (Dalal-Clayton & Bass, 2002) method. Ranganathan (1998) defines sustainability indicators as tools that can be used to measure as well as encourage progress towards an organisation's sustainability goals. These indicators enable organisation to effectively monitor improvements as well as encourage ongoing modifications and evaluation (Veleva, 2001a), translate elements of sustainability into quantifiable measures, and employed as tools for policy making by experts and stakeholders (Singh, et al., 2009). Azapagic (2004) further states that indicators must be able to operationalize both internal and external economic, environmental and social issues for performance measurement to assist decision-makers.

One of the challenges when evaluating sustainability is the identification and selection of an appropriate set of indicators (Fernandez-Sanchez & Rodriguez-Lopez, 2010; Lin et al., 2012) conclude that the bottleneck is the lack of clear process for the selection of indicators. Selection of ideal indicators is based on numerous criteria, example, easy to measure and interpret, broadly applicable, timely integrative, anticipatory, noon-destructive, recognizable to the public, cost effective and relevant to environmental management and policy makers. While there is much research on the proposed framework for the development of indicators, there is no common methodology (Weilhoefer, 2011). However, Molden et al. (2012) observes that once indicators have been identified and defined, they need to be measured qualitatively and quantitatively. In most instances, the difficulty lies not in the availability of data but rather the selection, interpretation and use of the indicators.

At the Rio Summit which was held in 1992, indicators were identified as a strategic goal in the Agenda 21 document and since then there has been a growing trend on the use of indicators to measure various aspects of sustainability (United Nations, 2001). With the introduction of the use of indicators in Agenda 21, many government and non-government organisations have been inspired to develop frameworks which employ the use of indicators at local, regional, national and international levels. At an organisational level, businesses have developed their own indicator sets to measure overall sustainability or specific aspects.

2.5.1.1. Global Reporting Initiative

The Global Reporting Initiative (GRI) is an Amsterdam-based multi-stakeholder non-profit organisation providing global standards on sustainability reporting. The organisation's first reporting framework was developed in the 1990s and subsequently upgraded and revised four times since its inception in 1999 as GRI 2, GR1 3, GRI 3.1 and as GR4 (released in 2012)(Wilbur & Wilbur 2013). The GRI reporting framework is now widely used across a myriad of industrial sectors as the reference standard for sustainability reporting (Skouloudis *et al*., 2009). The definition for sustainability reporting as described by the GRI is as follows:

"Sustainability reporting is the practice of measuring, disclosing, and being accountable to internal and external stakeholders for organizational performance towards the goal of sustainable development" (GRI, 2012). GRI 3.1 is made up of three main elements which are as follows:

- **Reporting guidelines**: The guidelines are the key feature of the GRI. They set quality and content principles, as well as managerial and performance indicators. The indicators cover numerous categories, namely, organizational, managerial, economic, environmental, social, human rights, society and product responsibility issues;
- **Sector supplements**: The supplements provide further guidance and indicators for sector specific issues.
- **Indicator protocols**: The protocols essentially specify the definitions and technical guidance for each of the performance indicators.

2.5.1.2. Lowell Centre Indicator Framework

In 1996, the Lowell Centre for Sustainable Production (LCSP) at the University of Massachusetts Lowell, US established the Lowell Centre Indicator Framework to promote industrial production practices that are safe, healthy, environmentally sound, socially responsible and economically viable over the long term. The LCSP defines sustainable production as "the creation of goods and services using processes and systems that are non-polluting; conserving energy and natural resources; economically viable, safe and healthful for employees, communities and consumers; and socially and creatively rewarding for all working people" (Lowell Centre for Sustainable Production, 1998). This definition is consistent with the current understanding of sustainable development which addresses all three aspects of environmental, social and economic aspects (Tseng *et al*, 2009). This indicator framework can be applied to all types of industries by including supplemental indicators which are specific to each type of industry (Veleva, 2001a). Further, the 16 principles of the Business Charter for Sustainable Development are embedded in the LCSP framework.

2.5.1.3. IChemE Sustainability Metrics

Specifically for the process industries, the Institution of Chemical Engineers (IChemE) developed a framework to report and measure their progress towards sustainability. Known as the Sustainability Metrices: Sustainable Development Progress Metrics, the assessment tool was developed in 2002 (Wilkinson, 2000). The IChemE's approach towards sustainable development is underpinned in the London Communique dated 1997 (a statement signed by the leaders of 18 global leading engineering societies). Since then, the IchemE has been collaborating with various other organisations to encourage its members to progress towards sustainable development through its activities (IchemE, 2002).

The objective of the Sustainable Metrices is to produce a practical tool for engineers using as far as possible information already available. The overall aim is to develop a wider understanding of sustainability within the process industry sector. The

IChemE defines engineering for sustainable development as providing for human needs without compromising the ability of future generations to meet their needs (IChemE, 2007). Hence, the impact of industrial operations in the context of sustainable development can be assessed using the concept of triple bottom line which encompasses environmental responsibility, economic returns (wealth creation) and social development. In driving towards the full implementation of sustainable development, engineers and process groups need to have the necessary instruments/tools to evaluate the sustainable performance of an industrial operating unit. The findings of the assessment can then be used to design or develop technological measures to address the issues identified, set performance targets, formulate standards for internal benchmarking and monitor progress periodically. In the process industries, the production network/chain includes extraction, transport, manufacture, distribution, sale, utilisation, disposal, recycling and final disposal (Sikdar, 2003. These involve suppliers, customers and contractors and therefore any research which involves assessing the sustainability of the process industry must include these elements within its research boundary (Labuschagne, 2005).

The IChemE metrics are intended to assist organisations to fix targets and establish internal standards to monitor their sustainability performance and progress in time. The metrics are divided into environmental, economic, and social indicators with the environmental indicators covering aspects on resource use by considering how much energy, material, and water are consumed and land is used (Delai & Takahashi, 2011). Others such as atmospheric, aquatic impacts, and impacts on land caused by emissions, effluents, and waste are taken into notice. The economic indicators focus on the profit gained, value added and taxes paid, and investments funded by the organisation. The social indicators include employment situation, health and safety at work, and also impacts to society. Not all the metrics proposed are applicable for every organization and it is up to the respective individual organization to select which of the metrics are relevant for them. The indicators selected must be chosen from each of the aspects of sustainability to give a balanced view of the sustainability performance. **Table 2.3** presents the indicators under the three pillars of sustainability (Saavalainen, 2015)**.**

Table 2.3: The IChemE Sustainable Metrices indicators

Environmental Indicators	Economic Indicators	Social Indicators
• Material intensity • Energy • Water • Land • Emission to atmosphere, aquatic and land	• Profit, value, taxes • Investments	• Work place (employment situation, health and safety) • Society

Source: IChemE (2007)

IChemE's Sustainble Metrices introduces a set of indicators which can be used by the process industries to measure sustainable performance within their operating unit. Each operating unit is envisaged as a process plant, a group of plants, part of a supply chain, a whole supply chain, a utility or other process system (IChemE, 2002). If comparable statistics are obtained from a number of unit operations, they can be aggregated to present a view of larger operations, on a company, industry or regional basis. The IChemE encourages its members to use the metrics for internal evaluation and to report their findings in entirety, or in part a proposed report template to demonstrate their commitment to sustainable production and eventually towards sustainable development (IChemE, 2007).

Although the selection of appropriate indicators of sustainable production is crucial (Ranganathan, 1998), this alone is not sufficient. These indicators need to be integrated into the various businesses processes and systems so that they can effectively function as a tool to implement and improve sustainable development or sustainable production.

2.6. Sustainable Development Initatives by the Government of Malaysia

In Malaysia, there has been a archetype shift in the management of environmental issues over the last four decades, i.e. from pollution control which is essentially coping with crisis and preventing the spread of damage to pollution prevention. Environmental management has undergone changes over the years, since the onset of industrialization. In the 1960s and 1970s, environmental management in industries and businesses was limited to coping with environmental crises as they occurred and minimising the spread of the damage. Subsequently, in the 1980s with newer and improved environmental regulations and government policies, environmental management in organizations meant regulatory compliance and the costs associated to it (Hezri, 2004).

Proactive environmental strategies were introduced in the 1990s where corporations began to assess and identify potential environmental impacts arising from their operations, take the necessary steps to reduce these impacts and implementing integrated environmental strategies which aim to achieve total environmental management. These strategies seek to go beyond regulatory compliance to protect or enhance their ethical images, avoid serious legal liabilities resulting from environmental pollution and contamination, incorporate the concept of sustainable development in their production processes, respond to the stakeholder interests in environmental protection and to minimize environmental risks (Hezri, 2004).

The awareness to undertake development in a sustainable manner was highlighted for the first time in the Third Malaysia Plan (1976-1980) published by the

Economic Planning Unit (EPU) under the Prime Minister's Department. The Plan formed the blueprint for the Government of Malaysia's five-year development strategy. From the Fourth, Fifth, Sixth, Seventh, Eighth, Ninth and presently the Tenth Malaysia Plan, the concept gained importance progressively, in line with global initiatives on sustainable development (EPU, 1981; 1986; 1991; 1996; 2000; 2005 and 2010).

The Third Malaysia Plan recognized the need for sound environmental policies and the formation of the Department of Environment under the Environmental Quality Act, 1974. The Plan also recognized the need for preserving the forest resources, land, natural ecosystems, recreational resources and fisheries. *"The effects of development on the nation's environment will not be ignored. Impairment of the country's land and forest resources as well as pollution from industries……….The Government recognizes the importance of adopting sound environmental policies and has therefore brought into force the Environmental Quality Act (1974) and established the Department of Environment. The Government will ensure that development will not be carried out in such a manner as to impair the productivity of Malaysia's renewable land and forest resources, cause extinction of unique elements of natural ecosystems and lead to excessive and harmful pollution of the environment resulting in unhealthy living conditions, the loss of recreation resources and the productivity of Malaysia's fisheries" (EPU, 1971,p.89).*

Following the Third Malaysia Plan, there has been a systematic progress with respect to policy development in ensuring that environmental protection and sustainable development are included in the nation's five-year blueprint development plan. The Fourth, Fifth, Sixth, Seventh, Eighth, Ninth and presently the Tenth Malaysia Plan have dedicated sections, which define policies, strategies and initiatives aimed at promoting sustainable practices in the major industries in Malaysia (EPU, 1981; 1986; 1991; 1996; 2000; 2005 and 2010).

It was during the implementation of the Eighth Malaysia Plan (2001-2005) that the incorporation of environmental considerations into development was intensified resulting in an integrated and holistic management of the environment and natural resources (EPU, 2000). During this period, institutional capacity and regulatory framework was strengthened and new approaches and planning tools were established for environmental protection. To this end the National Environmental Policy (NEP) was formulated in 2002.

Under the Ninth Malaysia Plan (2006-2010), environmental stewardship was promoted to ensure that the balance between development and environment is maintained (EPU, 2005). The Plan strongly emphasised the need for R&D to enable the achievement of enhanced environmental quality in the country. In line with the ninth principle of Islam Hadhari, environmental stewardship will continue to be promoted. This is to ensure that even as Malaysia prepares towards achieiving the status of a developed nation, the balance between development and environment is maintained. The rationale for environmental preservation would be mainly towards a threefold emphasis, namely the implementation of preventive measures to eliminate or mitigate issues at source (with the use of EIA, strategic environemntal assessments (SEA), cost-benefit analysis, market-based instruments and enviornmental auditing), intensifying conservation schemes and sustainably managing natural resources (EPU, 2005). In all these measures, efforts will be made to cultivate collaborations between stakeholders. A strong emphasis has also been placed on the need for research and development (R&D) as these initiatives enable the achievement of enhanced environmental quality in the country. Conservation and resource management was limited to aspects of biodiversity, forest and water resources. The following sub-sections provide a description of the chronology of initiatives undertaken by the GOM towards stimulating and implementing sustainable development principles.

Efforts towards sustainability are further reinforced under the Tenth Malaysia Plan (2011-2015) with the introduction of the AFFIRM framework for Awareness, Faculty, Finance, Infrastructure, Research and Marketing to develop a complete ecosystem for environmental sustainability (EPU, 2010) . Two focus areas have been identified for the next 5 years, namely, (i) developing a roadmap for climate resilient growth and (ii) enhancing conservation of the nation's ecological assets. Under the first focus area, the strategies to be implemented will be directed towards 'protection from risks of climate change, reducing Malaysia's carbon footprint, creating incentives for investments in renewable energy, promoting energy efficiency, improving solid waste management, conserving forests and reducing emissions to improve air quality'. The second focus area provides for 'ensuring equitable and sustainable utilisation of resources' (EPU, 2010). In addition, the GOM has also embraced the initiatives of Agenda 21 and a pilot project was set-up in 2000 involving four local authorities in four states in Malaysia, namely Pahang, Perak, Sarawak and Selangor.

In 2010, Malaysia was graded with an Environmental Performance Index (EPI) index value of 65.0 compared to the value of 53.0 for the year 2009 clearly indicating the progress towards sustainability (EPU, 2010). The latest data for 2012 indicate that Malaysia is ranked 25th of 163 countries and categorised as a 'strong performer' (YCELP, 2011). Developed by the universities of Yale and Columbia, the index is derived based on 25 performance indicators tracked across ten policy categories covering the environment, public health and ecosystem vitality (Siche, 2008).

The various government policies and national studies carried out to safeguard the environment and society developed are illustrated in **Figure 2.4.**

Insert Figure 2.4

Specifically, the list describes major policy-driven indicator development initiatives in Malaysia and provides a description, goals, main features, stages of implementation, agencies leading these initiatives and their level/extent of operationalization (Herzi, 2004). It is noted that all these policies look at sustainable development from a government policy formulation perspective and largely driven by the government. Whilst these initiatives look at sustainable development as a whole, their present form does not allow industries to evaluate their sustainable production practices neither do they enable the industrial to operationalise the concept of sustainable development at the manufacturing plant or facility level (EPU, 2002).

Table 2.4: Major Sustainable Development Indicator Initiatives in Malaysia (adapted from Hezri, 2004)

	MQLI	CES	USI	MSDI	KVRSQLI	HCI	PRC	SUDI	SDIS
Goal	Expanding the measure of Malaysian success beyond economic achievement	The integration of socio-economic information with environmental parameters	To design and test a set of urban indicators for the tracking of urban development towards sustainability	Develop a national system for tracking progress towards sustainability	To develop stress ratio (spatial, growth and distributional weights) for the allocation of resources for the districts within Klang Valley	Continuously create social and physical environment for healthy urban population	Define sustainable development for Penang utilising a bottom-up participatory approach to planning	Develop indicators to assess the improvement in urban issues such as water quality and waste management	Develop a state level system for monitoring sustainability in cognizant of the state's administrative and legislative powers
Main feature s	A composite index showing the improvement in Malaysian Quality of Life with 1980 as the base year	The statistics chosen are analysed according to the media-based approach accommodating the Pressure-State-Response (PSR) model	The first initiative in Malaysia linking indicators to benchmark values. MURNI-net is the networked system which will be used by local authorities to report on sustainability using the selected indicators	Aiming to integrate sustainability elements into national level development planning.	Index development involving benchmarks at the district levels from a regional perspective	Based on the World Health Organisation (WHO) framework. The community programme commenced in 1997 but its indicator development part is still at an early stage.	Based on the Sustainable Seattle model of active community-based monitoring and organised by an NGO.	The use of Environmental Management Systems (EMS) as the guiding framework	Fitness-for-purpose indicator frameworks rather than the usual definitive suite of indicators

Table 2.4: Continued.

	MQLI	CES	USI	MSDI	KVRSQLI	HCI	PRC	SUDI	SDIS
Implementation Stage	Institutionalisation	Institutionalisation	Testing	Identification	Formulation Completed	Identification	Formulation completed (one-off project)	Identification	Identification
Leading agency	Macroeconomics and Evaluation Section of the Economic Planning Unit, Prime Minister's Department	Department of Statistics (DOS)	Federal Town and Country Planning Department	Environment and Natural Resource section of the Economic Planning Unit, Prime Minister's Department	Federal Territory Development and Klang Valley Planning Division, Prime Minister's Department	Department of Health, Municipal Council of Kuching, Johor Bahru, Malacca	Socio-economic and Environment Research Institute (SERI)	Sarawak Natural Resources Board	Town and Country Planning Department of Selangor
Scale	National	National	National	National	Regional	Local	State	Local	State

MQLI (Malaysian Quality of Life Indicators); CES (Compendium of Environment Statistics); USI(Urban Sustainability Indicators and MURNInet); MSDI(Malaysia Sustainable Development Indicators); KVRSQLI (Klang Valley Regional Sustainable Quality of Life Index); HCI (Healthy Cities Indicators); PRC (Penang Report Card); SUDI (Sustainable Urban Development Indicators); SDIS (Sustainable Development Indicators for the State of Selangor). The implementation stage described above comprises four hierarchical levels (i) identification (ii) formulation completed (iii) testing and (iv) institutionalisation.

2.6.1. Legal Provisions

In Malaysia, sustainable development initiatives have their roots in addressing environmental issues. Although awareness has been increased to broaden the concept to encompass the social and economic elements of sustainable development, with respect to legal provisions, only environmental issues are presently regulated. Prior to the promulgation of the Environmental Quality Act in 1974, the approach to the management of environmental issues was largely curative in nature. With the enforcement of the EQA, 1974, environmental management was more holistic and streamlined. It is worthwhile to note although there was no one backbone integrated legislation for environmental quality before 1974, there were other pieces of legislature at the Federal and state levels that addressed specific elements of the environment. These include the Water Enactments 1920, the F.M.S Forest Enactment 1934, the Merchant Shipping Ordinance 1952, the Land Conservation Act, 1960, the Fisheries Act, 1953 and the Factories and Machineries Act, 1967 (Mohammad, 2011).

The EQA, 1974 comprises eight parts, with the first part providing definitions of key terms/words, followed by the second and third parts on administrative provisions and provisions relating to licences respectively. The fourth part stipulates the requirements for various aspects of environmental pollution including the control of scheduled wastes. Provisions on licensing appeals and the payment of cess, and environmental fund are included as the fifth part with the final sixth part dealing with miscellaneous matters. The Act is enforced by the Department of Environment which falls under the purview of the Ministry of Natural Resources and Environment (Government of Malaysia, 1974).

2.6.2. Agenda 21 and Malaysia

2.6.3. Sustainability Initiatives within the Energy Sector

One of the sectors that has embraced the concept of sustainable development is energy. Under the Eight Malaysia Plan, efficient utilisation of energy resources as well as the use of alternative fuels, in particular renewable energy such as hydropower was encouraged. The primary driver for this was the rising cost of petroleum (EPU, 2005). The Plan also identified energy intensive industries to include the chemical, cement & ceramic, iron and steel as well as food processing sectors.

Under the 9th Malaysian Plan, the use of a diversified range of fuels, namely renewable fuel was further strengthened. This again is mainly to reduce the nation's dependency on petroleum. Further to reduce energy wastage, the focus of the Plan is to implement energy efficiency initiatives in industrial, transport and commercial sections as well as government owned buildings. The initiatives developed are more integrated to enhance sustainable development in the energy sector, namely through efficient utilisation and demand-side management. An example of efforts towards the efficient use of energy is the implementation of two projects (with a combined grid of 12 MW) using renewable fuel. Additionally, a roadmap for the development of solar, hydrogen and fuel cells was formulated. The incorporation of energy efficient features in government buildings as well was also carried out and energy audits were undertaken at eight energy-intensive industries under the Malaysian Industrial Energy Efficiency Improvement Project (MIEEIP) to identify potential energy savings (EPU, 2005). Energy efficiency programmes include efficient lighting and air conditioning systems in commercial buildings and in industrial plants, improvements in plant, equipment and processes as well as end use (Razali & Adnan, 2015).

Initiatives under the renewable energy programme include the utilisation of the Clean Development Mechanism (CDM) to provide support for the implementation of Small Renewable Energy Projects (SREP). New sources of energy, such as solar and wind will also be developed using cost-effective technology. Efforts to promote the development of biofuel using palm oil as a renewable source of energy will be undertaken to achieve the status of world leader and hub for palm oil. The general planning for the sustainable development of the energy sector is coordinated by the Economic Planning Unit (EPU) whilst the development of renewable energy and enhancement of energy efficiency initiatives is driven forward by the Ministry of Energy, Water and Communications (EPU, 2005).

The production and consumption of biofuel has been driven largely by the National Biofuel Policy. Launched in August 2005, the four-pronged strategy of the policy include (1) producing a biofuel blend of 5% processed palm oil and 95% petroleum diesel (2) encouraging public use of biofuel by providing incentives (3) establishing an industry standard for biodiesel quality under SIRIM (Standard and Industrial Research Institute of Malaysia) and (4) setting up of biodiesel plants. Other energy and fuel-related policies include the Petroleum Development Act (1974), the National Energy Policy (1979), the National Depletion Policy (1980) and the Four Fuel Diversification Policy (1981, 1999). Besides solar energy, the other renewable energies are solid wastes, mini hydro, biogas and biomass (Tye *et al*., 2011).

2.6.4. Sustainability Initiatives within the Construction Sector

As a country that is in the midst to becoming a developed economy by 2020, there is a need for the construction industry to assess the sustainability of their projects (Ugwu & Haupt, 2007). The growing increase in global awareness on sustainability has further influenced the Malaysian construction industry. The industry is now under pressure to enhance efficiency and project delivery (Yunus & Yang, 2011). In 2007, the construction output was estimated at approximately RM 50 billion which represented 3-5 % of the Malaysian GDP per annum (CIDB, 2007) and provided employment opportunities for 800,000 workers or 8% of the total workforce. The construction industry has been criticised or compromising workers safety and health with long working hours, high risk working condition and adversely impacting environmental quality (Jaillon and Poon, 2008). Sustainable construction is when the development results in the establishment and responsible maintenance of a built environment (Kibert, 2007).

In 1998, a report prepared by the Construction Industry Development Board (CIDB), environmental protection during construction activities was raised as a concern and the report introduced steps to reduce such impacts (CIDB, 2007). Realizing the need for sustainable construction practices Said et al (2010) have developed a model framework that works for the identification of indicators for sustainability in the construction industry. The model comprises two stages, with the first stage describing the process for the development of the sustainability concept (in the context of the construction industry) followed by the second stage which addresses the implementation aspect. Another initiative undertaken is the implementation of the Industrialised Building Systems (IBS) which is an alternative option in maintaining sustainability in construction (Blismas et al., 2006). IBS involves utility components being constructed offsite. This method of construction promotes sustainability deliverables by controlling human resources and cost, minimising construction waste, employing efficient building material energy and, controlling the production environment and improving occupational health and safety performance (Luo et al. 2008; Jaillon et al. 2009 and Baldwin et al. 2009). However, the implementation of the

IBS in the construction industry in Malaysia is presently in the early stages where more studies are being conducted to see how IBS can enhance the sustainability of the construction industry in Malaysia. These include the development of guidelines on sustainable IBS design and construction to assist the designers making project level decisions and on the examination of sustainability performance levels.

2.7. The Petrochemical Industry in Malaysia

The petroleum and petrochemicals industry is one of the leading sectors in Malaysia. Petrochemicals are chemicals produced from natural gas, natural gas liquids, or refinery products derived from crude oil distillation, or cracking. Supported by Petroliam National Berhad (PETRONAS), Malaysia's national oil company, the petrochemical industry has made Malaysia a regional hub for petrochemicals. The industry produces a wide range of products and feeds into downstream industries, e.g. plastics, polymers, packaging, electrical and electronics, medical devices, automotive, construction and agriculture (fertilizer) (MGCCI, 2009).

Based on data obtained for 2006, Malaysia's three largest petrochemical export markets include India (31.1%), the Republic of Korea (27.9%) and Japan (14.6%) whilst imports of petrochemicals were primarily from Singapore (71.6%), Thailand (11.2%) and the USA (8.2%) (MGCCI, 2009). In 2008, 62% of the total investment in this sector was contributed by PETRONAS as the key investor. The largest foreign contributors of the industry were the USA, Germany and Japan accounting for 40%, 22.8% and 14% respectively of the total foreign investments (MGCCI, 2009).

Based on data published in 2007, Malaysia is a major exporter of petrochemical products within the ASEAN region, exporting both commodity grade polymers as well as petrochemical derivatives. The large investors in this sector in Malaysia include Dow

Chemicals, BP Chemicals, Shell, BASF, Eastman Chemicals, Toray, Mitsubishi, Idemitsu, Polyplastics, Kaneka, Dairen and Titan Petchem Group. Most of these existing companies are multinational corporations (MNCs) or joint ventures, with the MNCs providing technology input in the production of the petrochemicals. The industry feeds significantly into downstream industries involving the manufacture of polymer compounders, converters (such as plastics packaging producers) and fabricators (plastics injection moulding producers), products for application in the electrical and electronics sector, medical devices, automotive, construction and agriculture (fertilizer). The involvement of Malaysian-owned companies including small and medium entreprises (SMEs) is mainly in these downstream applications.

In promoting the industry, petrochemical zones have been developed by the Government of Malaysia where petrochemical plants are clustered together to create a value chain by sharing utilities and ensuring progress of downstream petrochemical activities. The major petrochemical zones are in the following locations (MGCCI, 2009):

- **Kertih, state of Terengganu**: Kertih has been transformed into a petrochemical hub. It houses the Petronas Petrochemical Integrated Complex that links the oil and gas value chain, i.e. from the upstream exploration and production to the final stage of petrochemical manufacturing.
- **Gebeng, state of Pahang**: Gebeng falls within the East Coast Industrial Development (ECID) Corridor also known as the East Coast Corridor, a new growth area earmarked for rapid industrial development in the states of Terengganu, Pahang and Kelantan. This corridor also forms part of the East Asian Growth Corridor (EAGC) which includes Sabah, Sarawak,

Brunei, the Philippines and Indonesia (Borneo). The EAGC was set up to support bilateral economic relationships between Malaysia, Indonesia and Philippines. Based on its close proximity to Kuantan which is the centre for the ECID, Gebeng has been designated as one of the key growth centres within the ECID and most of the industries operating within the Gebeng Industrial Estate are petrochemical plants. These include RP Chemicals, Eastman Chemicals, BASF, Kaneka, Polyplastics and Solutia

- Tanjung Langsat, state of Johor: Tanjung Langsat in Pasir Gudang within the state of Johor is a dedicated industrial area which is supported by the Pasir Gudang Port and the Tanjung Langsat Port. There are a number of large petrochemical complexes within this area, namely, BASF, Dairen Chemical, Idemitsu and Titan Petrochemicals.
- Bintulu, state of Sarawak: Bintulu is the largest producer of liquefied natural gas (LNG) in Malaysia. There are three LNG plants (PETRONAS) operating with a combined capacity of 24 million tonnes per year. Bintulu also houses Asian Bintulu Fertilizer, an ammonia/urea plant.

Photos of some of these petrochemical plants are presented as **Plates 2.1-2.5.**

Plate 2.1: BASF

Plate 2.2: Eastman

Plate 2.3: Kaneka

Plate 2.4: Petronas-MTBE

Plate 2.5:RP Chemicals Sdn. Bhd. (Formerly BP Chemicals)

The petrochemical industry was selected for this study as (1) Malaysia is a major exporter of petrochemical products within the ASEAN region and contributes significantly to the economy of the nation (MGCCI, 2010); (2) Petrochemical facilities are comparatively more polluting than other types of industries as the industry is classified as heavy industries which generates significant air emissions, wastewater, noise pollution and toxic and hazardous wastes (DOE, 1996); (3) Petrochemical facilities are categorized as major hazardous installations which are defined as "facilities that store and process large amount of flammable and/or toxic materials having the potential to cause adverse consequences to the surrounding population, property and environment" (GOM, 1996) and (4) The industry is known to be a high risk work environment due to the perilous nature of the job for the employees whom are exposed to the chemical pollutants in the air, as well as the physical hazards at the workplace (Lai, 2010) and because to date, no research has been carried out for the selection and identification of indicators which can be used by the industry to assess its sustainable production processes.

At an organisational level, for the petrochemical industry, sustainable development is best measured as sustainable production which specifically evaluates production processes which are key in determining sustainability. Many of these companies in Malaysia are aware and understand the importance of sustainable development although they are not certain how to operate sustainable production practices holistically within the organisation. Sustainable production must include all three aspects of the environment, society and economy. Additionally, if there is no system in place to assess sustainable practices, how would these companies benchmark themselves? How would they know that they are heading in the right direction? (Samuel, 2013).

In Malaysia, amongst the industry players, especially in the oil and gas, and petrochemical industry, global and local market leaders such as Shell and BP have incorporated sustainable principles in their upstream and downstream oil exploration processes as presented in their annual reports (Shell, 2006; BP 2006). It is critical for industries to be sustainable as their operations generate significant environmental impacts which directly affect the environment. Most industries typically use environmental management systems such as the ISO 14001 and ISO 14031 whilst others have derived specific key environmental performance indicators as an assessment tool (Sebhatu & Enquist, 2007). However, as seen earlier, the main shortcoming of using these indicators for evaluation is that they only address the environment whilst sustainable development encompasses a triad comprising the environment, social and economy and all three are inter-related (Searcy et al,, 2012). The added impact of social aspects needs to be taken into account in assessing sustainable development.

Why does the petrochemical industry in Malaysia want to include sustainability in their corporate identity? A few reasons as described by the World Resources Institute (2002) include minimising their risk of losing reputation of not being sustainable, ability to penetrate into new markets where consumers have a high preference for products manufactured in a sustainable manner, not want to be seen as being responsible for ecological degradation or socially irresponsible (Borland, 2009). Other tangible reasons include a reduction in the operating cost by means of efficient use of natural resources and lastly the development of innovative products and service will ensure continued long-term market share. Additionally, businesses that operate in a sustainable manner are now seen to have a competitive advantage over those who do not employ aspects of sustainable development in their operations (Abratt & Kleyn, 2012).

From a marketing perspective, manufacturers are beginning to develop a number of strategies which publicise the concept of "clean green", "eco", "organic" or "natural" status of their products (Sony et al., 2015). As the petrochemical industry produces the raw materials (petrochemicals) that are used in the manufacturing of the these products, the industry as part of the supply chain also needs to show compliance towards sustainability initiatives. The use of the sustainability concept now plays a key role in customers' choice when selecting their products. This provides an advantage to brands that do indeed implement sustainable production practices Carrete et al., 2012.

Performance indicators developed within a framework specifically intended for the assessment of sustainable production are a vital tool for industries to ultimately attain sustainable production. It provides a tangible and quantitative means to modify and implement production processes which are in line with the final objectives of sustainable production Winroth et al., 2016. The challenge for industries is to select indicators which are most appropriate and reflective of their operations and to incorporate these indicators within a framework or management system for implementation. Although, there are frameworks on sustainable production developed outside Malaysia, e.g. by the Lowell Centre for Sustainable Production in the US (Veleva, 2003a), in the context of Malaysia and the petrochemical industry, there remains data gaps which need to be fulfilled for effective implementation of elements of sustainable production (Samuel, 2013).

2.8. Research Framework

2.8.1. Lowell Centre for Sustainable Production

The Lowell Centre for Sustainable Production (LCSP) at the University of Massachusetts Lowell established the Lowell Centre Indicator Framework to promote industrial production practices that are safe, healthy, environmentally sound, socially responsible and economically viable over the long term**.** Although there are numerous organisations that have a list of indicators that they report, there is no structured system to select and apply the indicators over time to progressively become more sustainable**(**Veleva and Ellenbecker, 2001a). The LCSP framework was therefore developed as a tool to help organise existing indicators into five levels relative to the basic principles of sustainability as defined by the LCSP (Veleva et al., 2003). This enables companies to evaluate the effectiveness of sustainability indicator systems.

The LCSP Framework defines sustainable production as '*the creation of goods and services using processes and systems that are non-polluting; conserving of energy and natural resources; economically viable; safe and healthful for employees, communities and consumers; and society and creatively rewarding for all working people*' (Veleva and Ellenbecker, 2001b). The framework is based on the centre's ten (10) principles of sustainable production and these principles are summarised in **Table 2.5a.**

Table 2.5a: Principles of Sustainable Production as Defined by the Lowell Centre for Sustainable Production.

Principle	Description
1	Products and packaging are designed to be safe and ecologically sound throughout their life cycles; services are designed to be safe and ecologically sound.
2	Wastes and ecologically incompatible by-products are continuously reduced, eliminated, or recycled
3	Energy and materials are conserved, and the forms of energy and materials used are most appropriate for the desired ends.
4	Chemical substances, physical agents, technologies, and work practices that present hazards to human health to the environment are continuously reduced or eliminated.
5	Workplaces are designed to minimise or eliminate physical, chemical, biological and ergonomic hazards.
6	Management is committed to an open, participatory process of continuous evaluation and improvement, focused on the long-term economic performances of the firm.
7	Work is organised to conserve and enhance the efficiency and creativity of employees.
8	The security and well being of all employee is a priority, as is the continuous development of their talents and capacities.
9	The communities around workplaces are respected and enhanced economically, socially, culturally and physically; equity and fairness are promoted.
10	The long-term economic viability of the enterprise or institution is enhanced.

Source: (http://www.sustainableproduction.org).

The principles listed above are derived based on the centre's definition of sustainable development and although provide an inter-relationship between the environment, social and economic components of sustainable development, they are themselves not measurement tools for sustainable development. These principles were used to develop the LCSP Framework for the assessment of sustainable production.

The framework which is five-tiered allows (Table 2.5b) flexibility in the sense that indicators identified for each level can be re-arranged and as necessary additional new indicators can be integrated (Winroth et al., 2016).

Table 2.5b: Five Levels of the Lowell Centre for Sustainable Production Indicator Framework

Level 1	•Indicators that measure the extent to which an organisation is in compliance with the relevant regulatory requirements (both local and international) and/or in conformance to industry/association standards.
Level 2	•Indicators that measure the facility inputs, outputs and performance (environmental, social and economics) of an organisation. These indicators very common and key in ensuring competitive advantage via cost leadership, a business strategy which includes resource efficiency.
Level 3	•Indicators that measure the potential effects of an organisation on environmental impacts, occupational safety and health of the workers, public health, community development and economic performance.
Leve 4	•Indicators that measure the organisation's production impacts looking at the supply chain as well as product distribution, use and ultimate disposal.
Level 5	•Indicators that measure how an organisation's production process fits into the larger picture of a sustainable society, and measure the production effects on long-term quality of life and human development within the ecological carrying capacity.

Adapted from Veleva, et. al. 2003

The rationale of the five tiers is that any organisation must first begin with indicators which can be easily implemented, e.g. indicators relating to regulatory compliance and resource efficiency. And as the organisation progresses, moving up the tiers, more complex indicators involving related economic and social issues, and environmental indicators which are more broadly encompassing the life cycle of the product, e.g. supply chain, global warming, etc. (Veleva et al., 2003). However, eliminating indicators at all levels is not recommended, but rather indicators can be re-arranged or additional indicators which are industry-specific or country-specific can be included.

The purpose of the framework is not to determine if indicators are good or poor, but rather to present a lens through which firms can evaluate and improve their measurement efforts towards sustainability (Greiner, 2001). The five-tier framework is illustrated below (**Figure 2.5**).

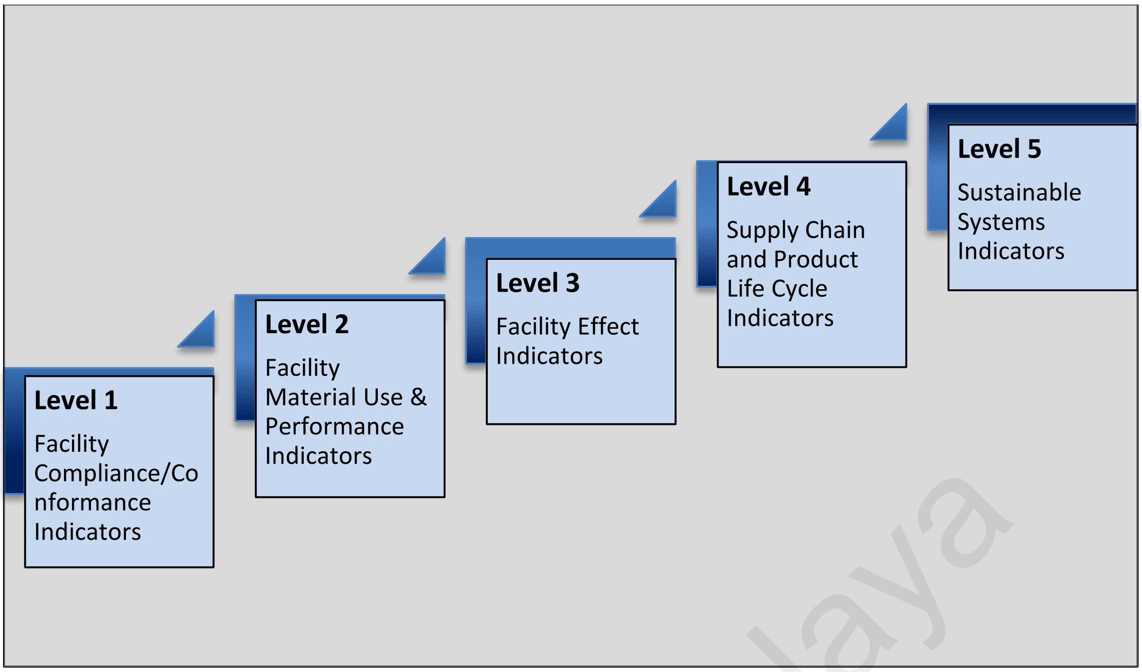


Figure 2.5c: Lowell Centre for Sustainable Production Indicators Framework

The LCSP framework encompasses a set of core indicators and supplemental indicators of sustainable production. Core indicators are described as a set of indicators that can be applied to any company or facility. These indicators are simplistic, based on available production process data and commonly measured aspects of production (examples include water use, energy use, employee job satisfaction, company contributions to charity) (Winroth et al., 2016). The core indicators are not considered more important or highly prioritised but rather they represent the first stage in the development of indicators of sustainable production. On the other hand, supplemental indicators are an open set, meaning they can vary between organisations. The purpose of these indicators is to address additional, production-specific aspects which may be relevant to an individual type of industrial sector or specific to a particular country (Veleva et al., 2003).

