THE IMPLICATIONS OF ENERGY TRANSITION ON SUSTAINABLE SUPPLY CHAIN MANAGEMENT PRACTICES IN THE OIL AND GAS INDUSTRY

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Abstract

The oil and gas (O&G) industry is increasingly pressured to manage its supply chain sustainably due to the negative impact of its activities and products on the environment and society. Unsustainable exploitation of the O&G has also led to concerns about its future availability, thus the security of energy supply. These issues resulted in the call for the transition to an energy system that favours low carbon and renewable sources. The O&G are expected to respond to these pressures by developing strategies that could enhance its competitiveness and compatibility with the future energy systems. As yet, little is known about the strategies especially with regard to sustainable supply chain management (SSCM) aspects. Therefore, this study aims to add to the discussion by focusing on understanding the implications of energy transition to SSCM practices in the O&G industry. It employs content analysis of sustainability reports of 30 O&G companies. The findings indicate that although 18 companies are involved in the research and development of alternative energy, the main focus is on developing unconventional O&G to increase fuel supply bases. In addition, among the alternatives, biofuels is the most preferred energy option due to its compatibility with the companies' existing business and infrastructure. Overall, there are considerable limitations in the discussions of the SSCM strategy in the reports. We find that the sustainability of the unconventionals' production processes received more attention than supplier and logistics management. The strategies for sustainable supply chain of the alternatives, except for biofuels, are hardly discussed or absent from the report. The findings could be useful to industry practitioners in decision making processes to improve existing SSCM practices during the transition, and to academics to identify areas for further investigations.

Keywords: *Energy transition, Sustainable supply chain management, Oil and gas industry*

1.0 Introduction

The world's economic development is powered by fossil-based energy, especially the oil and gas (O&G). The global consumption of energy is projected to grow by 37% between 2013 and 2035, where approximately 55% of it will come from the O&G sources (BP, 2015). Our dependency on the O&G has raised sustainability concerns due to the impacts of its exploitation such as carbon emissions and community displacement. In addition, the O&G are finite resources that could threaten the security of energy supply in the future. These issues spurred the call for the transition to an energy system that favours the development of alternative energy with low carbon content that can be produced from renewable sources such as wind, biomass and solar.

The current evolution process from high carbon to low carbon energy is very slow due the cost and technological limitations of the alternatives (Jiping, 2010). Fouquet (2010) suggests that the O&G industry will react to the transition by increasing its competitiveness and the response will be unprecedented in the history of energy transition. Present energy transition studies focus on viable energy options that could replace the O&G in the future and the management of the transition process (D'Alessandro et al., 2010; Kemp, 2010). However, little is known of the implications of the transition to the O&G industry supply chain practices. A lot of O&G companies such as Shell and Total are involved in the development of alternative energy to address pressure for the transition and for more sustainable practices. The impacts of this move on their sustainable supply chain management (SSCM) strategy are underexplored.

This study, therefore, aims to address the gap in order to understand the implications of the energy transition to SSCM practices in the O&G industry. It employs content analysis of sustainability reports of 30 O&G companies. The reports could shed some lights on the companies' stand about issues related to the energy transition, its associated challenges and the SSCM strategies used to overcome them. The content analysis addresses the following questions:

1. To what extent is energy transition being discussed in sustainability reports of O&G companies?
2. What are the types of energy currently being developed by the companies?
3. What are the SSCM strategies used to ensure sustainable development of the energy?

The outline of this paper is as follows. Section 2 reviews the literature related to SSCM practices in the O&G industry and energy transition. It is followed by Section 3 that describe the methodology used to achieve the aim of this study. Section 4 discusses the findings of the analysis. Finally, Section 5 concludes the paper by highlighting the main findings and presenting the implications to practice as well as future studies on the topic of energy transition in the O&G industry.

2.0 Literature Review

Various studies have been conducted to understand and to improve supply chain management practices in the O&G industry. However, the earliest studies that incorporate sustainability aspects were only published in 2007. These studies are on waste management in refinery supply chain (Lakhal et al., 2007) and the integration of corporate social responsibility in O&G supply chain management (Midttun et al., 2007). Other sustainability issues that were studied since include green supply chain management (Deng & Liu, 2011), life cycle analysis in the decommissioning process of oil platforms (Lakhal et al., 2009), closed-loop green supply chain (Li & Jianming, 2009), regulatory compliance related to environmental and social risks of O&G development (Wagner & Armstrong, 2010) and risk management in supply chain (Cigolini & Rossi, 2010). Naturally, these studies focus solely on the strategies related to the O&G development. As far as we know, no study has been conducted to explore the impact of energy transition on SSCM practices in the O&G industry.

Transition is defined as changes that occur when the structural character of society or its complex sub-system transforms through a gradual and continuous process of societal change (Martens & Rotmans, 2005). Another definition of the transition view the process as sociotechnical change through multi-level perspective, thus implies transition as changes from one sociotechnical regime to another (Geels & Schot, 2007). Therefore, transition studies involve understanding the interaction between various actors, societal, technological, and institutional factors. As these factors have their own interest and limitations, it influence and co-evolve with each other that results in system transformation.

The multi-level perspectives of the transition suggest that the macro level of the sociotechnical landscape of energy system comprises of material and immaterial elements in which regimes and special niches exist (Kemp, 2010). The sociotechnical regimes are the heart of transition because changes in the regimes will consequently transform the whole sociotechnical system (Kemp, 2010). The current energy system regime is dominated by fossil fuels, especially the O&G industry, that gives them the ability to guide decision making and direction of energy market.

However, the O&G regime is currently pressured by forces in the sociotechnical landscape such as political forces, regulations, and society to operate sustainably and to reduce the negative impacts of its operations and products on the environment. In addition, it is also experiencing uncertainty caused by economic instability and dwindling O&G reserves. Therefore, these factors have resulted in an ‘opening’ in the regime that encouraged the development of niches of alternative technology. Regime actors will usually increase their competitiveness through non-disruptive system improvement instead of system innovation to address this threat (Kemp, 2010). For example, the O&G industry is trying to increase the efficiency of its products as well as adopting various environmental protection measures such as waste management and reduction of gas flaring. In addition, it is also developing innovative technology to explore and produce unconventional sources of O&G. Therefore, the ability of the alternative niches to break into the current energy regime and change it lies at the rate of its development as well as the landscape push towards sustainable development.

