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Decommissioning of Offshore Oil and Gas Facilities: A Comparative Study Between Malaysia Practices and International Standards

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Abstract

Regulations for decommissioning are bound by international and domestic regulations. There are numerous decommissioning concepts to choose from, such as complete or partial removal, structure severance options which leave behind shell mounds and drill cuttings. However, in several international regulations there appears to be little clarity and/or opposing ideologies. Malaysia and Thailand have accessible resources for decommissioning legislation or guidelines in South East Asia. Nevertheless, they are differences in the regulations of these countries regarding the legal framework, the technical, financial and environmental framework. In this study, the feasibility of existing framework in decommissioning process of offshore installations or structures in Malaysia was studied and compared with international practices. Decision matrix analysis was used to systematically identify, analyse, and rate the performance of relationships between sets of values and information. Moreover, the scale of decommissioning activities over the next years, the data and information obtained were analysed using descriptive statistics approach. The results indicated that Thailand had the best decommissioning regulations because they have strict regulation in decommissioning. Most of the regulations covering the technical section are similar within all countries studied. Finally, recommendations given are from the aspects of frameworks on in-situ full or partial decommissioning, clarity on liabilities and residual risk management, financial security, residual risk funds, workflow optimisation, information management system, and waste management.

Keywords: Decommissioning Regulations, Offshore, Abandonment, Removal

Introduction

Over half of all hydrocarbons are today derived from mature fields with aging facilities. While the life of many platforms will be extended through modifications, a large number will face decommissioning over the coming years. In the North Sea itself, 20% of 1357 offshore installations, 726 sub-sea steel installations, and fixed steel installations have been operating over 30 years (OSPAR commission, 2013). On the other hand, 444 offshore installations have been servicing between 20 to 30 years in the South East Asian waters, while another 389 installations have exceeded 30 years of service life, and are still currently in operation (Lynos, 2012). In Malaysia, most platforms are shallow water platforms (50–70 m). They are over 20 years of age and 48% of the platforms have exceeded their 25-year design life (Zawawi et al., 2012). These platforms are expected to be decommissioned within the next few years.

Decommissioning of oil and gas offshore facilities is employed in compliance with national and international laws and standards. It is equally important for national policies to address all aspects of the decommissioning process, including the pre-decommissioning and post-decommissioning jobs. Each country has its own regulations that they abide by. However, there exist some similarities and differences between these regulations. The differences are identified in their legal, financial, environmental and technical frameworks. The best strategy and good assessment are essential for these fields to be considered for decommissioning.

Based on most legislation requirements investigated in this study (Department for Business Energy and Industrial Strategy UK, 2011; Government of USA, 2014a; Petroleum Institute of Thailand (2008); Petroleum Safety Authority (Norway), 2015a; PETRONAS, 2008) and current decommissioning practices (Techera and Chandler, 2015), it appears that decommissioning is the final stage of the life cycle of an industrial facility, and is the process of closing down an industrial facility via methods, which balances the sensitive boundaries of minimizing financial costs, costs to human life well-being and to the environment.

Methodology

Research Method

A comparative study was carried out between the regulations and guidelines for five countries, which are North Sea (Norway and UK), Gulf of Mexico (US), Gulf of Thailand (Thailand) and Malaysia. The national standards referred by each country for their respective offshore decommissioning program are determined in the literature review of the study. Studies were also done based on several journal findings. Having analysed the numerous legal frameworks, the discussion on a proposed 'best practice' decommissioning framework was organised for the structure in Figure 1 against a combination of legal, environmental, financial and technical frameworks