Based on the core and supplemental indicators an eight-step model was developed for the implementation of these indicators. The model reveals that using indicators of sustainable production is a process of continuous improvement, where the final objective or goal is to enable organisations to progress from merely adopting primary low level indicators (levels one, two or three) to using all/higher levels of the indicator framework (levels four and five) (Veleva, 2001b).

In developing this indicator framework and selecting the indicators, the LCSP have taken into considered comparability and commonality of the framework with other indicator systems (such as the Dow Jones Sustainability Group Index) as there is a clearly a need amongst investors, communities and consumers of standardized sustainability indicators that allow comparisons between companies (Azapagic, 2004; Olsthoorn et al., 2001; and Veleva, 2001b). The framework was developed by the LCSP with a total of twenty-two core indicators have been identified (LCSP, 2011).

The LCSP framework been tested and used to evaluate sustainable production activities in numerous businesses including the pharmaceutical industry (Veleva *et. al., 2003*).

2.8.2. GRI Indicators

Sustainability decision-making in the petrochemical sector needs to be based on indicators that identify the interactions of the organisation with the three pillars of environment, social and economics. The decision-makers in this industry need a framework that can enable the selection and operationalisation of the most relevant indicators, or key indicators (Fonseca et al., 2014). Performance indicators developed within a framework specifically intended for the assessment of sustainable production are a vital tool for industries to ultimately attain sustainable production. It provides a tangible and quantitative means to modify and implement production processes which are in line with the final objectives of sustainable production. The challenge for industries is to select indicators which are most appropriate and reflective of their operations.

To date, there are numerous frameworks and management systems which are specific to sectors as well as generic have been developed to assess environmental performance, sustainable development and sustainable production (Diakaki et al., 2006). Research on environmental performance indicators within specific industry sectors has been carried out including by Fiksel (2003) and Von Bahr *et al.* (2003) for cement manufacturing processes, Chaverri (1999) for fish canning facilities and Mauser (2001) for the dairy industry. Studies by Azapagic (2004) was centred on the development of sustainable production indicators for the mining and minerals industry whilst Veleva *et al.* (2003) employed the indicator framework developed by the LCSP as a tool to assess sustainable production practices in the pharmaceutical industry. Searcy (2004) designed sustainable development indicators for an electric utility.

In selecting the SPIs for the petrochemical industry or any other industry for that matter, the indicators should have the following characteristics (Liu & chu, 2014; Wang et al., 2009; Afgan et al., 2004):

- Represent core values/characteristics that define sustainable production in accordance to globally accepted definitions;
- Simple to implement and measure;
- Data on the indicators must already be in use by the organisation;
- Number of indicators must not be excessive;

- Indicators must be all encompassing, i.e. in addition to satisfying the local Malaysian context, the indicators must all cover global environmental issues such as global warming, acidification;
- Indicators must drive the right attitude. For example, measuring hazardous waste generated rather than reduction in hazardous material use could drive managers to simply recycle certain materials, rather than eliminate them from the production process. (change the example); and
- Indicators must be able to enable businesses to assess and quantify their achievements towards sustainable production.

The indicators must encompass all environmental, social and economic aspects of the petrochemical industrial sector. The GRI is to date has the most comprehensive list of performance indicators which can be used to assess sustainable development (production) and must be applicable to all stakeholders to measure and assess progress from a sustainable production perspective. The Global Reporting Initiative (GRI) is an organization that works towards a sustainable global economy by providing sustainability reporting guidance. GRI has pioneered and established a comprehensive Sustainability Reporting Framework for voluntary use. The framework is the world's most widely used sustainability reporting tool and the performance indicators listed therein are used to measure and report their economic, environmental, and social performance (GRI, 2012).

GRI was founded in the US in 1997 by two non-profit organisations namely the Coalition for Environmentally Responsible Economies (CERES) and the Tellus Institute. Within the organisation, the Global Reporting Initiative was started as a project to create an accountability mechanism to ensure companies follow a set of principles for responsible environmental operations Chatelain-Ponroy & Morin-Delerm (2016) Subsequently, in 1998, the principles were broadened to include social, economic and governance issues. GRI's guidance therefore evolved to become a Sustainability Reporting Framework. In 2001, CERES separated GRI as an independent institution. The second generation of the guidelines, known as G2 was unveiled in 2002 at the World Summit on Sustainable Development and embraced by the United Nations Environment Programme (UNEP). The following year, GRI was formally inaugurated as a UNEP collaborating organisation. In 2006, GRI launched G3 which was developed with the participation of more than 3,000 stakeholders comprising experts from business, civil society, labour groups and professional associations and, strongly collaborative links were developed with the United Nations Global Compact and the Organisation for Economic Co-operation and Development (OECD). This led to the development of sector specific guidelines for a number of industries known as the Sector Guidelines. In 2011, GRI published the G3.1 Guidelines which are essentially an update and completion of G3, with expanded guidance on reporting gender, community and human rights-related performance. This was followed by the fourth generation of Guidelines released in May 2013 (Einwiller et al., 2016).

2.8.2.1. Overview of the GRI and its Indicators

The search for appropriate sustainability indicators has been ongoing for many decades. Reseachers agree that a single indicator is not sufficient to define sustainability as a whole and that multiple number of indicators is required to capture the three pillar os sustainability for any one particular application. The exact number or range of numbers of indicators as well as the type of indicators are dependent on the various factors including but not limited to the type of industry or business, available resources with respect to data collection, practicality, economic feasibiliy and prevailing regulatory drivers and government initiatives that influence the direction of sustainability in a given economy. Al-Sharrah et al. (2010) states that if too few indicators are selected to represent sustainability, it is highly probable that critical aspects may be missed-out and if a large number of indicators are monitored, it may not be economical due the need to monitor large sets of data. Azapagic and Perdan (2000) further state that when dealing with a large number of indicators, it is difficult to quatify and assess meaningfully.

Under the GRI 3.1 guidelines, performance indicators have been described under a total of six categories. The six categories include Economic (EC1-EC9), Environment (EN1-EN30), Society (SO1-SO8), Human Rights (HR1-HR9), Labour Practices & Decent Work (LA1-LA14) and Product Responsibility (PR1-PR9). The numbers provided within the parentheses represent the indicators within each category. Of these, there are core indicators and additional indicators. The core indicators are defined under the guidelines as indicators which are '*of interest to most stakeholders and assumed to be material unless deemed otherwise on the basis of the GRI 3.1 Reporting Principles'*. To supplement these core indicators, a set of additional indicators have been identified and these are described under the guidelines as those which '*represent emerging practice or address topics that may be material to some organizations but not generally for a majority*' (GRI, 2012).

Under the category of Environment, out of the 30 performance indicators, 17 are core indicators and 13 are additional indicators. In the case of the Economic Performance Indicators, there are 7 core indicators and 2 additional indicators. The Social Performance Indicators are further sub-categorised into the Labour Practices and Decent Work Performance Indicators (9 core indicators and 5 additional indicators), the Human Rights Performance Indicators (6 core indicators and 3 additional indicators), Society Performance Indicators (6 core indicators and 2 additional indicators), Product Responsibility Performance Indicators (4 core indicators and 5 additional indicators) (GRI, 2012). The GRI indicators are presented in **Table 2.6**.

Table 2.6: The GRI 3.1 Indicator Categories

Category	**Economic**		**Environmental**	
Aspects	Economic Performance		Materials	
	Market Presence		Energy	
	Indirect Economic Impacts		Water	
	Procurement Practices		Biodiversity	
			Emissions, Effluents and Waste	
			Products and Services	
			Compliance	
			Transport	
			Overall	
Category	**Social**			
Sub-categories	Labour Practice and Decent Work	Human Rights	Society	Product Responsibility
Aspects	Employment	Investment and Procurement Practices	Community	Customer Health and Safety
	Labour/Management Relations	Non-discrimination	Corruption	Product and Service labelling
	Occupational Health and Safety	Freedom of Association and Collective Bargaining	Public policy	Marketing communications
	Training and Education	Child Labour	Anti-competitive behaviour	Customer privacy
	Diversity and Equal Opportunity	Forced and Compulsory Labour	Compliance	Compliance
		Security Practices		
		Indigenous Rights		

Each of these categories includes a corresponding set of core and additional performance indicators which are used in this research. The core and additional performance indicators listed under each of the six categories (economic, environment and the four categories under social, namely, Labour Practice and Decent Work, Human Rights, Society and Product Responsibility) listed in Table 2.6 above are further discussed in the sub-sections below. The description is extracted from GRI (2012)

GRI Category: Economic

The economic dimension of sustainability concerns the organization's impacts on the economic conditions of its stakeholders and on economic systems at local, national, and global levels. The Economic Indicators illustrate (1) flow of capital among different stakeholders; and (2) m economic impacts of the organization throughout society. The aspects considered under this dimension as well as their corresponding performance indicators are provided in **Table 2.7.**

Table 2.7: GRI 3.1 Indicators for the Economic Category

Type of Indicator		Indicators
		Aspect: Economic Performance
Core	EC1	Direct economic value generated and distributed including revenues, operating costs, employee compensation, donations and other community investments, retained earnings, and payments to capitals providers and governments.
Core	EC2	Financial implications and other risks and opportunities for the organization's activities due to climate change.
Core	EC3	Coverage of the organization's derived benefit plan obligations
Core	EC4	Significant financial assistance received from the government
		Aspect: Market Presence
Additional	EC5	Range of ratios of standard entry level wage compared to local minimum wage at significant locations of operations.
Core	EC6	Policy, practices and proportion of spending on locally-based suppliers at significant locations of operation.
Core	EC7	Procedures for local hiring and proportion of senior management hired from the local community at locations of significant.
		Aspect: Indirect Economic Impacts
Core	EC8	Development and impact of infrastructure investments and services provided primarily for public benefit through commercial, in-kind or pro bono assignment.
Additional	EC9	Understanding and describing significant indirect economic impacts, including the extent of impacts.

GRI Category: Environment

The environmental dimension of sustainability addresses an organization's impacts on living and non-living natural systems, including ecosystems, land, air, and water. Environmental Indicators cover performance related to inputs (e.g., material, energy, water) and outputs (e.g., emissions, effluents, waste). Further, this category also covers performance related to biodiversity, environmental compliance, and other relevant information such as environmental expenditure and the impacts of products and services. The indicators under the category of Environment are presented in **Table 2.8.**

Table 2.8: Indicators for the Environment Category

Type of Indicator		Indicators
		Aspect: Materials
Core	EN1	Materials used by weight or volume
Core	EN2	Percentage of materials used that are recycled input materials
		Aspect: Energy
Core	EN3	Direct energy consumption by primary energy source.
Core	EN4	Indirect energy consumption by primary source
Additional	EN5	Energy saved due to conservation and efficiency improvements

Table 2.8: Continued

Additional	EN6	Initiatives to provide energy-efficient or renewable energy based products and services, and reductions in energy requirements as a result of there initiatives
Additional	EN7	Initiatives to reduce indirect energy consumption and reductions achieved
		Aspect: Water
Core	EN8	Total water withdrawal by source
Additional	EN9	Water sources significantly affected by withdrawal of water
Additional	EN10	Percentage and total volume of water recycled and reused
		Aspect: Biodiversity
Core	EN11	Location and size of land owned, leased, managed in, or adjacent to, protected areas and areas of high biodiversity value outside protected areas.
Core	EN12	Description of significant impacts of activities, products and services on biodiversity in protected areas and areas of high biodiversity value outside protected areas.
Additional	EN13	Habitats protected or restored
Additional	EN14	Strategies, current actions, and future plans for managing impacts on biodiversity.
Additional	EN15	Number of IUCN Red List species and national conservation list species with habitats in areas affected by operations, by level of extraction risk.
		Aspect: Emissions, effluents and waste
Core	EN16	Total direct and indirect greenhouse gas emissions by weight
Core	EN17	Other relevant indirect greenhouse gas emissions by weight
Additional	EN18	Initiatives to reduce greenhouse gas emissions by weight
Core	EN19	Emissions of ozone-depleting substances by weight
Core	EN20	NO, SO, and other significant air emissions by type of weight
Core	EN21	Total water discharge by quality and destination
Core	EN22	Total weight of waste by type and disposal method

Table 2.8: Continued

Core	EN23	Total number and volume of significant spills
Additional	EN24	Weight of transported, imported, exported, or treated waste deemed hazardous under the terms of the Basel Convenstion Annex I, II, III and IV, and percentage of transported waste shipped internationally.
Additional	EN25	Identify, size, protected status, and biodiversity value of water bodies and related habitats significantly affected by the reporting organisation's discharges of water and runoff.
Core		Aspect: Products and Services
Core	EN26	Initiatives to mitigate environmental impacts of products and services, and extent of impact mitigation.
Core	EN27	Percentage of products and their packaging materials that are reclaimed by category.
		Aspect: Compliance
Core	EN28	Monetary value of significant fines and total number of non-monetary sanctions for non-compliance with environmental laws and regulations.
		Aspect: Transport
Additional	EN29	Significant environmental impacts of transporting products and other goods and materials used for the organisation's operations, and transporting members of the workforce
		Aspect: Overall
Additional	EN30	Total environmental protection and expenditures and investments by type

GRI Category: Social

The social dimension of sustainability concerns the impacts an organization has on the social systems within which it operates. The GRI Social Performance Indicators identify key Performance Aspects surrounding labor practices, human rights, society, and product responsibility. These are presented in **Tables 2.9, 2.10, 2.11** and **2.12**

Safety indicators

Although the sustainability is encompassed within economic, environment and social, the aspect of safety is embedded in these three components. It is part of environmental concerns when considering human toxicity, part of economics when considering costs and expenditures pertaining to health and safety and it is included in social indicators when evaluating work satisfaction (Al-Sharrah et al., 2010).

Table 2.9: Performance Indicators for the Social Sub-category of Labour Practices and Decent Work

Type of Indicator		Performance Indicators
		Aspect: Employment
Core	LA1	Total workforce by employed by employment type, employment contract, and region.
Core	LA2	Total number and rate of employee turnover by age group, gender, and region.
Additional	LA3	Benefits provided to full-time employees that are not provided to temporary or part-time employees, by major operations.
		Aspect: Labour/Management Relations
Core	LA4	Percentage of employees covered by collective bargaining agreements.
Core	LA5	Minimum notice period (s) regarding operational changes, including whether it is specified in collective agreements.
		Aspect: Occupational Health and Safety
Additional	LA6	Percentage of total workforce represented in formal joint management – worker health and safety committees that help monitor and advise on occupational health and safety programmes.
Core	LA7	Rates of injury, occupational diseases, lost days, and absenteeism, and number of work related fatalities by region.
Core	LA8	Education, training, counselling, prevention and risk-control programs in place to assist workforce members, their families, or community members regarding serious diseases.
Additional	LA9	Health and safety topics covered in formal agreements with trade unions.
		Aspect: Training and Education
Core	LA10	Average hours of training per year per employee by employee category.
Additional	LA11	Programme for skills management and lifelong learning that support the continued employability of employees and assist them in managing career endings.
Additional	LA12	Percentage of employees receiving regular performance and career development reviews.
Core	LA13	Composition of governance bodies and breakdown of employees per category according to gender, age, group, minority group membership, and other indicators of diversity.
Core	LA14	Ratio of basic salary of men to women by employee category.

Table 2.10: Performance Indicators for the Social Sub-category of Human Rights

Type of Indicator		Performance Indicators
		Aspect: Investment and Procurement Practices
Core	HR1	Percentage and total number of significant investment agreements that include human rights clauses or that have undergone human rights screening.
Core	HR2	Percentage of significant suppliers and contractors that have undergone screening on human rights and actions taken.
Additional	HR3	Total hours of employee training on policies and procedures concerning aspects of human rights that are relevant to operations, including the percentage of employees trained
		Aspect: Non-Discrimination
Core	HR4	Total number of incidents of discrimination and actions taken.
		Aspect: Freedom of Association and Collective Bargaining
Core	HR5	Operations identified in which the right to exercise freedom of association and collective bargaining may be at significant risk, and actions taken to support these rights.
		Aspect: Child Labour
Core	HR6	Operations identified as having significant risk for incidents of forced or compulsory labour, and measures to contribute to the elimination of forced or compulsory labour.
		Aspect: Forced and Compulsory Labour
Core	HR7	Operations identified as having significant risk for incidents of forced or compulsory labour, and measures to contribute to the elimination of forced or compulsory labour.
		Aspect: Security Practices
Addition	HR8	Percentage of security personnel trained in the organization’s policies and procedures concerning aspects
		Aspect: Indigenous Rights
Addition	HR9	Total number of incidents of violations involving rights of indigenous people and actions taken.

Table 2.11: Performance Indicators for the Sub-Category of Society

Type of Indicator		Performance Indicators
		Aspect: Community
Core	S01	Nature, scope, and effectiveness of any programs and practices that assess and manage the impacts of operations on communities including entering, operating and exiting.
		Aspect: Corruption
Core	S02	Percentage and total number of business units analysed for risks related to corruption
Core	S03	Percentage of employees trained in the organization’s anti-corruption policies and procedures
Core	S04	Actions taken in response to incidents of corruption
		Aspect: Public Policy
Core	S05	Public policy positions and participation in public policy development and lobbying.
Additional	S06	Total value of financial and in-kind contributions to political parties, politicians, and related institutions by country
		Aspect: Anti-Competitiveness Behaviour
Additional	S07	Total number of legal actions for anti-competitive behaviour, anti-trust, and monopoly practices and their outcomes.
		Aspect: Compliance
Core	S08	Monetary value of significant fines and total number of non-monetary sanctions for non-compliance with laws and regulations.

Table 2.12: Performance Indicators for the Sub-Category of Product Responsibility

Type of Indicator		Performance Indicators
		Aspect: Customer Health and Safety
Core	PR1	Life cycle stages in which health and safety impacts of products and services are assessed for improvement, and percentage of significant products and services categories subject to such procedures.
Additional	PR2	Total number of incidents of non-compliance with regulations and voluntary codes concerning health and safety impacts of products and services during their life cycle, by type of outcomes.
		Aspect: Product and Service Labelling
Core	PR3	Type of product and service information required by procedures, and percentage of significant products and services subject to such information requirements.
Additional	PR4	Total number of incidents of non-compliance with regulations and voluntary codes concerning product and service information and labelling by type of customers.
Additional	PR5	Practices related to customer satisfaction including results of surveys measuring customer satisfaction.
		Aspect: Marketing Communications
Core	PR6	Programmes for adherence to laws, standards, and voluntary codes related to marketing communications including advertising, promotion and sponsorship.
Additional	PR7	Total number of incidents of non-compliance with regulations and voluntary codes concerning marketing communications including advertising, promotion, and sponsorship by type of customers.
		Aspect: Customer Privacy
Additional	PR8	Total number of substantiated complaints regarding breaches of customer privacy and losses of customer data.
		Aspect: Compliance
Core	PR9	Monetary value of significant fines for non-compliance with laws and regulations concerning the provision and use of products and services.

2.9. Analytical Hierarchy Process

Multiple-criteria decisions are commonplace in any organisation (Parthasarathy & Sharma, 2014). There are essentially two kinds of decisions: intuitive and analytical. Intuitive decisions are not supported by data and documentation, and instead may appear to be arbitrary (Saaty, 2008). However, a surprising number of corporate decision-making that is undertaken is of the intuitive type. The person designated with the decision-making collates the relevant information, possibly biased by his or her own values and thought processes, and makes the decision. This model is considered a weak approach to decision-making in an organisation because (1) it is difficult to convince others because the decision maker is unable to justify it with persuasive logic (2) the decision may not be rooted in anything explicit or tangible (3) others within the organisation will not be able to identify to the decision nor contribute to it (4) the decision-maker may have difficulty in synthesizing his own and his subordinates' expertise and (5) this type of decision will be hard to review to assess its effectiveness as there is no learning or creation of a process through group participation (Saaty, 2006).

Developed by Saaty (1980), the Analytical Hierarchy Process (AHP) is a multi-criteria decision making (MCDM) method where the evaluation is carried out using pairwise comparison within an established matrix for decisions involving multiple conflicting and subjective criteria (Ishizaka and Labib, 2009; Saaty, 1980). AHP enables users to make effective decisions on complex issues which involve multi-criteria and provides a mechanism to establish decision models through a process that contains components which are both qualitative and quantitative. Qualitatively, AHP allows the user to deconstruct a decision problem from the overall goal into a set of manageable categories, indicators and sub-indicators and the quantitative aspect involves the assigning or allocation of weights to the elements identified within the criteria and sub-criteria levels (Alwaer and Clements-Croome, 2010).

Literature shows the AHP has been extensively used in various applications in MCDM processes. Several research publications have discussed these applications, highlighted the advantages of this tool as well as summarised successful case studies (Zahedi, 1986; Golden et al, 1989; Shim, 1989; Vargas, 1990; Saaty & Forman, 1992; Forman & Gass, 2001; Omkarprasad & Sushil, 2006; Vaidya and Kumar, 2006; Liberatore & Nydick, 2008; Ho, 2008; Yau, 2009; Sipahi & Timor, 2010; Benlian, 2011; Ishizaka, 2011; Lee & Ross, 2012;). Literature indicates that AHP is an effective yet flexible decision-making process to help decision-makers set priorities and select the most feasible option when both qualitative and quantitative aspects of a decision need to be considered (Saaty, 1980). In a study conducted by Pohekar and Ramachandran (2004), a review of 90 published papers on AHP was carried out. The findings of the review show that AHP is the most popular MCDM tool.

AHP is a method of deconstructing or decomposing a complex, unstructured situation or decision problem into its components, arranging these components or judgements on the relative importance of each variable and synthesizing the judgements to establish which judgement has the highest priority and should be acted upon to influence the outcome of the situation (Saaty, 1990). The process is facilitated through a series of pair-wise comparisons. By using pair-wise comparisons, the decision makers are not required to explicitly define a measurement scale for each judgement (Spires, 1991). The advantage of the AHP is that the tool can address with both qualitative and quantitative criteria (Saaty, 1980; Vargas, 1990). Three important components of the AHP are (Giri and Nejadhashemi, 2014; Young et al., 2009):

- Problem decomposition: the problem is decomposed into elements (which are grouped on different levels to form a hierarchy) and each element is further decomposed into sub-element until the lowest level of the hierarchy.

- Comparative Analysis: pairwise comparison between elements at each level to measure the relative importance.

- Synthesis of priorities: the priority weights of elements at each level will be computed using eigenvector.

A hierarchy is a representation of a complex problem in a multilevel structure where the first level is the goal, and this is followed sequentially by a number of levels comprising factors, criteria, sub-criteria, and so on down to a bottom level of alternatives (Saaty, 2006). In a typical decision-making structure normally there are three to four consecutive levels. Level 1 indicates the overall goal or focus of the decision, Level 2 signifies the criteria for the decision, Level 3 comprises the sub-criteria (if any) and Level 4 contains the decision choices or alternatives. Pair-wise comparisons are made of the criteria within each hierarchy by means of a nominal scale. Upon completion of the required pairwise judgement matrices between the criteria and the goal, the consistency ratio (CR) is calculated which is the measure of the inconsistency. Following this, the comparisons are quantified to establish a comparison matrix after which the eigenvector of the matrix is derived, signifying the comparative weights among various criteria of a certain hierarchy. Finally, the eigenvalue is used to assess the strength of the consistency ratio of the comparative matrix and determine whether to accept the information (Bozbura, 2007; Razavi et al., 2011). For ease of use, Saaty (1982) develop and commercialized the PC-based software, Expert Choice™, which is based on the AHP. The software has been widely used by operations research practitioners across the globe in various applications including engineering and IT, resource allocation, performance management framework for the construction industry (Vukomanovica & Radujkovica, 2013). In these applications, AHP has been used to prioritize or rank, select, evaluate and benchmark different types of alternatives.

The identification of SPIs and their prioritization is multi-objective, encompassing any tangible and intangible factors In this research, the AHP is the preferred MCDM tool used for the prioritisation of the SP indicators since this method is the only MCDM method which uses a hierarchical structure among the goal, criteria, sub-criteria and alternatives.

Despite the AHP approach is more than 20 years old, the model is one of the most widely used MCDM tool. A literature survey conducted by Water and Vries (2006) on AHP references available on online databases such as Science Direct, ProQuest and Anbar reveal an overwhelming number of more the 1600 publications ranging from mathematical articles to articles on all kinds of practical applications. AHP has been successfully used to identify the success factors of implementation of ISO 14001 in electrical and electronics sector (Sambasivan and Ng, 2007), to prioritise to develop indicators for intelligent building systems (Wong et. al, 2008; ALwaer and Clements-Croome, 2010), to prioritize rural roads in India (Dalal et al, 2009), as a methodology for the selection of construction projects (Nandi *et al.,* 2011) for prioritization of indicators in the management of human resources (Bozbura et al., 2007), evaluation of supply chain management and vendor selection (Bhagwat and Sharma, 2007; Koul and Verma, 2011), understanding the benefits of Total Quality Management in ISO9001-certified industries (Lewis et al, 2005), determining priority in safety management systems (Chan et al, 2004), benchmarking service quality (Kannan, 2010), for the comparison of different software models in office suites (Benlian, 2011) and, maritime ports (Yeo et al, 2010). Moghaddam and Karami (2008) employed AHP for the evaluation of sustainable agriculture development models. With respect to sustainable development, AHP has been successfully used to evaluate projects that qualify for Clean Development Mechanism (CDM) funding (Brent et al, 2005). In Malaysia, AHP has been used to evaluate the critical success factors of implementing the ISO 14001 EMS in the electrical and electronics sector (Sambasivan, 2008).

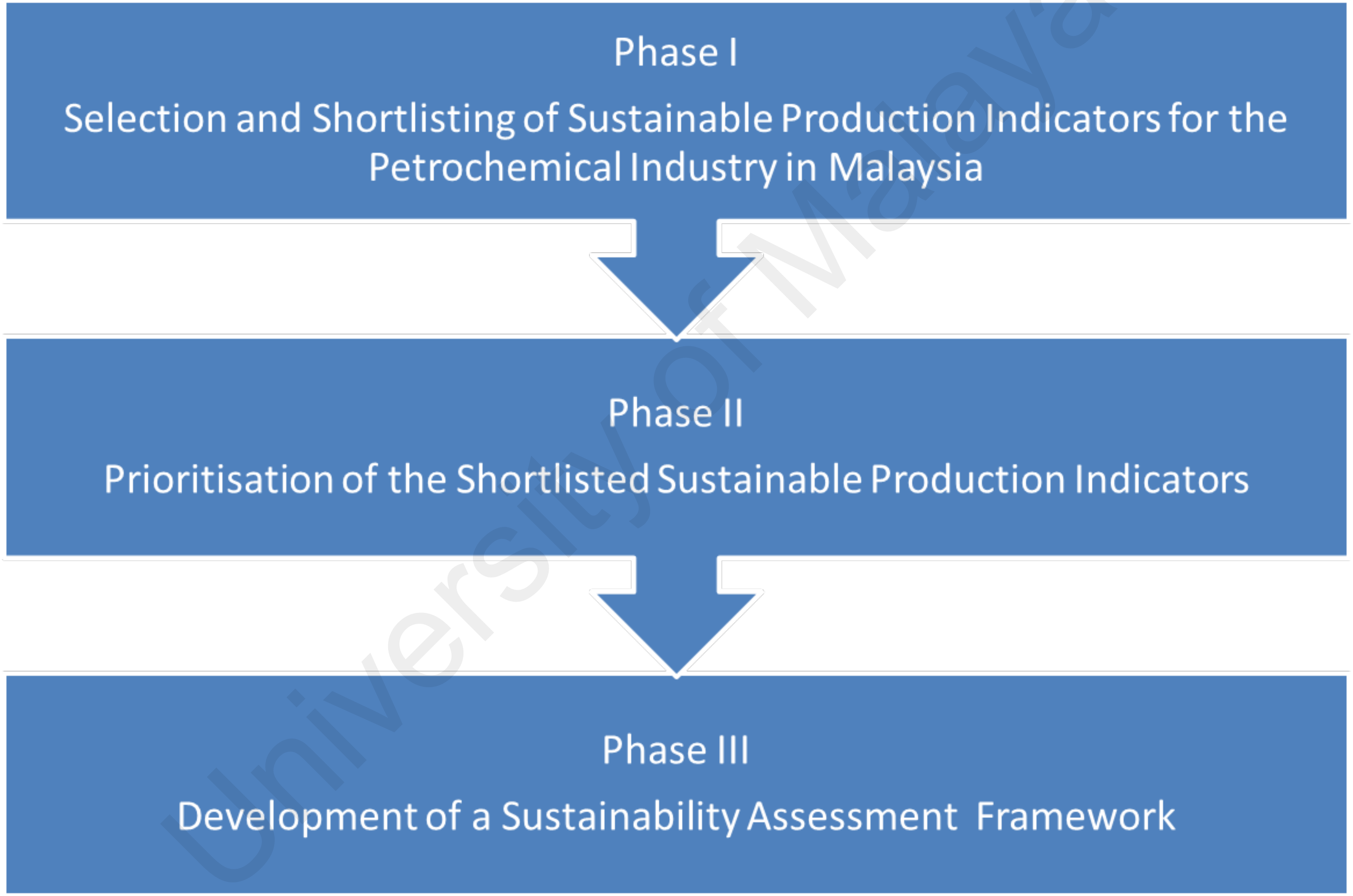
CHAPTER 3: RESEARCH METHODOLOGY

3.1. Research Overview and Design

This chapter discusses the methodology used to achieve the objectives of this research which are to (1) identify a set of SPIs representing economic viability, environmental protection and social responsibility to assess the sustainability of the petrochemical industry in Malaysia (2) prioritise the identified SPIs and rank them in accordance with their relative importance as perceived by the industry within the Malaysian context, (3) to develop an appropriate sustainability assessment framework based on the SPIs for the industry and; (4) to develop a clear and transparent process for the development of the framework. This is to enable its duplication in the future should there be changes in the external factors that would influence the type of SPIs as well as their ranking. The research methodology comprises both qualitative and quantitative phases. The qualitative phase includes a questionnaire survey and in-depth semi-structured interviews as research instruments with the quantitative phase involving the use of AHP developed by Saaty (1980; 2008).

In achieving the objectives, the research was carried out in three phases each addressing a specific aspect of the research. The three phases of the methodology are illustrated in **Figure 3.1**. The three phases are however inter-related with the findings of Phase 1 being used for Phase 2, and similarly, the Phase 2 findings forming the foundation for Phase 3. The research was carried out using a combination of questionnaire-based survey and in-depth semi-structure interviews with selected professionals from the petrochemical industry for indicator validation and, review of government guidelines and policies on sustainability for Phase 1 and; the use of AHP for Phases 2 and 3. Phase I of the research was further divided into four stages as described in **Figure 3.2.**

Figure 3.1: Overall research methodology



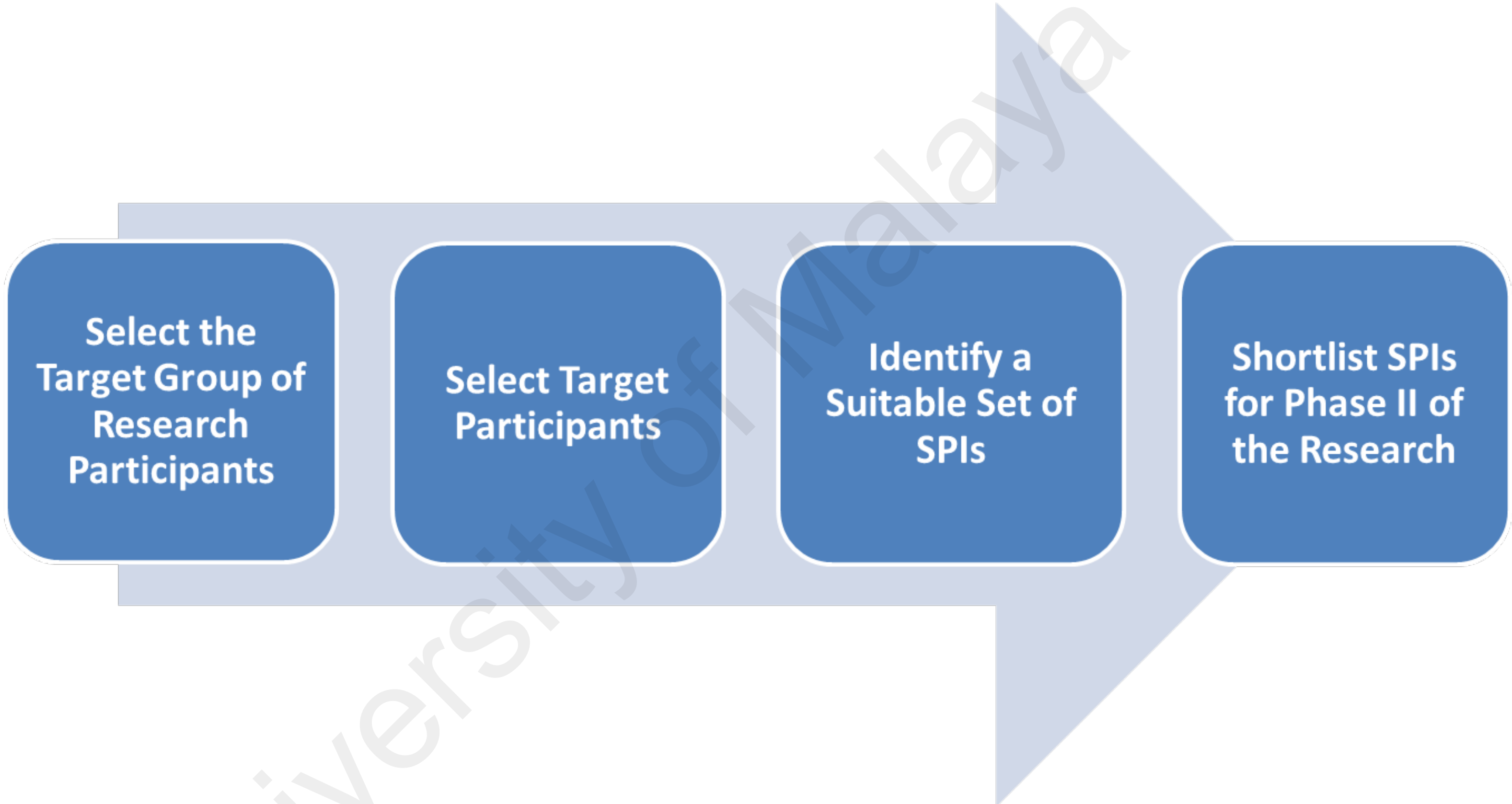


Figure 3.2: The four stages of Phase 1

The survey instruments used in Phase 1 of the research comprised the questionnaire survey method supplemented with semi-structured interviews.

In Phase 2, the SPIs identified from Phase 1 that are appropriate for the petrochemical industries operating in Malaysia were prioritised according to importance, applicability and relevance using AHP. The tool was then further used in Phase 3 where a suitable sustainability assessment framework was selected and modified for use in Malaysia. The final outcome of the research was to enable the selection framework to be employed by the petrochemical industry in Malaysia to measure and benchmark their performance with respect to sustainable production. For Phases 2 and 3, in-depth interviews were carried out using the Expert Choice® software.

3.2. Phase 1: Selection of Sustainable Production Indicators (SPIs) for the Petrochemical Industry in Malaysia

The primary objective of this phase was to determine a set of key SPIs based on discussions with the research respondents on sustainability of the petrochemical sector including identifying indicators that impact sustainability performance and those which are critical success factors of sustainability within the industry. The output of this stage was a set of shortlisted core and supplemental indicators that were used as the criteria in the AHP analysis which was undertaken in Phase 2 of the research. Based on the literature review which was carried out for this research, it has been established that a manageable number of indicators is between 20 and 25 (Kaplan and Norton, 1996); Reisinger et al., 2003). The research methodology employed is described in the following sub-sections.

3.2.1. Part 1: Selection of a Suitable Pool of Research Respondents

In order to select a susitable pool of respondants, the different stakeholders of the petrochemical industry in Malaysia was identified. Stakeholders, defined by Bryson (1995) and Foley (2005) as stakeholders as any person, group or organisation that can impact an organisation's attention, resources or outputs. Stakeholders' interests are the vital building blocks of business behaviour.

On the participation of stakeholders, Foley (2005) gives due cognisant that an organisation's stakeholders may change over time and their interest may vary both within and between groups and, potentially in conflict with each other (Crowther, 2002). Therefore, for purposes of this research which involves the development of SPIs for the petrochemical industry, it was important to establish which stakeholder has the right priority and strongest influence for this research.

One crucial research question was who or which group (s) of stakeholder would be the best to identify and select suitable SPIs in order to achieve the objectives of this research using the proposed AHP method? Work by Mascarenhas et al (2014) and Guijt (1999) support the notion that each stakeholder group has different information needs, priorities and expectations when involved in sustainability assessment of a given aspect.

A study by Rezaei-Moghaddam and Karami (2008) described the use of more than one group of stakeholders in their development of a sustainable agriculture development model using the AHP as the MCDM tool. In their study, the stakeholders comprised farmers, agriculture specialists as well as representatives from environmental movements and researchers on the subject as selected from their literature review. Similarly studies by Beltran et al. (2014) and Singh (2014) have used multiple stakeholder groups. Other studies indicate the use of a single specialist or expert panel/group (Han et al, 2007; Lin, 2010; Nandi et al., 2011; Lee and Ross (2012), Daim et al., 2013). In the study by Nandi et al (2011) involving the use of AHP in the selection of construction projects, the expert pool was confined to specialists within a single construction company.