Transition is a long and complex process because regimes that are stable will resist fundamental change (Raven, 2007). The stability can be attributed to supports from institutional structure, societal values and culture, and technologies that create path dependency in the regimes (Raven, 2007). Therefore, when a regime is established, it often results in incremental change or innovation to improve the regime that will consequently contribute to development of specific technological path which could effectively prevent other alternatives to be developed (Raven, 2007). Examples of such lock-ins are electricity grids which are mainly based on fossil fuels (Raven, 2007) and gas pipelines that transcend the national and continental boundary. Therefore, the technological lock-in can be one of the crucial factors in decision to pursue low carbon energy system. Various investments have been made by governments and O&G players to facilitate the development based on the sources of energy. Thus, future directions might be determined by the effectiveness and commitment of the major players and stakeholders in ensuring a successful transition.

According to Farrell and Brandt (2006), an oil transition, from conventional to unconventional sources, is currently happening in the O&G industry due to declining conventional O&G reserves and increasing difficulty to access them. There is also a growing debate about the shift in energy business where the majority of O&G reserves are being controlled by national O&G companies (NOCs) that has forced international O&G companies (IOCs) to explore the unconventional sources (Edwards et al., 2010; Wolf, 2009). Unconventionals are O&G that can be found in unconventional sources and from unconventional places such as deepwater and the Arctic (Ziegler et al., 2009). Therefore, it includes oil from coal and shale, extra-heavy oil and bitumen, heavy oil, deepwater O&G, polar O&G, natural gas liquids from gas-plants, and unconventional gas such as tight gas, coalbed methane and hydrates. These sources are also called unconventional due to the complexity in bringing the reserves to surface that requires the use of multiple technologies (ExxonMobil, 2010).

Oil transition is not a transition from abundant to scarce sources of oil, but a transition to high quality to lower quality resources (Farrell & Brandt, 2006). The main challenge in the transition is to manage: (1) economic risks to consumers and investors, (2) environmental risks, and (3) strategic risks related to access to oil reserves and supply disruptions (Farrell & Brandt, 2006). Greene et al. (2006) note that carbon emissions and dominance of oil market by the NOCs would continue to be a problem even if the transition happens efficiently. Therefore, IOCs are more likely to diversify their businesses by developing the alternative energy to increase their supply bases and competitiveness in the energy market, as well as to address the sustainability pressure (Edwards et al., 2010).

The main economic driver of the energy transition is the opportunity to produce cheaper or better energy service (Fouquet, 2010). The feed stocks of the alternative energy can be obtained from sources which are abundantly available such as solar, wind, hydro and plants. Therefore, the cost of their development could be cheaper than the O&G. In addition, these alternative sources offer better energy service in terms of carbon emissions. However, the viability of the alternative energy is limited and questioned in the long run until considerable technological progress is achieved, which is currently very slow and cost intensive (Lior, 2010). Nevertheless, the alternative energy, i.e. hydro, nuclear and renewable energy including biofuel, will account for about 20% of the energy share in 2035, where the renewables are projected to gain the most rapid share from 3% today to 8% (BP, 2015).

As one of the major players in the energy sector, the O&G industry will be affected by the transformation of the energy system due to the transition to low carbon energy (Edwards et al., 2010). They have the option to continue doing what they do best, which is to explore and produce O&G, but risks running out of business in the long run (Savitz & Weber, 2007). Or they could be involved in the cleaner energy race, by exploiting their expertise and technological advances in energy development, to remain resilient during the transition and ensure business longevity. It is, therefore, interesting to study the strategies that the O&G companies develop to respond to the energy transition. We aim to add to the discussion on the strategy by focusing on SSCM aspects of the transition by exploring this issue through content analysis of sustainability reports of O&G companies, which we will explain in the next section.

3.0 Methodology

Content analysis is a widely used method in various field of business research such as strategy and organizational behaviour, but less so in operations and supply chain management where it is employed in fewer than one percent of studies published between 2002-2007 (Tangpong, 2011). This method allows researchers to analyse data from various sources of text and especially advantageous in terms of accessibility of data sources due to its unobtrusive nature. Publicly available documents such as sustainability report offer rich source of secondary data that could help us understand how companies address the pressure to operate sustainably in supply chain (Tate et al., 2010). The use of the data sources that are obtained directly from the industry could also offer supply chain implications which are of more practical and managerial relevance for its applications in the industry context (Rabinovich & Cheon, 2011).

Table 1: List of companies selected according to listings

<table>
<tr><th></th><th>Dow Jones Sustainability Index</th><th>Platts Top 250 Global Energy Company</th><th>World's Largest O&G Company</th></tr>
<tr><th rowspan="4">Company name</th><td colspan="3">Repsol, Petrobras, Ecopetrol, BG Group, Eni, Statoil, Total</td></tr>
<tr><td colspan="2">MOL, Sasol</td><td></td></tr>
<tr><td rowspan="2"></td><td colspan="2">Hess, Exxon Mobil, BP, Shell, Occidental, Gazprom, Chevron, Rosneft, Lukoil, PetroChina, Suncor</td></tr>
<tr><td>CNPC, TNK-BP, Marathon Oil, Gazprom Neft, OMV, Husky Energy and Galp Energia</td><td>Saudi Aramco, ADNOC and Petronas</td></tr>
</table>

This paper is part of a larger content analysis study that was conducted to assess sustainability reporting practices in O&G industry and the integration of sustainability in its supply chain management practices (Wan Ahmad et al., in press). The sustainability reports of 30 O&G companies were used to collect the data needed for the study. In this paper, we focus our discussions on the implications of energy transition to SSCM practices in the industry.

The O&G companies chosen for the study, as shown in Table 1, were identified using three listings namely Dow Jones Sustainability Index (DJSI), Platts Top 250 Global Energy Company (Platts) and world's largest O&G companies ranking published by O&G Journal (OGJ). They were selected using purposive sampling method to ensure that the companies included in this study are industry leaders in terms of sustainability and financial performance, as well as those that are among the largest in the industry. The latest sustainability reports available were used that comprise of reports from the year 2009 (two companies), 2010 (25 companies) and 2011 (three companies).