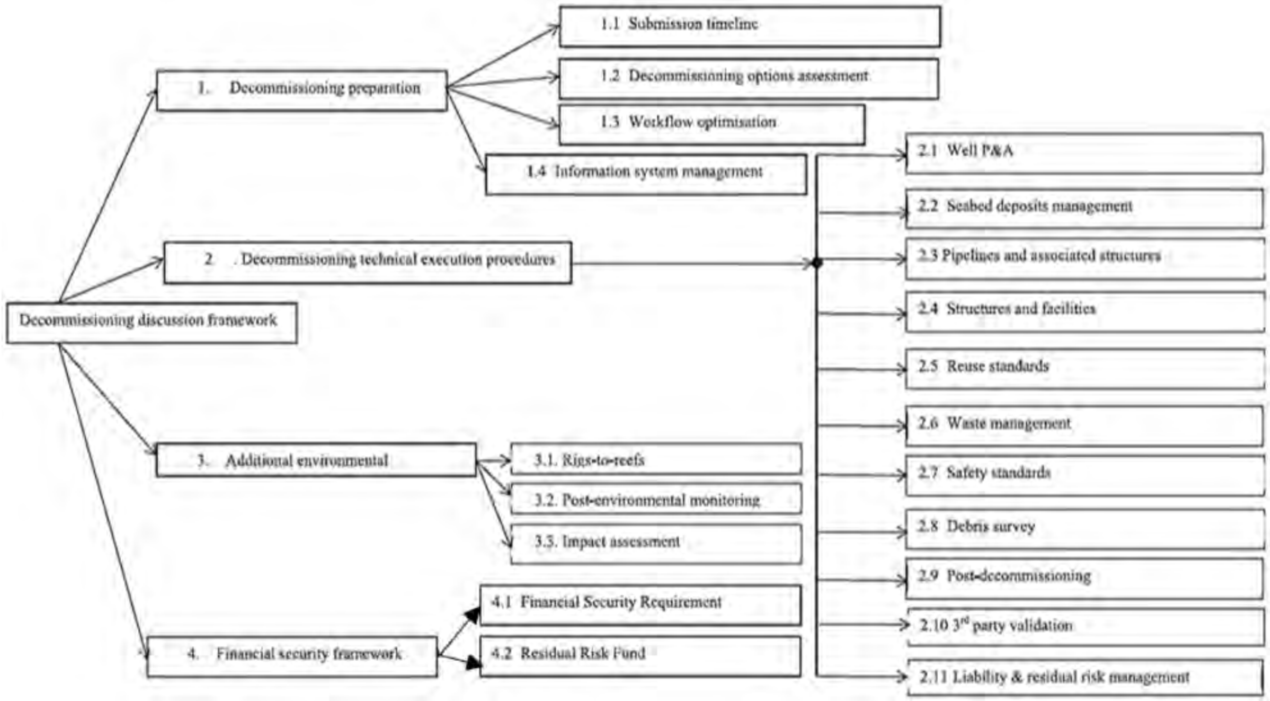

Figure 1—Mind map of the components for comparison of decommissioning regulation (M.L. Fam et. al., 2018).

Decision Matrix Analysis

Decision matrix is used to describe a multi-criteria decision analysis (MCDA) problem, where there are M alternative options, and each was assessed on N criteria and described by the decision matrix which has N rows and M columns. The alternative M was assessed by five grades {Best, Good, Average, Bad}. These assessments were replaced by scores, from 0 to 20 as shown in Table 1. Sums of scores were then be compared and ranked, to show the winning proposal.

Table 1—Range of marks for best decommissioning option

Range	Level
0-5	Bad
6-10	Average
11-15	Good
16-20	Best

Based on Figure 1, there are a total of 4 components to be assessed on decommissioning preparation, 11 on decommissioning technical execution procedures, 3 on additional environment and 2 on financial security framework, which makes a total of 20 components to be assessed for each country. Although Malaysia was also included in this analysis, the highest marks obtained by the other countries compared will be chosen as the ‘best practice'decommissioning framework, and hence choosing it as the best conceptual framework of viable decommissioning scheme for Malaysia. The determination of the best practice is based on the range of marks below:

Results and Discussion

Table 2 compares the decommissioning regulations of 5 countries and their level of strictness in the regulations. The analysis begins with determining the strictest applicable regulations for existing regulatory structure in the five case studies (Table 2). Suggested improvements or changes will be discussed to form a more vigorous framework.