Therefore, for purposes of this research, an evaluation of the stakeholders that play a role in impacting and influencing sustainable production practices in the petrochemical sector (directly or indirectly) was carried out. This was done to determine if the research respondents should comprise multiple groups of stakeholders or if the pool of respondents should be confined to a single stakeholder group.

In Malaysia, there are many stakeholders who influence and impact sustainability policy and decision-making within the petrochemical industry in different ways. These stakeholders include industry experts, i.e. those involved in the day-to-day operations at the petrochemical facility, the regulators who promulgate and enforce the various laws, regulations and guidelines pertaining to sustainability; the environmental, health and safety experts (private consultants with more than 10 years of experience in Malaysia) who provide technical specialist advice (consulting service) to the petrochemical sector and the non-government organisations that play a role as a 'watch-dog' to monitor and put pressure on industries as a whole to operate in a more sustainable manner. The 6 stakeholder groups are depicted in the Influence Diagram presented as **Figure 3.3**.

Figure 3.3: Influence diagramme showing the stakeholders that influence the sustainable practices of the petrochemical industry in Malaysia

For each of the stakeholder group identified, one individual was selected to represent each group except for the Government (Regulators) group where two individuals were selected. The single individual selected to represent each group was chosen from a preliminary screening process. In the screening process, up to 3 individuals from each group was identified and based on their experience, expertise and knowledge in sustainable production process in an industrial context, one individual was selected to represent each stakeholder group. This individual was deemed to be the expert for his/her stakeholder group. For the Governemtn (Regulaators) group, 2 individuals were selected to each represent the Department of Environment and the

Department of Occupational, Safety and Health which are the two most relevant agencies as most of the regulatory requirements for operating petrochemical plants fall under their purview. A description of the 7 individuals who participated in the interviews but wished to remain anonymous is provided in **Table 3.1** below.

Table 3.1: Details of the identified stakeholders who participated in Part 1 of Phase 1 of the research

No	Stakeholder	Organisation	Details of Experience of the Representative Interviewed
1	Industry Experts	Industry Expert A from Petrochemical Company A	12 years in the petrochemical plant holding responsibilities in plant operations as well as in environmental, health and safety management. Possessed a Bachelor's degree in chemical engineering.
2	Environmental, Health and Safety Consultants	Consultant A from a private environmental, health and safety consulting firm	17 years of experience as an environmental, health and safety consultant in a well-established consulting firm. Possessed a Bachelor's degree in environmental science.
3	Professional Body	Expert A from ENSEARCH (Environmental Management and Research Association of Malaysia)	22 years of experience in environmental, health and safety. Possessed a Bachelor's degree in environmental engineering.
4	Non-Government Organisations	World Wildlife Fund (WWF) Malaysia	Research Officer with more than 10 years in providing input with respect to ecological conservation in industrial projects and proposals.
5	Researchers at academic institutions	University of Malaya	Lecturer at the Faculty of Engineering with 20 years of research experience. Possessed a post-graduate degree in chemical engineering.
6	Government (Regulators)	Department of Environment, Ministry of Natural Resource and Environment	Assistant Director, Assessment Division with 15 years of service at the department. Possessed a Bachelor's degree in science (chemistry).
		Department of Occupational Safety and Health, Ministry of Human Resources	Safety Officer with 10 years of service with the department. Possessed a Bachelor's degree in Science (Physics).

In ascertaining the suitability of the identified stakeholders with the aim of determining if one group of stakeholder or multiple groups were to be used for this research, a screening exercise was carried out. This exercise involved the use of a semi-structured questionnaire which was followed up with an interview. A copy of the questionnaire is provided in **Appendix A**. The questionnaire was emailed to the individuals identified in Table 3.1 after an initial introductory telephone call was made to explain the objective of this exercise. The 7 individuals were then given a timeframe of 2 weeks to complete and submit the questionnaire. Once the questionnaire was submitted, it was analysed and these individuals were then interviewed to obtain their verbal feedback. As part of the interview process, questions that were related to the questionnaire were asked to determine their depth of knowledge on the subject.

Once the critical stakeholder group was identified for purposes of this study, the next step was to identify the target companies/organisations from where the expert pool of respondents was to be selected from. This was carried out in Part 2 as described in the following subsection.

3.2.2. Part 2: Selection of Target Companies and Survey Respondents

Based on the outcome of the questionnaire survey and the interviews described in the preceding section, the pool of research respondents was narrowed to industry practitioners (as described in detail in Chapter Four). At the time of the research in 2009, there were 36 companies registered with the Malaysian Petrochemical Association (MPA). Out of these, only 17 companies operated petrochemical facilities in Malaysia, and the remaining companies listed with the association were only involved in the trading of petrochemicals. For the study pool, all 17 companies were selected. Senior level staff involved in the management of environmental, health and safety (EHS) aspects of the operations were formally contacted via email and a follow-up telephone call to request their participation.

Upon their agreement a formal letter of invitation as well as a confidentiality agreement from the University of Malaya, where the research was carried out, were sent to these respondents. Both the documents were provided in hard copy as well as in electronic version. The survey pool members were given a timeframe of two weeks to respond. Based on the feedback via email, 13 companies which represented 76.5% of the operating facilities in Malaysia agreed to participate in this study. Some of these 13 facilities have similar parent companies comprising both Malaysian and multi-national corporations (MNCs). One EHS representative was selected from each of these 13 companies to form the expert pool of research respondents.

The remaining four companies (23.5%) declined to participate citing confidentiality reasons. Their company's respective corporate disclosure protocols with respect to sharing data or information on their EHS management practices did not permit them to be involved in this research.

As part of the research, it was important to analyse and understand the sustainability culture at the facilities as the culture to a large extent influenced their awareness and approach to managing day-to-day operations at the plant. Hence, a review of the 13 operating facilities that agreed to participate was carried out using secondary information, i.e. based on their annual reports, their respective website and other available information in the public domain.

In order to obtain a baseline of efforts currently being carried out with respect to sustainability, a questionnaire was developed with the aim of soliciting (1) background information on the company participating in the research, (2) an overview of the EHS management practices at the industrial plant including the monitoring of any elements/aspects of sustainability as well as to (3) understand the types of indicators monitored for the assessment of sustainable production processes.

Once the questionnaire was developed, a pilot study was first undertaken to test the potential response, suitability and comprehensibility of the questionnaire, and to determine if there was any ambiguity to the questions asked. As recommended by Lin

(2010) it was also important during the pilot study to obtain comments on the meaningfulness, relevance, and clarity of the GRI 3.1 criteria and ensure content validity. For purposes of this pilot study, three experts in the field of environmental management and sustainability were selected. Two of these professionals were employed in EHS consulting firms based in Malaysia and who each have more than 15 years of experience in providing EHS consulting services to the chemical and petrochemical industries and therefore understand their progress and challenges towards operating sustainably. The third person was a senior manager based at a petrochemical plant with more than 10 years of industry experience. Upon review of the questionnaire, comments were received from these experts, and minor amendments were made to the original survey instrument, i.e. some rephrasing and modification to enhance clarity and ensure that the input provided by the research respondents was accurate in response to the questions and relevant for purposes of the research. An example of the final survey questionnaire is presented in **Appendix B**.

The final questionnaire which was the survey instrument used was then sent to the EHS managers of the 13 participating facilities via email. They were given up to a maximum period of 4 weeks to review, complete and return the questionnaire to the researcher.

To increase the credibility of the data obtained (qualitative assessment) during this part of the research, member checking was employed in three ways: (1) member checking was carried out at the pilot survey whereby the views and opinions of three experts were interviewed and who candidly discussed the questions following each interview; (2) member checking took place during the course of the interviews as the researcher communicated the ideas back to the respondents to rephrase and interpret and; (3) the transcribed interview sessions (in verbatim form) from each of the respondent were sent back to each of them respectively, post-interview, to validate the contents of the transcription as well as to share the findings.

3.2.3. Part 3: Identifying the Sustainable Production Indicators (SPIs)

According to Lundin (2003), when developing a framework and selecting indicators, there are two distinctive approaches:

- the 'top-down' approach whereby experts in the field develop the framework and define the indicators; or
- the 'bottom-up' approach which incorporates the ideas from participation of different stakeholders in the design of the framework and the SPI selection process.

For the purpose of this study, elements of both the top-down and bottom-up approaches were employed. In the preceding part (Part 2), the selected pool of research respondents were requested to provide their feedback on the characteristics of the SPIs (e.g. in terms of ease of measurement, resources required, reliability, etc.) that would be suitable for sustainability assessment and, highlight and propose indicator systems which would be meaningful for the petrochemical industry. They were also asked to list the indicators monitored at their respective facilities as these indicators would be the most obvious choice to be incorporated as SPIs given appropriate methodologies have been developed to monitor these indicators. Based on the findings of Part 2, it appeared that most of the indicators already being monitored and those proposed were found within the Global Reporting Initiative Framework for sustainability reporting.

The original GRI framework was issued in 1999, and since then there have been three significant revisions with a fourth revision (issued in 2013) in transition phase. The second (GRI 2) and third (GRI 3) versions were both released in 2002 and 2006 respectively. The third version was slightly expanded in 2011 (GRI 3.1) by incorporating elements of human rights, local community impacts and gender. For purposes of this research although initially during Phase 1 of the research the GRI 3 was employed but subsequently when GRI 3.1 was released in 2011, the additional elements were incorporated. Therefore, this research was carried out based on the GRI 3.1 reporting guidelines (GRI, 2012).

Under the GRI 3.1 Guidelines performance indicators have been described under a total of six categories. The six categories include Economic (EC1-EC9), Environment (EN1-EN30), Society (SO1-SO8), Human Rights (HR1-HR9), Labour Practices & Decent Work (LA1-LA14) and Product Responsibility (PR1-PR9). The last four categories, namely, Society, Human Rights, Labour Practices & Decent Work and Product Responsibility collectively comprises the third pillar of sustainable development, i.e. Social. The numbers provided within the parentheses represent the indicators within each category. Of these, there are 'core indicators' and 'additional indicators'. The core indicators are defined as indicators which are most relevant to stakeholders and accept as material unless deemed otherwise on the basis of the GRI Reporting Principles. To supplement these core indicators, a set of 'additional indicators' have been identified and these are described under the guidelines as those that represent emerging practice or new aspects of sustainability that is material to some organizations but not for the majority (GRI, 2012). In this research, both the core and additional indicators were considered to determine their respective suitability for the assessment of the sustainability of production processes in petrochemical industries.

As the GRI is not country-specific, it was critical to evaluate these indicators and assess their suitability for the assessment of sustainability for the petrochemical industry in Malaysia. For these purposes, a screening exercise was carried out to select which of the 81 indicators and core indicators were applicable in the context of the petrochemical industry in Malaysia. The objective of this screening exercise was to reduce the number of indicators from 81 to only those that were relevant and the output of this screening phase was a pool of indicators suitable for use in this research. To this end, the selected research respondents participated in a close-ended questionnaire survey. Using their expert opinion and professional judgement chose GRI core indicators and additional indicators. In addition to the feedback obtained from the respondents' information obtained from the screening phase, a literature review on the Malaysian Government's policy and guidelines on sustainability was carried out to affirm the suitability of the selected indicators for this study.

In summary, the screening phase described above narrowed down the discussion to indicators that are presently being monitored by the industry. In developing SPIs for the petrochemical industry, it is best that the indicators selected are those which are already being monitored, or those that the industry feel are relevant, where the data can be readily obtained/measures and, can be monitored or tracked without incurring significant cost, time and resource. Any assessment tool developed should be easily used without having to make changes to the operational activities.

3.2.4. Part 4: Identifying and Shortlisting the Sustainable Production Indicators (SPIs)

The primary objective of this phase of the research was to shortlist a set of key SPIs based on input from the research respondents who are EHS experts in the petrochemical industry. These SPIs would best represent aspects of sustainability which are critical success factors for the industry in operating in a sustainable manner. The shortlisted indicators were prioritised indicators using AHP in Phase 2 of the research. This shortlisting phase is required to reduce the number of indicators as too many indicators will result in the loss of focus, require much effort, cost and time, as well as pose a challenge to monitor and track. Based on literature review, it has been established that a manageable number of indicators is between 20 and 25 (Kaplan and

Norton, 1996); Reisinger et al., 2003). The research methodology employed for the shortlisting of indicators for use of SPIs is described in the following paragraphs.

Based on the feedback of the screening phase, it was observed that most of the indicators were indeed being monitored by the participating companies. Therefore, this indicator framework was selected to be the pool from which the SPIs would be shortlisted.

Although the GRI represents one of the most comprehensive sustainability reporting framework (Gomes et al, 2015), not all the 81 indicators can be used directly as the intention of this research is to select key indicators that would enable the petrochemical industry to focus upon in benchmarking their sustainability performance. To this end, the need to shortlist the indicators from the GRI 3.1 pool is aligned with research by Moneva et al (2006) and Davis and Searcy (2010) on the use of the GRI indicators for corporate sustainability reporting.

In shortlisting the indicators from the screened out GRI 3.1 indicators, the researcher carried out interviews to understand why these indicators were monitored by the participating petrochemical facilities in Malaysia and if these indicators were important in the assessment of the sustainability of their operations, i.e. to be considered as SPIs in the current time as well as in the near future (although not monitored at present).

During the interview, the respondents were asked how the indicators were monitored by the participating petrochemical facilities in Malaysia and why these indicators were important in the assessment of the sustainability of their operations. Why is this indicator important? Is this a regulatory requirement? Is monitoring/tracking this indicator easily carried out in terms of effort, resources and cost? Can the data be readily interpreted? Should this indicator be included as an SPI?

When selecting an indicator it is important to select a system that is firstly already in place so that industries don't have to invest too much time and effort that is not financially burdensome, this also ensures a high degree of familiarity to the industrial experts – the key is to not re-invent the wheel but the build on existing framework. Industries can only benchmark indicators which they know and understand. Also, it is important that there is historical data – this means that the indicators must be in use over the last 5 years or so. Hence, one of the objectives of the questionnaire was to solicit information on the indicators presently in use by the industries. Maes et al (2011) agree that it is important to shortlist as not all indicators are easily measured because monitoring or tracking them may be too demanding with respect to expert knowledge, time measurement and information requirements. The researcher also asked the respondents if they believed there are other indicators that would be representative and to be added in the pool of shortlisted indicators, or modify some of the prevailing GRI 3.1 indicators to suit the Malaysian situation. In deciding the suitability of the new indicators or the modification of existing indicators, the researcher ensured that a significant majority of the respondents agreed, i.e. 75%.

During the interview, more detailed information was obtained from the research respondents on the implementation of EHS policies and procedures at their respective operating facilities as well as sustainability initiatives. These experts were asked to assess and review the complete list of GRI 3.1 indicators, assess if they could sufficiently represent sustainable production processes, and then to select indicators from the complete list of the GRI indicators which were currently being monitored by the petrochemical industry in benchmarking themselves on their progress towards sustainability. These experts were also asked to either modify the existing indicators or identify any additional indicators that could be included to ensure the final set of SPIs to be selected were relevant in the Malaysian context. They were also asked to check the appropriateness of the description of the indicators to remove any ambiguity.

The interview sessions were carried out in a manner that did not compromise their obligations and responsibilities to the management of their companies; and the strictest confidentiality to the research respondents was maintained at all times. As recommended by Lincoln and Guba (1985), the interviews were carried out at the place of work of the respondents, i.e. at the respective petrochemical facility to improve contextual richness and minimize fragmentation. The objectives of the interviews were to verify the information provided in the questionnaire; and to explore the experience of the respondents on the use of indicators to measure sustainable production. The interviews were also used to elicit, by probing, the general understanding of the respondent on the concept of sustainable development and sustainability at a production level. Adequate engagement was allowed for in each interview session to ensure the researcher is familiarized with the respondent and, to reduce possibilities of misinformation and perceptual distortions (Lincoln & Guba, 1985).

The data obtained from the questionnaire and the interview sessions were analysed and, triangulation was included to a limited degree by including information obtained from the annual reports of the participating companies. As described by Lincoln & Guba (1985), triangulation is described as adding to the credibility by applying multiple sources, methods, investigators or theory to a study.

Based on the analysis of the data, a list of shortlisted indicators was determined. Selection of a correct set or the most appropriate set of indicators is critical as these will form the input into the AHP process for this research (Phase 2). In the event there is a missing criterion (indicator) considered by the research respondent, but not by the AHP developed for the research, this would affect the rankings. Hence, to minimise this risk, considerable time was spent with the respondents to solicit a list of indicators most reflective of their operations and which can be used to assess sustainability.

3.3. Phase 2: Prioritisation of the Identified Sustainable Production Indicators (SPIs)

The second phase of the research involved prioritization of the SPIs identified from Phase 1 of the research and this was carried out using the Analytical Hierarchy Process (AHP) which is a MCDM tool. The key aim of this phase was to compare the relative importance of the SPIs, and then to prioritise them. The intended outcome of this phase is a list of SPIs which have been prioritised using weights in the AHP analysis.

3.3.1. AHP as the Multi Criteria Decision Making Tool

The AHP is a MCDM technique and has been proven to be the preferred tool for group decision making involving multiple criteria (Saaty, 2006; Bard and Sousk, 1990; Dyer and Forman, 1992). AHP assists decision-makers evaluate the importance of a criterion in an intuitive manner by incorporating both subjective and objective data into the hierarchical framework and adopting pairwise comparisons to determine the relative importance of the criteria for meeting the goal (Yau, 2009; Janssen, 2001). Since the environmental, economic and social criteria are so diverse and varied in characteristics with different measurement units, the use of an MCDM tool is very appropriate for studies such as this research (Milutinovic et al., 2014).

The AHP methodology can be broken-down into the following steps:

- Decomposition of the problem into a hierarchy
- Formulation of a relative importance matrix for all levels of the hierarchy
- Determination of the Eigen vector from the relative importance matrices
- Selection of the alternative with the highest Eigen value

The AHP model is structured as a logical hierarchy with a minimum of three levels, namely, the goal, the criteria and the alternatives (**Figure 3.4**). The first level (Level 1) defines the objective or the goal of the decision-making process. The next level (Level 2) contains the attributes or criteria which contribute to or affect the decision. This level can be further subdivided to accommodate a number of sub-criteria (Level 3) under the main criteria which would affect the final decision. The last level (Level 4) comprises the decision alternatives or the selection choices (Saaty, 2006).

The next step is the pairwise comparison of the criteria (and sub-criteria) by constructing a relative importance matrix. Each pair wise comparison involves assigning priority of one criteria (or sub-criteria) over the other but the comparison is carried out within the same level, and with respect to the element in the immediate upper level using a relative scale measurement. These comparisons which are carried out between criteria at the same level with respect to the goal are used to decide on the relative importance of one criterion versus another (Saaty, 1980, 1988). Using these priorities, the relative importance matrix is formulated and the Eigen vector of the matrix is found. The normalised Eigen vector presents the priority of the variables and the principal Eigen value is utilised to obtain a measure of the consistency of the judgement. The final step is to rate each of the selection alternatives (in this research the preferred framework) with reference to each of the criteria variables. At this stage, the rating is also carried out in a pair-wise manner based on the relative scale of measurement. The normalised principal Eigen vectors for these matrices are then calculated. These Eigen vectors represent priority indices of all the alternatives with reference to each criteria variable. The resultant vector obtained from the product of the relative importance Eigen vectors and the transpose of the matrix of the priority indices gives the rankings of the alternatives being considered.

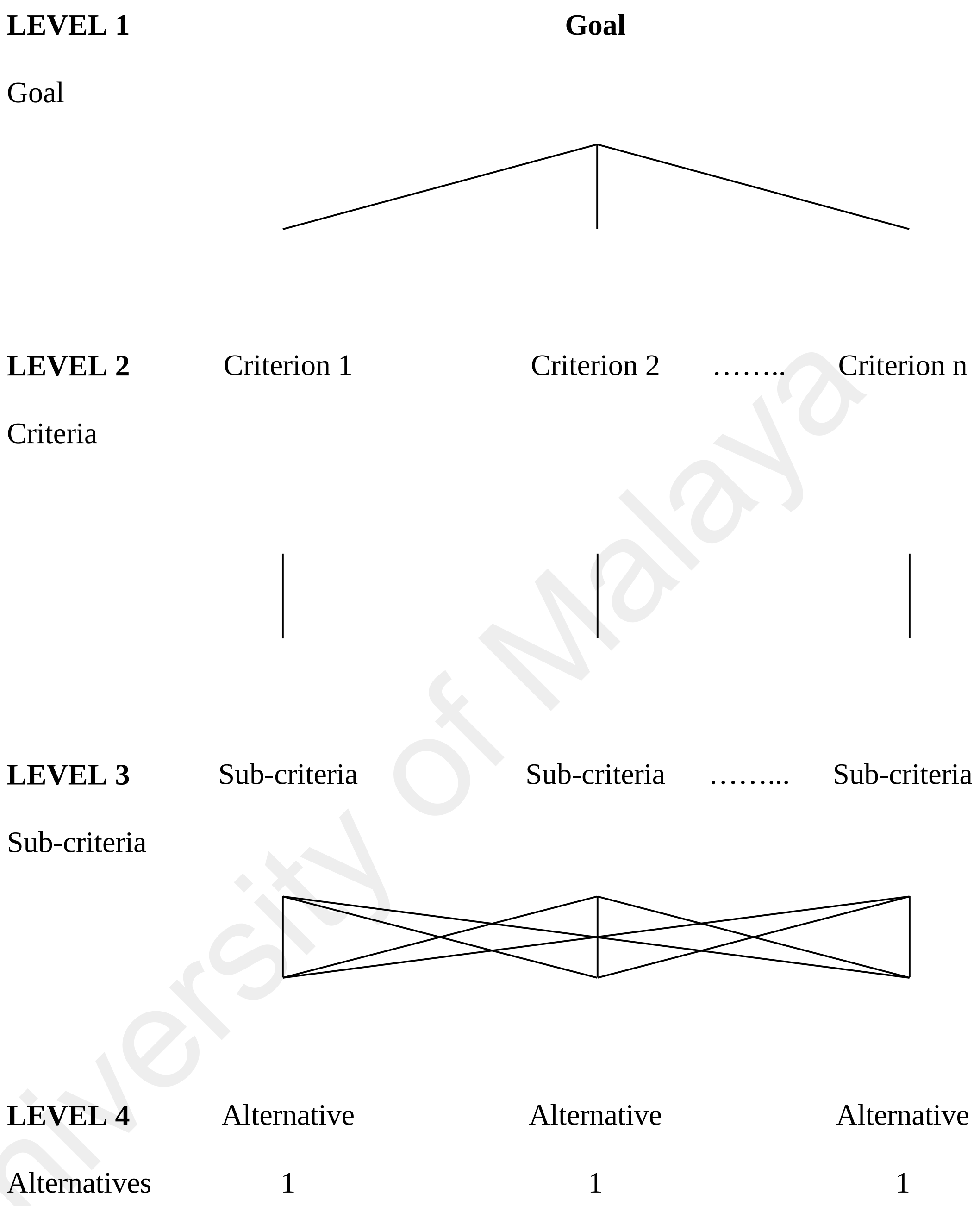


Figure 3.4: An example of a typical AHP Hierarchy (Yau, 2008)

A study by Podgorski (2015) has demonstrated that AHP can be successfully used to selected (and prioritise) key performance indicators from a larger pool of indicators. The prioritisation of the SPIs was carried out in Phase 2 of the research with the selection of the alternatives carried out in Phase 3.

The AHP analysis process described above was facilitated with the use of a computer software, Expert Choice®. By synthesizing the results of these analyses, the relative importance of the criteria (and the sub-criteria) meeting the goal was computed and a suitable alternative derived.

3.3.2. Structuring the AHP Hierarchy

The creation of the hierarchy is the first step in the AHP and provides the relationships between the goal and the criteria and there is no limit to the number of layers in a hierarchy, for example, the criteria can own sub-criteria and the sub-criteria can own its own sub-criteria. In its fundamental form, this structure comprises a goal, criteria and sub-criteria levels and the alternative level. For Phase 2 of the research, as the goal was for prioritisation of the indicators, the AHP model constructed excluded Level 4 (the alternative level). This level was however included for the AHP analysis in Phase 3 of the research.

The AHP model was constructed with Level 1 as the goal which is prioritisation of the SPIs, followed by Level 2 (criteria) comprising the six key performance indicator categories of the GRI 3.1, namely, Economy, Environment, Society and Labour Practice and Decent Practice and Level 3 (sub-criteria) comprising the shortlisted indicators under each of the main indicator level (see **Tables 3.2**, **3.3**, **3.4**, **3.5, 3.6 and 3.7** which described the criteria and sub-criteria). The detailed discussion on the reasons these indicators were shortlisted from the GRI 3.1 is provided in Chapter Four. Some of the shortlisted indicators were used directly whilst others were modified to be more specific and effective as an SPI for the petrochemical industry in Malaysia. (To note that where the indicators were modified, the modified indicators were given the same code but with an added ‘a’ as a suffix).

Table 3.2: Shortlisted and/or modified performance indicators on economics

Original GRI 3.1 Indicator		Indicator for Use as an SPI for the Petrochemical Industry in Malaysia	
Code	**Description**	**Code**	**Description**
EC 6	Policy, practices and proportion of spending on locally-based supplier at significant locations of operations	EC 6a	Percent of contracts with local suppliers per unit sales revenue
EC 7	Procedures for local hiring, and proportion of senior management hired from the local community at locations of significant operation	EC 7a	Percent of staff hired from the local community

Table 3.3: Shortlisted and/or modified performance indicators on Environment

Original GRI 3.1 Indicator		Indicator for Use as an SPI for the Petrochemical Industry in Malaysia	
Code	**Description**	**Code**	**Description**
EN1	Materials used by weight or volume	EN1	Materials used by weight or volume
EN3	Direct energy consumption by primary energy source.	EN3	Direct energy consumption by primary energy source
EN5	Energy saved due to conservation and efficiency improvements.	EN5	Energy saved due to conservation and efficiency improvements.
EN8	Total water withdrawal by source	EN8a:	Water Consumption per unit product
EN16	Total direct and indirect greenhouse gas emissions by weight.	EN16	Total direct and indirect greenhouse gas emissions by weight.
EN21	Total water discharge by quality and destination.	EN21a	Total treated wastewater discharge by unit product’
EN22	Total weight of waste by type and disposal method.	EN22a	Total weight of waste per unit product’
EN23	Total number and volume of significant spills	EN23a	Number of incidents involving reportable loss of primary containment
EN28	Monetary value of significant fines and total number of non-monetary sanctions for non-compliance with environmental laws and regulations.	EN28a	Number of EHS regulatory non-compliances

Table 3.4: Shortlisted and/or modified performance indicators on Labour Practices and Decent Work

Original GRI 3.1 Indicator		Indicator for Use as an SPI for the Petrochemical Industry in Malaysia	
Code	**Description**	**Code**	**Description**
LA2	Total number and rate of employee turnover by age group, gender, and region.	LA2a	Rate of employee turnover by age group and gender
LA7	Rates of injury, occupational diseases, lost days, and absenteeism, and number of work related fatalities by region.	LA7a	Number of Lost Time Injuries (LTIs)'

Table 3.5: Shortlisted and/or Modified Performance Indicators on Society

Original GRI 3.1 Indicator		Indicator for Use as an SPI for the Petrochemical Industry in Malaysia	
Code	**Description**	**Code**	**Description**
S01	Nature, scope, and effectiveness of any programs and practices that assess and manage the impacts of operations on communities including entering, operating and exiting.	SO1a	Percent of community programmes that communicate the impacts of the operations on communities'
S02	Percentage and total number of business units analysed for risks related to corruption.	SO2a	Percentage of business units analysed for risks related to corruption'.
S03	Percentage of employees trained in the organization's anti-corruption policies and procedures.	S03	Percentage of employees trained in the organization's anti-corruption policies and procedures.

Table 3.6: Shortlisted and/or modified performance indicators on Product Responsibility

Original GRI 3.1 Indicator		Indicator for Use as an SPI for the Petrochemical Industry in Malaysia	
Code	**Description**	**Code**	**Description**
PR1	Life cycle stages in which health and safety impacts of products and services are assessed for improvement, and percentage of significant products and services categories subject to such procedures.	PR1a	Number of environmental, health & safety elements included in the product life cycle assessment.

Table 3.7: Shortlisted and/or modified performance indicators on Human Rights

Original GRI 3.1 Indicator		Indicator for Use as an SPI for the Petrochemical Industry in Malaysia	
Code	**Description**	**Code**	**Description**
HR4	Total number of incidents of discrimination and actions taken.	HR4	Total number of incidents of discrimination and actions taken.

Using these criteria and sub-criteria, the AHP model for SPI prioritisation was developed as shown in **Figure 3.5.** This model was then input into the Expert Choice® Software to compute the prioritisation. An image of the decision 'treeview pane' of the AHP model is presented in **Figure 3.6.**

Goal	Prioritization of SPIs					
Criteria	Economic	Environment	Society	Labour Practices and Decent Work	Human Rights	Product Responsibility
Sub-criteria	EC6a	EN1	SO1a	LA2a	HR4	PR1a
	EC7a	EN3	SO2a	LA7a		
		EN5	SO3			
		EN8a				
		EN16				
		EN21a				
		EN22a				
		EN23a				
		EN28a				

Figure 3.5: AHP model for the SPI prioritisation

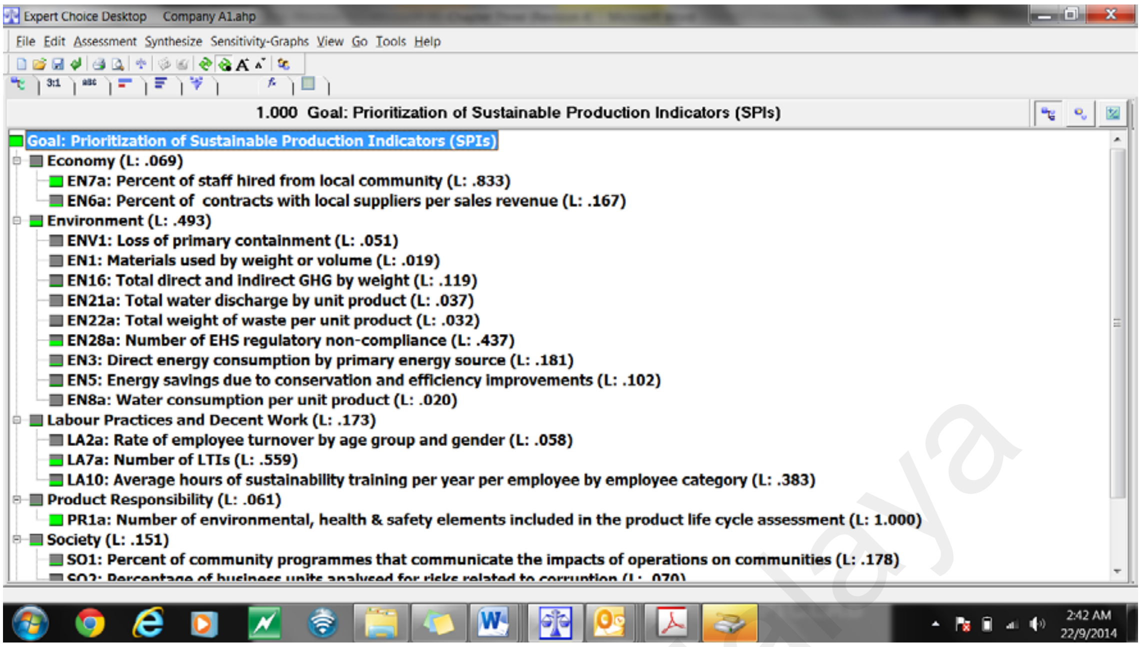


Figure 3.6: Example of the Expert Choice Treeview Panel of the AHP Model (Company A1)

3.3.3. Pairwise Comparison

After structuring the AHP hierarchy, the second step involved the estimation of the relative priorities of the criteria and sub-criteria with respect to the goal. A pairwise comparison is a direct one-on-one comparison between two different criteria (and sub-criteria) that share a common parent (Saaty and Hu, 1998). According to Saaty (1982), studies have confirmed that the human brain is highly capable of discriminating intensities, initially into three basic levels: low, medium and high; and that subsequent discrimination within each of these ranks can also be well sorted into low, medium and high values. Thus, a scale of 3 times 3 which yields the 9-value basis is derived leading to Saaty's 9-point scale which consists of numerical judgments ranging from equal to extreme (1, 3, 5, 7, 9) to express difference in priority (importance) 1 for equally important, 3 for moderately more important, 5 for strongly more important, 7 for very strongly more important and 9 for extremely more important. Intermediate values (2, 4, 6, 8) were used if it was too difficult to choose between two successive classes (Saaty, 1980).

In soliciting the judgement on the pairwise comparison of the criteria and the sub-criteria, typically, a group discussion with all respondents involved is undertaken to compare the prioritised indicators against the alternatives. These group decisions would be carried out in moderated workshops where with the assistance and guidance of a moderator or facilitator, the pool of respondents discuss and debate collectively and, provide input on the preferred alternative. However, in the event all the respondents are unable to join a common discussion forum due to time or inaccessibility (due to distance), research has shown that the geometric mean of the individual scores can be used to calculate the combined scores. This means that the pairwise comparisons are carried out with individual respondents and the judgement from all 13 respondents is obtained by calculating the geometric mean of the individual scores.

In this research, the 13 respondents are located at major petrochemical industry across five states in Malaysia. Requesting them to take time away from their daily responsibilities as the EHS senior managers at their respective petrochemical facilities to travel to a workshop venue at a common location was a significant challenge. The difficulties included time constraints including travel and participation in the workshops would take a minimum of 2-3 days and selecting a common date that would be feasible for all 13 research respondents. In such instances, Saaty (1982) who developed the AHP has provided an alternative method whereby the interviews are carried out individually, and the recorded individual scores are combined to calculate the geometric mean of the group scores.

As an example, the calculation of the geometric mean was carried out as follows. If the values of 2, 3 and 7 were recorded from one pair-wise comparison by three different respondents, the mean would be $\sqrt[3]{2 \, x \, 3 \, x \, 7} = 3.48$ which would be a 3 on the pairwise comparison scale. The geometric mean is used because it is not affected significantly by extremely small or large numbers. In some instances where the experience and opinion of one of the respondents is highly regarded, a hierarchy can be developed among the members of the group, where their input scores will also be assigned with a weight and this will reflected in the final input value. This "member hierarchy" can take into account various ranking factors that could be related to company rank, influence, expertise, experience, etc. For the present study, the researcher concluded that a member hierarchy was not required since all the 13 respondents held the same position at their respective facilities, i.e. they were all senior EHS Manager, and their rank, responsibilities and influence at their place of work was determined to be same based on the background information on their roles as obtained during the interview sessions. Further, the role of all the 13 facilities at the Malaysian Petrochemical Association was the same, i.e. neither of them played a more significant role with respect to making decisions on sustainability management.

The use of the geometric mean to calculate the combined individual pair-wise comparisons has been established in research involving AHP prioritization and ranking (Nagesha, 2005).

The 13 research respondents were asked to complete a series of pairwise comparisons for the selected criteria as well as the sub-criteria with respect to the goal. AHP has three judgment modes (verbal, numerical or graphical) by which a decision maker can provide judgments about the relative importance of objectives or criteria. For example, in the context of prioritizing SPIs, for the Level 2 criteria, what is the relative importance of the environmental indicators criteria against the society indicators criteria?

The respondents were guided individually to provide their judgment by expressing the relative strength or intensity of impact of the criteria in the hierarchy in numerical terms using a Likert scale indicating the importance of one criterion over another with respect to a higher-level criterion. The description of the Likert scale used is presented in **Table 3.8.**

Table 3.8: Saaty's Fundamental Scale (scale for relative importance for pairwise comparison using AHP)

Intensity of relative importance	Definition	Description
1	Equal importance	Two activities contribute equally to the objective
3	Moderate importance of one over another	Experience and judgement slightly favour one activity over another
5	Essential or strong importance	Experience and judgement strongly favour one activity over another
7	Demonstrated importance	An activity is favoured very strongly over another and its dominance is demonstrated in practice
9	Extreme importance	The evidence favouring one activity over another is of the highest possible order of affirmation.
2,4,6,8	Intermediate values between the two adjacent judgements	When compromise is needed between the 1 and 3, 3 and 5, 5 and 7, and 7 and 9.
Reciprocals of above non-zero numbers	If any activity has one of the above numbers compared with a second activity, then the second activity has the reciprocal value when compared to the first	A reasonable assumption
Rationales	Ratios arising from the scale	If consistency were to be forced by obtaining n numerical values to span the matrix.

Adapted from Saaty (2006)

Prior to the commencement of the pairwise comparisons, the respondents were again refreshed with the background of the study and the goals of the research which is to prioritize the SPIs to enable the development of a suitable tool for the assessment of sustainable production processes at the petrochemical plant level. The intensity scale (Table 3.8) was also explained to them to ensure correct understanding. Some simple examples of comparisons between two items and the assigning of weightage were provided. These steps were essential to ensure consistency in making the comparisons and weighing them. The research methodology for Phase 2 is summarized in **Figure 3.7**. The weights from the pair-wise comparisons were then input into the Expert Choice® (Version 11.5 Windows) software which is an advanced decision support computer software tool, purchased from Expert Choice Inc. in the US. The Expert Choice® software (Licence Number: G0000-11500-003B0-1000F-0AA01-96156) is a MCDM support software tool based on the AHP methodology to model a decision problem and to evaluate the relative desirability of alternatives.