Table 2: The keywords used in this study

Topic	Keyword
Energy transition	Transition, shift, diversif*,
Types of energy	Conventional, renewable, alternative, new energy
Unconventional oil and gas	Oil, petroleum, gas, shale, coal seam gas, coalbed methane, heavy oil, oil/tar sands, bitumen
Renewable / alternative energy	Bio*, solar, wind, geothermal, nuclear, hydro
Sustainable supply chain	Suppl*, network, transport, distribution, logistics, production

We searched for statements that could help us identify patterns in the discussion on energy transition and SSCM in the reports. Table 2 shows the keywords that were used in the content analysis according to their categories. This study focuses on two types of transition that are currently happening in the O&G industry: (1) transition to the development of unconventional O&G sources, and (2) transition to the development of alternative energy sources. Accordingly, all statements related to the supply chain management practices of these energy sources were analyzed. To perform the analysis, simple counts of the number of times the keywords appear in the reports were conducted (Rabinovich & Cheon, 2011). In addition, we analyze the inferences made in the use of the keywords to uncover their interrelationships that could help us achieve the aim of this study. The next section discusses the results of the content analysis.

4.0 Results and discussion

Following are the results of the content analysis that we will discuss according to the questions posed earlier in the introduction section.

4.1 The extent of energy transition discussions in the sustainability reports of O&G companies.

The analysis of the sustainability reports reveals that “energy transition” is an issue that attract considerable interest among the companies where it was mentioned explicitly by eleven of them. Energy transition is one of the most important issues for stakeholders of two of the companies based on the results of their materiality study. The study is part of the voluntary sustainability reporting practices recommended by the Global Reporting Initiatives (GRI) to identify issues that should be addressed in the report. Material issues include those that could affect company ability to create, preserve or erode economic, environmental and social values and performance of the company, its stakeholders and larger society (GRI, 2015).

Generally, the discussions on the energy transition in the reports are not that extensive and are mainly focused on strategic aspects. This could be due to the wide range of issues that a company should disclose related to its commitment towards and performance in sustainable economic, environmental and social development. The O&G sector guidance for sustainability reporting version 3.0 by GRI and the voluntary reporting guidelines by International Petroleum Industry Environmental Conservation Association (IPIECA) were used, respectively, by 83% and 57% of the O&G companies studied. These guidelines do not contain indicators specific to energy transition. However, they include issues that could be used to understand O&G company strategy in dealing with energy security and climate change. These are the fundamental drivers for transition towards energy system that favours low carbon and renewable energy sources.

The voluntary nature of the sustainability reporting results in reports that differ greatly in terms of its coverage. Nevertheless, considering all the reports included in this study as a whole, we identify three main issues related to energy transition as follows:

(1) challenges in the transition to low carbon energy systems,
(2) strategic management of the transition
(3) the role of natural gas in the transitional phase from high carbon to low carbon energy systems.

Energy transition requires a balanced approach in the development of energy options that could address the environmental problems caused by carbon-intensive fossil fuel. Therefore, the O&G industry is facing tremendous challenge in balancing the needs to address increasing energy demand and economic development against the concerns related to unsustainable energy exploitation and climate change (ADNOC, 2011; BP, 2011; ExxonMobil, 2011b). Concerted efforts by all energy players and institutional actors are necessary to ensure that the energy policies developed to facilitate the transition would not disrupt economic and social development, while able to address the impact of energy development and use on the environment.

As many O&G companies are government-linked, they often play a crucial role in ensuring energy security of their home countries. Therefore, energy transition issues related to safeguarding of national interest were also discussed in the reports. Sasol, for example, stresses that the local context and the socioeconomic development needs of emerging economies must be considered, in order to develop public policies that are economically efficient and facilitate fair cost sharing so as not to hinder their competitiveness (Sasol, 2011). Overall, the discussions focus on how the companies could contribute to the security of future energy supply, specifically through: (1) expansion of current O&G development infrastructure and reserves, (2) development of energy efficient technologies, (3) diversification of business portfolio to include alternative energy.

One of the main concerns among the O&G companies during the transition is their exposure to the risks from legislative and regulatory requirements related to carbon emission reduction measures (BG, 2011; Hess, 2011; Repsol, 2011). The involvement of various governments in the development of national, regional and sector-based carbon regulations could eventually form a global carbon market (Shell, 2011). This would:

(1) encourage the adoption of energy technologies and use of energy sources that are faster and less costly to implement,

(2) discourage governments from giving preferential treatment to technologies that need support from subsidy, and
(3) incentivize the development of commercially viable technologies that could reduce carbon emissions.

However, these regulatory measures and the related international agreements are evolving at different phase and timing (ExxonMobil, 2011b; Petrobras, 2011). Therefore, it is difficult to predict their impact on the O&G business, which could discourage companies from investing in energy and emission reduction measures to address climate change (ExxonMobil, 2011b; Hess, 2011).

In order to facilitate the development of the alternative energy, institutional support in the form of various fiscal, taxation and other instruments are introduced such as green certificates, subsidies, tax exemptions and loans (Roy et al., 2013). While the O&G companies studied are supportive to the use of these incentives to stimulate the development of the energy, the general sentiment is that the policies should not be at the expense of the O&G industry ability to compete. The imposition of the fiscal or taxation measure to reduce the use of O&G and to promote the renewable energy may create market opportunities for the renewables, but it may also affect the oil market negatively (Petrobras, 2011).

BP suggests that governments should provide limited transitional support that is sufficient for the development and early deployment of the low carbon technologies, and not as ongoing subsidy to reduce emission. The support should only be provided to emerging technologies that can contribute towards significant carbon reduction and economically viable for commercial development (BP, 2011). Although these are valid concerns, the O&G industry, as the incumbent major source of energy, has the advantages in terms of technological and market infrastructure that could help maintain their competitiveness. The renewables, on the other hand, need these supports because market forces alone are insufficient to create the momentum and incentives for their deployment and for the transition to low carbon energy system (Roy et al., 2013).

Not every company that we studied explicitly discussed its strategy in dealing with the energy transition. Nevertheless, the aspect is present in the discussion on issues related to climate change and energy security. MOL, for example, conducted an impact assessment study to identify the risks and opportunities that are present during the transition. Based on the results of the study, the company will focus on improving energy efficiency and expand its involvement in the development of renewable energy (MOL, 2011).

Generally, the O&G industry believe that they could contribute towards the achievement of sustainable energy systems through deployment of more energy efficient technologies both in the development of O&G and the fuel that they produce. In addition, approximately 57% of the companies are involved in the development of alternative energy. Hess (2011) suggests that diverse mix of energy products must be available during the transition phase. Involvement in the alternatives could help O&G companies green their supply chain, consequently transition themselves to be more compatible with low carbon energy future. Ultimately, energy transition provides new business opportunities for the companies to cater for the growing niche of sustainable energy market. The O&G companies could also exploit their expertise to develop alternative energy technologies that could benefit from the economies of scale of and integration with the existing energy infrastructure (Szklo & Schaeffer, 2006).