Table 2—Comparison of decommissioning regulations

Factors	Criteria	Countries				
		Norway	UK	USA	Thailand	Malaysia
Decommissioning Preparation	1. Submission Timeline	√[31]	×[9]	√[1]	√[18]	√[38]
	2. Decommissioning Options Assessment	√[31]	√[9]	√[14]	√[44]	√[39]
	3. Workflow Optimization	–	√[46]	—	—	–
	4. Information Management System	√[15],[31]	√[9]	—	√[18]	√[36]
Decommissioning Technical Execution Procedures	5. Well P&A	√[41]	√[36]	√[20]	√[32]	√[36]
	6. Seabed Deposit Management	√[22]	√[21]	√[15]	√[44]	√[3]
	7. Pipelines & Associated Structures	√[49]	√[10]	√[1]	√[18]	√[39]
	8. Structures & Facilities	√[15]	√[9]	√[1]	√[32]	×[38]
	9. Reuse Standard;	–[16]	–[16]	√[5]	√[32]	×[37],[38]
	10. Waste Management	√[34]	√[9]	√[46]	√[32]	√[45]
	11. Safety Standards	√[35]	√[49]	√[15]	√[32]	√[15]
	12. Debris Survey	—	√[15],[36]	√[20]	√[32]	√[32]
	13. Post-Decommissioning	√[31]	√[36]	√[27]	√[32]	√[20]
	14. 3rd Party Validation	–	–	—	√[32]	×20
	15. Liability & Residual Risk Management	√[34]	√[9]	√[26]	√[20]	×[38]
Additional Environment	16. Rig - to reefs	–[16]	–[16]	√[23]	√[18]	√[33]
	17. Post-environment Monitoring	√[15]	√[9]	√[20]	√[32]	×[20]
	18. Impact Assessment	√[31]	√[10]	–	×[15],[24]	√[33]
Financial Security Framework	19. Financial Security Requirement	×[15]	√[9]	√[20]	√[32]	×[20]
	20. Residual Risk Fund	√[42]	–	–	–	–
Key: √ Mentioned specifically		14	15	15	17	12
× Not specific		Good	Good	Good	Best	Good

Factors	Criteria	Countries				
		Norway	UK	USA	Thailand	Malaysia
– Not mentioned						

According to the analysis, Thailand shows the strictest regulation in decommissioning. Hence, it may be considered portraying the best decommissioning regulations. This is because Thailand takes its stakeholder engagement very seriously and public participation is required to review and comment on the scoping phases. Also, compliance with the DEA and EMP should be audited and verified, so the decommissioning processes that are currently undergoing in Thailand should serve as a template to replicate in other areas of South East Asia. Based on findings, Malaysia shows the most lenient regulation. This is because to date, only a handful of fixed offshore platforms in Malaysian waters have been decommissioned and so far, performed without a proper governing localized regulatory framework. In additional, decommissioning works is still a very new area for the oil and gas company in Malaysia. While some countries have been performing decommissioning for many decades, Malaysia is just beginning to see the need for a greater understanding for this procedure. However, residual liability remains uncertain in Malaysia. In the North Sea and United States, where decommissioning is more experienced than other areas, the regulations are mostly similar, hence there is not much difference between their scores. However, the North Sea takes on goal-setting approach while the US takes on prescriptive approach. Both approaches (prescriptive and goal setting) have their merits and their weaknesses and depending on a person/organisations viewpoint one could argue for or against either approach. The goal setting approach arguably offers greater flexibility to the operator to design a fit-for-purpose well abandonment plan without unnecessary overspend to meet regulations which may not be applicable/suitable for the well type. Having fewer clear guidelines in place puts increased emphasis on the regulator to carefully review, and subsequently approve, any decommissioning plans to ensure they are fit for the purpose to achieve well integrity for the long-term. Interestingly, in countries that adopted a goal-setting approach to decommissioning it is common to see the operators refer to guidelines from prescriptive bodies to demonstrate that they have followed "industry best practice.

Decommissioning Market over the Next Years

An intense period of decommissioning is ramping up worldwide, as oil and gas wells and installations developed from the 1970s onward reach the end of their useful lives. Decommissioning is a costly challenge. For many countries, the value at stake in handling these projects properly could be worth several billion dollars. In recent decades, the North Sea and the Gulf of Mexico have seen multiple waves of decommissioning activity. Now other hot spots are emerging around the globe. And they must prepare for what is typically a massive task.