Step 1: Description of the Goal	•The background and goal of the research was explained clearly to the respondents and they were encouraged to ask questions for better understanding of the AHP process.
Step 2: Development of the Hierarchy Framework	•A clear and detailed explanation was provided on the hierarchy framework with the aid of the Expert Choice® software which was developed using the shortlisted indicators from Part 1 of the research.
Step 3:Undertake Pair-Wise Comparisons using Saaty's 9-point scale	•The respondents were then asked to compare the importance of the criteria presented in Level 2, pair by pair, using Saaty's 9-point scale. The results were input into Expert Choice®. Similarly, the respondents were asked to repeat the pairwise exercise with the Level 3 sub-criteria.
Step 4:Calculate Inconsistency Ratio	•The researcher input the pair-wise comparison data into Expert Choice® and the inconsistency ratio was calculated When the ratio in any of the comparisions of criteria (Level 2) or sub-criteria (Level 3) exceeded 0.1, the software highlighted the source of the inconsistency. Without influencing the respondent's decision, the respondent was asked to relook, revise or reconsider the weighting of the affected pair(s) again (repeat Step 3). If the inconsistency ratio was less than 0.1, the researcher proceeded to Step 5.
Step 5: Review of the Weighting Process	•The weighting input was re-entered into Expert Choice ® to recalcualte the consistency ratio again. In some instances when the inconsistency ratio was calculated to be above 0.1, Steps 3 and 4 were repeated. When the inconsistency ratio dropped below 0.1, the judgement was taken to be correct, and the researcher proceeeded to tbe next step (Step 6).
Step 6: Verification of Results	•The analysed results namely the weighting and the rainking of each of the criteria and sub-criteria were reported back to the respondents for confirmation. This also gives them an opportunity to raise any concerns in the event the ranking or prioritisation is perceived to be inaccurate and not relfective of the indicator system for the petrochemical industry in Malaysia.
Verification of Results	

Figure 3.7: Summary of the Phase 2 research methodology

Synthesis of Priorities

Once a pairwise comparison was carried out and the weigths generated, the AHP derives the weights or priorities for the relevant elements by solving for the principal eigenvector of the matrix. The relations between the weights w_i and judgement a_{ij} are simply given by the following equation (Saaty, 1980).

$w_i / w_j = a_{ij}$ (Equation 1)

Associated with a square matrix are its eigenvector and corresponding eigenvalues. The eigenvector provides the priority ordering, and the eigenvalue is a measure of the consistency of the judgment. The principal eigenvector becomes the vector of priorities when normalised (Saaty, 1990):

$Aw = \lambda max\ w$ (Equation 2)

By convention, the comparison of strength (priorities) is always of an activity appearing in the column on the left against an activity appearing in the row on the top. The normalised principal right eigenvector of the matrix represents the priority values of those criteria. Assume that n activities are being considered.

Let P1, P2, ..., Pn be the set of activities. The quantified judgement on pairs of activities Ci and Cj are respresented by an n-by-n matrix, A = aij (i,j = 1,2,.....,n). The pairwise comparison of four activities:

	P1	P2	P3	P4
P1	1	a_{12}	a_{13}	a_{14}
P2	$\frac{1}{a12}$	1	a_{23}	a_{24}
P3	$\frac{1}{a13}$	$\frac{1}{a14}$	1	a_{34}
P4	$\frac{1}{a14}$	$\frac{1}{a24}$	$\frac{1}{a34}$	1

The pairwise comparison judgement matrices obtained from Phase 2 of the study were translated into the largest eigenvector problem. Expert Choice® was employed to solve the eigenvector.

3.3.4. Consistency Ratios

The judgements of the pair-wise comparisons are sometimes inconsistent. In addressing this inconsistency, Saaty (2006) proposed a consistency ratio to gauge the degree of inconsistency in at the pairwise comparison. A consistency ratio of 0.10 or less is considered acceptable. If the value exceeds 0.10, the judgement will need to be revised. To assess the consistency ratio, the AHP method provides a measure known as the consistency ratio (CR). Examining the CR is crucial to prove the consistency of the pairwise comparisons or judgements used the AHP analysis. Inconsistency is possible typically when a respondent makes casual errors inadvertently or exaggerated judgements during the process of pair-wise comparison (Kranjc & Glavic, 2005; Kim & Kumar, 2009). Searcy (2004) explains consistency in judgement of pair-wise comparisons as follows. Assuming that one respondent prioritises or judges indicator A (or criteria A) to be six times more important than Indicator B (or criteria B). If the respondent also indicates that Indicator B is two times more important than Indicator C (criteria C), then Indicator A should be considered as eight times more important that Indicator C. Otherwise, the judgement is deemed as being inconsistent. Using this logic, a consistency ratio (CR) is calculated by dividing a consistency index (CI) with an appropriate random index (RI). The testing of the consistency enables the detection of inconsistencies in the evaluations and rankings of the preferences estimated by the respondents. A CR value of 0.10 or less is acceptable (Saaty, 1982) and any value greater than 0.10 indicates unacceptable inconsistency and the judgements will need to be repeated until the value is 0.10 or below.

3.3.5. Normalisation

Normalising is typically used in situations where the criteria are widely disparate and combining them becomes difficult. It is an effective method to ensure that the criteria assessed are on equal footing and dimensionless.

3.4. Phase 3: Determination of a Suitable Assessment Framework

3.4.1. Alternatives Considered

The first stage of the AHP was the construction of a hierarchical network to present the problem, with the top (Level 1) as the overall goal or objective of the decision-making, the middle (Level 2) representing the criteria and the sub-criteria, and the final level (Level 3) at the bottom of the hierarchy representing alternatives. For this research, the overall objective was to evaluate which sustainability production framework would be most appropriate for use by the petrochemical industry in Malaysia. Therefore, the overall goal of 'selection of a sustainable production framework' was placed at the top of the analytic hierarchy. The next level of the hierarchy was the nineteen SPIs identified in this research . And, at the last level, three possible alternatives were placed at the bottom.

In this section, the two proposed sustainable production framework were compared with respect to the criteria (SPIs). Based on available literature, two main alternatives were considered as the framework for the assessment of sustainable production in the petrochemical industry in Malaysia:

- Lowell Centre for Sustainable Production
- IChemE

In determining the most appropriate assessment framework, the methodology employed for Phase 2 of the research was used. The 13 research respondents were requested to select the most appropriate framework based on the SPIs identified.

Through the prioritisation process, one is able to determine the relative contribution of each alternative to the goal of the organisation (Saaty et al., 2007), i.e. whether the alternative contains the SPIs which best reflect the sustainability of petrochemical operations in the Malaysian context.

The sustainable production indicators identified from the research findings and their classification into the five-tier concept of the LCSP were then presented back to 1 out of the 13 respondents involved in the study. The objective of this exercise was to obtain feedback from the respondents on the relevance of the identified and prioritised sustainable production indicators and the applicability of these indicators within the proposed framework on the assessment of sustainable production with the industry.

The feedback was solicited via an unstructured interview setting. A list of questions was used as a guide for the interview where the respondents were able to provide their comments. The one company that was selected for this pilot testing of the framework was Company F. This company was selected because it is a Malaysian company with petrochemical production facilities located within the country as well as globally making the company conversant with local requirements as well as progressive in terms of sustainable development due to its presence in other geographic regions and secondly, this company operates the most number of petrochemical plants (a total of 6) in Malaysia. The company's 6 production facilities are located spread out in 3 states in Peninsula (West) Malaysia and 1 state in East Malaysia. The EHS Managers at each of the facility (who were also the respondents for this research) are responsible for the environmental, health and safety matters as well as sustainability related initiatives at their respective facilities but collectively they report to the EHS Group Leader at Company F's corporate office in Kuala Lumpur. In obtaining feedback on the use of the framework from Company F, instead of reverting to the 6 EHS respondents, the researcher presented the identified SPIs, the priorities as well as the framework to the EHS Group Leader. Being the lead or the decision-making person for Company F on the sustainability related matters, and having an overall understanding of the environmental, social and economic issues for each of the 6 production facility and the direction of the company towards implementing sustainable production measures, the group leader was identified as the best person to provide feedback. With respect to experience, he has worked in the oil and gas industry for more than 25 years and has been in the current position for the last 5 years. Therefore, he is conversant with industry's expectations and long-term aspirations with respect to sustainable operations. The challenges and the areas where the implementation of sustainability initiatives are needed to improve the industry's targets are well-known to him.

CHAPTER 4: RESULTS AND DISCUSSION

4.1 Phase 1: Selection of Sustainable Production Indicators (SPIs) for the Petrochemical Industry in Malaysia

4.1.1 Part 1: Selection of a Suitable Pool of Research Respondents

A summary of the main points extracted from the interviews with the 6 stakeholder groups (to ascertain which group would be the most relevant to form the pool of respondents) is presented in **Table 4.1**.

Table 4.1: Summary of the key points from the interviews with the stakeholder groups

No	Stakeholder Group	Key points of the Interview
1	Government/Regulators (Department of Environment	• Good grasp of the concept of sustainability • Some idea on the GRI 3.1. sustainability reporting system • Sound knowledge on environmental regulatory requirements • Aware and conversant on the concept of environmental indicators and their use in assessing environmental sustainability • Knowledge on the other two pillars of sustainability, i.e. economics and social and the impact of their influence on sustainability issues was limited due to inexperience in dealing with these indicators. • Some knowledge on issues concerning occupational safety and health and the current regulatory requirements but not sufficient to participate in the research.
2	Non-Government Organisation	• Good knowledge on the concept of sustainable development on a broader perspective, i.e. national level and global level issues impacting large communities • Knowledge on how the concept of sustainable development could be translated or operationalized to a petrochemical production facility was limited • Thoughts on the petrochemical industry were generally not positive as the industry was perceived to be a very polluting industry (aligned with the oil and gas industry) and therefore very stringent measures required to eliminate the impacts. The economic contribution of the industry was not appreciated. • Has never visited a petrochemical facility with limited knowledge on the processes involved. Overall, l does not have a good appreciation of the environmental, health and safety issues except a general perception that the sector is highly polluting. • Did not have any knowledge on the GRI 3.1 indicator reporting system.
3	Professional Body – Malaysian Petrochemical Association	• Moderate level of knowledge regarding sustainability indicators and the GRI 3.1 reporting framework • Conversant with the collaborative efforts of member companies within the association members • Good knowledge on finance-related matters, government incentives, sourcing for green supply chain, human resources and identifying sites for expansion projects. • Limited knowledge on the operational aspects of the industry • Only general understanding on the impacts of the operations on the social element of sustainability
4	Academic Researchers	• Aware of the GRI 3.1 reporting framework but knowledge on the reporting aspect was limited • Good theoretical knowledge on the technical aspects of the petrochemical industry • Aware of the environmental, health and safety impacts arising from the operation of these plants. • Knowledge on the economics and social aspects of sustainability was observed to be at a cursory level.

Table 4.1: Continued.

No	Stakeholder Group	Key points of the Interview
5	Environmental, Health and Safety (EHS) Consultant	• Good knowledge of the GRI 3.1 reporting framework and the use of the indicators to assess sustainability • Conversant with the regulatory requirements of the Department of Environment, the Department of Occupational Safety and Health and management systems, namely, the ISO14001 Environmental Management System and the OHSAS18001. • In-depth knowledge of the impacts arising from petrochemical operations in terms of environmental and occupational health. • Lack of experience on the issues related to the day-to-day management of the operations within the petrochemical plant. • Knowledge on how the social and economic aspects affect the production operations is limited.
6	Petrochemical Industry Expert	• Good knowledge on the GRI 3.1 indicators and their use in sustainability reporting • Clear understanding of the day-to-day operations of a petrochemical plant. • Thorough knowledge on the environmental, health and safety impacts of the petrochemical production activities • Conversant with the regulatory requirements that pertain to the operations of the petrochemical plant to ensure compliance. • Understand the social aspects that affect sustainability of the facility operations.

Based on the outcome of these interviews, it is concluded that to achieve the objectives of this study, only the industry experts were most appropriate as their knowledge of the petrochemical industry, its various operations, the challenges in achieving sustainable operations and the potential types of SPIs for use in this research was the most comprehensive. The representatives of the remaining stakeholder groups although play an over-arching role governing selected elements of the EHS management practices are not fully knowledgeable on all the aspects required to participate in this study which requires comprehensive background knowledge and hands-on day to day experience on the operational aspects of the petrochemical industry, and an understanding of the environmental, health & safety and social impacts that potentially can arise from this industry sector. The other observation was that each of these groups was skewed towards their area of expertise, and did not necessarily understand the remaining elements of sustainability with regards to production activities within the petrochemical industry.

For example, the interview with an official from the Department of Environment (DOE), indicated that whilst the officer interviewed was a senior person who was very conversant with the environmental indicators and environmental regulatory requirements, the officer's knowledge on the health & safety, as well as, the social and economic indicators were not adequate to contribute to this research. With the representative from one of the NGOs interviewed, the researcher observed that the representative's perspective on sustainability was driven by current local and global trends in environmental and social impacts and the interviewed representative was not familiar with the aspects such as health and safety of workers within a petrochemical plant. The NGO representative also appeared to be biased towards the petrochemical industry, i.e. that the industry is a very polluting industry and therefore very stringent measures should be taken to eliminate the impacts. This does not totally reflect the philosophy of the concept of sustainability which also takes into account the economic contribution. The petrochemical industry contributes significantly to the economic performance of Malaysia and therefore supports the development of the country which also includes advancement in public/community facilities such as the provision of safe and clean drinking water supply, education facilities, etc. Therefore, as the representative from the NGO did not have any industry-specific experience, and observed to have a lack of depth on the operational details as well as an understanding of all the GRI 3.1 indicators, the representative was not considered.

The individual representing the Malaysian Petrochemical Industry was knowledgeable about the collaborative efforts of the sector, finance and taxation, government incentives implemented to promote this sector as well as industry-specific issues including sourcing for green supply chain, human resources and identifying sites for expansion projects. However, with respect to operational aspects of the industry, the knowledge, experience and exposure from this stakeholder were observed to be limited. The respresentative of the academic/research community was conversant with the technical aspects of the petrochemical industry, the processes involved and the environmental, health and safety impacts arising from the operation of these plants. However, with respect to the economics and social elements, his knowledge was at a cursory level simply because of their lack of involvement in studies or activities relating to these two components of sustainability. The EHS consultant who participated in this research was conversant with the regulatory requirements of the Department of Environment, the Department of Occupational Safety and Health and management systems, namely, the ISO14001 Environmental Management System and the OHSAS18001 for occupational safety and health. Having completed numerous environmental impact assessments, environmental audits, environmental monitoring as well as the management systems audit, the representative had a good understanding of the impacts arising from an environmental and occupational health aspect. The only experience lacking which was critical to be part of the research was the experience in incorporating the social and economic considerations in the day-to-day operations of the petrochemical plant. As sustainability is built on the three pillars of economics, environment and social, a good understanding of how all three influence one another in the context of an industrial operation is critical in identifying the most critical SPIs as well as ranking them.

With the petrochemical industry expert, there was clear understanding of the day-to-day operations of a petrochemical plant. This was because most of the indicators assessed are operational indicators, and in order to provide judgement on the suitability of these indicators, detailed knowledge on the benefits and challenges involved in the actual implementation and monitoring of these indicators is required. The industry expert was also conversant with regulations enforced by the relevant technical agencies as they have to ensure that the plant operations comply with regulatory requirements. They also take part in the corporate social responsibility initiatives and understand the needs of the community well and how the impacts from their operations impact the community. The researcher then concluded that the most relevant and appropriate group to participate in this study was the industry experts who themselves are involved in the day-to-day operationalisation of sustainability initiatives at their respective facilities. They were best placed to identify and prioritise SPIs which would be relevant for the sustainability of petrochemical industries in Malaysia.

The selection of the EHS Managers as a single stakeholder group for purposes of this research concurs and is aligned with the methodology used by past researchers. For a study on the development of sustainability indicators for an electric utility, Searcy et al., 2006 also utilised only one group of stakeholders, i.e. the internal stakeholders (those employed in the energy sector) for the case study as they were the most conversant with aspects of sustainability as compared to the external stakeholders or those outside the electric utility industry.

In this research the stakeholder group comprising the research respondents were made-up of a single stakeholder group, i.e. the EHS Managers of the participating petrochemical industries. Once the critical stakeholder group was identified for purposes of this study, the next step was to identify the target companies/organisations from where the expert pool of respondents was selected.

4.1.2 Part 2: Selection of Target Companies and Survey Respondents

Of the 17 companies which were approached to participate in the study, 13 companies (76.5%) agreed to participate. These facilities belong to six multi-national companies. For confidentiality reasons, the companies are identified as A, B, C, D, E, and F. Company A operates two facilities (A1 and A2), Companies B, C, D and E operate one facility each and Company F operates 6 facilities.

A summary on the description of these 13 operating facilities and, their reporting practices as well as the direction and commitment towards sustainability are presented in Table 4.2. The information presented in the table was also supplemented with information from desktop research of these companies.

Table 4.2: Summary of the sustainability reporting and progress of the participating companies

Company	Equity Ownership	Product	No. of Employees	Environmental Impacts	Status of Reporting and Progress Towards Sustainability*
Company A (Two operating subsidiaries, A1 and A2)	Malaysia – US-British Joint Venture	Petrochemical Derivatives	500 (A1 & A2)	Air emissions Wastewater discharges Hazardous wastes Non-hazardous wastes Noise	Company A as the parent company undertakes annual sustainability reporting since 1992. The company then started adopting the GRI reporting requirements in 2005 for selected indicators only. Occupational safety and risk minimization top the sustainability agenda. The company implements life cycle assessment for its operations; has in place energy reduction initiatives and ensures that operations are not located within environmentally sensitive areas. In their 2010 sustainability report, the company has reported on their air emissions (GHG), water conservation and waste generation.
Company B	Malaysia-US Joint venture	Petrochemical Derivatives	150	Air emissions Wastewater discharges Hazardous wastes Non-hazardous wastes Noise	Company B undertakes annual reporting and fully adheres to the six codes of the Responsible Care® Management System. The company commenced reporting per the GRI requirements for selected indicators only in 2011. The company has clearly identified its sustainability goals in relation to economic growth, environmental and societal aspects. Under economic growth, Company B works together with their suppliers and customers to meet their sustainability goals as part of the company's life cycle management. On the environment category, goals and targets have been set for energy efficiency, GHG reduction, hazardous waste reduction, reducing reportable environmental releases, Toxic Release Inventory (TRI), Volatile Organic Compounds (VOC), reduction in energy consumption and; NO_2 and SO_2 reduction. Under societal aspects, the company has implemented incident tracking system for injuries, illness, days away from work and safety accidents; implements procedures for enhanced recruiting, training and communication system; maintains Community Advisory Panels (CAPs), community engagement programmes and supports efforts such as colunteerism, philanthropy and in-kind donations.

Table 4.2: Continued.

Company	Equity Ownership	Product	No of Employees	Environmental Impacts	Status of Reporting and Progress Towards Sustainability*
Company C	Malaysia-Germany Joint Venture	Petrochemical Derivatives	500	Air emissions Wastewater discharges Hazardous wastes Non-hazardous wastes	Company C undertakes annual reporting and commenced GRI reporting for selected indicators only in 2011. The company has implemented sustainability responsibility throughout the company and has developed strategic guidelines to this end. The company has incorporated the GRI sustainability indicators as much as possible and based on this 2010 sustainability report, they have management systems or procedures in place for employee training & education, employee feedback, equal employment, monitoring loss time injuries (LTI), safety during transportation, air emissions, waste generation, climate protection (GHG and carbon footprint), energy (direct & indirect), water conservation, wastewater generation and product stewardship.
Company D	Japanese	Engineering plastics	180	Air emissions Wastewater discharges Hazardous wastes Non-hazardous wastes Noise	Company D undertakes annual reporting and commenced GRI reporting in 2012 for selected indicators only. Overall, the company is committed towards reducing its environmental impacts and business risks, improve product stewardship and minimize occupational injuries. The company has set annual targets for the reduction of energy, GHG (CO_2) emissions and waste generated; and implements LCA and Environmental Accounting. On occupational safety and health, the average frequency of accidents and loss time injury is monitored.
Company E	Malaysian	PVC Resins	120	Air emissions Wastewater discharges Hazardous wastes Non-hazardous wastes Noise	Company E does not undertake annual reporting, and does not carry out GRI reporting. Compliance to regulatory requirements is given priority. Although no specific targets have been set, the company is committed to reduce air emissions, hazardous waste and wastewater discharges.

Table 4.2: Continued.

Company	Equity Ownership	Product	No of Employees	Environmental Impacts	Status of Reporting and Progress Towards Sustainability*
Company F (Comprising 6 operating facilities, F1, F2, F3, F4, F5, F6 and F7)	Malaysian	Petroleum & Petrochemical Derivatives	41,000	Air emissions Wastewater discharges Hazardous wastes Non-hazardous wastes Noise	Company F undertakes annual reporting. Company F has been voluntarily reporting on their corporate sustainability performance since 2007 as part of their commitment to conduct business in a safe, responsible and ethical manner. The company understands sustainability as running its business in a socially responsible and holistic manner which would ensure growth and success for both the present and future generations. To track their performance, 7 indicators were identified in 2011: (i) Total Energy Savings (ii) Lost Time Injury (v) Fatal Accident Rate (vi) Loss of Primary Containment (iii) Greenhouse Gas Emissions (iv) Dividend Payment to the Malaysian Government and (vii) Percentage of Women Employees. All seven indicators are captured under the GRI 3. Whilst these seven indicators are used to benchmark the company's progress towards sustainability, other initiatives include increasing energy efficiency, reducing carbon footprint, management of environmental complaints, fresh water conservation and biodiversity conservation.

*: Progress towards sustainability was evaluated based on the respective 2010 Annual Report for each of the six companies named in this table.

Once the 13 participating companies were identified, suitable representatives from each of the 13 companies were selected. These representatives essentially comprised senior industrial experts from the Environmental, Health and Safety (EHS) Department of the 13 companies. A summary of their age bracket, gender, educational level and years of experience is presented in **Table 4.3**.

Table 4.3: Demography of the research respondents

Operating Facility	Age (years)	Gender	Educational Level	Years of Experience in the Petrochemical Industry
A1	40-45	M	Bachelor’s Degree in Engineering	10-15
A2	35-40	F	Bachelor’s Degree in Science	5-10
B	40-45	M	Bachelor’s Degree in Science	10-15
C	40-45	M	Bachelor’s Degree in Engineering	10-15
D	40-45	M	Bachelor’s Degree in Science	10-15
E	35-40	M	Bachelor’s Degree in Science	10-15
F1	40-45	M	Bachelor’s Degree in Engineering	10-15
F2	40-45	M	Bachelor’s Degree in Engineering	10-15
F3	35-40	M	Bachelor’s Degree in Engineering	10-15
F4	40-45	M	Bachelor’s Degree in Engineering	10-15
F5	40-45	M	Bachelor’s Degree in Engineering	10-15
F6	40-45	M	Bachelor’s Degree in Engineering	10-15
F7	40-45	M	Bachelor’s Degree in Engineering	10-15

It is noted that the research respondent identified had significant years of experience, i.e. with 92.3% of the respondents having between 10 and 15 years of experience. This coupled with the fact that 77% of the survey respondents were within 40-45 years of age bracket with the remaining 23% in the 35-40 years group indicate a pool of respondents with a high level of maturity and understanding on the operational details of petrochemical plants. All 13 respondents have university degrees either in the field of engineering or science giving them a sound technical background and the ability to understand and effectively contribute to this research. It is noted that out of the 13 respondents, 12 of them were men with only one woman. Due to the demanding nature of the EHS practitioners in industrial operations, especially in the petrochemical or oil & gas sectors, where long hours at the plant and undertaking physically strenuous activities are part of the job requirements, it is not uncommon to find the pool on EHS industry experts dominated by men. To note that for purposes of this research, gender is not a criterion and therefore there is no gender bias.

4.1.3 Part 3: Identifying the Sustainable Production Indicators (SPIs)

4.1.3.1 Screening of the GRI 3.1 Indicators Monitored

All 13 of the research respondents (100%) agreed that based on the indicator systems they have been exposed to, the Global Reporting Initiative 3.1 (GRI 3.1) which is essentially a reporting framework was a good option as a source of meaningful indicators which can be used for the selection of sustainable production indicators (SPIs). However, of the 13 companies, only 1 company (Company E) does not embrace the GRI reporting requirements at the time of the research and the company was not involved in any form of sustainability reporting. The remaining 5 companies (A, B, C, D and F) have identified selected GRI indicators most relevant to their operations and have been reporting the performance/progress of these indicators.

The comments received from the 13 respondents on the suitability of these indicators are summarised as follows:

1. The indicators cover the three pillars of sustainability, namely, environment, economic and society;
2. The framework is widely accepted as a credible tool for industries to measure and benchmark their performance with respect to sustainability;

3. All the 13 facilities (100%) were implementing the GRI 3.1 reporting requirements at some level/extent and based on their own experience they agreed that the GRI 3.1 indicators were a suitable starting pool for the selection of SPIs.
4. Most of indicators presented in the GRI 3.1 can be measured and tracked without incurring too much effort or cost as the indicators are practical and easily comprehensible. Indicators as suitable in the local context (Malaysia) can be selected.
5. Numerous indicators have been listed for each of the six categories enabling the industry to select indicators which are most relevant to them.

The use of the GRI 3.1. was also identified by Bastida-Ruiz et al. (2013) as being a flexible reporting framework that allowed the industrial sector to select indicators which best define sustainability in their local context.

Not all indicators are appropriate for all organisations as the GRI 3.1 framework allows individual organizations to select indicators that are most relevant and applicable to their operations. The framework has several levels of compliance; however, certain core indicators are compulsory for inclusion in order for the report to have minimum compliance with the GRI 3.1 guidelines. An organization with a nascent sustainability reporting programme starts by reporting the basic core indicators and subsequently move on to the additional indicators over time to achieve higher levels of GRI 3.1 compliance. Similarly, with respect to selecting and tracking indicators, the petrochemical industry can start by selecting indicators from the basic core and then move on to the additional indicators as they progress towards sustainability.

The findings of the screening phase where the research respondents were asked to indicate which of the core and additional indicators within the six GRI 3.1 categories were presently monitored by the 13 participating companies are presented below.

GRI 3.1: Category: Economy

There are nine indicators under the category of Economy of the GRI 3.1 which are further divided into three aspects, i.e. Economic Performance (EC1, EC2, EC3, EC4), Market Presence (EC5, EC6, EC7) and Indirect Economic Impacts (EC8, EC9) (GRI, 2011). **Table 4.4** summarises the feedback obtained from the research respondents regarding the use of these indicators at their facilities.

Table 4.4: GRI 3.1 Category: Economy Indicators Monitored by the Participating Industries

GRI 3.1 Category: Economy	Core/ Additional	Monitored for Sustainability Assessment (%)
Aspect: Economic Performance		
EC1. Direct economic value generated and distributed including revenues, operating costs, employee compensation, donations and other community investments, retained earnings, and payments to capital providers and governments.	Core	0
EC2. Financial implications and other risks and opportunities for the organisation's activities due to climate change.	Core	0
EC3. Coverage of the organisation's derived benefit plan obligations.	Core	0
EC4. Significant financial assistance received from the government	Core	0
Aspect; Market Presence		
EC5. Range of ratios of standard entry level wage to local minimum wage at significant locations of operations.	Additional	0
EC6. Policy, practices and proportion of spending on locally-based suppliers at significant locations of operations.	Core	100
EC7. Procedures for local hiring and proportion of senior management hired from the local community at locations of significant.	Core	100
Aspect: Indirect Economic Impacts		
EC8. Development and impact of infrastructure investments and services provided primarily for public benefit through commercial, in-kind or pro-bono assignment.	Core	0
EC9. Understanding and describing significant indirect economic impacts, including extent of impacts.	Additional	0

Based on the feedback, under the first aspect of Economic Performance, none of the four indicators were monitored by the 13 respondents. Similarly, the two indicators under Indirect Economic Impacts were also not monitored. The only two indicators monitored within this category were the indicators under the aspect of Market Presence, i.e. EC6 and EC7. This represents 22% of the total number of indicators under the Economic category was monitored. EC6 and EC7 which pertain to having policies and procedures in place for the use of local suppliers and for the employment of locals from the nearby communities were monitored as these indicators constitute part of their corporate social responsibility to show their commitment to the local community in which they are operating in.

<u>GRI 3.1 Category: Environment</u>

Under the category of Environment of the GRI 3.1, the thirty indicators are further divided into nine aspects, namely, Materials (EN1, EN2), Energy (EN3, EN4, EN5, EN6, EN7), Water (EN8, EN9, EN10, EN11, EN12, EN13, EN14, EN15), Emissions, Effluent & Waste (EN16, EN17, EN18, EN19, EN20, EN21, EN22, EN23, EN24), Biodiversity (EN25), Products and Services (EN26, EN27), Compliance (EN28), Transport (EN29) and Environmental Accounting (EN30) (GRI, 2011).

Table 4.5 presents the percentage of indicators under Environment presently monitored by the participating companies.

Table 4.5: GRI 3.1 Category: Environment Indicators Monitored by the Participating Industries

Indicator	Core/Additional	Monitored for Sustainability Assessment (%)
GRI 3.1 Category: Environment		
Aspect: Materials		
EN1. Materials used by weight or volume	Core	100
EN2. Percentage of input materials used which are reprocessed materials.	Core	61.5
Aspect: Energy		
EN3. Direct energy consumption by primary energy source.	Core	100
EN4. Indirect energy consumption by primary energy source.	Core	53.9
EN5. Energy saved due to conservation and efficient improvements.	Additional	84.6
EN6. Energy reduction due to renewable energy-based sources.	Additional	84.6
EN7. Reductions achieved due to indirect energy consumption	Additional	0

Table 4.5: Continued.

Aspect: Water		
EN8. Total water withdrawal by source	Core	100
EN8a. Water consumption per unit product **(new)**	New	100
EN9. Water sources significantly affected by the withdrawal.	Additional	100
EN10. Percentage and total volume of water recovered and reused.	Additional	15.4
EN11. Location and size of land owned, leased, managed in, or adjacent to, protected areas and areas of high biodiversity value outside protected areas.	Core	15.4
EN12.Description of significant impacts of activities, products and services, on biodiversity in protected areas, and areas of high biodiversity value, outside protected areas.	Core	100 (at differing levels)
EN13. Habitats protected or restored.	Additional	23
EN14. Strategies, future actions and current plans for managing impacts on biodiversity.	Additional	0
EN15. Number of IUCN Red List species and national conservation list species with habitats in areas affected by operations, by level of extinction risk.	Additional	0
Aspect: Emissions, Effluent and Waste		
EN16. Total direct and indirect greenhouse gas emissions by weight.	Core	100
EN17. Other indirect green-house gas emissions by weight	Core	100
EN18. Reductions in GHG achieved as a result of initiatives to reduction these sources.	Additional	61.5
EN19. Emissions of ozone-depleting substances by weight.	Core	30.1
EN20. NO, SO, and other significant air emissions by type and weight.	Core	100
EN21. Total water discharge by quality and destination.	Core	100
EN22. Total weight of waste by type (scheduled and not scheduled) and disposal method.	Core	100
EN23. Total number and volume of significant spills.	Core	92.3
EN24. Weight of transported, imported, exported, or treated waste deemed hazardous under the terms of the Basel Convention Annex I, II, III, and VIII, and percentage of transported waste shipped internationally.	Additional	100

Table 4.5: Continued.

Aspect: Biodiversity		
EN25. Identity, size, protected status, and biodiversity value of water bodies and related habitats significantly affected by the reporting organization's discharges of water and runoff.	Additional	100
Aspect: Products and Services		
EN26. Initiatives to mitigate environmental impacts of products and services, and extent of impact mitigation.	Core	0
EN27. Percentage of packaging materials that are reclaimed by category.	Core	0
Aspect: Compliance		
EN28. Monetary value of significant fines and total number of non-monetary sanctions for noncompliance with environmental laws and regulations.	Core	100
Aspect: Transport		
EN29. Significant environmental impacts of transporting products and other goods and materials used for the organization's operations, and transporting members of the workforce.	Additional	100
Aspect: Environmental Accounting		
EN30. Percentage of environmental protection expenditure per annum (against the annual revenue).	Additional	100

EN1 was monitored by all 13 participating facilities with EN2 being monitored by 61.5% of the petrochemical facilities . Under the aspect of Energy, EN3 was monitored by all the facilities (100%) with EN4 monitored by 53.9%. EN5 and EN6 were monitored by 84.6% of the facilities. None of the facilities monitored EN7. For the aspect of Water, EN8, EN9 and EN12 were monitored by 100% of the respondents. EN10 and EN11 were monitored by 15.4% of the participating facilities. Only 23% of the facilities monitored EN13 with EN14 and EN15 not monitored by any of the facilities. Under Emissions, Effluent and Waste, six (EN16, EN17, EN20, EN21, EN22 and EN24) of the nine indicators were monitored by 100% whilst the remaining three indicators, EN18, EN19 and EN23 were monitored by 61.5%, 30.1% and 92.3% respectively. For Biodiversity, 100% of the respondents monitored EN25 whilst both the indicators under the aspect of Products and Services were not monitored by any of the participating companies. The remaining three indicators within this category, i.e. EN28, EN29 and EN30 under the aspects of Compliance, Transport and Environmental Accounting were monitored by 100% of the respondents. For the category Environment, except for three indicators (EN7, EN14 and EN15), the rest of the 27 indicators were monitored by the 13 participating industries. This represents 90% of the total indicators listed under the category of Environment. In a study carried out in Thailand on the status of GRI reporting involving 41 manufacturing facilities from the petrochemical and energy sectors, the findings indicate that only 50% of the indicators are monitored. Unlike in the current research carried out in Malaysia, it is observed that the reporting of indicators under the category of Environment in Thailand is significantly lower. The reasons cited in the study include a general lack of awareness, as well as, lack of experience in GRI 3.1 reporting within the manufacturing facilities that were part of the study (Chindavijak et al., 2015).

For the aspect of Materials, both the indicators were monitored as materials affect the cost of production. The reduction of raw materials within the production process is critical for the survival of industries in a resource constrained world. In addition to lessening environmental impacts, there are also economic benefits which include a reduction of cost as well as the dependence on external suppliers (Saravia-Cortez et al., 2013). For Energy, all of the participating companies (100%) monitored the two core indicators (EN3 and EN4) with 84.6% of the respondents monitoring the two additional indicators (EN5 and EN6). The monitoring of direct energy sources, implementation of conservation and efficiency programmes and exploring renewable energy alternatives are part of the thrust areas on sustainability assessment for the petrochemical industry (Al-Sharrah et al., 2010). Further, direct energy consumption is related to greenhouse emissions which is a key pollutant arising from the petrochemical industry. The monitoring of indirect energy sources was carried out by 53.9%. For Water, four indicators under this aspect were assessed. Whilst water consumption and source are monitored, the monitoring of volume of water recovered and reused was very small (15.4%). The primary reason for this is the relatively low price for industrial water supply in Malaysia and therefore a lack of incentive for water conservation.

Emissions to the environment in the form of greenhouse gases (EN16 and EN17) and reduction in GHG achieved as a result of initiatives to reduce at source (EN18) were satisfactorily monitored at 100%, 100% and 61.5% respectively.

With respect to the use of ozone-depleting substances (ODS), it was observed that the use of ODS was not well documented with only 30.1% of the respondents monitoring this indicator. The respondents that do not monitor ODS (69.9%) indicated that in compliance with prevailing regulations, they have phased-out the use of ODS-based refrigerants whilst those who were documenting ODS consumption were progressively replacing equipment with those that use non-ODS substances as per regulatory requirements. Malaysia is a signatory to the Montreal Protocol, and has promulgated the Environmental Quality (Refrigerant Management) Regulations (1999) that require the phase out of use of HCFCs (an ODS) by 2030. From 2030 onwards, the purchase, storage and use of ODS will be prohibited, and equipment which previously used ODS will need to be replaced or retrofitted. The progress made by the petrochemical industry is aligned with global trends on the reduction and/or discontinuation on the use of ODS. The latest Millenium Development Goals Report (UN, 2015) states that ODS have been mostly eliminated since 1990 and scientists predict that the earth's ozone layer is expected to recover by the middle of this century.

Emissions of NO_2, SO_2, other polluting emissions (EN20), wastewater discharges (EN21) and waste (solid waste and scheduled waste) (EN22) were very well monitored at 100% each. Various aspects of Biodiversity were monitored by all the participating companies (100%). One of the reasons for monitoring aspects of Biodiversity is impression management and reduce the legitimacy gap whereby organisations continually seek to ensure that they are operating within the bounds of norms of their respective society and their activities are seen to be legitimate where their activities do not harm the society that they operate within (Deegan and Unerman, 2006).

Nik and Hossain (2015) surveyed annual reports of 200 Malaysian companies listed on the Malaysian stock exchange to determine the extent of disclosure with respect to environmental indicators related to climate change and global warming. Energy savings and efficiency were monitored and reported by 65.8% of the companies, whilst air pollution issues were monitored by 55.7%. Biodiversity aspects were monitored by only 15% with 13% of the companies monitoring their performance with respect to climate change and global warming. Similar to the current research, energy and air pollution are satisfactorily monitored at greater than 65% for each category. The study concluded that because there is a lack of regulatory drivers, Malaysian companies tend to monitor and report environmental indicators without clear and specific objectives.

As a basis of comparison, the research findings were compared against a similar study carried out by AlNaimi et al. (2012). The study which reviewed the corporate social responsibility reporting themes as well as the depth of reporting in Qatar noted that out of the 25 public listed companies examined, none of these companies provided any form of reporting under the category of Environment and Energy. The specific indicators under these categories included reduction of chemical emissions to the air or water, compliance with regulatory requirements and implementation of environmentally-friendly techniques, energy sources and consumption. Of the 25 companies, 6 % represented the industry sector. Of the remaining companies, 6% represented the insurance sector with 44% representing the service sector and banking/financial sectors. These companies showed satisfactory reporting on human resources and management, product development and community involvement. The study concludes that the very weak reporting on environment and energy maybe due to the lack of incentive towards green reporting. In this regard, the petrochemical industry in Malaysia has shown good progress by performing better Qatar because enforcement of regulations in environment and energy is more stringent in Malaysia.