Even though tremendous efforts are being put into advancing the energy transition, it is a complex process that will take decades to complete. The O&G industry stress that natural gas will play a critical role during the transitional phase from high carbon to low carbon energy systems (BP, 2011; Chevron, 2011; Shell, 2011). Natural gas is a cleaner energy option compared to other fossil fuel due to its lower carbon content. About 40% of the world's energy is currently generated from coal, which when replaced with the natural gas could reduce approximately 50% of the carbon emission from power generation (Total, 2011). Furthermore, it has the advantage over other low carbon energy due to the widely available technologies that are needed to produce the energy (Shell, 2011); therefore, less costly to be deployed (Shell, 2011). The market for natural gas is also becoming global since advancement in the natural gas production and transportation technologies as well as the introduction of products based on gas-to-liquid (GTL) technology facilitate its growth (Gazprom, 2010).

The next section will further discuss the energy transition issue specific to the two types of energy currently being developed by the O&G companies, namely unconventional O&G and alternative energy.

4.2 Types of energy being developed by oil and gas companies

The development of unconventional O&G and alternative energy were reported by 80% of the companies studied. The discussions generally focus on strategic issues related to company progress in the development of the unconventional O&G and alternative energy, the advantages of the resources to enhance company position in the market and for energy security, as well as the challenges and risks involved. Table 3 shows the types of energy that are reported by the companies – approximately 60% and 67% of the companies discussed about the development of unconventional O&G and alternative energy, respectively.

Table 3: O&G company involvement in unconventional O&G and alternative energy

	Unconventional O&G				Alternative energy					
Company	SOG	CBM	HOI	OTS	BIO	SOL	WIN	GEO	NUC	HYD
ADNOC										
BG	x	x								
BP	x			x	x	x	x			
Chevron					x	x		x		
CNPC	x	x	x		x			x		
Ecopetrol			x		x	x	x	x		
Eni	x		x	x	x	x				

ExxonMobil	x	x	x	x	x					
Galp					x	x	x			
Gazprom		x			x					
Gazprom Neft	x			x						
Hess	x				x					
Husky			x	x						
Lukoil			x		x	x	x	x		x
Marathon	x			x						
MOL	x		x	x	x			x		
Occidental										
OMV					x	x	x			
Petrobras	x				x					
PetroChina	x	x	x	x	x	x	x	x		
Petronas										
Repsol	x				x		x	x		x
Rosneft										
Sasol	x				x	x				x
Saudi Aramco						x	x	x		
Shell	x	x		x	x		x			
Statoil	x		x	x			x			
Suncor				x	x		x			
TNK-BP			x							

Total	x	x		x	x	x			x	
Total	16	7	9	12	19	12	11	8	1	3

* Shale O&G/tight O&G (SOG);coal seam gas/coalbed methane (CBM); heavy oil/extra heavy oil (HOI); oil/tar sands/bitumen (OTS);biofuel/biogas/biomass (BIO); solar (SOL); wind (WIN); geothermal (GEO); nuclear (NUC); hydroelectric (HYD)

The content analysis reveals that shale/tight O&G (SOG) is the most discussed unconventional sources in the sustainability reports of the companies studied. The development of this source of energy, specifically shale gas, is experiencing rapid growth that has caused a shale revolution in the United States, and is set to making the country energy independent (Wang et al., 2014). It has also been dubbed as a game changer that could transform the economics of electricity generation (Hess, 2011). Apart from shale O&G, oil/tar sands/bitumen (OTS) is also discussed quite considerably beyond the strategic issues. The discussions on issues related to production process and risk related to their exploitation are more comprehensive compared to the discussions on coal seam gas or coalbed methane (CBM) and heavy oil (HOI).

Generally, we found that eight companies did not disclose if they are involved in the development of any of the unconventional O&G sources. Further analysis show that five of them are NOCs. In addition, three of the companies are among the five largest in the world in terms of reserves holding, namely Saudi Aramco (first), ADNOC (second), and Rosneft (fourth). Overall, 13 companies are developing at least two types of unconventional sources – five of the companies are NOCs, specifically China National Petroleum Company (CNPC), Gazprom Neft, MOL, PetroChina, and Statoil.

The results of the analysis of the O&G company involvement in the unconventional O&G could support the suggestion that IOCs are more likely to explore the resources (Edwards et al., 2010). The O&G industry is highly competitive business due to increasing difficulty in accessing reserves where approximately 80% of the world's O&G supplies come from just three areas, that is Russia, the Persian Gulf and West Africa (Xu, 2008). The five largest O&G companies are NOCs that control about 62% of world's oil reserves (PetroStrategies, 2012). The IOCs are generally more technologically advanced than the NOCs and possess the technical know-how to develop the unconventional O&G (Edwards et al., 2010). Therefore, increased competition will force the IOCs to develop the unconventional sources which are outside of NOCs control (Kjärstad & Johnsson, 2009; Mitchell & Mitchell, 2014). The production of unconventional resources could also help in rebalancing the control of O&G reserves between NOCs and IOCs (Eni, 2011).

With regard to the alternative energy, 16 companies are involved in the development of at least two types of the alternatives. Overall, 10 companies gave no indication of their involvement in the development of the energy. Among the companies are ADNOC and Rosneft, which are the only two companies in the top ten largest studied that do not discuss about the alternative energy in their reports.

As shown in Table 3, biofuel (BIO) is the most discussed alternative energy among the companies due to the compatibility of its development with the available O&G infrastructure and technology. According to Total (2011), biomass is the only alternative energy that could supplement the supply of fossil fuel. For example, the fossil fuel can be blended with oil produced from vegetable and animal fat for transportation and electricity generation (Petrobras, 2011). The sulphur content of diesel can also be reduced when mixed with biofuel, which could consequently improve its quality (Ecopetrol, 2011).

The involvement of O&G companies in biofuel is mainly driven by the need to comply with government mandates for the blending of diesel with biofuel to reduce carbon emission (Oberling et al., 2012). Biofuels could also help the companies that are facing dwindling O&G reserves to diversify their fuel supply bases, while taking into consideration the technological lock-ins related to energy development and use (Oberling et al., 2012). These findings are consistent with the factors disclosed by the O&G companies as crucial for their involvement in alternative energy. The companies seek to invest in the energy sources that can be integrated into the current business and areas of operations so that they could exploit the resulted synergies to enhance their competitive advantage in the market (OMV, 2011; Repsol, 2011; Sasol, 2011).