In the North Sea, an intense phase of decommissioning is getting underway. The challenges are especially acute, owing to the size and complexity of some of the facilities, the difficult physical and regulatory environment, and intense scrutiny by public and nongovernmental organizations. Aggregate estimates for North Sea - decommissioning start at close to $150 billion, covering the cost of removing more than 600 fixed installations and more than 7,000 wells. (BCG article, 2018.) Meanwhile, in the Gulf of Mexico, the US government and operators and contractors have already gained significant decommissioning experience. The challenges in the Gulf are intensifying. Operators are expected to remove more than 2,000 structures and more than 9,000 wells in the coming years, according to estimates by the BSEE and the US Government Accountability Office. While earlier decommissioning waves included 600-tonne structures in water depths of up to 100 meters, the upcoming portfolio includes 11,000-tonne structures in depths exceeding 100 meters. About 25% of the plugging and abandonment activity (approximately 2,000 wells) will be at those depths. The complexity of such projects means that costs will also be higher, and operators and contractors will need more advanced technologies and capabilities. (BCG, 2018)

Most countries have just begun their first decommissioning projects and will soon see a steady flow of intense activity. Additionally, the government has issued guidelines for decommissioning upstream installations and regulations that clarify requirements related to the decommissioning process, financial security, and the transfer of assets to the state. The next wave of opportunity for Malaysian oil and gas players could be in an unlikely space – decommissioning work. Some US$100 bil worth of decommissioning jobs are available in the Asia-Pacific region over the next decade. According to research firm Wood Mackenzie, nearly 2,600 platforms and 3,500 wells in more than 380 fields are expected to cease production. Sources say more than 20 platforms around Malaysia could be decommissioned in the next five years, although the combined value of the jobs has not been determined. (Focus Malaysia, 2018).

Discussions

Based on the criteria given in Table 2, generally, all 5 countries studied have specific and clear regulations on decommissioning options assessment (DOA), Well P&A, pipelines and associated structures, waste management, safety standards, post-decommissioning and post-environmental monitoring. In other words, these criteria are said to be vital in any decommissioning programme. In this study, DOA is the most important part in the decommissioning plan. The relationship between decommissioning costs, potential environmental and societal impacts, and safety is often complicated. To protect the environment, navigation, fishing and other sea users, DOA acts as a powerful tool that can help evaluate relevant decommissioning options against a defined set of criteria and sub-criteria. It helps to evaluate the impacts of the proposed decommissioning activities on the environment as it includes evaluation criteria on safety, environment, technical, societal and economical. Usually, the DOA will be submitted for public hearing and consultation. (Norwegian Petroleum Act), (Petroleum Act 1998), (Laister & Jagerroos, 2019), (PETRONAS, 2008). Decision-making is not only a human right but many research consider it as a crucial aspect in EIA (Julie, 2007; Abaza et al, 2004; Sadler, 1996). People have a right to be involved as it will affect their lives, and the opinions and views of experts should not be the sole consideration in decisions (Fitzpatrick et al, 2008; Vanclay et al, 2002). Technical requirements such as well P&A, pipelines and associated structures, waste management, safety standards, post-decommissioning and post-environmental monitoring are as equally important in a decommissioning programme. After all, the primary objective of the requirements for these criteria are developed specifically to ensure all decommissioning activities are performed safely under safe work practices and industrial standards while protecting the environment and marine life. The least factors applied by the five countries are workflow optimisation and residual risk fund. Only the UK government has a strategy on a well P&A optimising programme as part of the bigger decommissioning workflow. Based on the author's opinion, this may be due to the reason that other governments consider the existing Well P&A regulation is sufficient enough for a successful decommissioning programme. Moreover, sufficient funding is a key factor in decommissioning and environmental remediation projects, which are generally very expensive. A significant proportion of sites requiring decommissioning or remediation are state-owned and implementation costs are paid from national budgets. Often, the amount of funds allocated to environmental clean-up activities depends on the priorities of the government. Hence, it could be a possibility that government of the countries studied, except Norway, do not prioritise residual risk funds.