GRI 3.1 Category: Labour Practices and Decent Work

Under the category of Labour Practices and Decent Work, there are six aspects, i.e. Employment (LA1, LA2 and LA3), Labour/Management Relations (LA4 and LA5), Occupational Safety and Health (LA6, LA7, LA8 and LA9) Training & Education (LA10, LA11 abd LA12), Diversity and Equal Opportunity (LA13), and Equal Remuneration for Men and Women (LA14). The indicators monitored under this category for sustainability assessment by the participating companies are presented in **Table 4.6**.

Table 4.6: GRI 3.1 Category: Labour Practices and Decent Work Indicators Monitored by the Participating Industries

GRI 3.1 Category: Labour Practices & Decent Work	Core / Additional	Monitored for Sustainability Assessment (%)
Aspect: Employment		
LA1. Total workforce by employment type, employment contract, and region.	Core	100
LA2. Total number and rate of employee turnover by age group, gender, and region.	Core	100
LA3. Benefits provided to full-time employees that are no provided to temporary or part-time employees, by major operation.	Additional	0
Aspect: Labour/Management Relations		
LA4. Percentage of employees covered by collective bargaining agreements.	Core	0

Table 4.6: Continued.

GRI 3.1 Category: Labour Practices & Decent Work	Core / Additional	Monitored for Sustainability Assessment (%)
LA5: Minimum notice period(s) regarding operational chances including whether it is specified in collective agreements.	Core	0
Aspect: Occupational Safety and Health		
LA6. Percentage of total workforce represented in formal joint management-worker health, and safety committees that help monitor and advise on occupational health and safety programmes.	Additional	100
LA7. Rates of injury, occupational diseases, lost days, and absenteeism, and number of work-related fatalities by region.	Core	100
LA8. Number of education, training, counseling, prevention, and risk-control programs in place to assist workforce members, their families, or community members regarding serious diseases.	Core	100
LA9. Health and safety topics covered in formal agreements with trade unions.	Additional	0
Aspect: Training and Education		
LA10. Average hours of training per year per employee by employee category.	Core	100
LA11.Programmes for skills management and lifelong learning that support the continued employability of employees and assist them in managing career endings.	Additional	100
LA12.Percentage of employees receiving regular performance and career development reviews.	Additional	100
Aspect: Diversity and Equal Opportunity		
LA13: Composition of governance bodies and breakdown of employees per employee category according to gender, age group, minority group membership, and other indicators of diversity.	Core	0
Aspect: Equal Remuneration for Women and Men		
LA14. Ratio of basic salary of men to women by employee category.	Core	100

Under Employment, both the core indicators (LA1 and LA2) were monitored by 100% of the participating companies whilst the third additional indicator (LA3) was not monitored by any of the companies. The two core indicators under Labour/Management

Relations were also not monitored. For the aspect of Occupational Safety and Health, 75% of the indicators were monitored (LA6, LA7 and LA8) with two being core indicators. All four of the indicators under Training and Education were monitored by 100% of the respondents.

As with most businesses, employment related data provide is critical in benchmarking their performance. Similarly, as part of the social component of sustainability, the two criteria under the Employment category are commonly used. Based on the feedback from the participating facilities, indicators excluded under the Labour Practice and Decent Work aspect were LA4 and LA5 as they pertain to collective bargaining agreement requirements and trade unions as in Malaysia there is no trade union that is selective towards the petrochemical industry. On the aspect of Occupational Safety and Health, three of the four indicators were monitored. These included two core indicators and one additional indicator which relate to participation of the workforce in safety committees, rates of injuries and related parameters and training. The remaining indicator (LA9) relates to trade unions and therefore was not monitored by the participating industries. Under Training and Education, all four (100%) of the indicators comprising two core and two additional indicators were monitored. This trend observed in the types of indicators monitored is typical of the petrochemical industry in general. The industry gives prominence to employee-related indicators as the industry is closely linked to the oil and gas sector (Wolf, 2005).

GRI 3.1 Category: Society

Under the category of Society, the eight indicators are grouped under four aspects, namely, Community (SO1), Corruption (SO2, SO3, SO4), Public Policy (SO5, SO6, SO7) and Compliance (SO8). A summary of the indicators monitored is presented in **Table 4.7.**

Table 4.7 GRI 3.1 Category: Social (Society) Indicators Monitored by the Participating Industries

GRI 3.1 Category: Society	Core/ Additional	Monitored for Sustainability Assessment (%)
Aspect: Community		
SO1.Number of community programmes carried out to communicate the impacts of operations on communities, including entering, operating, and exiting (Number of community-company partnership).	Core	100
Aspect: Corruption		
SO2. Percentage of business units analysed for risks related to corruption.	Core	25
SO3. Percentage of employees trained in anti-corruption policies and procedures.	Core	100
SO4. Number of actions taken in response to incidents of corruption	Core	100
Aspect: Public Policy		
SO5. Public policy positions and participation in public policy development lobbying	Core	0
SO6. Total value of financial and in-kind contributions to political parties, politicians, and related institutions by country.	Additional	0
SO7. Total number of legal actions for anti-competitive behaviour, anti-trust and monopoly practise and their outcomes.	Additional	0
Aspect: Compliance		
SO8. Monetary value of significant fines and total number of non-monetary sanctions for non-compliance with laws and regulations.	Core	100

For the aspect of Community, only one core indicator has been listed and this was monitored by 100% of the participating industries. The three core indicators (SO2, SO3 and SO4) defined under the aspect of Corruption were monitored by 25%, 100% and 100% of the participating industries. None of the industries monitored any of the three core indicators (SO5, SO6 and SO7) listed under the aspect of Public Policy. For the aspect of Compliance, the single core indicator was monitored by 100% of the participating industries.

The indicators under the aspects of Community, Corruption and Compliance are monitored by the participating industries. Petrochemical industries in Malaysia are classified as heavy industries and hazardous installations. Therefore, as part of legal requirements they are required to engage with the local community especially to communicate the impacts arising from the operation of the petrochemical industries. Therefore, 100% of the participating industries monitor this indicator. The three core indicators listed under Corruption are monitored by the industries. As the petrochemical sector is a downstream industry of the oil and gas sector, the stringent policies on corruption are transferred to the sector as well. Therefore, business units are analysed for risks related to corruption, employees are trained in anti-corruption policies and procedures are in place to investigate incidents of corruption (Lu & Castka, 2009). None of the indicators under Public Policy were monitored as 100% of the respondents indicated that they don’t have such policies in place. The core indicator under the aspect of Compliance is monitored by 100%.

GRI 3.1 Category: Product Responsibility

The indicators under Product Responsibility are further divided into five sub-categories or aspects, i.e. Customer Health and Safety (PR1 & PR2), Product and Service Labelling (PR3, PR4 & PR5), Marketing Communication (PR6 & PR7), Customer Privacy (PR8) and Compliance (PR9). **Table 4.8** lists the indicators as monitored by the participating companies.

Table 4.8: Indicators under GRI 3.1 Category: Social (Product Responsibility) Monitored by the Participating Industries

Performance Indicators	Core/ Additional	Monitored for Sustainability Assessment
Aspect: Customer Health and Safety		
PR1. Life cycle stages in which health and safety impacts of products and services are assessed for improvement, and percentage of significant products and services categories subject to such procedures.	Core	100 (at varying levels, some more extensive than others)
PR2. Total number of incidents of non-compliance with regulations and voluntary codes concerning health and safety impacts of products and services during their life cycle, by type of outcomes.	Additional	0
Aspect: Product and Service Labelling		
PR3. Type of product and service information required by procedures, and percentage of significant products and services subject to such information requirements.	Core	0
PR4. Total number of incidents of non-compliance with regulations and voluntary codes concerning product and service information and labelling by type of customers.	Additional	0
PR5. Practices related to customer satisfaction including results of surveys measuring customer satisfaction.	Additional	0
Aspect: Marketing Communications		
PR6. Programmes for adherence to laws, standards, and voluntary codes related to marketing communications including advertising, promotion nd sponsorship.	Core	0
PR7. Total number of incidents of non-compliance with regulations and voluntary codes concerning marketing communications including advertising, promotion, and sponsorship by type of customers.	Additional	0
Aspect: Customer Privacy		
PR8. Total number of substantiated complaints regarding breaches of customer privacy and losses of customer data.	Additional	0
Aspect: Compliance		
PR9. Monetary value of significant fines for non-compliance with laws and regulations concerning the provision and use of products and services.	Core	0

Based on the feedback obtained from the respondents, only one indicator, i.e. the only core indicator under the aspect of Customer Health and Safety is monitored by the participating companies (100%). The indicator involves the assessment of health and safety impacts at different cycles of the product.

GRI 3.1 Category: Human Rights

Under the category of Human Rights, there are seven aspects, Investment and Procurement Practices (HR1, HR2 & HR3), Non-Discrimination (HR4), Freedom of Association and Collective Bargaining (HR5), Child Labour (HR6), Forced and Compulsory Labour (HR7), Security Practices (HR8) and Indigenous Rights (HR9). The feedback on these indicators is presented in **Table 4.9.**

Table 4.9: Indicators under GRI 3.1: Category Social (Human Rights) Monitored by the Participating Industries

Performance Indicators	Core/ Additional	Monitored for Sustainability Assessment
Aspect: Investment and Procurement Practices		
HR1. Percentage and total number of significant investment agreements that include human rights clauses or that have undergone human rights screening.	Core	0
HR2. Percentage of significant suppliers and contractors that have undergone screening on human rights and actions taken.	Core	0
HR3. Total hours of employee training on policies and procedures concerning aspects of human rights that are relevant to operations, including the percentage of employees trained	Additional	0
Aspect: Non-Discrimination		
HR4. Total number of incidents of discrimination and actions taken.	Core	75
Aspect: Freedom of Association and Collective Bargaining		
HR5. Operations identified in which the right to exercise freedom of association and collective bargaining may be at significant risk, and actions taken to support these rights.	Core	0

Table 4.9: Continued.

Performance Indicators	Core/ Additional	Monitored for Sustainability Assessment
Aspect: Child Labour		
HR6. Operations identified as having significant risk for incidents of child labour, and measures to contribute to the abolition of child labour.	Core	0
Aspect: Forced and Compulsory Labour		
HR7. Operations identified as having significant risk for incidents of forced or compulsory labour, and measures to contribute to the elimination of forced or compulsory labour.	Core	0
Aspect: Security Practices		
HR8. Percentage of security personnel trained in the organization's policies and procedures concerning aspects of human rights that are relevant to the operations.	Additional	0
Aspect: Indigenous Rights		
HR9. Total number of incidents of violations involving rights of indigenous people and actions taken.	Additional	0

Of these only the core indicator under Non-Discrimination, i.e. HR4 which is an indicator that tracks the total number of incidents of discrimination and the actions taken is monitored by 75% of the participating companies.

Based on the feedback from the 13 companies in this indicator screening phase, the researcher conducted the in-depth interviews with the 13 research respondents. This is discussed in the proceeding section (Section 4.2.3.2).

4.1.3.2 Part 4: Identifying and Shortlisting the Sustainable Production Indicators (SPIs)

This section presents the findings of the in-depth interview carried out with the 13 research respondents which was carried out upon completion of the screening survey. The previous screening survey helped identify the types of indicators that the participating companies were monitoring and this was useful to understand at which level these companies were at with respect to sustainability. Further, the screening phase also reinforced the suitability of using the GRI 3.1. as the starting pool from where the indicators were selected for use as SPIs in this study. Without the screening phase, the in-depth interviews would not have been useful.

In this part of the research, the respondents provided feedback on the suitability of each of the indicators listed under the six categories of the GRI 3.1 specifically for use as an SPI. For some of the indicators which were deemed appropriate for use as SPIs, they proposed modifications to make them more meaningful for use as well as representative of the situation within the petrochemical industry in Malaysia. The feedback obtained from the 13 respondents were collated, reviewed and summarised in six individual tables, each pertaining to the six categories of the GRI 3.1 respectively. These findings are discussed separately under each of the six headings.

4.2.3.2.1 Findings

GRI 3.1: Category Economy: Assessment of the Indicators for Use as SPIs

The feedback obtained from the 13 respondents on the suitability of each of the indicators under the three aspects of Economy is presented in **Table 4.10** below.

Table 4.10: Category Economy: Assessment of the Indicators for Use as SPIs

Type of Indicator		Indicators	Suitability as SPI for the Petrochemical Industry in Malaysia
		Aspect: Economic Performance	
Core	EC1	Direct economic value generated and distributed including revenues, operating costs, employee compensation, donations and other community investments, retained earnings, and payments to capitals providers and governments.	Unsuitable and presently not tracked by all 13 companies in the research. (1) Multiple criteria; and (2) most of the criteria will not remain consistent over the longer period. For example, the criteria "*donations and other community investment*". This cost will change depending on the economic performance of the company or the economic situation of the country. During economic downturns, companies will tend to reduce their commitment to community-related investments. This does not necessarily mean the company is operating less-sustainably. Similarly, for the criteria, *"capital providers and governments"*, the entities within this group will not be the same throughout the operational lifetime of the company.
Core	EC2	Financial implications and other risks and opportunities for the organization's activities due to climate change.	Unsuitable and presently not tracked by all 13 companies in the research. In Malaysia, presently, there are no specific legal provisions which regulate environmental impacts (air emissions) in terms of climate change. As this is not compliance driven but more of an industrial best practice which is dependent on the corporate requirements of each of the companies, this indicator is not suitable to represent the entire industry in Malaysia.
Core	EC3	Coverage of the organization's derived benefit plan obligations.	Unsuitable and presently not tracked by all 13 companies in the research. The quantum of coverage for the benefit plan varies significantly between companies due to reasons beyond sustainability making this indicator not a good representation of sustainable development.

Table 4.10: Continued.

Type of Indicator		Indicators	Suitability as SPI for the Petrochemical Industry in Malaysia
Core	EC4	Significant financial assistance received from the government	Unsuitable and presently not tracked by all 13 companies in the research. In Malaysia, petrochemical industries are categorised as heavy industries with significant investments which are classified as large enterprises. Financial assistance from the government is typically provided to industries that fall within the category of small to medium enterprises. As such, this indicator is not suitable for use as an SPI for this research.
		Aspect: Market Presence	
Additional	EC5	Range of ratios of standard entry level wage compared to local minimum wage at significant locations of operations.	Unsuitable and presently not tracked by all 13 companies in the research. In the petrochemical industry, there are generally a large number of employees, i.e. between 200 and 400 with numerous departments. Benchmarking this ratio for each department will require inter-department effort which is not always easy. Furthermore, in Malaysia, the petrochemical industry is located in designated industrial clusters which are located away from city centres. In attracting workforce to these areas, these companies pay higher than market driven wages. Hence, these higher wages are not based on sustainability factors and may be misleading if used as an SPI for this study.
Core	EC6	Policy, practices and proportion of spending on locally-based suppliers at significant locations of operation.	Suitable and currently tracked by all the 13 participating companies. These companies all have policies for giving local suppliers preference if they meet the requirements. To ensure the indicator is specific and to enable a more quantitative and effective monitoring, this indicator was modified to '*EC6a: Percent of contracts with local suppliers per unit sales revenue*'.

Table 4.10: Continued.

Type of Indicator		Indicators	Suitability as SPI for the Petrochemical Industry in Malaysia
Core	EC7	Procedures for local hiring and proportion of senior management hired from the local community at locations of significant.	Suitable and currently tracked by all the 13 participating companies. As all the participating companies are located in areas away from urbanised centres, as part of their CSR programme, the companies have policies and procedures in place for the preferential selection of candidates from the local community if he or she meets the desired academic qualification and work experience as indicated in the job specification. For use as an SPI, the indicator was modified as *'EC7a: Percent of staff hired from the local community'*
		Aspect: Indirect Economic Impacts	
Core	EC8	Development and impact of infrastructure investments and services provided primarily for public benefit through commercial, in-kind or pro bono assignment.	Unsuitable and presently not tracked by all 13 companies in the research. Determining the impact of infrastructure investments and services as described in this indicator is not easily achievable without significant resource, time and effort. The impacts can be in the form of economic and social impacts.
Additional	EC9	Understanding and describing significant indirect economic impacts, including the extent of impacts.	Unsuitable and presently not tracked by all 13 companies in the research. Similar to the EC8, in order to monitor this indicator effectively, significant resource, time and effort is required.

From the GRI 3.1 Economic Performance Indicators, of the 7 core indicators (EC1, EC2, EC3, EC4, EC6, EC7 and EC8) and two additional indicators (EC5 and EC9), only two of the core indicators (EC6 and EC7) were deemed suitable as SPIs. These indicators were selected only when 75% and more of the respondents agreed on its use for this study. However, to improve the usefulness of these two indicators as SPIs for the petrochemical industry in Malaysia, they were modified to reflect the prevailing practices at the participating companies. EC6 under GRI 3.1 looks at policies, practices and proportion of spending on locally-based suppliers at significant locations of operations. There are three parameters to be tracked, i.e. policies, practices and spending trends on local suppliers. Further, these activities are to be monitored at significant locations of operations. Except for some similarities in operations between the participating companies, there are considerable differences. If the location of the operations to be monitored are not specified, tracking this indicator would be complex as there are numerous variables. Therefore, EC6 was renumbered as EC6a and redefined as 'percent of contracts with local suppliers per unit sales revenue' which is specific and addresses the percent contracts issued to local suppliers against the sales revenue which is essentially describes the economic gains to the local suppliers arising from the contracts.

EC7 is an indicator which is used to measure the commitment of the company towards hiring staff from the local community including ensuring that staff from the local community are also represented at the management level. Based on actual challenges faced by the participating companies with respect to hiring staff at the managerial level, the respondents felt that it would suffice for the indicator to measure that total number of staff hired from the community. This is because hiring senior staff who could take on management roles was not easy as most of these participating companies are located in areas outside of main urban centres where the workforce for senior level position is limited. Therefore, the participating companies face difficulties in hiring management level staff from the local community. The indicator was then modified (EC7a) to represent the percentage of staff (all levels) hired from the local community without any breakdown in employment levels.

Table 4.11 presents the original description of the shortlisted indicators as well as the version of the modified indicators.

Table 4.11: Proposed SPIs for the Category Economy

GRI 3.1 Indicator	Modified GRI 3.1 Indicator Code and Description
EC6: Policy, practices and proportion of spending on locally-based supplier at significant locations of operations	EC 6a: Percent of contracts with local suppliers per unit sales revenue
EC7: Procedures for local hiring, and proportion of senior management hired from the local community at locations of significant operation	EC 7a: Percent of staff hired from the local community

GRI 3.1 Category: Environment

Table 4.12 presents the comments and findings on the suitability of the GRI 3.1 indicators presented under the category of Environment as obtained from the interview with 13 respondents.

Table 4.12: Suitability of the GRI 3.1 Indicators for the Environment Category

Type of Indicator		Indicators	Suitability as SPI for the Petrochemical Industry in Malaysia
		Aspect: Materials	
Core	EN1	Materials used by weight or volume	Suitable and monitored by the 13 participating companies. For a more representative use of this indicator, the respondents agreed to modify this indicator to "*EN1a: Total raw material consumption (tonnes) per unit product*".
Core	EN2	Percentage of materials used that are recycled input materials	Unsuitable as the input or feedstock materials/raw materials are products from the oil and gas industry. This indicator is applicable to industries with production processes that allow the input of recycled materials. In the petrochemical industry, the primary feedstock are petroleum fractions. Only a small percentage of the feedstock (less than 5%) is reprocessed materials. Within the production process some off-specification products will be produced as a result of process upsets (not achieving the right temperature or pressure) and these will be reprocessed again as feedstock to prevent wastage.

Table 4.12: Continued.

Type of Indicator		Indicators	Suitability as SPI for the Petrochemical Industry in Malaysia
		Aspect: Energy	
Core	EN3	Direct energy consumption by primary energy source.	Suitable and monitored by all 13 participating companies. This indicator was selected for use as an SPI in this research without any modification.
Core	EN4	Indirect energy consumption by primary source.	Unsuitable as not all 13 companies monitor this indicator. Based on the feedback from the respondents only 53.9% monitor this indicator whilst the remaining don't do so as it takes up too much time and effort to obtain the necessary data for a meaningful assessment of this indicator. As an SPI, the measurement of the indicator needs to be relatively straightforward without having to take up too much time, effort and data.
Additional	EN5	Energy saved due to conservation and efficiency improvements.	Suitable and monitored by 84.6% of the companies within the research pool. This indicator which was used without any modification was deemed suitable as progress made with respect to energy conservation and efficiency within the petrochemical production processes is a key element of sustainable development.
Additional	EN6	Initiatives to provide energy-efficient or renewable energy based products and services, and reductions in energy requirements as a result of these initiatives.	Unsuitable for use as due to the nature of the petrochemical products since the feedstock for the industry is derived from non-renewable sources, i.e. the petroleum industry.
Additional	EN7	Initiatives to reduce indirect energy consumption and reductions achieved.	Similar to the rationale provided for EN4, this indicator was also deemed unsuitable for use as an SPI for purposes of this research.

Table 4.12: Continued.

Type of Indicator		Indicators	Suitability as SPI for the Petrochemical Industry in Malaysia
		Aspect: Water	
Core	EN8	Total water withdrawal by source	Suitable but with modification to the following to enable more meaningful assessment of water consumption, i.e. in relation to the production capacity as larger operations will use more water in proportion to the larger production capacity and lesser water used for the smaller operations. *'EN8a: Water Consumption per unit product'*
Additional	EN9	Water sources significantly affected by withdrawal of water	Unsuitable as all 13 operating facilities do not abstract water from any natural water course. The water used in the production processes are obtained from the piped treated supply provided by the water supply authorities at their respective locations.
Additional	EN10	Percentage and total volume of water recycled and reused	Unsuitable with only 15.4% of the companies embarking on water recycling initiatives.
		Aspect: Biodiversity	
Core	EN11	Location and size of land owned, leased, managed in, or adjacent to, protected areas and areas of high biodiversity value outside protected areas.	Unsuitable and not monitored by any of the 13 participating companies. The indicator is not applicable to the petrochemical industry in Malaysia as they are located within designated medium-heavy industrial areas which are located from ecological sensitive areas.
Core	EN12	Description of significant impacts of activities, products and services on biodiversity in protected areas and areas of high biodiversity value outside protected areas.	Unsuitable and not monitored by any of the 13 participating companies for reasons as described for EN11.
Additional	EN13	Habitats protected or restored	Unsuitable and not monitored by any of the 13 participating companies for reasons as described for EN11.
Additional	EN14	Strategies, current actions, and future plans for managing impacts on biodiversity.	Unsuitable and not monitored by any of the 13 participating companies for reasons as described for EN11.

Table 4.12: Continued

Additional	EN15	Number of IUCN Red List species and national conservation list species with habitats in areas affected by operations, by level of extraction risk.	Unsuitable and not monitored by any of the 13 participating companies for reasons as described for EN11.
		Aspect: Emissions, effluents and waste	
Core	EN16	Total direct and indirect greenhouse gas emissions by weight.	Suitable and monitored by all participating companies. This indicator was used without any modification as an SPI for purposes of this research.
Core	EN17	Other relevant indirect greenhouse gas emissions by weight.	Unsuitable and not monitored by any of the 13 companies in the research pool. The key indirect greenhouse gas emissions have been factored into indicator EN16 and do not need to be duplicated as EN17 as for the petrochemical industry, there are no other relevant indirect greenhouse gas emissions.
Additional	EN18	Initiatives to reduce greenhouse gas emissions by weight.	Unsuitable although all 13 participating companies undertake initiatives to reduce greenhouse gas emissions by weight. The reason this indicator was not considered is due to the difficulty in quantifying this indicator.

Table 4.12: Continued.

Core	EN19	Emissions of ozone-depleting substances by weight.	Unsuitable as presently only 30.1% of the participating companies monitor this parameter. ODS is typically used in the form of refrigerant in air conditioning unit or chillers. The most common refrigerant used in R-22 which is a HCFC (an ODS). Malaysia is a signatory to the Montreal Protocol, and has promulgated the Environmental Quality (Refrigerant Management) Regulations (1999) that require the phase out of use of HCFCs by 2030. As the timeline for compliance is not immediate, the remaining 69.9% are not monitoring the indicator. This indicator was not selected for use as an SPI as compliance related issues are captured under EN 28 and not to be duplicated with this indicator.
Core	EN20	NO, SO, and other significant air emissions by type and weight	Unsuitable and not monitored by the 13 participating industries as these gases are not the primary sources of emissions. Petrochemical industries are more concerned about carbon dioxide, methane and nitrogen dioxide. Therefore this indicator was not selected for use as an SPI in this research.
Core	EN21	Total water discharge by quality and destination.	Suitable and monitored by all 13 participating companies. However, for a more meaningful use of this indicator as an SPI, the indicator was modified as follows: '*EN21a: Total treated wastewater discharge by unit product'*

Table 4.12: Continued.

Core	EN22	Total weight of waste by type and disposal method.	Suitable and monitored by all 13 participating companies. The indicator was modified as follows as all respondents agreed that the disposal method was not a good indicator for sustainability in Malaysia as there are very limited options for industries with respect to waste disposal. '*EN22a: Total weight of waste per unit product*' *Waste here is defined as both hazardous and non-hazardous wastes.*
Core	EN23	Total number and volume of significant spills	Suitable and monitored by 92.3% of the participating companies. The indicator was modified to limit the incidents to those which are significant enough to warrant reporting to the Department of Environment in Malaysia. '*EN23a: Number of incidents per year involving reportable loss of primary containment*'.
Additional	EN24	Weight of transported, imported, exported, or treated waste deemed hazardous under the terms of the Basel Convention Annex I, II, III and IV, and percentage of transported waste shipped internationally.	Unsuitable although 65% of the companies keep track of the data described within this indicator. This indicator was not selected as not all petrochemical plants import their waste via the Basel Convention.
Additional	EN25	Identify, size, protected status, and biodiversity value of water bodies and related habitats significantly affected by the reporting organisation's discharges of water and runoff.	Unsuitable and not monitored by all the participating companies for reasons described under EN11.

Table 4.12: Continued.

Core		**Aspect: Products and Services**	
Core	EN26	Initiatives to mitigate environmental impacts of products and services, and extent of impact mitigation.	Unsuitable as there are multiple attributes to this indicator making the tracking complex. Each of the attributes also has different units of measurement. Prior to obtaining approval for the construction of a petrochemical facility, an Environmental Impact Assessment is required for submission to the Department of Environment. The impacts are assessed and mitigation measures are recommended. These measures are then implemented by the operating facility with periodical compliance audits submitted to the Department of Environment. Beyond this the research respondents did not recommend as separate indicator to monitor this compliance. Further, compliance-related issues are covered under indicator EN28.
Core	EN27	Percentage of products and their packaging materials that are reclaimed by category.	Unsuitable with only 38.5% of the companies monitoring this indicator. It is noted that only the percentage of packaging materials (of raw materials) are monitored as the petrochemical products cannot be reclaimed. This indicator does not provide a meaningful assessment of sustainability for the petrochemical industry.
		Aspect: Compliance	
Core	EN28	Monetary value of significant fines and total number of non-monetary sanctions for non-compliance with environmental laws and regulations.	Suitable and tracked by all the participating companies. For use as an SPI for this research, the indicator was modified to *'EN28a: Number of EHS regulatory non-compliances'*

Figure 4.12: Continued.

		Aspect: Transport	
Additional	EN29	Significant environmental impacts of transporting products and other goods and materials used for the organisation's operations, and transporting members of the workforce	Unsuitable and only 25% of the participating companies monitor the impacts of transporting products and raw materials but not members of the workforce. The respondents agreed that since impacts arising from transportation of raw materials and products were addressed as part of the EIA process, and monitored via compliance audits, selecting this indicator would be a duplication of the EN28a indicator.
		Aspect: Overall	
Additional	EN30	Total environmental protection and expenditures and investments by type	Unsuitable with only 25% of the participating companies undertaking some form of environmental accounting,

There are in total 30 indicators listed under the category of Environment which is one of the six categories under GRI 3.1. Of the 30 indicators, 17 indicators are core indicators with the remaining 13 indicators as additional indicators. These 30 indicators are grouped under seven aspects namely, Material, Energy, Water, Biodiversity, Emissions, Effluents & Waste, Products & Services, Compliance and Transport.

Under Materials, the core indicator EN1 was deemed suitable and being monitored by the 13 participating companies. EN1 refers to materials used by weight or volume and in its current form, the respondents argued that each operating facility had its own production capacity and the volume of materials used or output was proportional to the operating capacity. Therefore, a larger plant will utilise a larger quantity of materials as compared to a smaller plant. Hence, the indicator was modified to become EN1a: Total raw material consumption (tonnes) per unit product. Further to note that the type of material was qualified as raw material to be more specific. The second indicator under the same aspect, EN2, was deemed unsuitable for the reasons summarised in the table.

The aspect of Energy has five indicators, i.e. two core indicators (EN3 and EN4) and three additional indicators (EN5, EN6 and EN7). Of these, EN3 (direct energy consumption by primary energy source) was deemed suitable as it was a representative indicator for the assessment of sustainability in the petrochemical industry. All respondents (100%) agreed that the indicator in its current form did not require any modification. EN4 however, was deemed as an unsuitable indicator as described in the table. Of the three additional indicators, only one indicator, i.e. EN5 was selected to use. This indicator refers to the energy saved due to conservation and efficiency improvements. All 13 respondents agreed that the indicator could be used in its original form and no modification was necessary.

Water is the third aspect under which there are three indicators comprising one core indicator (EN8) and two additional indicators (EN9 an EN10). The core indicator EN8 which relates to total water withdrawal by source was deemed suitable as an SPI subject to modification. The proposed modified version of the indicator was EN8a: Water consumption per unit product.

EN9 which is an additional indicator was deemed unsuitable by the respondents as water supply is obtained from the piped supply provided by municipality. And the source of the public supply is largely from dams but in some of the states where the participating industries are operating, the source also includes groundwater. The proportion of how much from dams (reservoirs) and from groundwater fluctuates depending on the supply available and the demand. These details are not available to the participating companies to enable the tracking of this indicator. Therefore, this indicator was decided as not suitable due to the lack of data. Indicator EN10 although a good reflection of sustainability, was not shortlisted as only 15.4% of the participating companies monitor this indicator. The cost of obtaining piped water supply provided by the municipality is relatively low as rainfall is abundant in Malaysia and water shortages are not common. There are also presently no regulatory drivers and as such none of the participating companies were tracking the volume of water recycled although 75% of the respondents indicated that water recycling is carried out at the industrial plant. Untreated process water undergoes treatment in a wastewater treatment plant and the some of the treated water is then recycled onsite for general cleaning and for landscaping purposes with the remaining treated wastewater discharged offsite into a river system or a municipal drain.

There are five indicators under the aspect of Biodiversity. Of these two are core indicators and three are additional indicators. Biodiversity is tracked from different angles. For example, three of the participating companies are located within the same industrial estate and their discharges flow into large stormwater drains which ultimately discharge into a common river system. Although each of these three companies monitor the water quality as well as the aquatic biota within the river as part of their regulatory requirements, water quality or biodiversity of the of the aquatic biota are not suitable as SPIs because in addition to these three companies, there are more than 40 other companies that operate within the same industrial estate and discharge into the same river system. Therefore, the water quality and biodiversity of the river are subjected to varirous other external factors and not representative of the impacts arising from one company alone. Further, petrochemical industries in Malaysia are located within dedicated industrial estates away from areas with high biodiversity. These industries do not own or lease land located within protected areas (EN11), the discharges and emissions from the industries do not result in adverse impacts on biodiversity (EN12), no habitats were directly impacted or restored (EN13), no specific initiatives on habitat restoration or protection programmes (EN14) apart from the general initiatives on environmental conservation undertaken as part of the companies' corporate social reporting programme and there are no species under the IUCN Red List species or any national conservation list affected by the operations of these operating plants (EN15). Based on these arguments, all five indicators were found to be unsuitable by 100% of the respondents.

Under the aspect of Emissions, effluents and waste, there are 16 core indicators and three additional indicators. EN 16 which is an indicator that tracks the total direct and indirect greenhouse gas emissions according to weight was selected for use as an SPI by 100% of the respondents. Greenhouse gas is an important parameter monitored by the petrochemical industry and therefore easily incorporated into the list of SPIs.

The primary source of GHG in the petrochemical industry is from flaring. Flaring of gases is a common activity undertaken by the petrochemical plants. Flares are critical safety devices which are used in petrochemical facilities to burn off excess hydrocarbon gases which cannot be recovered or recycled as an alternative to releasing the polluting volatile emissions to the atmosphere. During the flaring exercise, the gases are combined with steam and/or air, and burnt-off in the flare system producing water vapour and carbon dioxide. In operating sustainability, the petrochemical industry endeavors to undertake the flaring activity only when absolutely required, i.e. during start-up, shut-down and also during unplanned interruptions such as power disruptions and process upsets. The resulting emissions from the combustion of the gases which are greenhouse gases (GHG) contribute to global warming (Meinshausen, 2009).

Based on the data compiled by the World Bank's Global Gas Flaring Reduction (GGFR) Public Private Partnership, global gas flaring has been persistent at around 150 Billion Cubic Meters (BCM) during the period 1994-2009, representing about 30% of the European Union's yearly gas consumption and resulting in annual emissions of some 400 million tonnes of carbon dioxide equivalent (MtCO2e) into the atmosphere (World Bank, 2012). From a social perspective, gas flaring is a dissipation of non-renewable natural resources since the flared gas has an energy content (calorific value) that is wasted without use as soon as the gases are combusted at the flare (Peterson et al., 2007). Accordingly, flaring implies that the most cost-beneficial refinery operation is not achieved (Zadakbar et al., 2008).

The following indicator, EN17 was not selected as the petrochemical industry presently does not monitor any other form of indirect greenhouse emissions. EN18 was also not selected as the indicator was seen to comprise both qualitative and quantitative initiatives and attempting to accurately quantify the qualitative initiatives would be a complex effort. EN19 was not selected as only 30.1% of the participating companies monitored this parameter which is the quantification of emissions arising from ozone-depleting substances by weight. The indicator EN20 was not monitored by any of the participating companies as these gases are not the primary sources of emissions as described in Table 4.12. As the companies do not track the emissions of NOx, SOx and other significant pollutants by type and weight, indicator EN20 was also omitted. EN21, EN22 and EN23 were all monitored by the participating companies and hence were selected for use as SPIs. However, all three were modified for ease of use, i.e. to be specific in the sustainability parameter to be tracked. EN21 which originally referred to the 'total water discharge by quality and destination' was modified to EN21a, an indicator to track the 'total treated wastewater discharge by unit product'. Similarly, EN22 was modified to EN22a to specifically track the total weight of waste per unit product as compared to its original definition of 'total weight of waste by type and disposal method'. EN23 was also selected but modified to specifically track the 'number of incidents per year involving reportable loss of primary containment'. The two additional indicators, EN24 and EN25 were not selected. Although 65% of the participating companies monitor waste that is imported via the Basel Convention, this indicator was not selected as it is only relevant if and when waste is imported under the transboundary movement of hazardous waste. Since the movement of such waste is carried out on an intermittent basis and possibly only on limited frequency over the entire operating life of the industrial plants, the indicator was not selected. Further, only 65% of the participating industries monitored this indicator.

Under the aspect of Compliance, the only single indicator (core), EN28, was selected for use. The indicator was modified to specifically track the ‘number of EHS regulatory non-compliance’ as the original version of the indicator involved tracking the ‘monetary value of significant fines and total number of non-monetary sanctions for non-compliance with environmental laws and regulations’. The two indicators, each from the aspects of Transport and Overall, were not selected for use as SPIs in this research for reasons described in Table 4.12.

From the 30 indicators provided under the category of Environment, nine indicators were identified and selected for use as SPIs in this research. Of these eight are core indicators and one indicator selected from the additional indicators. To note that of these nine indicators, four indicators (EN1a, EN8a, EN21a & EN22a) were modified per unit of product as these indicators represented the raw materials required to produce one unit of the product as well as the emissions discharged (output) from the production of one unit of the product. This is in line with the concept of sustainable products (LCSP, 2011). The remaining five indicators are related to both the production process as well as the general operations of the petrochemical plant. These indicators are summarized in Table 4.13.

Table 4.13: Proposed SPIs for the Category Environment

GRI 3.1 Indicator	Modified GRI 3.1 Indicator Code and Description
EN1: Materials used by weight or volume	EN1a: Total raw material consumption (tonnes) per unit product
EN3: Direct energy consumption by primary energy source.	EN3: Direct energy consumption by primary energy source. (Used in original form without any modification)
EN5: Energy saved due to conservation and efficiency improvements.	EN5: Energy saved due to conservation and efficiency improvements. (Used in original form without any modification)
EN8: Total water withdrawal by source	EN8a: Water Consumption per unit product
EN16: Total direct and indirect greenhouse gas emissions by weight.	EN16: Total direct and indirect greenhouse gas emissions by weight. (Used in original form without any modification)
EN21: Total water discharge by quality and destination.	EN21a: Total treated wastewater discharge by unit product (Used in original form without any modification)
EN22: Total weight of waste by type and disposal method.	EN22a: Total weight of waste per unit product
EN23: Total number and volume of significant spills	EN23a: Number of incidents per year involving reportable loss of primary containment
EN28: Monetary value of significant fines and total number of non-monetary sanctions for non-compliance with environmental laws and regulations.	EN28a: Number of EHS regulatory non-compliances

GRI 3.1 Category: Labour Practices and Decent Work

There are nine core indicators under this category (LA1, LA2, LA4, LA5, LA7, LA8, LA10, LA13 and LA14) and five additional indicators (LA3, LA6, LA9, LA11 and LA12). These 14 indicators are grouped under four aspects. The feedback obtained from the indicators assessed is presented in Table 4.14.