Therefore, it is not surprising to discover that the discussions about the alternative energy are concentrated on the biofuel. Perhaps with the exception of solar and wind, the other alternative energy, i.e. geothermal, nuclear and hydroelectric, are marginally mentioned in the sustainability reports. Overall, we discover that 18 companies are in planning and/or conducting research and development activities to explore the potentials of the alternative energy. In addition, 11 companies disclosed that they have formed partnership with other energy companies or research institute, or have acquired other companies to facilitate their development of the alternative technologies. For example, Repsol acquired a company that promotes alternative energy projects (Repsol, 2011), and Total acquired a start-up company involved in developing purified silicon for solar power (Total, 2011).

In the next section, we will discuss the strategy that the O&G companies used to address the pressure to operate sustainably throughout their supply chain as they transition towards low carbon energy system.

4.3 Sustainable supply chain management strategy of O&G companies

Issues related to the sustainability of supply chain management practices are discussed by approximately 73% of the companies studied. Naturally, the discussions are concentrated on the O&G supply chain, and less so on the alternative energy. In this study, we focus on three supply chain functions namely supplier management, production management and logistics management to understand the strategy that the O&G companies used in integrating sustainable practices in the development of the unconventional O&G and the alternative energy. Table 5 and Table 6, respectively, summarize the results of the content analysis for the unconventional O&G and the alternative energy.

Table 5: The strategy used to ensure sustainable unconventional O&G supply chain

Types	Supplier management	Production management	Logistics management
SOG	• Discussion with vendors & contractors: - Disclosure of hydraulic fracturing chemicals; - Preference for more environmental friendly additives.	• Water management: - Build water treatment plant; - Protection of water layers at different depths; - Reduce freshwater consumption; - Re-use wastewater of other industries for production; - Recycle produced water; - Lining wells with multiple steel and concrete barriers to prevent water contamination. • Waste management - treat and/or dispose by-products according to local, state & federal regulations.	• Use pipeline network to transport water: - Reduce traffic and road deterioration; - Reduce the need for pits to temporarily store water.
CBM	n/a	• Water management – treat produced water before re-use or disposal.	n/a
HOI	n/a	• Water management – recycle wastewater.	n/a
OTS	• Use local supplier	• Water management: - Use underground water aquifers or non-potable water to generate steam; - Use water storage system; - Treat and recycle wastewater. • Production process: - Improve process efficiency to reduce life cycle GHG emissions; - Use in situ (underground steam injection) technology that has smaller footprint than mining. • Energy management: - Use cogeneration to reduce energy requirements and generate energy; - Use natural gas to generate steam. • Management of tailing: - Use dry tailings for land reclamation; - Operate radar based system to detect and prevent migratory birds from landing on ponds used to store tailings; - Continuous monitoring, assessment and management to protect ground and surface water.	

Based on the results shown in Table 5, it is apparent that issues related to the sustainability of unconventional O&G production process received more attention than supplier and logistics management. The unconventional sources pose greater environmental risks compared to the conventional sources due to the quality and the location of the deposits (Farrell & Brandt, 2006). Consequently, the recurring sustainability issues found most in the reports and the strategy taken to address them are related to the impact of the production of the unconventionals on water resources and, to a lesser degree, on carbon emissions, energy use and waste. The discussions are particularly focused on the development of shale O&G and oil sands.

Shale O&G deposits are located in non-permeable rock that must be developed using the combination of hydraulic fracturing and horizontal drilling technology (Merrill & Schizer, 2013; Wang et al., 2014). The production processes require massive amount of water, which are mixed with proppants such as sand or other materials and chemicals, as well as energy to crack the source rock so that the O&G can flow freely. While various risks associated with the development of shale O&G are also present in the development of other conventional O&G sources, the risk of groundwater contamination is unique to the fracturing activities (Merrill & Schizer, 2013).

The contamination could occur due to stray gas leaks, such as methane and propane, caused by poor well constructions that could consequently lead to the release of hydraulic fracturing fluids and saline formation waters (Vengosh et al., 2014). The water generated from the production processes could also cause surface water contamination because it contains hypersaline formation water and toxic materials such as oil, bitumen, metals and added chemicals (Vengosh et al., 2014). These in turn, pose great safety and health risks in terms of, for example, degradation of drinking water aquifers. The use of freshwater could also compete with domestic usage that could strain local water supply (Merrill & Schizer, 2013). The content analysis helps us to identify the strategies that O&G companies are using to address these issues with regard to water bodies protection measures, management of wastewater and efficiency of water consumption.

Unlike shale O&G, oil sands can be developed through: (1) surface mining – oil sands are removed using shovels and trucks, where hot water process is used to extract its bitumen contents, and (2) in situ techniques – steam injection is used to extract bitumen from deeper oil sand reservoirs to reduce its viscosity so it can be pumped to the surface (Bergerson et al., 2012). The environmental problem unique to the oil sands that is discussed in the sustainability reports is tailings, which are toxic by-products of oil sands production that can cause air and water emissions (Small et al., 2015). The use of tailing ponds to store the by-product is a major public concern that has led to tighter regulations to reduce the ponds by authorities in Alberta – the world's largest producer of oil sands (Schindler, 2014).

Tailings spill could cause severe environmental impacts that threaten food and water supplies of indigenous communities that rely on the river close to oil sands production sites for their daily provisions (Schindler, 2014). Oil sands tailing ponds could also release volatile organic compounds that could pose health risks, and greenhouse gases known to potentially cause global warming (Small et al., 2015). However, there is a lack of considerations of the consequences of oil sands development in its expansion plans (Schindler, 2014). The discussions on specific strategy taken by the O&G companies to address the risks from oil sands tailings focused on land reclamation of sands mining pits and preventive measures to protect water bodies. What is almost entirely missing in the discussions, and in unconventional O&G production in general, is their stakeholder engagement strategy to address local community concerns and prevent the community from shouldering most of the environmental impacts of the energy development with little or no economic benefits in return.

Hydraulic fracturing dominates the discussions on the O&G companies' supplier management strategy with regard to the disclosure of the chemicals used in the processes and their preference for more environmental friendly substitutes. The companies, such as Shell, Hess and Marathon, reported that they support suppliers' initiatives to disclose the chemicals in dedicated database and to relevant authorities (Hess, 2011; Marathon, 2011; Shell, 2011). This is an important step to ensure transparency and traceability in O&G supply chain activities that could enhance accountability of companies in the chain.

The only logistical issue discussed is the infrastructure to transport water for production activities. BG studied the social impact of shale gas development where it discovered that local residents are concerned about truck used to transport water more than fracking activities (BG, 2011). This could be due to the safety and health risks that could result from the increase in road traffic and road deterioration.