Another criterion to be included in decommissioning regulations is a decommissioning fund. In terms of financial security, particularly for earlier petroleum revenue systems without an outlined scope on decommissioning, and in which structures eventually make up the responsibility of the government. It is therefore relevant to reserve funds for decommissioning aged platforms which were under old risk sharing agreement or production sharing agreement with imprecise decommissioning liabilities to the operator/government. As an example, the Malaysian government ultimately owns the assets and has commenced an abandonment fund contributed by operators for these contributing operators' eventual use for decommissioning. Before the beginning of this abandonment fund, the previous operators would not have access to thus fund and would need to provide or negotiate the costs of decommissioning. Any delineation should be provided on what represent an attainable claim against the fund that has been created. For instance, whether transportation of decommissioned waste will be allowed to be claimed under this fund. There are protocol documented on guaranteeing that waste management companies know who to bill (operators) for the costs of handling waste in Norway's guidelines (Norwegian Climate and Pollution Agency, 2011). The guidelines have also noted that for the past few decommissioning activities, waste costs had been underestimated, therefore indicating that waste estimation might create a budgeting issue in terms of reserving proper funds for it. It is conjointly crucial to notice that how a decommissioning fund ought to be managed also depends mainly on the tax structure as well as the initial production agreement structure. The nuclear industry has been more serious on future decommissioning liabilities, and many countries have started a fund from the day the plants begin to operate, and have also began to restrict the types of decommissioning claims that could be made against such funds. In the US, nuclear power plants decommissioning omit costs used on fuel dumping, non-radiological decommissioning and site restoration costs (U.S. Congress Office of Technology Assessment, 1993, p. 137). The decommission fund for offshore structures could also define whether waste management, remediation costs (despite decontamination of offshore items being managed to specified methods. For example, a need for remediation not due to negligence) could be claimed against this fund.

Strength

The Goal-Setting Approach. The goal setting approach requires the operator to build their own objectives and making a case to the regulator that they are managing safety effectively. Naturally, there are legal boundaries that form the limits of the individual safety cases. There are also slight variations between the system in Norway and in the UK, whereby in the former it is known as acknowledgement of compliance, while in the latter, commonly, a safety case. Such goal-setting systems solely applicable wherever relevant statutory provisions are sturdy enough, both in terms of general management and technical management. The flexibility in a goal-setting regime permits exemptions to be granted, only with justification or identification of remedial measures that show compliance to overall safety goals. The "as low as reasonably practicable" (ALARP) concept is a crucial part of the goal-setting system. It is designed to add value as a means of how much major hazards can be controlled and risks mitigated before damage are out of all proportion to the profit obtained. This is essential as the responsibility now lies with the operator to guarantee safety, rather than having a prescriptive approach where a list of ticked safety elements in a form could give inaccurate security on the strength of a safety management system. Also, each platform is different and managed differently hence, the goal-setting system may be more extensive. This resonates notably when transitioning from the regular hydrocarbon production activities to unfamiliar decommissioning activities such as well plugging, working without full access to all areas of the facility as each area is demolished part by part. Having strict regulations may not be the finest option and the current framework also has voids in which there could be enhancement across the conventional decommissioning framework. It is suggested that science-based decision-making, which is a type of goal-setting system could be one improvement to the decommissioning framework, which is suitable for various offshore environment.

Norway's Removal Grant Act. In the North Sea, and in the area regulated by Norway, some structures are left behind, which have been allowed by the Norwegian government due to the extreme complications and risk for removing it. Normally, the pipeline networks in the North Sea and the Gulf of Mexico are permitted to remain in the seabed if it had been cleaned pigged and cap and covered with concrete mats. While there may be possible benefits in the form of advanced technology in removal of large structures like the concrete substructures in the forthcoming, there should be adequate survey and maintenance for the structures such as the pipelines which might remain forever. Hence, it is necessary to have a funding system, such as the removal grants cct in Norway in which a similar grant mechanism can deposit funding for any future liability acquired such as the resurfacing of disused pipelines from corrosion. Removal grants act provide direct allocation to include a fraction of the Norwegian State's percentage of abandonment costs (Stortinget, 2000). Perhaps such principles could comply for such a standard to be used for the management of any other structures in which disposal is deferred or left in-situ.