Table 4.14: Suitability of the GRI 3.1 Indicators of the Labour Practices and Decent Work Category

Type of Indicator		Performance Indicators	Suitability as SPI for the Petrochemical Industry in Malaysia
		Aspect: Employment	
Core	LA1	Total workforce employed by employment type, employment contract, and region.	Unsuitable. The details described within this indicator are monitored by the Human Resources Department of all the 13 participating companies. However, this indicator was described as unsuitable for use as an SPI in this study. In Malaysia, with the petrochemical industry, the number of total workforce employed is heavily reliant upon market demands of the petrochemical products as well as the economic situation of the country. Therefore, any increase or reduction in LA1 may not necessarily be reflective of the sustainability progress. Further, due to the volatility of the industry, at least in the Malaysian setting, between 30-40% of the staff are employed based on short term contracts (of up to 5 years) which are renewable upon exipry based on the situation.
Core	LA2	Total number and rate of employee turnover by age group, gender, and region.	Suitable and currently monitored by all the 13 participating companies. For use in this study, the indicator was slightly modified as '*LA2a*: *Rate of employee turnover by age group and gender*'. The 'region' component was excluded as this study is only based on the Malaysian setting.

Type of Indicator		Performance Indicators	Suitability as SPI for the Petrochemical Industry in Malaysia
Additional	LA3	Benefits provided to full-time employees that are not provided to temporary or part-time employees, by major operations.	Unsuitable and currently not monitored by any of the 13 participating companies. The respondents interviewed indicated that this indicator is not suitable as the contractual benefits for both the full-time and temporary employees are dynamic, i.e. changing with the country's economic situation, market demands and trends in the employment sector.
		Aspect: Labour/Management Relations	
Core	LA4	Percentage of employees covered by collective bargaining agreements.	Unsuitable and currently not monitored by any of the 13 participating companies. Presently, the Malaysian law expressly recognizes the right to organise and to collectively bargain. The government has over the past four decades ratified a number of International Labour Organisation ("ILO") conventions. However, unions have historically failed to exert much influence on the Malaysian industrial landscape. This can be attributed to the strict regulation of Malaysian trade unions which arose as a result of trade unions being a "breeding ground" for subversive elements shortly following World War II. Membership of trade unions is limited to workers who are in similar trades, occupations or industries. All trade unions must register themselves with the Director-General of Trade Unions ("DGTU") and the scope of collective bargaining is considerably limited. Employees within the petrochemical industry are part of a trade union for this sector but because the activities of trade unions are limited, the use of this indicator was deemed as unsuitable for purposes of this study.

Type of Indicator		Performance Indicators	Suitability as SPI for the Petrochemical Industry in Malaysia
Core	LA5	Minimum notice period (s) regarding operational changes, including whether it is specified in collective agreements.	Unsuitable and currently not monitored by any of the 13 participating companies. The reason this indicator was not considered for this study is similar to the explanation provide above for LA4.
		Aspect: Occupational Health and Safety	
Additional	LA6	Percentage of total workforce represented in formal joint management – worker health and safety committees that help monitor and advise on occupational health and safety programmes.	Currently monitored but concluded as being unsuitable for purposes of this study. Worker health and safety committees have been established in all 13 companies, and records are maintained on the membership profile of these committees. Typically, these committee members comprise employees from the Environmental, Health and Safety Departments. However, as an SPI, the majority of the respondents agreed that it is not suitable because this indicator is linked to employee turnover which is influenced by external factors such as economic climate, general trend in the industry, contraction and expansion due to market demands.
Core	LA7	Rates of injury, occupational diseases, lost days, and absenteeism, and number of work related fatalities by region.	Suitable. All aspects of this indicator, i.e. rates of injury, occupational diseases, lost days, absenteeism and number of work related fatalities are monitored by all 13 participating companies. For purposes of this research, it was unanimously agreed that the scope or coverage of the indicator be limited to '*LA7a: Number of Lost Time Injuries (LTIs)*' as this indicator is presently used as a key indicator for sustainability at these companies. Further, the number of LTIs is also regulated under the Occupational Safety and Health Act, 1994. As compliance is a key SPI for the petrochemical industry, the use of LTIs as an SPI is reasonable.

Type of Indicator		Performance Indicators	Suitability as SPI for the Petrochemical Industry in Malaysia
Core	LA8	Education, training, counselling, prevention and risk-control programs in place to assist workforce members, their families, or community members regarding serious diseases.	Unsuitable for use as an SPI for this research but tracked in a non-quantifiable manner by most of the 13 companies in this study. This indicator has numerous attributes which need to be tracked and consolidated making it not appropriate for use as an SPI for this study. Further, elements of this indicator such as counselling is subjective and is difficult to be quantified.
Additional	LA9	Health and safety topics covered in formal agreements with trade unions.	Unsuitable and presently not tracked by the participating companies.
		Aspect: Training and Education	
Core	LA10	Average hours of training per year per employee by employee category.	Suitable and monitored by all the participating companies. This indicator was selected for use as an SPI in this research without any further modifications.
Additional	LA11	Programme for skills management and lifelong learning that support the continued employability of employees and assist them in managing career endings.	Unsuitable although the 13 companies do take into consideration the elements of this criteria and have programmes in place which are monitored for effectiveness. This indicator was not considered as the measurement is a mix of both qualitative and quantitative which is complex.
Additional	LA12	Percentage of employees receiving regular performance and career development reviews.	Unsuitable as in all the 13 participating companies, regular performance and career development reviews are mandatory as part of their human resource development policies and procedures. Therefore, this indicator is expected to be constant with little fluctuation.
Core	LA13	Composition of governance bodies and breakdown of employees per category according to gender, age, group, minority group membership, and other indicators of diversity.	Unsuitable and not monitored by any of the participating companies.

Type of Indicator		Performance Indicators	Suitability as SPI for the Petrochemical Industry in Malaysia
Core	LA14	Ratio of basic salary of men to women by employee category.	Unsuitable as an SPI for this research but is monitored by the 13 participating companies. Based on the feedback from the research respondents, there is no discrimination in salary structure between men and women in the workforce.

Under the aspect of Employment, only LA2 was selected for use as an SPI as the other two indicators within the aspect, namely, LA1 and LA3 were deemed unsuitable. LA1 involves tracking the total number of workforce by employment type, contract and region, and this indicator was not selected as the employment profile is very much dependent on market trends of supply and demand within the petrochemical industry. A similar argument was put forward for the dismissal of indicator LA3 from the pool of SPIs. LA2 was deemed suitable but in order to improve the focus of the indicator, a sligh modification was made to its definition, i.e. ‘LA2a: Rate of employee turnover by age, group and gender’. There are only two indicators under the aspect of Labour/ Management Relations, i.e. LA4 which tracks the percentage of employees covered by the collective bargaining agreements and LA5 which refers to the minimum notice period regarding operational changes. Both these were not selected for reasons described in **Table 4.14**. For the aspect of Occupational Health and Safety, there are two additional indicators (LA6 and LA9) and two core indicators (LA7 and LA8). Of these four indicators, only one was selected for use (LA7) which is a core indicator. LA7 involves the tracking of injury rate as well as occupational diseases, lost days, absenteeism and number of work related fatalities by region. For use as an SPI for this study, the indicator was modfieid to LA7a which is described as ‘number of lost time injuries (LTIs)’ as this is presently a legal requirement and all the participating companies monitor this indicator. The three other indicators, LA6, LA8 and LA9 were not selected for reasons described in the table. In the last aspect of Training and Education, out of the five indicators listed, only one indicator was selected for use as an SPI in this study. LA10 is involved in the tracking of the average hours of training per yer per employee by employee category. This indicator was deemed suitable as 100% of the participating companies track this as training is a critical component for the petrochemical sector. The remaining four indicators were not selected as the indicators were either not being monitored by the majority of the participating companies or because they were believed to be not meaningful for the assessment of sustainability as described in Table 4.14.

For this category, a total of three indicators were identified to be suitable to be used as an SPI in this research. All three are core indicators. Of these one indicator was maintained in its original form (LA10) whilst two indicators were modified (LA7a). The selected SPIs are presented in **Table 4.15**.

Table 4.15: Proposed SPIs for the Category Labour Practices and Decent Work

GRI 3.1 Indicator	Modified GRI 3.1 Indicator Code and Description
LA2: Total number and rate of employee turnover by age group, gender, and region.	LA2a: Rate of employee turnover by age group and gender
LA7: Rates of injury, occupational diseases, lost days, and absenteeism, and number of work related fatalities by region.	LA7a: Number of Lost Time Injuries (LTIs)
LA10: Average hours of training per year per employee by employee category.	LA10: Average hours of training per year per employee by employee category. (Used in original form without any further medication)

GRI 3.1 Category: Society

Under the category of Society, there are a total of six core indicators (SO1, SO2, SO3, SO4, SO5 and SO8) and two additional indicators (SO6 and SO7). The GRI 3.1

indicators under the category of Society were assessed on their suitability as SPIs and their feedback provided in **Table 4.16**.

Table 4.16: Suitability of the GRI 3.1 Indicators of the Society Category

Type of Indicator		Performance Indicators	Suitability as SPI for the Petrochemical Industry in Malaysia
		Aspect: Community	
Core	S01	Nature, scope, and effectiveness of any programs and practices that assess and manage the impacts of operations on communities including entering, operating and exiting.	Suitable and the aspects of this indicator are recorded and tracked for planning purposes. However, for use in this research, the indicator was modified for quantitatively tracking and trending this indicator as follows: ‘*SO1a: Percent of community programmes that communicate the impacts of the operations on communities*’
		Aspect: Corruption	
Core	S02	Percentage and total number of business units analysed for risks related to corruption.	Suitable however, only 25% of the research companies monitor and track this indicator. However, the majority of the respondents agreed that this is a suitable indicator since corruption is seen as a very serious matter and training is provided annually especially to employees at management level. For purpose of this research, the indicator was slightly modified to only address the percentage, i.e. ‘*SO2a: Percentage of business units analysed for risks related to corruption*’.
Core	S03	Percentage of employees trained in the organization’s anti-corruption policies and procedures.	Suitable and monitored by the 13 participating companies. This indicator was used without any adjustments as an SPI for this research.

Table 4.16: Continued

Type of Indicator		Performance Indicators	Suitability as SPI for the Petrochemical Industry in Malaysia
Core	S04	Actions taken in response to incidents of corruption.	Unsuitable as this indicator is very subjective and not easily quantifiable although records are maintained by the Human Resources Department on the disciplinary actions taken on employees that being investigated as well those who have been found to be guilty of corruption.
		Aspect: Public Policy	
Core	S05	Public policy positions and participation in public policy development and lobbying.	Unsuitable and presently not monitored by the participating companies.
Additional	S06	Total value of financial and in-kind contributions to political parties, politicians, and related institutions by country.	Unsuitable and not applicable. All the 13 companies involved in the study do not contribute (financial or in-kind) to political parties, politicians and related institutions.
		Aspect: Anti-Competitiveness Behaviour	
Additional	S07	Total number of legal actions for anti-competitive behaviour, anti-trust, and monopoly practices and their outcomes.	Unsuitable and not monitored by the participating industries. This is a complex indicator with multiple attributes and therefore not selected for use as an SPI for this research.
		Aspect: Compliance	
Core	S08	Monetary value of significant fines and total number of non-monetary sanctions for non-compliance with laws and regulations.	Not selected a similar indicator which addresses compliance has been selected under the category of Environment.

Indicator SO1 is used to track the community programmes undertaken by the companies and this was found to be a valuable indicator for the assessment of sustainability. Petrochemicals are hazardous installations and it is important that the surrounding community located at least within a 5-km radius of the plant site be well informed of the operations with respect to the environmental impacts as well as on health risks arising from the operation of the petrochemical plants. However, the indicator was modified to become SO1 which was defined as ‘percent of community programmes that communicate the impacts of the operations on communities’. Although the indicator SO2 was only monitored by 25% of the participating companies, it was deemed suitable as corrupation is a reflection of corporate governance. The petrochemical industry places a very high value on corporate governance and as such tracking activities relating to corruption isseen as being proactive and in line with best industry practices. For use in the study, the incidicator was modified to ‘SO2a: Percentage of business units analysed for risks related to corruption’. For similar reasons, indicator SO3 was selected for use. Under the aspect of Public Policy, there are two core indicators (SO5 and SO8) and two additional indicators (SO6 and SO7). Of these, none were selected for use as an SPI for this study because they were not being monitored at the participating facilities for the reasons explained in Table 4.16..

Overall, out of the total of eight indicators, three indicators were selected for use as SPIs as summarised in Table 4.17**.** Two indicators were modified and only indicator used in its original form.

Table 4.17: Proposed SPIs for the Category Society

GRI 3.1 Indicator	Modified GRI 3.1 Indicator Code and Description
SO1: Nature, scope, and effectiveness of any programs and practices that assess and manage the impacts of operations on communities including entering, operating and exiting.	SO1a: Percent of community programmes that communicate the impacts of the operations on communities
SO2: Percentage and total number of business units analysed for risks related to corruption.	SO2a: Percentage of business units analysed for risks related to corruption’
SO3: Percentage of employees trained in the organization’s anti-corruption policies and procedures.	SO3: Percentage of employees trained in the organization’s anti-corruption policies and procedures. (Used in original form without any modification)

GRI 3.1 Category: Product Responsibility

There are four core indicators (PR1, PR3, PR6 and PR9) and five additional indicators (PR2, PR4, PR5. PR7 and PR8) in the category of Product Responsibility. The findings on the assessment of these indicators with respect to sustainability assessment is presented in Table 4.18 below.

Table 4.18: Suitability of the GRI 3.1 Indicators of the Product Responsibility Category

Type of Indicator		Performance Indicators	Suitability as SPI for the Petrochemical Industry in Malaysia
		Aspect: Customer Health and Safety	
Core	PR1	Life cycle stages in which health and safety impacts of products and services are assessed for improvement, and percentage of significant products and services categories subject to such procedures.	Suitable and monitored by the 13 participating companies. However, the indicator was modified as follows for more effective use as an SPI for purposes of this research. *'PR1a: Number of environmental, health & safety elements included in the product life cycle assessment'.*
Additional	PR2	Total number of incidents of non-compliance with regulations and voluntary codes concerning health and safety impacts of products and services during their life cycle, by type of outcomes.	Not suitable as it is presently not monitored. The complexity of obtaining the necessary data throughout the life cycle of the petrochemical product requires significant resources, effort and time. Therefore, it was deemed unsuitable.
		Aspect: Product and Service Labelling	
Core	PR3	Type of product and service information required by procedures, and percentage of significant products and services subject to such information requirements.	Unsuitable and is not presently monitored. All respondents agreed that this indicator is subjective and can have various interpretations.

Table 4.18: Continued.

Type of Indicator		Performance Indicators	Suitability as SPI for the Petrochemical Industry in Malaysia
Additional	PR4	Total number of incidents of non-compliance with regulations and voluntary codes concerning product and service information and labelling by type of customers.	Unsuitable and currently not monitored. At present in Malaysia, there are no regulations with respect to product safety and labelling. Further, the petrochemical products which are produced are not the final products but form the raw material for other consumer products. Therefore, this indicator was deemed unsuitable for the petrochemical industry in Malaysia.
Additional	PR5	Practices related to customer satisfaction including results of surveys measuring customer satisfaction.	Unsuitable as currently these details are not monitored by the participating companies. The 'customer' for the petrochemical industry refers to the consumer product manufacturing companies that use these petrochemicals as part of their raw material. For examples, one of the petrochemical polymers produced by the industry is used in the manufacture of plastic drinking water containers. These consumer manufacturing companies although are taken to be customers for the petrochemical industry, most of their satisfaction surveys are based on the QA/QC aspects, i.e. if the petrochemical meets the requirements. Therefore, there is not much data maintained on this aspect and hence, the indicator as not selected. The use of this indicator was decided to be more applicable and relevant to finished products and not so much intermediary products.
		Aspect: Marketing Communications	
Core	PR6	Programmes for adherence to laws, standards, and voluntary codes related to marketing communications including advertising, promotion and sponsorship.	Unsuitable and presently not monitored. As in the case of PR5, this indicator is best suited for use in the assessment of a finished product and not an intermediary product as in the case of the petrochemical industry.

Table 4.18: Continued.

Type of Indicator		Performance Indicators	Suitability as SPI for the Petrochemical Industry in Malaysia
Additional	PR7	Total number of incidents of non-compliance with regulations and voluntary codes concerning marketing communications including advertising, promotion, and sponsorship by type of customers.	Unsuitable and presently not monitored for the reasons described under PR6.
		Aspect: Customer Privacy	
Additional	PR8	Total number of substantiated complaints regarding breaches of customer privacy and losses of customer data.	Unsuitable and not monitored for the reasons described under PR6.
		Aspect: Compliance	
Core	PR9	Monetary value of significant fines for non-compliance with laws and regulations concerning the provision and use of products and services.	Unsuitable and not monitored as this indicator is relevant for a finished product, as in the case of the indicators PR6, PR7, PR8 and PR9.

Out of the nine indicators (4 core and 5 additional) described above, only one indicator (core) was selected for use as an SPI in this research (see Table 4.19). This indicator, PR1, was modified before use as the ‘number of environmental, health and safety elements included in the product life cycle assessment’ to reduce the number of parameters to be tracked. The rest of the indicators under this category was not selected as they were either not monitored by the majority of the participating companies or were subjective in the definition which is not a desired characteristic of indicators. Further, two indicators, PR5 and PR6 were found not monitored by the participating companies.

Table 4.19: Proposed SPIs for the Category Product Responsibility

GRI 3.1 Indicator	Modified GRI 3.1 Indicator Code and Description
PR1: Life cycle stages in which health and safety impacts of products and services are assessed for improvement, and percentage of significant products and services categories subject to such procedures.	PR1a: Number of environmental, health & safety elements included in the product life cycle assessment.

GRI 3.1 Category: Human Rights

Under the category of Human Rights, there are eight indicators grouped into five aspects. Indicators HR1, HR2 and HR3 are grouped under the aspect of Investment and Procurment Practices with remaining four aspects, i.e. Non-Discrimination, Freedome of Assication & Collective Bargaining, Child Labour, Forced & Compulsory Labour, Security Practices and Indigenous Rights having one indicator each (HR4, HR5, HR6, HR7, HR8 and HR9 respectively. The feedback obtained from the respondents is summarised in **Table 4.20.**

Table 4.20: Performance Indicators for the Social Sub-category of Human Rights

Type of Indicator		Performance Indicators	Suitability as SPI for the Petrochemical Industry in Malaysia
		Aspect: Investment and Procurement Practices	
Core	HR1	Percentage and total number of significant investment agreements that include human rights clauses or that have undergone human rights screening.	Unsuitable and not monitored as these clauses are not included for investments in Malaysia for all the companies participating in this research. Therefore, this indicator is not suitable for use as an SPI.
Core	HR2	Percentage of significant suppliers and contractors that have undergone screening on human rights and actions taken.	Unsuitable and not monitored as such clauses are not included in the suppliers and contractors engaged by the participating companies. The government has over the past four decades ratified a number of International Labour Organisation (ILO) conventions, and the labour laws of Malaysia generally comply with the fundamental principles of the ILO. The potential for a breach in human rights is unlikely and therefore, this indicator was deemed unsuitable.

Table 4.20: Continued.

Type of Indicator		Performance Indicators	Suitability as SPI for the Petrochemical Industry in Malaysia
Additional	HR3	Total hours of employee training on policies and procedures concerning aspects of human rights that are relevant to operations, including the percentage of employees trained	Unsuitable and not monitored by the participating companies. The subject of human rights, generally, is not an issue of concern as the Malaysian labour laws comply with the requirement of the ILO. Therefore, such topics are not part of the employee orientation programme.
		Aspect: Non-Discrimination	
Core	HR4	Total number of incidents of discrimination and actions taken.	Suitable and presently monitored by 75% of the respondents. As discrimination covers a range of issues, for purposes of this research discrimination refers to equal employment opportunities for both men and women. Although other forms of discrimination exists in Malaysia, i.e. racial discrimination, discrimination towards the disabled, indigenous groups, political opinions, not just in the petrochemical sector but in the majority of sectors, due to the sensitive nature of these types of discrimination and the fact that the present legal framework which is described as weak in addressing these discriminations ((The Equal Rights Partnership, 2012), only gender equality was considered for this indicator. For purposes of this *research the indicator was modified as 'HR4a: Total number of incidents of discrimination'* where the second part involving the actions taken has been omitted.
		Aspect: Freedom of Association and Collective Bargaining	
Core	HR5	Operations identified in which the right to exercise freedom of association and collective bargaining may be at significant risk, and actions taken to support these rights.	Unsuitable and presently not monitored by the participating companies. The government has over the past four decades ratified a number of International Labour Organisation ("ILO") conventions. However, unions have historically failed to exert much influence on the Malaysian industrial landscape. This can be attributed to the strict regulation of Malaysian trade unions which arose as a result of trade unions being a "breeding ground" for subversive elements shortly following World War II. Membership of trade unions is limited to workers who are in similar trades, occupations or industries. All trade unions must register themselves with the Director-General of Trade Unions ("DGTU") and the scope of collective bargaining is considerably limited.

Table 4.20: Continued.

Type of Indicator		Performance Indicators	Suitability as SPI for the Petrochemical Industry in Malaysia
		Aspect: Child Labour	
Core	HR6	Operations identified as having significant risk for incidents of child labour, and measures to contribute to the abolition of child labour.	Unsuitable in the context of Malaysia as child labour is legally prohibited in the country.
		Aspect: Forced and Compulsory Labour	
Core	HR7	Operations identified as having significant risk for incidents of forced or compulsory labour, and measures to contribute to the elimination of forced or compulsory labour.	Unsuitable in the context of Malaysia as forced labour is legally prohibited in the country.
		Aspect: Security Practices	
Additional	HR8	Percentage of security personnel trained in the organization's policies and procedures concerning aspects of human rights that are relevant to the operations.	The security personnel at all the participating companies are out-sourced from private security firms. The only requirement imposed by the companies is that the security personnel be trained on standard health and safety measures.
		Aspect: Indigenous Rights	
Additional	HR9	Total number of incidents of violations involving rights of indigenous people and actions taken.	Not monitored and unsuitable as described under HR4.

Malaysia is a transitional middle-income economy, i.e. moving from the status of a developing nation towards achieving developed economy status by 2020 (Mokthsim and Salleh, 2014). Countries in the world can be described under three categories, i.e. developed economies, economies in transition and developed economies. One of the criteria for a developed nation is the The country has ratified 16 ILO conventions and most of these conventions relate human rights in employment. These are listed below:

1. Forced Labour Convention, 1930
2. Right to Organise and Collective Bargaining Convention, 1949
3. Equal Remuneration Convention, 1951
4. Minimum Age Convention, 1973
5. Worst Form of Child Labour Convention, 1999
6. Labour Inspection Convention, 1947
7. Tripartite Consultation (International labour Standard) Convention, 1976
8. Recruiting of Indigenous Workers Convention, 1936
9. Contracts of Employment (Indigenous Workers) Convention, 1939
10. Penal Sanctions (Indigenous Workers) Convention, 1939
11. Employment Service Convention, 1948
12. Protection of Wages Convention, 1949
13. Guarding of Machinery Convention, 1963
14. Minimum Age (Undergound Work) Convention, 1965
15. Maritime Labour Convention, 2006
16. Promotional Framework of Occupational, Safety and Health Convention, 2006

For the overall protection of human rights in Malaysia, the Human Rights Commission of Malaysia (SUHAKAM) was established under the Human Rights Commission of Malaysia Act (1999). One of the major concerns on human rights at the workplace is the inadequate protection provided for migrant workers. Migrants from neighbouring countries within the Southeast Asia region arrive in Malaysian cities and plantations to work in the construction, electronics, manufacturing and palm oil sectors. Based on 2015 data, reportedly, there are 2.9 million documented migrant workers in Malaysia with an estimated 3.1 million residing as undocumented workers. According to the ILO, they are a hidden and neglected workforce (Robertson

& Fair Labor Association, 2009). Prevailing legislation prevents migrant workers from forming their own trade unions. Often times, although they are allowed to join existing unions, they face challenges in participating in such unions and prevented from holding office. However, of the 13 participating companies, migrant workers are mostly hired by their contractors for outsourced supporting services such as housekeeping, waste disposal and maintenance. They are not directly employed by these companies and they don’t work within the production floor.

All the 13 respondents (100%) agreed that human rights infringement at the workplace in the context of employment is generally not monitored by the industry as the labour laws of Malaysia have been harmonised with the International Labour Organistion (ILO) and therefore the fundamental protection for workers has been established under the labour laws of the country as listed below:

- Employment Act, 1955
- Employment Regulations, 1957
- Industrial Relations Act, 1957
- Trade Unions Act, 1959
- Children and Young Persons (Employment) Act, 1966
- Minimum Retirement Age Act, 2012
- Minimum Wage Order, 2012

All participating companies (100%) confirmed that their respective management fully comply with the prevailing legal requirements as compliance to these laws are mandatory. The relevant provisions under these Acts have been incorporated in the employment contract as well as the companies management procedures (as applicable and relevant). The petrochemical sector being the downstream industry of the oil and gas industry is required to maintain a high level of regulatory compliance and therefore, most of the indicators listed under the five aspects were not selected as the respondents did not expect to see any trending or pattern since most of the criteria of these indicators have been addressed. Further, except of one indicator, the remaining seven indicators are not monitored by the participating companies. HR4 which is a core indicator under the aspect of Non-Discrimination refers ot the 'total number of incidents of discrimination and action taken'. This indicator was monitored by 75% of the participating companies and was deemed to be suitable for use as an SPI with some qualifications. The indicator was modified to only track incidents of discrimination involving equal employment opportunities as most of the participating companies had policies in place for equal employment. The modified indicator is described as 'HR4a: Total number of incidents of discrimination'.

The single indicator selected from the category Human Rights for use as an SPI in this study is presented in **Table 4.21**.

Table 4.21: Proposed SPIs for the Category Human Rights

GRI 3.1 Indicator	Modified GRI 3.1 Indicator Code and Description
HR4: Total number of incidents of discrimination and actions taken.	HR4a: Total number of incidents of discrimination

Overall, **Table 4.22** summarises the GRI 3.1 indicators which were evaluated and selected for use as SPIs in this research. The applicability of the modified and new indicators in the context of sustainable production processes in the Malaysian petrochemical industry were evaluated and verified via an extensive literature review.

Table 4.22: Summary of the GRI 3.1 Indicators Assessed and Selected for use as SPIs

	GRI 3.1 Category: Economic Performance Indicators		GRI 3.1 Category: Environmental Performance Indicators		GRI 3.1 Category: Labour Practices and Decent Work Performance Indicators		GRI 3.1: Category: Human Rights Performance Indicators		GRI 3.1: Category: Society Performance Indicators		GRI 3.1: Category: Product Responsibility Performance Indicators	
	Core	Additional	Core	Additional	Core	Additional	Core	Additional	Core	Additional	Core	Additional
Number of Indicators	EC1, EC2, EC3, EC4, EN6, EC7, EC8	EC5, EC9	EN1, EN2, EN3, EN4, EN8, EN11, EN12, EN16, EN17, EN19, EN20, EN21, EN22, EN23, EN26, EN27, EN28	EN5, EN6, EN7, EN9, EN10, EN13, EN14, EN15, EN18, EN 24, EN25, EN29, EN30	LA1, LA2, LA4, LA5, LA7, LA8, LA10, LA13, LA14	LA3, LA6, LA9, LA11, LA12	HR1, HR2, HR4, HR5, HR6, HR7	HR3, HR8, HR9	SO1, SO2, SO3, SO4, SO5, SO8	SO6, SO7	PR1, PR3, PR6, PR9	PR2, PR4, PR5, PR7, PR8
Shortlisted SPI in original form	-	-	EN1, EN3, EN16,	EN5	LA10	0	0	-	SO3	-	-	-
Modified SPIs/ New SPIs	EC6a, EC7a		ENV1, EN 8a, EN 21a, EN 22a, EN 28a		LA2a, LA7a,		HR4a		SO1a, SO2a		PR1a	

With the identification of a total of nineteen SPIs for use in the assessment of sustainable production of petrochemical industries, the next step was to affix a suitable measurement unit for each of the indicators. This is to enable the petrochemical industry to track the performance of these indicators. For an indicator to be effective, it needs to be measurable (Veleva and Ellenbecker, 2001a). The respondents were requested to propose the units currently used at their respective operating facilities and a concensus was arrived on the most suitable units to be employed to measure the SPIs as presented in **Table 4.23.**

Table 4.23: Units of Measurement for the SPIs Identified for the Petrochemical Industry in Malaysia

GRI 3.1 Category	SPI for the Petrochemical Industry in Malaysia	Unit of Measurement
Economy	EC6a: Percent of contracts with local suppliers per unit sales revenue’.	%
	EC7a: Percent of staff hired from the local community	%
Environment	EN1: Materials used by weight or volume	Tonne/m
	EN3: Direct energy consumption by primary energy source	Joules
	EN5: Energy savings due to conservation and efficiency improvement	Joules
	EN8a: Water consumption per unit product	m^3
	EN16: Total direct and indirect GHG by weight	Tonnes of CO_2 equivalent
	EN21a: Total water discharge by unit product	m^3
	EN22a: Total weight of waste per unit product	tonne
	EN23a: Number of incidents per year involving reportable loss of primary containment	No unit
	EN28a: Number of EHS regulatory non-compliance	No unit
Human Rights	HR4a: Total number of incidences of discrimination	No unit
Labour Practices and Decent Work	LA2a: Rate of employee turnover by age group and gender	%
	LA7a: Number of LTIs	No unit
	LA10a: Average of hours of sustainability training per year per employee by employee category	Hours
Product Responsibility	PR1: Number of environmental, health and safety elements included in the product life cycle assessment	No unit

Table 4.23: Continued.

GRI 3.1 Category	SPI for the Petrochemical Industry in Malaysia	Unit of Measurement
Society	SO1: Percent of community programme that communicate the impacts of operations on communities	%
	SO2: Percent of business units analysed for risks related to corruption	%
	SO3: Percent of employees trained in anti-corruption policies and procedures	%

4.2 Phase 2: Prioritisation of the Identified Sustainable Production Indicators (SPIs)

In Phase 2 of the research, the 19 shortlisted SPIs from Phase 1 of the research were prioritised using AHP. The SPIs were structured as a hirerchy that includes four levels as discussed in Chapter Three. The indicators shortlisted included six of the existing GRI 3.1 indicators, 12 modified indicators and one new indicator which were proposed by the respondents of this survey. The need to understand the priority of economic, environmental and social indicators with respect to sustainability is very important as they enable to organisation to focus on the indicators of importance. This argument is in agreement by research conducted by Lee (2012).

4.2.1 Pairwise Comparisons using the Analytical Hierarchy Process

4.2.1.1 Level 2 Pairwise Comparisons using the Analytical Hierarchy Process

An example of the AHP model which was constructed in Expert Choice® for one of the companies, i.e. Company A2 is shown in treeview pane view. The model shows the outcome of the prioritization of the six categories of the GRI 3.1, i.e. Economy, Environment, Human Rights, Labour Practice and Decent Work, Society, Product Responsibility and Economic based on the pair-wise comparison undertaken by the 13 respondents using the 9-point Likert scale is presented in Figure 4.1 below. The concept employed in using this methodology is similar to that of Deb and Lomo-David (2014).

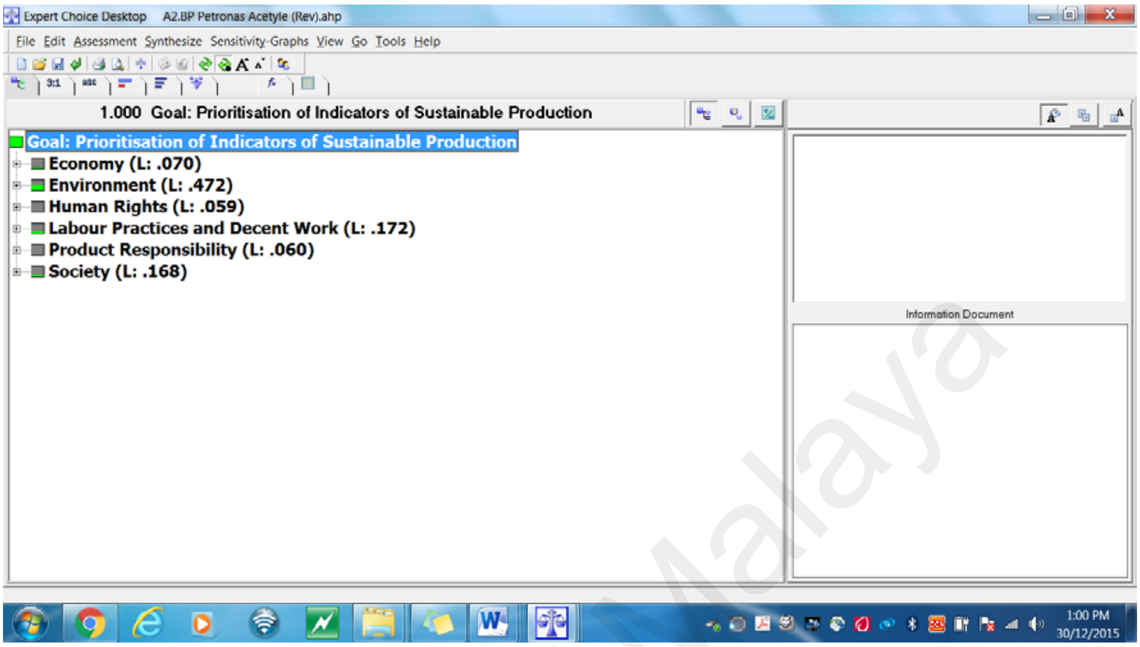


Figure 4.1: Treeview pane of the Expert Choice software showing the AHP model for the prioritization of the the six indicator categories

The weights calculated using the Expert Choice® software based on the pairwise comparison carried out with the 13 respondents is presented in Table 4.24. These weights were derived using the geometric mean method described in Chapter Three of this research. The Consistency Index (CI) calculated for the pair-wise comparison of the six categories was 0.0805 which is less than 0.1 or 10% which indicates that the judgement of the 13 respondents with respect to the pair-wise comparison was consistent.

Table 4.24: Ranking of the six categories of the GRI 3.1

Level 2 Criteria	Relative weights using AHP	Rank
Environment	0.377	1
Labour Practices and Decent Work	0.197	2
Society	0.133	3
Economy	0.106	4
Product Responsibility	0.102	5
Human Rights	0.057	7

Based on the weights calculated, the aspect Environment was ranked as the category with the highest priority (0.3777) amongst the six categories. The second highest priority was observed to be for the category of Labour Practices and Decent Work (0.197). The third and fourth ranks were assigned to Society (0.133) and Economy (0.106) respectively. The two least priority categories were Product Responsibility (0.102) and Human Rights (0.057). **Figure 4.2** presents a bar-chart representation on the ranking of the six categories.

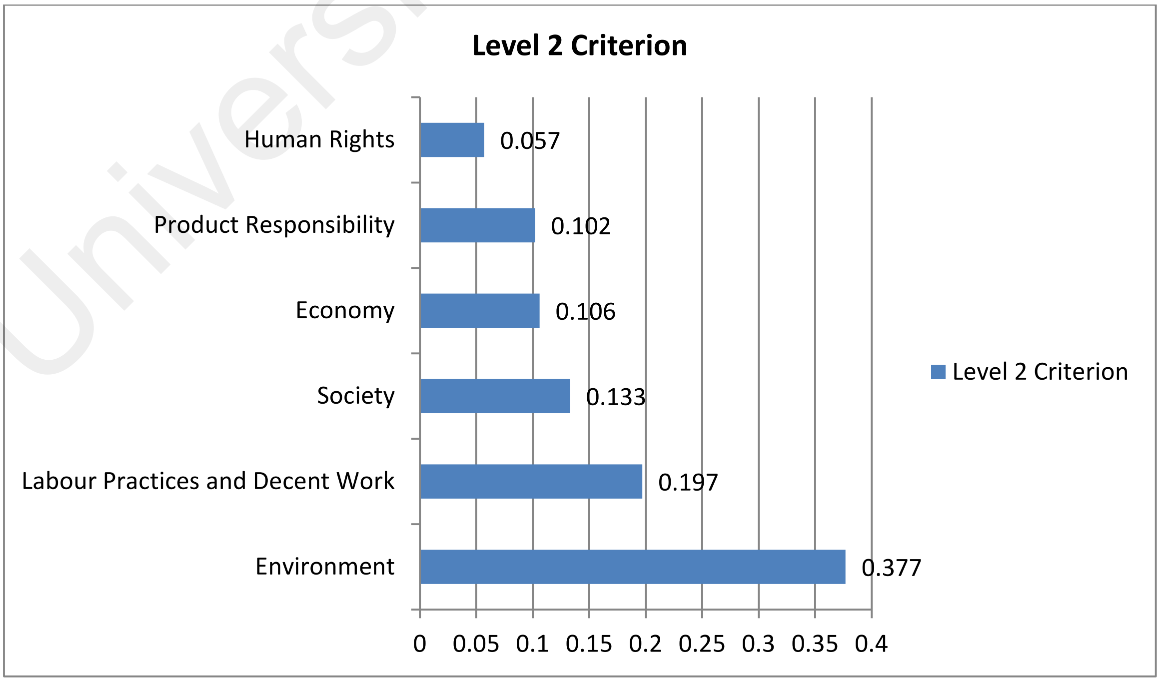


Figure 4.2: Prioritisation of the Level 2 Criteria (Indicator Categories)

Environment

The category Environment was ranked first in the order of priority based on the AHP method. The weightage given to this category was also observed to be signficantly higher than the remaining categories. The dimension of Environment in sustainability deals with resource exploitation, emissions/discharges and environmental risks which are the three main concerns of environmental protection. Each of the three issues are a resultant of anthropogenic pressure as a result of on the environment in one way or another. The ranking of Environment as the category with the highest priority was well supported by the approach of the petrochemical industry (and industries in general) in Malaysia where during the early years of sustainability assessment, much of the attention was focused on the environmental sustainability of industries. The indicators specified within this category relate to air, water and waste-related pollution, consumption of raw maerials, biodiversity, compliance and anthropogenic activities that result in environmental degradation (e.g. transportation). Post independence, with the onset of industrialization in the 1960s and the implementation of the National Economy Plan, environmental pollution was identified as a challenge for the newly developing country (Mokthsim and Salleh, 2014). As a result, regulatory drivers as well as the thrust of Government policies and initiatives on sustainability began first with environmental sustainability and progressively included the social and economic components ((EPU, 1981; 1986; 1991; 1996; 2000; 2005 & 2010). The main backbone for environmental management, the Environmental Quality Act was promulgated as early as 1974 and through the past four decades, the regulations within the Act have been progressively revised for better management of environmental issues with respect to emissions and discharges to the environment. Further, with respect to the implementation of management systems, the ISO 14001 was pursued extensively by companies in Malaysia since the early 80s where manufacturing facilities including the petrochemical industry have since adopted the system for a more structure management of environmental issues. One of the eight development goals identified by the United Nations to be achieved by 2015 is ‘Ensuring Environmental Sustanability’ as described in the Millennium Development Goals (MDGs) Report (UN, 2015).