Table 6: The strategy used to ensure sustainable alternative energy supply chain

Types	Supplier management	Production management	Logistics management
BIO	• Sourcing practices: - Use local & family farmers; - Use non-edible and waste feedstock. • Supplier development: - Train farmers about crops and cultivation techniques; - Provide inputs, e.g. plant seeds, insecticides & spraying equipment. • Supplier business conduct requirements: - Respect for human rights; - Against biofuel cultivated, produced or manufactured in biodiversity-rich areas; - Supply chain traceability; - Affiliation with international bodies that promote sustainable biofuel.	• Life-cycle assessment: - Conduct field survey to mitigate impacts on fauna & flora; - Assess social and economic situation. • Land management: - Use barren land from farms; - Protect the land rights of indigenous people; - Avoid deforestation in inhabited areas; - Measure the amount of carbon stored in lands. • Agricultural development: - Use of mechanical harvesting process; - Avoid leaves burning; - Biological control of pests& diseases. • Water management: - Use recycle water • Waste management: - Use proper industrial waste bio-fertilization; - Use process waste to generate energy.	• Use multimodal logistics system. • Construct pipelines, terminals, barges/pushers, collecting centres and intermediate pumping stations. • Substitute road transportation for pipeline and waterways to reduce: - Logistics costs; - GHG emissions.
SOL	• Supplier management: - Ensure that third-party manufacturer meet quality standards; - Supplier compliance audit program on safety, health & environmental requirements.	n/a	n/a
WIN	n/a	• Use buffer zone between wind turbines and wildlife areas.	

Table 6 summarizes the SSCM strategies that are used in alternative energy development. We found that the discussions are concentrated on sustainability of biofuel supply chain – discussions on geothermal, nuclear and hydroelectric energy are absent from the reports. Involvement in the alternative energy production requires realignment of the O&G companies' broader supply chain management strategy and design. While the fundamental supply chain sustainability issues related to supplier, production and logistics management of the energy are generally similar to the O&G, the differences in the characteristics and the context of the alternatives' supply bases could present huge challenge to the companies. For example, although alternative energy is cleaner than the O&G, their feedstocks must be acquired from sustainable sources that do not compete with food production and the intermittency of power source such as solar and wind could make them unreliable energy options to address energy security concerns. Since the SSCM strategy of biofuel development is discussed most in the reports studied, we will focus our discussions on that energy.

Generally, the main issue in the development of biofuel is the viability of its supply in the long run (Markevicius et al., 2010) The feedstocks for biofuel production could come from oil plants, corn, sugar cane, animal waste or agricultural residue (Eksioglu et al., 2009; Shell, 2010). Many of these plants are also food crops. Therefore, the amount of land available for the production of these crops for biofuels is limited because it has to compete with food production (Eksioglu et al., 2009). To address this issue, some O&G companies are developing second and third generation of biofuels or biogas produced from non-food crops such as waste oils and animal fats (Ecopetrol, 2011; Eni, 2011), farming and forest waste (Chevron, 2011; Total, 2011), and algae (ExxonMobil, 2011a; MOL, 2011). In addition, barren and underused agricultural land are used to plant the crops for biofuels to avoid displacement of existing farming activities and deforestation, as well as to protect the land rights of the indigenous people (Repsol, 2011; Shell, 2011).

These conditions are also part of supplier business conduct requirements in supplier selection process to ensure that responsible practices are integrated into the supply chain right from its origin (Petrobras, 2011; Shell, 2011). The inclusion of small and family farmers could enhance the economic and social benefits of biofuel development such as what being practiced by Galp, Ecopetrol and Petrobras. These farmers could have limited capabilities and resources to conduct their farming activities sustainably and to address problems related to, for example, plant diseases and insects. Therefore, trainings about different types of crops and cultivation techniques, as well as farming provisions such as seeds and tools are given, which could mitigate negative impact to the environment and enhance the economic development of the local communities (Galp, 2011).

Transportation, compaction and drying of biofuel feedstocks as the activities that will cause adverse environment impact if done in inappropriate scale and sequence (Čuček et al., 2010). However, there is no discussion on these issues in the examined sustainability reports, except for transportation. The discussions on transportation-related strategy are concentrated on the use of multimodal transports, especially pipeline and waterways to reduce the cost and environmental impact of logistics activities (Galp, 2011; Petrobras, 2011). The inter-connectedness of biofuel supply chain actors and the effectiveness of logistics strategy and infrastructure are crucial to the competitiveness of biofuel (Gold & Seuring, 2011). For example, decisions related to centralization or decentralization of production activities could affect its overall cost, eventually its sustainability, as distances between production facilities and customer market increase. Yet, this issue is not discussed in the reports.

The development of unconventional O&G and alternative energy require careful consideration of its impact to the environment and society. As energy is important to economic development, various institutional, technological and social challenges must be overcome to ensure energy options that are compatible with sustainable future can be developed to its full potential. The next section concludes this study where we will highlight the main findings of the content analysis and offer several implications to practice as well as future studies.

5.0 Conclusions

This study aims to understand the implications of energy transition on SSCM practices in the O&G industry through content analysis of sustainability reports of 30 companies in the industry. In order to reach such understanding, we identify the extent of the discussions on energy transition among the companies studied, the types of energy sources being developed and the SSCM strategy that the companies used for each of the source. The main findings from the analysis are as follows:

1.0 Even though energy transition is generally discussed on strategic level, it is apparent that O&G companies are concerned with: the measures that are used to enhance the speed of the transition, the viability of the alternative energy development compared to the O&G, and the compatibility of the O&G business in future low carbon energy systems.

2.0 O&G companies are transitioning themselves towards becoming energy companies by being involved in research and development of alternative energy. The companies seek to develop the energy sources that could create synergies with existing business and areas of expertise.

3.0 While the O&G companies are supportive to the development of the alternative energy to address energy security concerns, their main focus is on the development of unconventional O&G that pose greater economic and environmental risks.

4.0 Discussions on SSCM strategy of the unconventional O&G are concentred on the sustainability of its production processes and measures to manage water resources, carbon emissions and waste management.

5.0 The sustainability of the biofuels supply chain is the main focus due to the extent of O&G industry involvement in its development as well as regulatory requirements for blending of diesel with the biofuel to reduce fossil fuel carbon content, thus reduce the fuel environmental impact.