Frameworks on In-Situ Full or Partial Decommissioning. There are three multi-criteria decision Analysis that have been operationally used for decommissioning considerations around the world, they are: comparative assessment, net environmental benefit analysis, best practical environmental option. There are strong similarities between these different methodologies that are based on the principle that no single decommissioning option performs best for all areas and context (Fowler et al. 2014). Due to the current regulation in the OSPAR framework that restrain non-virgin materials for artificial reef projects (Table 2). There can be extended clarity on in-situ full or partial decommissioning, particularly in the countries obliged to the OSPAR convention (Norway, the United Kingdom) that have to deal with limitation for in-situ decommissioning. However, if there had been a framework for science-based decision (Chandler et al., 2017) to govern the decision, corals that are facing extinction which grows healthily (Bell and Smith, 1999) on North Sea oil rigs could dismiss ideas that increased exposure to sedimentation and oily discharges from the operations could influence the organisms living on an oil rig, and encourage the thought that rigs-to-reefs could be an opportunity in the North Sea to expand the diversity of corals in the region. The environmental governing framework could thus clarify on types of coral species have been found on rigs and the most suitable location for it to be shifted as an artificial reef while considering whether trans-located species can live or the prevention to bring in invasive marine colonies. So, it is important for governing regulation and protocols to be competent to eliminate the impression that all rigs are simply ‘dumped’ into the ocean and reinforce the concept of a purposefully relocated rig. Thailand notably, is taking a science-based regime (Petroleum Institute of Thailand, 2008) to permit drilling muds to be left on the seabed, as the operators have to demonstrate the leaching rates of an agreed sample size of drilling muds expected to be left behind, or the assumed chemical stirred up if drilling muds are to be excavated and removed.

Clarity on Liabilities and Residual Risk Management. The Rigs-to-reef project structure in the US transfers their liability regarding the costs of full disposal, and not based on the maintenance provision of the rigs. Thus, one alternative to upgrade the existing governing regulation is to use science to explain region specific corrosion rates, and extreme weather circumstances for an appropriate maintenance fee (Table 2). The USA system is based on economical in situ decommissioning in comparison to full disposal and could barely give supervision on handling a structure continuously. It is suggested to have a payment scheme or fee based on survey costs and appraisal lifespan of the artificial reef.

The suggestion is to announce rigs-to-reef as a reuse option (if not already implemented), and to enhance this option with instructions on concerns on thriving marine ecology, or to prevent invasive species from relocating near the shore. Liability or ownership should be transferred to an organisation who will be around and who knows how to manage it. For instance, a department of fishery or environment. Perpetual liability has its shortcomings, due to its difficulties in managing companies that have gone bankrupt or have shut down operations in a country.

Financial Security. A scope which needs more concentration is whether the operators or lessors have the financial ability to accomplish the decommissioning activities successfully. In some cases, in the Gulf of Mexico, there may be tendency for big companies to hand over sunset properties to smaller, inexperienced companies, in which these smaller companies are more financially susceptible to volatility in the industry, which may portray them incompetent to complete the decommissioning activities. Some other issue is the variation in what manner the assets are being handled. Decommissioning expenditures could be fully settled by the operator or share between the operator and the taxpayers, relying on the initial production agreement and laws of the country owning the assets. The Thai protocols on financial security are much stringent. Such a system could also cut down the number of incidences of operators being badly financed to complete the decommissioning process. Generally, the guidelines established should satisfy the structure of the projects, so that it can streamline the decommissioning process. A vital system to a stringent financial guideline of operators is for a body to be able to authorise penalties on the company should they fail to meet the requirements. The UK government has thought through that and modified the energy act 2016 to allow the oil and gas authority to take pre-emptive procedure, for any approaching signs in which an operator is incapable of satisfying its requirement is highlighted while there may be capacity to make other better efforts. In additional, the oil and gas authority is authorised to place penalties should any operator unable to meet its responsibility. Indeed, this is the most relevant and practical if conducted early enough.

Residual Risk Funds. As a measure of planning beforehand, there should also be a segregated fund for managing residual risks related to it. This fund could be granted at the beginning of production and be updated when more information emerges from the surveying of existing pipelines and based on the number of maintenance work required. Similarly, appropriate explanation of allowable expenses needs to be interpreted, such as time monitoring cost claimed from such fund, and whether using a fixed option hereafter can also be claimed from the fund. If the fund can make modifications to contributing rates, realising future fixed solutions can be handled with greater security, in contrast to demanding a company to pay after a project elapse, or in worse case, left the country.