The latest Millennium Development Goals (MDGs) Report which was released in 2015 shows that several of the MDGs goals have been met (UN, 2015). For example, global poverty reduced 50% in 2010 which is 5 years ahead of the 2015 timeframe and 90% of children in developing countries enjoy primary education with the inequality between boys and girls enrolled reducing. Although these achievements bring about significant success of the various programmes in place, with respect to Goal 7, Ensuring Environmental Sustainability, there still remain areas which need improvement for their degrading trends to be reversed. Although ozone depleting substances have been almost removed and the earth’s ozone layer expected to recover by the middle of this century, global emissions of carbon dioxide have increased by over 50% since 1990 (UN, 2015). Hence, the continuing need to focus on environmental related issues as the main component under the umbrella of sustainability.

Labour Practices and Decent Work

The category with the second highest priority was Labour Practices and Decent Work. The performance indicators under this category include indicators relating to employment, labour/management relations, occupational safety and health, training and education, diversity and equal opportunity, equal remuneration for women and men. Based on literature review which includes the annual reports as well as the sustainability reports of the companies selected for this study, and the petrochemical sector puts significant prominence with respect to employee welfare, occupational safety and health and empowerment. Furthermore, the petrochemical sector is closely related to the oil and gas sector which also highly prioritises this aspects of this category. The feedstock for the petrochemical industry originates from the oil and gas industry and most of the petrochemical facilities which are part of this research have parent companies that are in the oil and gas business. Hence, this category is given the next highest priority. From a legislative presepctive the Occupational Safety and Health Act was promulgated in 1996 and under the Act, regulations and legally enforceable Code of Practices have been developed to ensure the protection of workers' health and safety.

Society

Under the category Society, the identified performance indicators addresses the relationship with the receiving community (or local community which is impacted by the operations of the petrochemical companies), corruption, public policy, anti-competitive behavior and compliance. The interaction of an industry or a business with the local community plays a key role in the successful long-term operation of the establishment (Steurer et al., 2005). Industries have realised that they need the support of the local community and with this awareness industries have developed and implemented corporate social programmes to foster a positive goodwill.

Economy

The economic dimension of sustainability which is ranked as the fourth most important category, covers an organization's impacts on the economic conditions of its stakeholders and on economic systems at local, national, and global levels. The indicators within this category illustrate the flow of capital among different stakeholders; and the economic impacts of the organization throughout society. Within the category, the performance indicators include economic performance, market presence and indirect economic impacts. As in the case of any business operation, the economics of the operation determines the operational life and feasibility of the business. The indicators under this category also include those relating to financial implications related to activities that result in environmental impacts such as climate change as well as the giving preference to the local community for employment.

Product Responsibility

The Product Responsibility indicator set addresses the impact of products and services management on customers and users. It is the responsibility of companies to ensure that the design of their products and services are fit for their intended use and do not pose hazards to health and safety of the user. Further, communications related to both products and services and users need to take into consideration the information needs of customers and their rights to privacy. On the category of Product Responsibility, the performance indicators can be grouped into smaller clusters of customer health and safety, product and service labelling, marketing communications, customer privacy and compliance.

Human Rights

The performance indicators described under Human Rights require companies to report on the extent to which human rights are considered in investment and supplier/contractor selection practices. Additionally, the indicators cover employee and security forces training on human rights as well as non-discrimination, freedom of association, child labour, indigenous rights, and forced and compulsory labour. This category received the lowest priority ranking by the pool of research respondents. One of the reasons as to why this category was not deemed as an important category as in Malaysia within the petrochemical, issues such as human rights and child labour typically don’t arise as the industry standards adequately cover these aspects. Based on the feedback from the research respondents, in their entire time of service (most of them have more than 10 years of working experience in the petrochemical industry), they have not had to deal with such issues or had known of such issues within their organisation. Also, since 12 of the 13 organisations selected are multinational companies with facilities across the globe, they have corporate requirements that ensure these aspects are not breached as the reputation loss they face would affect both their social and financial performance.

4.2.1.2 Level 3 Pairwise Comparisons using the Analytical Hierarchy Process

This section presents the findings of the research which involved Level 3 of the hierarchy matrix. The indicators under each of the six categories were ranked using pair-wise comparison by the 13 respondents. The result for one of the company, Company A2, is provided in a treepane view of the AHP model using the Expert Choice® is shown in Figure 4.3. For the rest of the remaining 12 participating companies**,** the collective results were used to calculate the relative weights to rank the indicators.

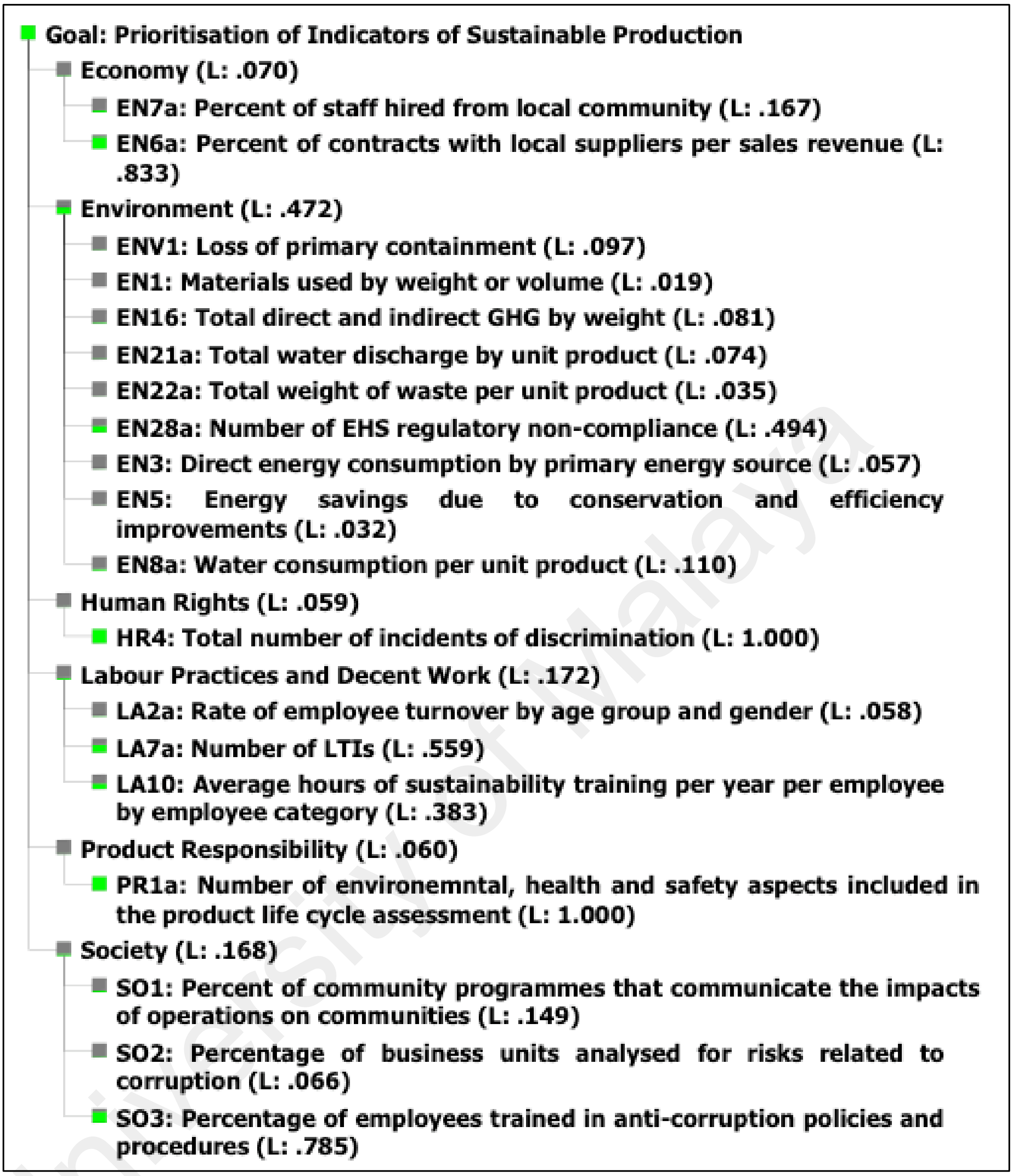


Figure 4.3: Treepane View of the AHP Model for Company A2

Environment

Table 4.25 presents the ranking of the indicators within the category of Environment. The CI calculated for the pair-wise comparison of the nine indicators within the category was 0.1.

Table 4.25: Ranking of the indicators within the category of Environment

Indicators (Level 3 Criteria)	Relative weights using AHP	Rank
EN28a: Number of EHS regulatory non-compliance	0.3379	1
EN5: Energy savings due to conservation and efficiency improvements	0.1251	2
EN3: Direct energy consumption by primary energy source	0.1204	3
EN16: Total direct and indirect GHG by weight	0.0864	4
EN23a: Number of incidents per year involving reportable loss of primary containment	0.0737	5
EN21a: Total wastewater discharge by unit product	0.0585	6
EN8a: Water consumption per unit product	0.0420	7
EN22a: Total weight of waste per unit product	0.0329	8
EN1: Materials used by weight or volume	0.0236	9

Figure 4.4 illustrates the ranking of the indicators under the category of Environment in the form of bar charts.

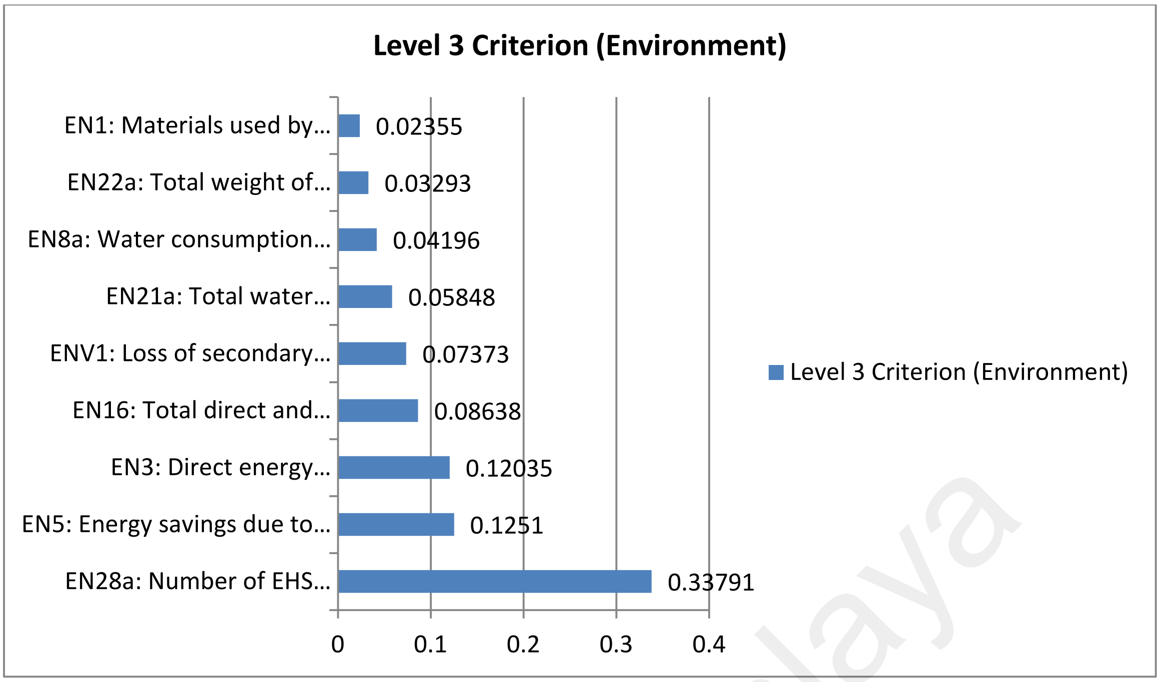


Figure 4.4: Ranking of indicators under the category of Enviroment

Environment

Under Environment, a total of nine SPIs were shortlisted based on Phase 1 of the research. Of these nine SPIs, the indicator with the highest priority or rank is Number of EHS Regulatory Non-Compliance. This finding is aligned with the general philosophy of the petrochemical industry whereby compliance to EHS regulatory is crucial. Prevailing EHS regulations in Malaysia include the (1) Environmental Quality Act, 1974 and its subsidiary regulations enforced by the Department of Environment and, the (2) Occupational Safety and Health Act, 1996 and its subsidiary regulations as enforced by the Department of Occupational Safety and Health and (3) regulations governed by other government technical agencies which pertain to environmental, health and safety matters. For example, there are provisions under the Street, Drainage and Building Act 1974, the Local Government Act, 1976 as well as the Town and Country Planning Act, 1976 which addresses environmental issues. Regulatory compliance is also a significant element in both the ISO 14001 and the OHSAS 18000 management systems.

The SPI ranked second is Energy Savings due to Conservation and Efficiency Improvements followed by Direct Energy Consumption by Primary Energy Source. Energy has gained importance in the last decade. The SPI ranked fourth in the analysis is Total Direct and Indirect GHG by Weight.

Coming up as number five is Loss of Secondary Containment. This SPI refers to any release of pollutants into the environment as a result of a breach in containment and warrants reporting to the regulators. This includes spillages which occur directly from the container used to store hazardous chemicals or untreated wastewater. Most of the raw materials used in the production of petrochemicals are classified as hazardous chemicals and these are typically used in bulk quantities at the industrial facilities. Adequate secondary containment (typically provided in the form of a concrete bund) is provided to ensure that even if the storage tank/vessel is damaged, the material is contained from release to the environment (soil, groundwater and any surface water bodies). A breach in secondary containment will result in potential contamination of soil, groundwater and surface water.

The sixth and seventh place is Total Wastewater Discharge Per Unit Product and Water Consumption Per Unit Product. Due to the nature of the petrochemical production process, wastewater is generated in large quantities. The wastewater is treated onsite in wastewater treatment systems and only discharged if the treated effluent meets regulatory standards. One method of tracking water conservation initiatives is to calculate the total wastewater discharged per unit product as well as the consumption per unit product.

Tracking of materials used in the production process was listed as the indicator with the least priority as in the petrochemical industry since much of the raw materials are consumed with very little opportunity for recycling or reuse. Only the intermediary ‘products’ from the process which are rejected due to process upsets or not meeting the required specifications are recycled into the system. Even then, most of the respondents agreed that the proportion of these reject process intermediaries is not significant. Hence, this indicator received the lowest ranking. However, the respondents did agree that sustainable materials management is important for the industry and data should be maintained for record keeping. This is because in the future, with advanced in research, opportunities for recycling and reuse may be possible.

Labour Practices and Decent Work

Table 4.26 presents the ranking of the indicators within the category of Labour Practices and Decent Work. The CI calculated from the pair-wise comparison between the three indicators within this category is 0.0952.

Table 4.26: Ranking of the indicators within the category of Labour Practices and Decent Work

Indicators (Level 3 Criteria)	Relative weights using AHP	Rank
LA7a: Number of loss time injuries	0.5647	1
LA10a: Average hours of sustainability training per year per employee by employee category	0.2711	2
LA2: Rate of employee turnover by age group and gender	0.0998	3

Figure 4.5 illustrates the ranking of the indicators in the form of bar charts.

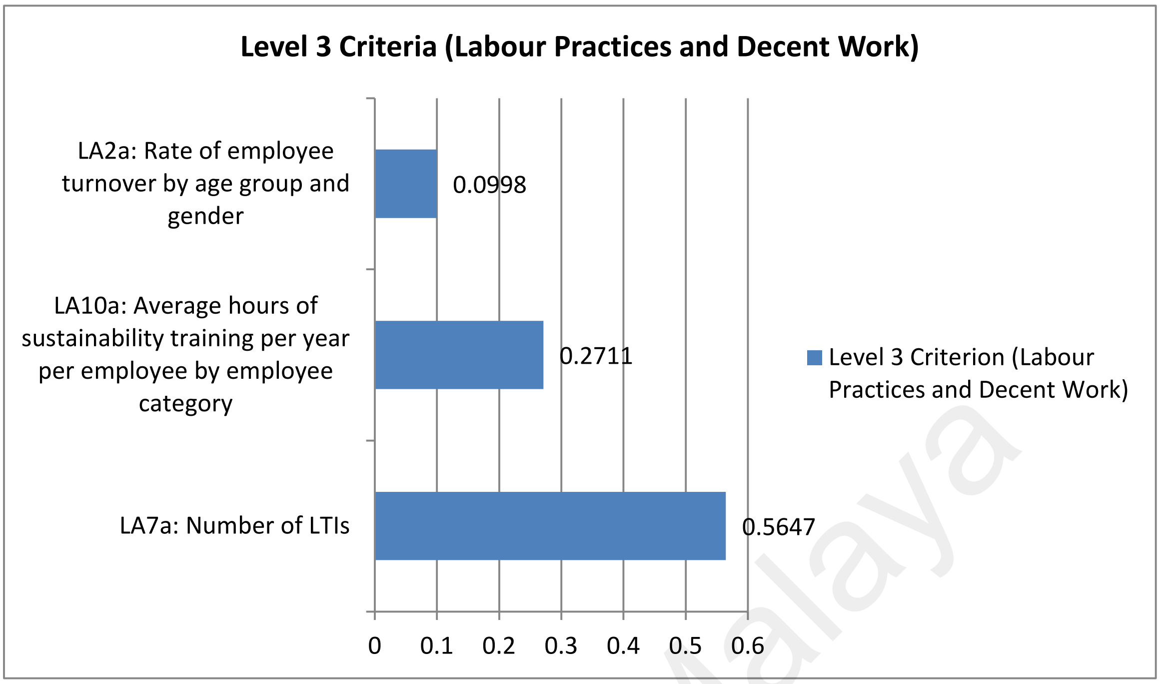


Figure 4.5: Ranking of indicators under the category of Labour Practices and Decent Work

Under the category of Labour Practices and Decent Work, there are three SPIs which were shortlisted and assessed. Of these, the SPI with the highest rank was the Number of Loss Time Injuries (LTIs) followed by the Average Hours of Sustainability Training Per Year Per Employee by Employee Category and Rate of Employee Turnover by Age, Group and Gender. In the petrochemical industry, the LTI for a given industrial operation is one of the most rigorously monitored indicator as it relates directly to occupational health and safety. A lost-time injury is defined as an occurrence that resulted in a fatality, permanent disability or time lost from work of one day/shift or more. Further LTIs are required to be tracked by law, and there are reporting procedures to be adhered to with the Department of Occupational Safety and Health.

Society

Table 4.27 presents the ranking of the indicators within the category of Society. The CI computed for the pair-wise comparison involving the three indicators under this category was 0.0277.

Table 4.27: Ranking of the indicators within the category of Society

Indicators (Level 3 Criteria)	Relative weights using AHP	Rank
SO3: % of employees trained in anti-corruption policies and procedures	0.3219	1
SO1: % of community programmes that communicate the impact of the operations on the community	0.2566	2
SO2: % of business units analysed for risks related to corruption	0.1865	3

Figure 4.6 illustrates the ranking of the indicators in the form of bar chart.

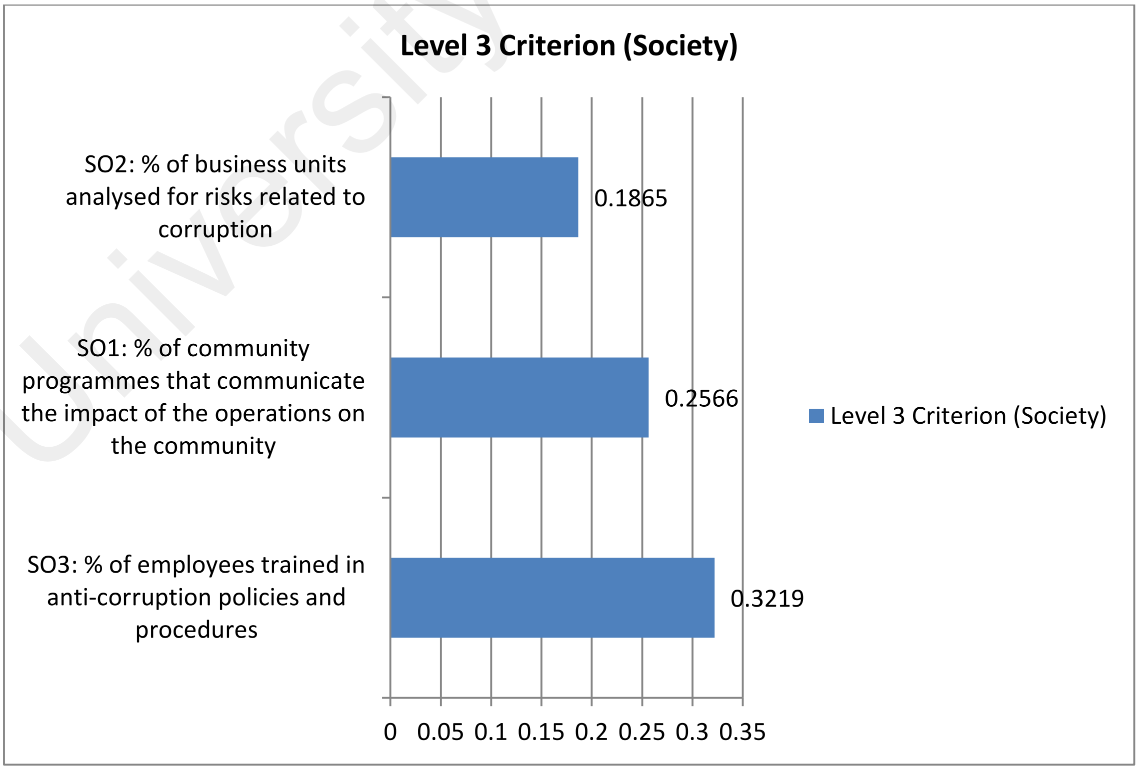


Figure 4.6: Prioritisation of level 3 criterion (Society)

The highest weight (0.3219) was given to the indicator SO3 which is related to the training provided for anti-corruption. Corruption is an unhealthy practice that is strictly curbed by the petrochemical industry. The industry is commited to complying with prevailing regulations on anti-corruption. Malaysia has ratified the United Nations Convention Against Corruption or UNCAC and is a member of the Asian Development Bank and the OECD Anti-Corruption Initiative for Asia and the Pacific and, the Asia Pacific Group on Money Laundering. Within the country, the primary statute governing anti-bribery and similar offences is the Malaysian Anti-Corruption Commission Act (2009) which came into force in 2009 (and repealed the previous Anti-Corruption Act 1997).

In addition, other statutes and codes include the following:

- Penal Code
- Customs Act 1967
- Election Offences Act 1954
- Anti-Money Laundering and Anti-Terrorism Financing Act 2001
- Societies Act 1966
- Trade Unions Act 1959
- Youth Societies and Youth Development Act 2007
- Financial Services Act 2013 and Islamic Financial Services Act 2013
- Companies Act 1965.

Training is the one of the best ways to create awareness amongst employees on a givens subject. Similarly, in curbing corruption, as part of their employee orientation programme, they are exposed to topics on corrupation and anti-bribery. Further, employees of these companies are required to understand and abide by their respective business code of practice and some of the common topics covered under these codes include but not limited to the following:

- Prohibition on bribery and corruption
- Limits of gifts and business entertainment
- Conflicts of interest
- Confidentiality

The second highest weight (0.2566) was assigned to indicator SO1 which tracks the percentage of community programmes that communicate the impact of the operations on the community. One of the drivers for this initiative is the requirement under the Control of Industrial Major Accident Hazards (CIMAH) Regulations, 1996 of the Occupational Safety and Health Act 1996 (GOM, 1996) to inform the community residing within the zone of the impact of a petrochemical plant of the environmental, health and safety impacts of the operations. The zone of impact is typically between 3-5 km from the petrochemical plant boundary. In addition to contributing to the social responsibility of the petrochemical plants, informing the community of the impacts arising from such plants ensure compliance to the OSHA 1996.

The indicator with the least priority was SO_2 which monitors the number of business units analysed for risks related to corruption (0.1865). The participating companies indicated that as part of their corporate policy, they undertake a risk analysis to identify business units for potential bribery or corruption issues.

Economy

Table 4.28 presents the ranking of the indicators within the category of Economy. The CI calculated for the pair-wise comparison between the two indicators was 0.

Table 4.28: Ranking of the indicators within the category of Economy

Indicators (Level 3 Criteria)	Relative weights using AHP	Rank
EC6a: Percent of staff hired from local community	0.6433	1
EC7a: Percent of contracts with local suppliers per sales revenue	0.2567	2

Figure 4.7 illustrates the ranking of the indicators in the form of bar charts.

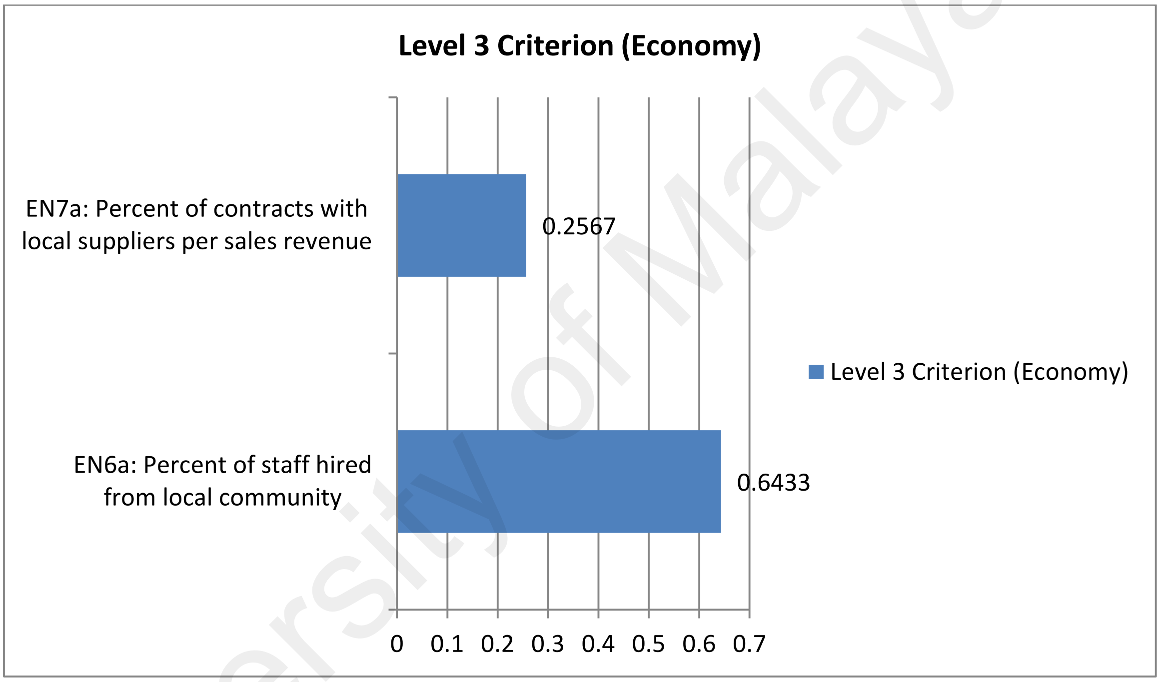


Figure 4.7: Prioritisation of Level 3 Criteria (Economy)

Indicator EC6a which represents the percentage of staff hired from the local community was judged to be more important than EC7a which denotes the percentage of contracts with local suppliers per sales revenue. The weights assigned to both EC6a and EC7a were 0.6433 and 0.2567, respectively. All 13 companies (100%) indicated that as part of their corporate human resource policy, there are requirements to ensure employees at their operating plants are hired as much as possible from the local community. This is also part of their CRS initiatives, i.e. to be able to provide employment for the local community and thereby contributing to the local economy. Of the 13 participating companies, four of them are multinationals operating in Malaysia. In addition to contributing to the economy, by employing staff from the local community, they are also indirectly contributing to the transfer of knowledge and skills. And this is recognised as a form of corporate social responsibility to the community that they are operating within. In the towns of Gebeng (state of Pahang) and Kertih (state of Terengganu), where nine out of the 13 participating companies are located, much of the economic progress, infrastructure development, improvement and increase of residential areas and amenities especially primary and secondary schools as well as technical training centres.

Similarly, the 13 participating companies prioritise local suppliers over those from other states providing the quality and specification of the material or service procured meets the specified requirements. This indicator was weighted much less than indicator EC6a because the majority of the raw material and equipment suppliers for the petrochemical industry are located outside of the state as these are more of the high-end services where technical specialisation and expertise is needed. And most of such companies are located in the more developed states in Malaysia such as the states of Selangor, Johor, Penang and the Federal Territory of Kuala Lumpur. Most of the contracts given to businesses/suppliers operating within the local community were for services such as office-related services, landscaping, catering, building maintenance, operation of the workshop, housekeeping, canteen operation and security.

Product Responsibility

For Product Responsibility, only one SPI was selected which represents the number of environmental, health and safety elements to be included in the assessment of a product life cycle **(Table 4.29).**

Table 4.29: Ranking of the indicators within the category of Product Responsibilty

Indicators (Level 3 Criteria)	Relative weights using AHP	Rank
PR1: Number of environmental, health and safety elements included in the product life cycle assessment	1	1

Product life cycle assessment Life Cycle Assessment (LCA) is a tool for the systematic evaluation of the environmental aspects of a product or service system through all stages of its life cycle. It does not include social and economic impacts. The 13 participating petrochemical industry subscribe to Responsible Care which can be summarized as the worldwide chemical industry's concerted commitment towards safe handling, storage, use and disposal of chemicals throughout their entire life cycle, whilst at the same time advocating their role in enhancing the quality of life and contributing to sustainable development (Belanger et al., 2014). Of the 13 companies, 54% subscribe to the principles of Product Stewardship which requires these companies to continuously identify, assess, control and communicate HSE risks throughout their products' life cycle. The primary objective in incorporating the concepts of Product Stewardship within their corporate sustainability framework allows for better compliance with internationally accepted regulatory requirements with the main focus minimising product risks by implementing mitigation measures to maintain product safety while concurrently managing environmental impacts. As part of industry's contribution to the United Nations' Strategic Approach to International Chemicals Management (SAICM), these companies (54%) voluntarily commit to the Responsible Care Global Charter and the Global Product Strategy.

Human Rights

Under the category of Human Rights**,** only one SPI was selected. Hence, it was assumed that the indicator, HR4, which tracks the total number of incidences of discrimination under this category **(Table 4.30)** was the prioritized indicator.

Table 4.30: Ranking of the indicators within the category of Human Rights

Indicators (Level 3 Criteria)	Relative weights using AHP	Rank
HR4a: Total number of incidences of discrimination	1	1

Discrimination is defined in the GRI 3.1 as treating a person unequally by forcing unfair responsibilities or by denying privileges instead of treating the person fairly on merit. Discrimination also includes harassment which is described as comments made which are unwelcome.

All 13 of the participating companies (100%) practice the elimination of discrimination at the workplace. Their HR policies also stipulate the need for equal opportunity in employment. Malaysia in general encourages fair distribution of employment opportunities among the different ethnic groups to promote racial harmony and social integration. With the prevailing legislative framework there are no definite provisions concerning fair and equal treatment for men and women with respect to salaries and financial compensation. The Employment Act 1955 (GOM, 1955) stipulates statutory benefits and labour protection for all workers without discriminating their sex, religion and social origin. It even contains specific provisions prohibiting discrimination between local and foreign workers.

4.3.1.3. Computation of Global Weights to Prioritise the SPIs

The application of AHP in this research yields three sets of results and these include (a) weights and prioritisation of each of the six categories of the GRI 3.1., i.e. Economy, Environment, Labour Practices and Decent Work, Society, Product Responsibility and Human Rights which enabled the ranking of the categories; (b) priority weights of the SPIs within each of the six categories; and (c) the overall priority weights of all the 19 SPIs investigated in this research. AHP permits the aggregation of individual judgements and for the conversion of qualitative data into mathematical weightings (Lo et al., 2013). It was therefore justifiable in adopting AHP as the method in fulfilling he objectives of this research.

Upon computing the normalised priority weights for (a) and (b) as described above, the overall prioritisation of the 19 SPIs was synthesized in this section by calculating the global weights. The global weights were obtained by multiplying the weight of each criteria by the local weight of the sub-criteria (Lee and Ross, 2012). For example, the global weight for EN28a: Number of EHS regulatory non-compliance was calculated by multiplying the weight of environment (0.377) (by its own local weight (0.3379). The calculated global weights are presented in **Table 4.31**.

Table 4.31: Global Ranking of the 19 shortlisted indicators

GRI 3.1 Category (Level 2 Criteria)	Rank	Indicators (Level 3 Sub-Criteria)	Local Weight	Local Rank	Global Weight	Global Rank
Environment	1	EN28a: Number of EHS regulatory non-compliance	0.3379	1	0.1274	1
		EN5: Energy savings due to conservation and efficiency improvements	0.1251	2	0.0472	7
		EN3: Direct energy consumption by primary energy source	0.1204	3	0.0454	8
		EN16: Total direct and indirect GHG by weight	0.0864	4	0.0326	11
		EN23a: Number of incidents per year involving reportable loss of primary containment	0.0737	5	0.0278	12
		EN21a: Total wastewater discharge by unit product	0.0585	6	0.0220	14
		EN8a: Water consumption per unit product	0.0420	7	0.0160	16
		EN22a: Total weight of waste per unit product	0.0329	8	0.0124	17
		EN1: Materials used by weight or volume	0.0236	9	0.0089	18
Labour Practices and Decent Work (0.197)	2	LA7a: Number of Loss Time Injuries (LTIs)	0.5647	1	0.1112	2
		LA10a: Average hours of sustainability training per year per employee by employee category	0.2711	2	0.0534	6
		LA2a: Rate of employee turnover by age group and gender	0.0998	3	0.0197	15
Society (0.133)	3	SO3: % of employees trained in anti-corruption policies and procedures	0.3219	1	0.0428	9
		SO1: % of community programmes that communicate the impact of the operations on the community	0.2566	2	0.0341	10
		SO2: % of business units analysed for risks related to corruption	0.1865	3	0.0250	13

Table 4.31: Continued.

GRI 3.1 Category (Level 2 Criteria)	Rank	Indicators (Level 3 Sub-Criteria)	Local Weight	Local Rank	Global Weight	Global Rank
Economy (0.106)	4	EN6a: Percent of staff hired from local community	0.6433	1	0.0682	4
		EN7a: Percent of contracts with local suppliers per sales revenue	0.2567	2	0.0272	13
Product Responsibility (0.102)	5	PR1a:Number of environmental, health and safety elements included in the product life cycle assessment	1	1	0.102	3
Human Rights (0.057)	6	HR4: Total number of incidents of discrimination	1	1	0.057	5

Based on the data presented in the table, the SPIs with the top five highest global weights are listed as follows:

1. EN28a: Number of EHS regulatory non-compliance (0.1274)
2. LA7a: Number of Loss Time Injuries (LTIs) (0.1112)
3. PR1a: Number of environmental, health and safety elements included in the product life cycle assessment (0.1020)
4. EN6a: Percent of staff hired from local community (0.0682)
5. HR4: Total number of incidents of discrimination (0.0570)

The SPI with the highest global weight value means that it is of highest importance and strongly preferred from amongst the 19 shortlisted SPIs for use as an indicator for sustainability assessment in the petrochemical industry and, therefore ranked as the indicator with the highest priority. Similarly, the indicators with the lowest global weight are the indicators with the lowest importance and therefore with the least priority from amongst the 19 SPIs in this study. The indicator EN28a which represents the number of EHS regulatory non-compliance had the highest priority. Regulatory compliance is always seen as an important element in sustainability as it is the very fundamental requirement in environmental, health and safety management as seen in the elements of ISO 14001 (ISO, 2014; Testa et al., 2014) and OHSAS 18001 (BSI, 2007). This is followed by SPI LA7a which represents the number of loss time injuries (LTIs). The number of LTIs is an element of process safety. As defined by the American Institute of Chemical Engineers, process safety is defined as a combination of engineering and management competencies that are targeting at averting catastrophic accidents, specifically explosions, fires, and toxic releases that associated with the usage of chemicals and petroleum products (Crowl et al., 2001). The American Petroleum Institute has defined process safety as an integral element of safety management that addresses the concerns of major hazards that impact safety and cause environmental damage leading to loss in profits. The primary objective of process safety management is to establish plant systems and procedures that avert unnecessary releases that may ignite and cause toxic impacts, local fires or explosions (API, 2010).