It is important to note that the extensiveness of a company’s sustainability report could determine the completeness of its information disclosure, thus the results of our content analysis. Nevertheless, the analysis helps us to identify several important implications of energy transition on the sustainability of the O&G industry. In order to address the challenges of the transition, O&G companies must develop internal capabilities such as risk management strategies to: (1) exploit opportunities to improve the sustainability of their operations, and (2) overcome the threats that could affect their viability to remain in business. This requires supportive organizational culture that promotes continuous innovation and improvement of business practices and technological development of energy options that are more sustainable.

Several factors limit the findings of this study that could present opportunities for future studies. As mentioned earlier, the extent of sustainability reporting disclosure among O&G companies could differ greatly due to its voluntary nature and the amount of indicators that could be reported. Although sustainability report offers unobtrusive method for data collection, the data that could be used to understand the full implications of energy transition on O&G industry are limited. This issue could be addressed by conducting case studies that allow access to various sources of information for more detailed investigations. In addition, performance-related factors of the SSCM strategy used during the transition could also be included in the study to understand its effectiveness and opportunities for improvement. Finally, we are not able to identify the structural changes in the design of O&G companies’ supply chains caused by their involvement in the alternative energy development. Future research could look into this aspect, for example in terms of the changes that occur in the key supply chain processes and functions.

Greater understanding of the realities of the current energy system and, perhaps, willingness to forego the immediate benefits of energy options that have higher environmental and social costs could determine the success of energy transition and its impact on the O&G industry. This study provides insights on the implications of the energy transition to the industry that help us to understand the challenges that the industry has to overcome. The findings are also useful to industry practitioners as they provide an overview of relevant issues that could be used in decision making processes, and to academics to identify areas for further investigations.

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7.0 References

Adnoc. (2011). 2010 Sustainability Report. Abu Dhabi, UAE: Abu Dhabi National Oil Company.

Bergerson, J. A., Kofoworola, O., Charpentier, A. D., Sleep, S., & MacLean, H. L. (2012). Life cycle greenhouse gas emissions of current oil sands technologies: surface mining and in situ applications. *Environmental science & technology, 46*(14), 7865-7874.

BG. (2011). Sustainability Performance Report 2010. Berkshire, United Kingdom: BG Group Plc.

BP. (2011). Sustainability Review 2010. London: British Petroleum.

BP. (2015). Energy Outlook 2035. London: British Petroleum p.l.c.

Chevron. (2011). 2010 Corporate Responsibility Report. San Ramon, CA: Chevron Corporation.

Cigolini, R., & Rossi, T. (2010). Managing operational risks along the oil supply chain. *Production Planning & Control: The Management of Operations, 21*(5), 452 - 467.

Čuček, L., Lam, H., Klemeš, J., Varbanov, P., & Kravanja, Z. (2010). Synthesis of regional networks for the supply of energy and bioproducts. *Clean Technologies and Environmental Policy, 12*(6), 635-645. doi: 10.1007/s10098-010-0312-6

D'Alessandro, S., Luzzati, T., & Morroni, M. (2010). Energy transition towards economic and environmental sustainability: feasible paths and policy implications. *Journal of Cleaner Production, 18*(4), 291-298. doi: DOI: 10.1016/j.jclepro.2009.10.015

Deng, M. M., & Liu, L. J. (2011). The Analysis and Discussion about Green Supply Chain Management of Oil Industry in China. *Applied Mechanics and Materials, 65*, 32-35.

Ecopetrol. (2011). Sustainability Report 2010. Bogota, Colombia: Ecopetrol S.A.

Edwards, S., Ishaq, O., & Johnsen, O. (2010). Oil and gas 2030: Meeting the growing demand for energy in the coming decades. Retrieved from

Eksioglu, S. D., Acharya, A., Leightley, L. E., & Arora, S. (2009). Analyzing the design and management of biomass-to-biorefinery supply chain. *Computers & Industrial Engineering, 57*(4), 1342-1352. doi: DOI: 10.1016/j.cie.2009.07.003

Eni. (2011). Eni for Development 2010. Rome: Eni.

ExxonMobil. (2010). 2010 The Outlook of Energy: A View to 2030 (pp. 56). Texas: ExxonMobil.

ExxonMobil. (2011a). 2010 Corporate Citizenship Report. Texas: Exxon Mobil Corporation.

ExxonMobil. (2011b). Corporate Citizenship Report. Texas: ExxonMobil.

Farrell, A. E., & Brandt, A. R. (2006). Risks of the oil transition. *Environmental Research Letters, 1*.

Fouquet, R. (2010). The slow search for solutions: Lessons from historical energy transitions by sector and service. *Energy Policy, 38*(11), 6586-6596. doi: DOI: 10.1016/j.enpol.2010.06.029

Galp. (2011). Sustainability Report 2010. Lisbon: Galp Energia.

Gazprom. (2010). Sustainability Report - 2008/2009. Moscow: OAO Gazprom.

Geels, F. W., & Schot, J. (2007). Typology of sociotechnical transition pathways. *Research Policy, 36*(3), 399-417. doi: DOI: 10.1016/j.respol.2007.01.003

Gold, S., & Seuring, S. (2011). Supply chain and logistics issues of bio-energy production. *Journal of Cleaner Production, 19*(1), 32-42. doi: DOI: 10.1016/j.jclepro.2010.08.009

GRI. (2015). Materiality in the context of GRI framework Retrieved 13 February 2015, 2015, from https://www.globalreporting.org/reporting/G3andg3-1/guidelines-online/TechnicalProtocol/Pages/MaterialityInTheContextOfTheGRIReportingFramework.aspx

Hess. (2011). 2010 Corporate Sustainability Report. New York, USA: Hess Corporation.

Jiping, Z. (2010). Embracing the Low-Carbon Economy of Sustainable Energy Development. *Journal of Petroleum Technology*(April 2010), 18-20.

Kemp, R. (2010). The Dutch energy transition approach. *International Economics and Economic Policy, 7*(2), 291-316. doi: 10.1007/s10368-010-0163-y

Kjärstad, J., & Johnsson, F. (2009). Resources and future supply of oil. *Energy Policy, 37*(2), 441-464. doi: DOI: 10.1016/j.enpol.2008.09.056

Lakhal, S. Y., H'Mida, S., & Islam, M. R. (2007). Green supply chain parameters for a Canadian petroleum refinery company. *International Journal of Environmental Technology and Management, 7*(1-2), 56-67. doi: 10.1504/ijetm.2007.013236

Lakhal, S. Y., Khan, M., & Islam, M. R. (2009). An “Olympic” framework for a green decommissioning of an offshore oil platform. *Ocean & Coastal Management, 52*(2), 113-123.