Workflow Optimisation. Combined work operations or batch decommissioning can be proposed for the intent of operating economies of scale (Table 2). The output of an optimising programme will be an announced manual that concentrates on lowering well P&A costs, as a measure of their method in boosting the economic recovery. The main aspect of the programme is to encourage work collaboration, and the usage of improved contracting models (such as for massive lift vessels) and stimulate the work-sharing campaigns. With a framework and structured environment towards work-sharing, such as optimising well identification well plugging sequencing and timing, there will be reduced cost work environment which may lessen the frequency of occurrences of operators being badly financed to complete the decommissioning project. The function of industrial organisations such as Decomm North Sea (Decomm North Sea, 2017) should also become one of the stakeholders for the development of framework. Such organisations could assist in facilitating collaboration (work-sharing campaigns) and bridge industrial application from scientific advancements as its members range from operators to technology developers. Another aspect worth focusing is the theory of batch decommissioning, in which, structures could be cleaned and left temporarily standing in location, until an ample number of structures could be removed simultaneously to lower transportation costs of massive lift vessels. This amount could perhaps be restricted to two structures, while considering a short operation window period during the summer for decommissioning operations in temperate climates. This could also be relevant in countries like Thailand (Petroleum Institute of Thailand, 2008), where there are multiple structures designed for accommodation, production, solely for drilling in one location. Thus, if a field were to be depleted these structures may not be valuable at about the same timeframe anymore. One approach that is also associated to workflow sharing among the Asia Pacific region, is the construction of decommissioning yards, as such work differ significantly with a peak and lull cycle, and would be more economical to have a regional yard, and tap on the advantage of existing waste management facilities infrastructure in a particular location.

Information Management System. A centralised data management system (See Item 4 Information Management System in Table 3, Section 3) in relation to offshore items decommissioned in situ will be essential for the dense network of pipelines and other subsea equipment, notably those segments of pipelines that are awaiting an action until the pipeline network sitting above it is decommissioned. There have been many pipelines in which a decommissioning decision has been postponed to its proximity to a live pipeline. Ultimately, all pipelines will discontinue to be in use, and having a unified management system could manage a working base on the potential total residual risks. One such recommendation could be GIS mapping of residual pipelines – pipelines above and under each other, with survey footage, make of pipeline, etc. documented.

Waste Management. In South-East Asia there is concern that there are inadequate yards to process the wastes. In existing yards, requirements of siting such a polluting industry must also be developed. Also, specialised waste management treatment is needed for mercurial or radioactive wastes from the oil and gas industry. It has been reported that crude oil in South East Asia have much higher levels of mercury than the rest of the world (Chaiyasit et al., 2010), as such it is important that there is a vigorous waste management policy while transporting the waste, and if the waste (such as contaminated equipment) is shipped to another country to be managed, there should be a system for secure operating mechanisms in such facilities (usually at a developing country, with more lax enforcements), and the material flow of the treated waste. As the wastes also exist in bigger quantity, there is a need for adjusting and updating of waste regulations due to the significantly greater quantity of waste encountered from the heavy offshore structures. Most waste restrictions are classified as concentration of contaminant per surface area, or per mass of the total object, without considering the total mass of contaminants that could be brought in due to the heavy offshore structures. Norway, is looking into upgrading requirements for leaching tests, reducing values for re-melting of metals (Norwegian Climate and Pollution Agency, 2011, p. 27).

Conclusions

From the study, Thailand shows the strictest regulation in decommissioning. Hence, it may be considered portraying the best decommissioning regulations. Meanwhile, Malaysia shows the most lenient regulation. In the North Sea and United States, where decommissioning is more experienced than other areas, the regulations are mostly similar, hence there is not much difference between their scores. Generally, all five countries studied have specific and clear regulations on DOA, well P&A, pipelines and associated structures, waste management, safety standards, post-decommissioning and post-environmental monitoring. In other words, these criteria are said to be vital in any decommissioning programme. The strength of the compared decommissioning regulations is the goal-setting approach and Norway's removal grant act. Nevertheless, recommendation has been given on frameworks on in-situ full or partial decommissioning, clarity on liabilities and residual risk management, financial security, residual risk funds, workflow optimisation, information management system and waste management.

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