The third most important indicator with a global weight of 0.1020 is PR1a which tracks the number of environmental, health and safety elements included in the product life cycle assessment. Life cycle assessment (LCA) is a tool for assessing the environmental aspects and potential impacts associated with a product through all stages of its life cycle (ISO, 2006). The consideration of environmental impacts throughout the product life cycle also forms one of the fundamental element of Responsible Care which is subscribed for all 13 participating industries. Responsible Care ® is the chemical industry's commitment to sustainability. The ethics and principles compel companies to innovate for safe and more environmentally friendly products and processes, and to work to eliminate harm throughout the entire life cycle of their products. Responsible Care ® encompasses all aspects of a company's business and throughout the life cycle of their products. Because of the commitment of these companies to Responsible Care®, this SPI was determined to the third most important indicator.

In fourth position was the indicator, EN6a which represents the percent of staff hired from local community (0.0682). All the 13 participating companies (100%) subscribe to some form of corporate social responsibility whereby there is commitment to contribute to the economic growth and quality of life of the local community where the company is operating in. Corporate social responsibility has been defined in many ways. Dahlsrud (2006) identified up to 37 various definitions for CSR. Although there are various meaning, the common key points across these definitions are the integration of social and environmental concerns in the business operations and the interaction of these businesses with their stakeholders based on a voluntary basis.

The fifth most weighted (ranked) SPI (0.0570) is HR4: Total number of incidents of discrimination. As 46% of the participating companies are multinationals with their parent company originating from outside of Malaysia, the research respondents from these companies stressed the importance of operating in a manner that did not discriminate the largely locally-based employees. Hence, their policies on human resources management included an element on discrimination. Of the 13 participating companies, 86% were multinationals with foreign ownership. Therefore, the respondents weighted this SPI as the fifth most important indicator to show fairness more so in a multi-racial country. Social responsibility which includes employee discrimination it tied very closely to sustainability as cited by the research respondents. In a study of Bateh et al. (2014), the reasons highlighted as to why companies engage in social responsibility is because it helps gain competitive advantage in the market place, minimise the company's exposure to reputational risks, and gain higher productivity and value through improved reputation (Hoang Yen & Thanh Tu, 2014). Cases of indiscrimination identified within companies originating from developed countries but operating in developing countries have only caused significant reputational risk because of the lack in social responsibility. For example, the loss of reputation for Nike as a result of poor practice on social responsibility at their sports apparel factories in Bangladesh in the late 90s (Islam and Deegan, 2010). Therefore, HR4 was identified as one of the top five SPIs by the petrochemical industry in Malaysia.

The five indicators with the lowest ranking (in descending order) are presented below:

1. EN21a: Total wastewater discharge per unit product (0.0220)
2. LA2a: Rate of employee turnover by age group and gender (0.0197)
3. EN8a: Water consumption per unit product (0.0160)
4. EN22a: Total weight of waste per unit product (0.0124)
5. EN1: Materials used by weight or volume (0.0089)

The SPI will the lowest ranking was materials used by weight or volume with a global weight of 0.0089. EN1 is used by companies to report on the usage of material (cost of material flows) which contributes to the estimation of the cost of operations. The indicator is also used to track how much of the material used comprises renewable and non-renewable resources. For the petrochemical industry, as explained by the respondents, the feedstock (main raw material) originates from crude oil processing which is a non-renewable source. There are no alternative source from where the feedstock can be obtained. This being the case, material consumption will be expected to remain the same, or constant over a long period of time. Monitoring an indicator that is not expected to change does not provide any meaningful data and therefore this indicator was given the least preference from amongst the 18 SPIs.

The next lowest weight was given to EN22a which tracks the total weight of waste per unit product (0.0124). Data maintained on the quantity of waste generated is useful to ascertain if the company is actively pursuing initiatives on waste minimization. In addition, the data can also be used to indicate potential improvements in process efficiency and productivity. The cost of processing and/or disposal of waste contributes to the overall cost of operation. Although there is no specific definition of waste (liquid or solid) under the GRI 3.1, in the context of this research, waste is assumed to be solid waste. For the petrochemical industry, based on other studies, the largest proportion of their solid waste is spent catalysts which are used in the process which account between 65-70% of the total waste (Raouf et al., 2005). The remaining waste type include the spent catalytic drums, sludge from the wastewater treatment plant and reject products or reject intermediary products (Raouf et al., 2005; Abduli et al., 2007). This composition profile was verified by the research respondents. These solid waste streams are classified as scheduled waste or hazardous waste under the Environmental Quality (Scheduled Waste) Regulations, 2005 which needs to be handled and disposed at only authority-licensed facilities. At all the plants (100%), the spent catalyst is sold to catalyst recovery facilities within the country as well as overseas for regeneration and harvesting of the valuable metals and potential reuse whilst the reject products and intermediary products were reused back into the process as raw material/feedstock within the plants. Based on the feedback from the research respondents, over the past 5 years, none of the participating companies reviewed their process as part of waste minimisation initiatives. Studies by Raouf et al. (2005) indicate that generally petrochemical companies are not inclined to change their chemicals (used in the process) or processes and would rather manage the waste generated. One reason for this is the industry uses specialty chemicals that are not easily substituted without affecting the quality of the final product and process modification or improvement is not easily achievevable as it would be mean the technology of the process will require reassessment. Any process modification would also result in increased capital expenditure for new equipment or retrofitting existing equipment to accommodate the new process changes. The likelihood of these changes were determined by the respondents to be low as the petrochemical market is very much driven by demand and supply; and dependent on the oil and gas sector and therefore, such investment costs need very strong justification. Therefore, the respondents agreed that this SPI although a key indicator for waste management would not be suitable for the present time but can be re-evaluated with increased awareness and voluntary initiatives by the industry in the future.

The third lowest indicator was identified as EN8a: Water consumption per unit product (0.0160). Water consumption was not seen as an indicator that would be critical to monitor because presently there is no significant impetus for water minimisation in processes. This is largely due to the undisupted water supply at relatively low cost. There is currently a two-tier pricing system for piped water supply which is RM 2.07 (USD 0.48) for consumption below 35 m^3 and RM 2.28 (USD 0.53) per m^3 for consumption above 35 m^3. In developed countries like the US and much of Europe, the cost of industrial water is high as they practice increasing block-tariff system where users pay depending on the volume consumed. This system was introduced to encourage water minimisation and conservation. In the case of Malaysia, there is only a two-tier pricing system, the cost of piped water supply is comparitvely lower and this is also one of the reasons why manufacturing facilities from the US and Europe are established in Malaysia where the low cost of water supply is low and it reduces the overall operating cost (OECD, 2009). According to the United Nations World Water Development Report: Water for a Sustainable World (2015), globally, the industrial sector utilises 37% of primary global energy consumption and 19% for water withdrawals. In Malaysia, domestic and industrial water use roughly constitutes up to 25% of total water usage (Sukereman, 2014). Coupled with the low water tariffs, there is little incentive for industries to conserve water by implementing water minimisation initiatives. Therefore, this SPI was ranked lower in the list of the 18 selected indicators with the possibility that with time and changes in policy and regulatory drivers this SPI may be ranked higher.

The respondents concluded that for industries, their primary goal is profitability (bottom line) and with greater awareness on the importance of water resources and its depletion, policy intervention is required. The Government of Malaysia via the respective ministries will need to formulate policies which can be the foundation for the promulgation of laws on water reuse and the introduction of water conservation measures within industrial operations.

The fourth lowest rank was given to EN21a which represents total wastewater discharge per unit product. Monitoring of wastewater enables an organisation to monitor the impact of the discharge (the pollution loading) into the receiving water body as well as the operational cost relating to the treatment of the wastewater to meet the prevailaing regulatory requirements. As in the case of the indicator EN22a on the monitoring of waste, the same explanation exists where the petrochemical industry is less inclined to implement process modifications that would result in reduced wastewater generation. This indicator does however have a higher weight simply because prevailing regulations on wastewater discharge quality and discharge rate are regulated more stringently as compared to waste generation.

The fourth lowest rank was assigned to SPI LA2a which is for rate of employee turnover by age group and gender (0.0197). This is an important indicator but can be subject to influence from external factors not related to sustainability or the implementation of sustainable operations but more from an economic perspective. As with most countries in the developmental growth phase, in Malaysia, it is not uncommon to experience high employee turnover for various reasons. Based on a study by Sheehan & De Cieri (2014), the average turnover of the present generation of employees in the Asia Pacific region was 18 months as compared to four years of employees in previous generations. Further, statistics show that up to 50% of Malaysia's present generation of employees have been immigrating to neighbouring countries, namely Singapore and Australia. Most of these immigrants were once employed in Malaysian organizations (Choong et al., 2013). In a study by Queiri et al., 2014, the reason for the high turnover is not due to strategies developed by human resources but rather due to cultural and economic factors. Therefore, this indicator although an important indicator from a socio-economic point of view was not ranked high with respect to priority as an SPI as any changes in this indicator is not entirely a reflection of sustainability practices within the industry.

The fifth lowest rank was given to EN21a is a modified indicator which tracks the total wastewater discharge per unit product. The original indicator (EN21) only tracked the total wastewater discharge. This indicator monitors the discharge of effluents or process water to a facility for treatment which minimises the pollution loading into the environment and at the same time lowers the organization's financial costs and the risk of regulatory action for non-compliance with environmental regulation. Although all of the participating facilities (100%) monitor the flow rate of the discharge of their treated effluent, they however do not calculate the quantity of wastewater discharged per unit product which is a more meaningful indicator. Due to the lack of data, to start monitoring this data more time will be required. Therefore, although this is an important indicator, it was ranked the fifth lowest in this study.

4.3 Phase 3: Determination of a Suitable Assessment Framework

4.3.1 Alternative Frameworks Considered

In the preceeding section, the findings of the second phase of this research was discussed. The AHP was constructed as a hierarchical network to prioritise the SPIs with Level 1 representing the overall goal or objective of the decision-making, i.e.

prioritisation of the SPIs followed by Levels 2 and 3 that represent the indicator category and the indicators themselves.

For this last phase of the research, the AHP was constructed with an additional final level, i.e. Level 4 at the bottom of the hierarchy representing the alternatives. The objective of this last phase of the research was the selection of an appropriate sustainability production framework for use by the petrochemical industry in Malaysia. Therefore, the AHP model was revised with Level 1 now representing the overall goal of 'selection of a sustainable assessment framework', Level 2 and Level 3 were combined to represent only the indicator category and and Level 4 comprised the alternatives which were identified as follows:

- Lowell Centre for Sustainable Production (LCSP) Framework
- IChemE Sustainability Metrics

4.3.2 Assessment on the Alternatives

The two potential frameworks were selected from extensive review of literature on the subject but more importantly, they were selected by the 13 respondents based on (1) applicability to the Malaysian industrial sector, (2) relevance to the petrochemical industry as well as the (3) familiarity to the other stakeholders identified for the regulation and implementation of measures/programmes on sustainability in Malaysia. Although there were other similar frameworks available, the respondents were not conversant with the use of those frameworks and therefore they were not included.

The AHP methodology was used to determine the selection of a suitable framework between the two assessment framework shortlisted above. The criteria used for the selection of framework were the six categories of sustainability as expressed under the GRI 3.1, namely, economy, environment, labour practices and decent work, product responsibility, society and human rights. An example of one of the AHP model view for one of the 13 participating companies is presented in **Figure 4.8.**

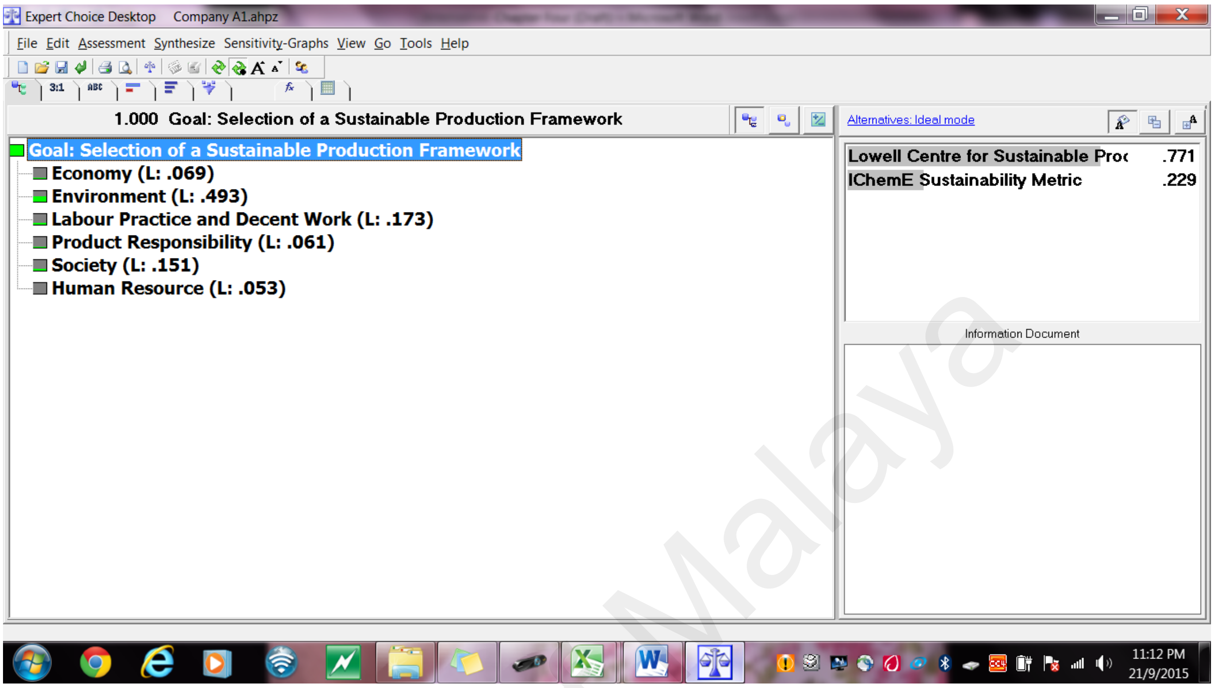


Figure 4.8: AHP model treepane view showing the selection of the alternatives

Based on the findings of the AHP analysis, the priority ranking of both the frameworks are presented in **Table 4.32** below.

Table 4.32: Alternatives Ranked According to Priority using AHP

Alternatives	Weight	Rank
Lowell Centre for Sustainable Production Framework	0.860	1
IChemE Sustainability Metrics	0.140	2

The Consistency Index (CI) calculated for the pair-wise comparison carried out with each of the 13 respondents in the selection of a suitable sustainable production framework was below 0.1 which is less than 0.1 or 10%. This indicates that the judgement of the 13 respondents with respect to the pair-wise comparison was consistent.

The final values in selecting the suitable framework was obtained by calculating the geometric mean of the priorities calculated for 13 the respondents. The use of the geometric mean to calculate the combined individual pair-wise comparisons is established in research involving AHP prioritization and ranking (Nagesha, 2005; Saaty, 1982).

The need for a suitable assessment framework to be used in conjunction with the 19 shortlisted SPIs in this study concurs with the Moneva *et al* (2006) who noted that the two key shortcomings of the GRI was that there is no requirement for independent verification of the selected SPIs and the different application levels which allow the organisations to selectively report on the indicators. In addressing these challenges, this research sought feedback from a pool of industry experts (in the form of the 13 EHS managers) and uses a framework in conjunction with the indicators to enable the industry to select indicators at appropriate levels reflective of the sustainability status of the industry.

The LSCP Framework was selected as the more appropriate framework for use by the petrochemical industry in Malaysia for the following reasons:

- Under the GRI 3.1 guidelines, sustainability performance indicators have been described under a total of six categories. The six categories include Economic (EC1-EC9), Environment (EN1-EN30), Society (SO1-SO8), Human Rights (HR1-HR9), Labour Practices & Decent Work (LA1-LA14) and Product Responsibility (PR1-PR9). Of these, there are core indicators and additional indicators. However, the GRI is solely a reporting framework which identifies up to 81 indicators (core and additional) but does not provide any guidance on how to select them and neither does the reporting framework describe how organisations can progressively benchmark their growth in achieving sustainable operations. The LCSP when used in conjunction with the GRI 3.1 enables the petrochemical industry to benchmark their sustainability performance.

- The definition of sustainable production is consistent with current understanding of sustainable development since it emphasizes environmental, social and economic aspects of an organisation’s activities. This definition is consistent with the current understanding of sustainable development, since it emphasizes environmental, social and economic aspects of firms’ activities. Specifically, the framework highlights six main aspects of sustainable production namely, energy and material use (resources), natural environment (sinks), social justice and community development, economic performance, workers and products. In the case of the IChemE, although the three elements of sustainability are present, the indicators identified under each of the three elements are not as extensive as the LSCP framework (*summarise and compare between the indicators in the LSCP and the IChemE*)
- The concept of having supplemental indicators in addition to the core indicators is provided as an option. This provides the flexibility to the industry to choose to include specific indicators that can be used to evaluate production-specific impacts.
- The 16 governing principles of the Business Charter for Sustainable Development have been embedded into the LCSP which was developed to assist industries track their sustainable performance. The LCSP’s six main aspects of sustainable production described earlier are based on the principles of the charter which were developed as a framework to assist the business sector (regardless of the type of industry) in implementing their respective sustainability strategies. The charter is relevant to industries in emerging markets as a common and accessible starting point.

- In the LCSP, the 5-level indicator system enables organisations to progressively assess their performance. This attribute is not found in any of the other frameworks described and it viewed by the research respondents as a critical attribute which is most useful in realising the sustainability objectives of the organisations. The framework allows organising existing indicators and developing new ones. The philosophy of the framework is that organisations need to begin with simple, easy to implement measures of compliance and resource efficiency and work towards more complex indicators which address environmental and social effects including supply chain and social/community impacts. In doing so, the framework does not recommend excluding the lower level indicators as it progresses forward but rather to include these indicators as well as they are important. For example, compliance with regulatory and industry standards (Level 1) is satisfying the fundamental premise of sustainable production. Similarly, monitoring or tracking the efficiency and productivity of an organisation is also vital for sustainability assessment. The respondents agree that the concept of having 5 levels within the assessment framework represent the five main steps in gearing towards becoming a sustainable industrial operation by moving in a stage-wise manner from the basic indicators to more sophisticated indicators. This 5-level concept proposed under the LCSP framework can be adopted to classify the shortlisted 18 sustainable production indicators:
    - ***Level One Indicators***: Evaluate the compliance status of the petrochemical facility with respect to prevailing regulations and industrial best practices/standards.

- ***Level Two Indicators***: Measure the inputs, outputs and performance such as emissions/discharges, by-products, wastes and training needs of the petrochemical facility.
- ***Level Three Indicators***: Assess the impacts of a petrochemical operation on environmental, health and safety of employees, health risks to the local community as well as the social economic impacts.
- ***Level Four Indicators***: Measure the production impacts of the petrochemical facility by examining the supply chain as well as the product distribution and disposal (encompassing the product life-cycle as much as possible).
- ***Level Five Indicators***: As the highest level of sustainability achievement, the indicators at this level demonstrate how a petrochemical plant's production process fits into the larger concept of a sustainability society. The indicators in this level measure effects of production on long-term quality life and societal development within the ecological carrying capacity.

In developing a framework which can be used by the petrochemical industry in Malaysia to measure their sustainability, the 19 sustainable production indicators which were identified in this research were assessed to see which level they would fall into as based on the five-tier concept defined in the LCSP Framework. **Table 4.33** lists the 19 indicators and their categorisation into the five levels.

Table 4.33: Classifying the 19 SPIs under the proposed five-tiers of the assessment framework

Level	Aspect of Sustainability	Sustainable Production Indicator
1	Economy	Nil
	Environment	EN28a: Number of EHS regulatory non-compliances
	Labour Practice and Decent Work	LA7a: Number of loss time injuries (LTIs)
	Human Rights	Nil
	Society	Nil
	Product Responsibility	Nil
2	Economy	Nil
	Environment	EN1: Material used by weight or volume
		EN3: Direct energy consumption by primary energy sources
		EN5: Energy savings due to conservation and efficiency improvements
		EN8a: Water consumption per unit product
		EN21a: Total wastewater discharge per unit product
		EN22a: Total weight of waste per unit product
	Labour Practice & Decent Work	LA2a: Rate of employee turnover by age group or gender
		LA10a: Average hours of sustainability training per year per employee by employee category
	Human Rights	Nil
	Society	SO2: Percent of business units analysed for risks related to compliance
		SO3: Percent of employees trained in anti-corruption policies and procedures
	Product Responsibility	Nil

Table 4.33: Continued.

Level	Aspect of Sustainability	Sustainable Production Indicator
3	Economy	EC6a: Percent of staff hired from the local community
	Environment	EN16: Total direct and indirect GHG emissions by weight
		EN23a: Number of incidents per year involving reportable loss of primary containment
	Labour Practice and Decent Work	Nil
	Human Rights	Nil
	Society	SO1: Percent of community programmes that communicate the impact of the operations on the community
	Product Responsibility	Nil
4	Economy	Nil
	Environment	Nil
	Labour Practice and Decent Work	Nil
	Human Rights	Nil
	Society	Nil
	Product Responsibility	PR1: Number of environment, health and safety elements included in the product life cycle assessment

Based on the findings of the research, under Level 1, two indicators have been identified each under Environment and Labour Practice and Decent Work respectively. The indicators pertain to the number of EHS non-compliance as well as the number of Loss Time Injuries (LTIs). For the Level 2 indicators, three out of the six elements of sustainability were represented. These include indicators under Environment, Labour Practice and Decent Work and Society. Under Environment, the 6 indicators represent material/resource, energy, water, wastewater and waste. This was perceived by the research respondents as being complete as it addressed the key facets of environmental issues arising from the operation of a petrochemical production facility. With respect to Labour Practice and Decent Work, a total of 2 indicators were identified and these assess employee turnover and sustainability training. A total of 2 indicators for Society were selected and these represent assessment of business risks and training provided to employees on anti-corruption policies. A total of 4 indicators fell within Level 3 and these include 1 indicator addressing the element Economy which addresses the hiring of locals from the community, 2 indicators on Environment which look at GHG emissions and incidents that result in the loss of primary containment and 1 indicator on Society which looks at community programmes on the impact of the petrochemical facility's operations. The remaining 3 aspects of sustainability, i.e. Labour Practice and Decent Work, Human Rights and Product Responsibility were not represented. Only one SPI fell under Level 4. This indicator represents the number of environmental, health and safety elements in the product life cycle assessment.

The 19 indicators identified in this study satisfy all criteria recommended under the LCSP except criteria No: 5 which is the use of both core and supplemental indicators.

Because the 19 indicators were developed specifically for the petrochemical industry, the need to have core and supplemental or additional indicators is not necessary. In the LCSP Framework, the methodology uses core and supplemental indicators where core indicators are a standard set of indicators that can be applied to any organisation. These indicators are simple with respect to data collection and include parameters which are readily measured, monitored and recorded by the petrochemical industry whilst supplemental indicators are those that are an open set and vary between companies/facilities. Supplemental indicators were introduced to address the challenge that not all production facilities have similar operations and a set of standardised indicators may miss out key impacts (Veleva and Ellenbecker, 2001a). Because in this research only the petrochemical industry was being considered and the assessment tool was to be used by industries within this sector to assess the sustainability of their operations at a plant level as well as be able to compare performance between industries, the use of supplemental indicators was not necessary as there would be no common basis for comparison.

The concept of the 5-tier level is essential for the production facility or the company to assess the level that they are at. For example, under the element Environment, the indicators fall within Level 1, Level 2 and Level 3 but are not found in Level 4 or 5. Hence, in improving the sustainability performance, the petrochemical industry should strive to monitor and incorporate indicators which fall within Level 4 which are indicators that address supply chain and product life cycle assessment. The effectiveness of the Level 1 indicators can be further strengthened to include indicators to cover the economic and social components of sustainability.

As the final step in the development of a suitable assessment framework, an eight-stop continuous loop model for measuring sustainability was developed. This loop is presented in **Figure 4.9.**

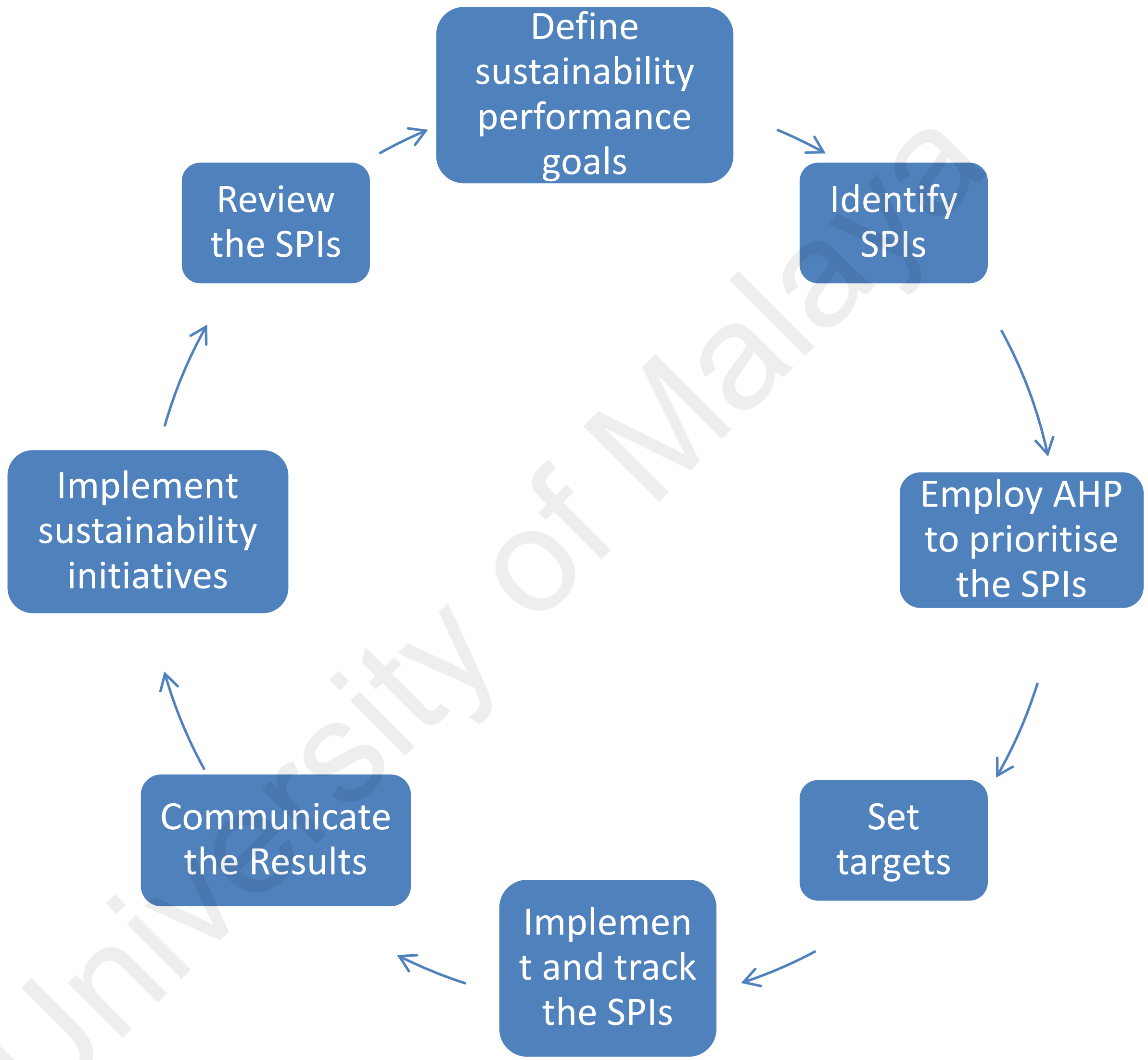


Figure 4.9: Continuous –loop model for measuring sustainability performance for the petrochemical industry

The first step involves the defining of sustainability performance goals and objectives which are aligned with the sustainability direction of the petrochemical industry both locally and globally. These goals should address key aspects of the industry's sustainability initiatives involving its stakeholders. This is followed by the second step whereby potential SPIs which reflect the goals are identified. The industry can use the 19 SPIs identified in this research as a starting point. The third step in this model involves the prioritisation of the indicators using the AHP method. The need to prioritise is critical as industrial facilities have limited resources in terms of operating costs, time and manpower. Hence, if these resouces are significantly constrained, the SPIs which have the highest priorities and influence on the sustainability goals of the organisation should be addressed first. The prioritisation process should involve key personnel within the industry, namely, the employees within the environmental, health and safety division who are responsible for the implementation of the sustainability initiatives. Top management participation and commitment is also important as they determine the allocation of resources. Further, other relevant departments within the organisation, for example, Human Resources, should also be engaged (GEMI, 1994). The benefits of having middle management and employees within the EHS division participate in the selection and prioritisation of the indicators include readily available data and increase commitment and accountability.

The fourth step involves setting specific targets for each of the prioritised SPIs. For example, to reduce the number of loss time injuries by 25% within a period of 2 years. This is in line with the concept of continuous improvement and ensures commitment from management. The fifth step is critical whereby it involves data collection, calculation as well as the interpretation of results. In ensuring the success of this step, the following will need to be considered, i.e. (1) type of information required (2) type of computer software that may be required to calculate certain data, for example the use of the Sangria software for the computation of greenhouse gas emissions (3) employees/department responsible to collect the data (4) any training that may be required for the employees involved and (5) methods to verify the data collected. The sixth step essentially involves the monitoring and communication of the data obtained. In ensuring the success of implementing SPIs, the seventh step becomes critical. Here management needs to take the necessary mitigation measures or corrective actions as part of their cleaner production and pollution prevention measures to ensure the established targets are achieved. The last step which completes the continuous loop is the periodical review of indicators to ensure they are still current and relevant to the industry. Where necessary, the SPIs may need to be replaced or modified in tandem with new goals and targets that the petrochemical industry may choose to adopt with the dynamic changes in the progress towards sustainable operations. To this end, the need for training is pivotal to increase awareness amongst all levels of the organisation and to keep abreast with recent advances in sustainability (Linnenluecke & Griffiths, 2010).

4.3.3 Testing the Framework for the Petrochemical Industry in Malaysia

In the final phase of the research, the SPIs identified from the research findings and their classification into the five-tier concept using the selected LCSP framework were then presented back to Company F which operates 6 petrochemical plants. This was carried out to test the tool for its approrpriateness and to obtain feedback or comments regarding the effectiveness of the tool as well as areas for improvement.

The one company that was selected for this pilot testing of the framework was Company F. This company was selected because it is a Malaysian company with petrochemical production facilities located within the country as well as globally making the company conversant with local requirements as well as progressive in terms of sustainable development due to its presence in other geographic regions and secondly, this company operates the most number of petrochemical plants (a total of 6) in Malaysia. The company's 6 production facilities are located spread out in 3 states in Peninsula (West) Malaysia and 1 state in East Malaysia. The EHS Managers at each of the facility (who were also the respondents for this research) are responsible for the environmental, health and safety matters as well as sustainability related initiatives at their respective facilities but collectively they report to the EHS Group Leader at Company F's corporate office in Kuala Lumpur. In obtaining feedback on the use of the framework from Company F, instead of reverting to the 6 EHS respondents, the researcher presented the identified SPIs, the priorities as well as the framework to the EHS Group Leader. Being the lead or the decision-making person for Company F on the sustainability related matters, and having an overall understanding of the environmental, social and economic issues for each of the 6 production facility and the direction of the company towards implementing sustainable production measures, the group leader was identified as the best person to provide feedback.

With respect to experience, he has worked in the oil and gas industry for more than 25 years and has been in the current position for the last 5 years. Therefore, he was conversant with industry's expectations and long-term aspirations with respect to sustainable operations. The challenges and the areas where the implementation of sustainability initiatives are needed to improve the industry's targets are well-known to him.

The salient points derived from the outcome of the interview with the Group HSE Leader of Company F are summarised below:

- The shortlisted SPIs are aligned with the aspects of sustainability that the petrochemical industry is pursuing. Specifically, the SPIs identified in this research are the target indicators for Company F and therefore would be relevant to the rest of the facilities across the industry.
- The use of the 5-tier concept adopted from the LCSP framework is apt for the industry because unlike standard frameworks which are 1-dimensional where it involves only the tracking of the number of indicators, the 5- tier concept allows for the organisation to categorise the indicators into 5 levels, representing from the most basic level to the highest level which the industry should strive to do.
- On the approach and methodology for the identification of the SPIs, he opined that the methodology described under Phase 1 and Phase 2 of this research as described under Sections 3.2 and 3.3 respectively can be replicated with a satisfactory level of consistency to update the SPIs as well as their ranking using the AHP method. This will be necessary because the changes in concepts pertaining to sustainable production processes are dynamic and with the changes in the international scenario as well as the regulatory scenario in Malaysia, there will be a need to update the SPIs. He indicated that for the petrochemical industry, judging from historical trends in sustainable production initiatives, a minimum timeline of 5 years for the review of the current set of SPIs is reasonable. One of the charateristics of a sustainable

development indicator is to ensure that it is broad enough to adaptable to changes that will evolve in efforts undertaken to achieve sustainability. Hence, there is a need for indicators to be reviewed periodically (United Nations, 2007). He further added that the selection of a tool that is reliable whereby it can be used repeatedly with ease without losing consistency is essential and agreed that the approach and methodology proposed in this research is reliable.

- The continuous-loop model which has been developed as part of this research was noted to be practical and in line with the principles of ISO 14001 as well as ISO 9001 and therefore can be implemented in an integrated manner.

As recommended by Van Oers and Roders (2014), the insights gains from studies similar to this research should be incorporated into policies and/or actions that would enable the petrochemical industry to optimise their performance by focusing on the indicators that are most relevant to the industry as they progress towards sustainable production. Further, sustainability should be regarded as a journey where there is continuous improvement with time and not a fixed destination (Hogevold and Svenson, 2012). There is a need for companies to manage their own related business network's impact on life and the ecosystem as a whole (Svensson and Wagner, 2015).

CHAPTER 5: CONCLUSION

5.1 Conclusion of the Research

The objective of this original research was to develop a tool for the assessment of sustainable production in the Malaysian petrochemical industry.

Based on the research methodology that was developed, a total of 19 SPIs were shortlisted from the 81 GRI 3.1 performance indicators representing the economic, environmental and social components of sustainability. These 19 SPIs were then prioritised using the Expert Choice® Computer Software which is based on AHP, a well recognised MCDM tool, to understand which of these indicators had the highest impact on sustainability within the petrochemical industry. By understanding the importance of these SPIs, the petrochemical industries can then effectively channel their resources and develop their sustainability strategies around these SPIs.

To track the progress of the petrochemical industry, the 19 indicators were integrated into an established assessment framework, the LCSP Framework. The framework is composed of five tiers or levels (representing the entire product lifecycle) to enable petrochemical companies to begin with indicators which can be easily implemented, e.g. indicators relating to regulatory compliance and resource efficiency (Level 1) and move upwards towards indicators that are more complex under Level 4 and 5.

This research has established a clear and transparent process to enable the industry to identify SPIs most relevant to the industry and to enable the industry to track its progress towards sustainable production processes. In future, under the impact of external factors that would influence the type of SPIs as well as their ranking, e.g.

changes in domestic regulatory policies, more advanced research in sustainability as well as the introduction of more innovation technologies, the petrochemical industry can duplicate this process to identify SPIs most relevant to the industry and continue to track their progress towards sustainability.

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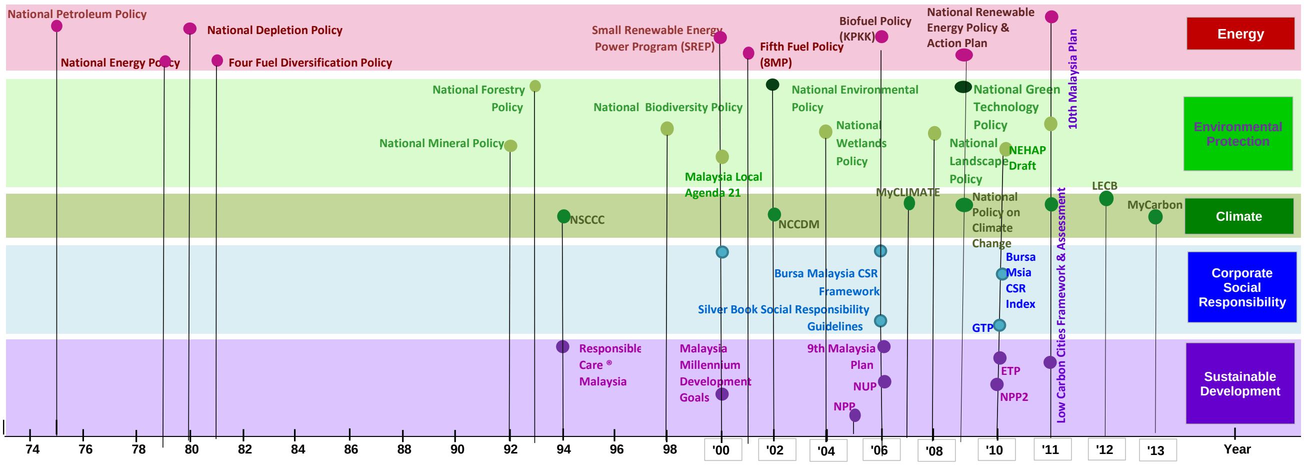

Figure 2.4: Government initiatives towards sustainable development

ETP	Economic Transformation Programme
GTP	Government Transformation Programme
LECB	Low Emission Capacity Building
MyCarbon	National Corporate Greenhouse Gas (GHG) Reporting Programme
MyCLIMATE	Malaysia Network for Research on Climate, Environment & Development
NCCDM	National Committee on Clean Development Mechanism
NEHAP	National Framework (Policy) on Environmental Health
NPP	National Physical Plan
NPP2	2nd National Physical Plan
NSCCC	National steering Committee On Climate Change
NUP	National Urbanization Plan