Li, L., & Jianming, L. (2009). Study on Supply Chain Management Model of China's Petroleum Industry based on Cyclic Economic Idea.

Lior, N. (2010). Sustainable energy development: The present (2009) situation and possible paths to the future. *Energy, 35*(10), 3976-3994. doi: DOI: 10.1016/j.energy.2010.03.034

Marathon. (2011). 2010 Corporate Social Responsibility Report. Houston: Marathon Oil Corporation.

Markevicius, A., Katinas, V., Perednis, E., & Tamasauskiene, M. (2010). Trends and sustainability criteria of the production and use of liquid biofuels. *Renewable and Sustainable Energy Reviews, 14*(9), 3226-3231. doi: DOI: 10.1016/j.rser.2010.07.015

Martens, P., & Rotmans, J. (2005). Transitions in a globalising world. *Futures, 37*(10), 1133-1144. doi: DOI: 10.1016/j.futures.2005.02.010

Merrill, T. W., & Schizer, D. (2013). The Shale Oil and Gas Revolution, Hydraulic Fracturing, and Water Contamination: A Regulatory Strategy. *Columbia Law and Economics Working Paper*(440).

Midttun, A., Dirdal, T., Gautesen, K., Omland, T., & Wenstøp, S. (2007). Integrating corporate social responsibility and other strategic foci in a distributed production system: A transaction cost perspective on the North Sea offshore petroleum industry. *Corporate Governance, 7*(2), 194-208.

Mitchell, J. V., & Mitchell, B. (2014). Structural crisis in the oil and gas industry. *Energy Policy, 64*, 36-42.

MOL. (2011). MOL Group Annual Report. Budapest: MOL Hungarian Oil and Gas Plc.

Oberling, D. F., Obermaier, M., Szklo, A., & La Rovere, E. L. (2012). Investments of oil majors in liquid biofuels: The role of diversification, integration and technological lock-ins. *Biomass and Bioenergy, 46*, 270-281.

OMV. (2011). Sustainability Report 2010. Vienna, Austria: OMV Aktiengesellschaft.

Petrobras. (2011). Sustainability Report 2010 *Corporate Communication/ Social Responsibility/ Sector Management for Guidelines and Practices of Social Responsibility*. Rio de Janeiro, Brazil: PETROBRAS.

PetroStrategies. (2012). World's Largest Oil and Gas Companies 2012, from http://www.petrostrategies.org/Links/worlds_largest_oil_and_gas_companies.htm

Rabinovich, E., & Cheon, S. (2011). Expanding horizons and deepening understanding via the use of secondary data sources. *Journal of Business Logistics, 32*(4), 303-316.

Raven, R. (2007). Niche accumulation and hybridisation strategies in transition processes towards a sustainable energy system: An assessment of differences and pitfalls. *Energy Policy, 35*(4), 2390-2400. doi: DOI: 10.1016/j.enpol.2006.09.003

Repsol. (2011). Repsol Corporate Sustainability Report. Madrid: Repsol.

Roy, J., Ghosh, D., Ghosh, A., & Dasgupta, S. (2013). Fiscal instruments: crucial role in financing low carbon transition in energy systems. *Current Opinion in Environmental Sustainability, 5*(2), 261-269.

Sasol. (2011). Sustainable Development Report. Johannesburg: Group Safety, Health & Environment Centre.

Savitz, A. W., & Weber, K. (2007). The sustainability sweet spot: How to achieve long-term business success. *Environmental Quality Management*.

Schindler, D. W. (2014). Unravelling the complexity of pollution by the oil sands industry. *Proceedings of the National Academy of Sciences, 111*(9), 3209-3210.

Shell. (2010). Shell Biofuels: Sustainable Low CO_2 Fuel Today. The Hague, The Netherlands.

Shell. (2011). Sustainability Report 2010. The Hague: Royal Dutch Shell PLC.

Small, C. C., Cho, S., Hashisho, Z., & Ulrich, A. C. (2015). Emissions from oil sands tailings ponds: Review of tailings pond parameters and emission estimates. *Journal of Petroleum Science and Engineering, 127*, 490-501.

Szklo, A., & Schaeffer, R. (2006). Alternative energy sources or integrated alternative energy systems? Oil as a modern lance of Peleus for the energy transition. *Energy, 31*(14), 2513-2522. doi: http://dx.doi.org/10.1016/j.energy.2005.11.001

Tangpong, C. (2011). Content analytic approach to measuring constructs in operations and supply chain management. *Journal of Operations Management, 29*(6), 627-638. doi: 10.1016/j.jom.2010.08.001

Tate, W. L., Ellram, L. M., & Kirchoff, J. F. (2010). Corporate social responsibility reports: A thematic analysis related to supply chain management. *Journal of Supply Chain Management, 46*(1), 19-44. doi: 10.1111/j.1745-493X.2009.03184.x

Total. (2011). Society and Environment Report 2010. Courbevoie, France: TOTAL S.A.

Vengosh, A., Jackson, R. B., Warner, N., Darrah, T. H., & Kondash, A. (2014). A critical review of the risks to water resources from unconventional shale gas development and hydraulic fracturing in the United States. *Environmental science & technology, 48*(15), 8334-8348.

Wagner, J., & Armstrong, K. (2010). Managing environmental and social risks in international oil and gas projects: Perspectives on compliance. *The Journal of World Energy Law & Business, 3*(2), 140-165. doi: 10.1093/jwelb/jwq002

Wan Ahmad, W. N. K., De Brito, M. P., & Tavasszy, L. A. (in press). Sustainable supply chain management in the oil and gas industry: a review of corporate sustainability reporting practices. *Benchmarking: An International Journal*.

Wang, Q., Chen, X., Jha, A. N., & Rogers, H. (2014). Natural gas from shale formation – The evolution, evidences and challenges of shale gas revolution in United States. *Renewable and Sustainable Energy Reviews, 30*(0), 1-28. doi: http://dx.doi.org/10.1016/j.rser.2013.08.065

Wolf, C. (2009). Does ownership matter? The performance and efficiency of State Oil vs. Private Oil (1987-2006). *Energy Policy, 37*(7), 2642-2652. doi: DOI: 10.1016/j.enpol.2009.02.041

Xu, Y.-C. (2008). The competition for oil and gas in Africa. *Energy & Environment, 19*(8), 1207-1226.

Ziegler, W. H., Campbell, C. J., & Zagar, J. J. (2009). Peak Oil and Gas. *Geologi, 2*(6), 81-90.