

## Decommissioning of Offshore Platform: A Sustainable Framework

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[Concept Framework: Semi-PSS for Sustainable Decommissioning of Offshore Platform in Malaysia](#)



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**Abstract** - The decommissioning activities for fixed offshore platforms in Malaysia are expected to rise significantly. For many of the approximate 300 oil platforms, their service life is approaching the end. Thus far, only a handful of offshore platforms in Malaysian waters have been decommissioned mainly due to lack of regulatory framework and weak decommissioning plans. The shortage of decommissioning yards provides another major challenge in managing onshore disposal. With a number of options viable in decommissioning our used platforms, a review of these possibilities is timely. The scope of this paper entails the decommissioning methods particularly in the Gulf of Mexico, where conditions are similar to Malaysian waters. Evaluations of methodology as well as sustainability implications are discussed. The usual methods of decommissioning involve any of these options: complete removal, partial removal, reefing or re-using. Employing the aspects of sustainability as a pillar of the study, a conceptual framework of a viable decommissioning scheme is drawn. It was conceptually found that refurbishing the whole of the structure as a livable hub has its own unique potentials. Given the calm conditions of Malaysian waters and the sturdy design of the platforms, the restored structures hold possibilities either as ocean townships or futuristic cities such as a 'sea-stead'. This novel idea of decommissioning is presented and further discussed in the paper. **Keywords**-Sustainable; Decommissioning; Fixed Offshore Platforms; Malaysia; conceptual framework.

### INTRODUCTION

As of the year 2010, regionally, there is an estimated 1733 offshore structures<sup>1</sup> in Asia Pacific with Indonesia and Malaysia leading in numbers. Circa the year 2000, Malaysia has roughly 300 shallow water fixed platforms<sup>2</sup> operated by various operators in three regions: namely, Peninsular Malaysia Operation (PMO), Sarawak Operation (SKO) and Sabah Operation (SBO). Most of these platforms are shallow water platforms which are especially appropriate in Peninsular Malaysia waters, where water depths range from 50-70 m. In the context of this paper, the water depths no greater than 200m define shallow waters<sup>3</sup>, in accordance to the PETRONAS Guidelines for Decommissioning of Upstream Installations. Many of these platforms are over 20 years of age and 48% of the platforms have exceeded their 25-year design life. About 28% of these platforms are off Sarawak, 12% off Sabah region, and the remaining 8% off Peninsular Malaysia<sup>4</sup>. In light of the pivotal protests surrounding Shell's 1995 proposals for the toppling of the Brent Spar oil operators today are pressured by environmentalists into warranting "sustainable" decommissioning practices<sup>5</sup>. As an exceptional and flexible performer, steel has long been recognized and acclaimed for its strength, durability, functionality and dry construction method. Hence the usage and disposal of offshore platform steel greatly affects the sustainability aspect of decommissioning.

### DECOMMISSIONING

The challenges of offshore decommissioning are quite substantial due to rising concerns of sustainable development, the complexity and uniqueness of each removal activity, the high costs involved as well as the complex regulatory structure<sup>5</sup>. Decommissioning of an oil platform may involve leaving in place, dismantling, removing or sinking disused facilities<sup>6</sup>. This expression is widely accepted within the oil and gas industry rather than using the terms "abandonment", "removal" or "disposal"<sup>7</sup>. Other technical activities include plugging and abandonment of wells, pipelines, risers and related facilities, which will not be discussed in this paper. The decommissioning process differs between countries. For Malaysia, PETRONAS Petroleum Management Unit (PMU) identified four main phases: pre-decommissioning, implementation, post decommissioning and field review<sup>8</sup>. The scope of works will depend primarily on the type of installation and option for decommissioning.

In Malaysia, there is no governing legislation for decommissioning. However, plans would have to be in compliance with at least eight laws: Merchant Shipping Ordinance, Continental Shelf Act, Exclusive Economic Zone Act, Environmental Quality Act, Fisheries Act, Occupational Safety and Health Act, Natural Resources and Environmental Ordinance and Conservation of Environment Enactment<sup>9</sup>. The regulatory framework of Malaysia is the 2008 PETRONAS Guidelines for Decommissioning of Upstream Installations, requiring "decommissioning of facilities to be evaluated on a case by case basis based on the standards imposed"<sup>3</sup>. It is very much based on key international conventions such as the London Dumping Convention 1972/1996; United Nations Convention on the Law of the Sea (UNCLOS) 1982; and the International Maritime Organization's (IMO) Guidelines and Standards 1992<sup>10</sup>.

There are three main decommissioning alternatives. The first one is to leave a platform in place. Proper shutting down and stripping of all equipment directly involved in oil extraction are the key components of this option. This involves the plugging of wells in addition to the complete removal and severance of conductors, while all other parts of the platform remain. This scenario would entail the lowest costing due to minimal planning, engineering, and mobilization and disposal costs. Secondly, a partial removal with either offshore/onshore disposal of material that is toppled in place or taken to another location. Topsides must first be completely removed. Removal here would entail the most expensive removal costing. The third option is to completely remove a platform from the ocean. Materials from platform are removed for multiple destinations for reuse or recycling purposes after ensuring all wells are plugged. No other parts of the platform would remain above 4.5 meters below the mudline.

Remnants of the structure could be disposed of at a deep ocean disposal site, on the sea floor near the original site of operations, or removed to shore for salvage. Onshore disposal involves cutting up the structure into manageable pieces which are then transported to shore for either recycling purposes or disposal. Often, operators opt for the latter as waste consists of mainly steel which has a recovery rate of 98%<sup>6</sup>.

### SUSTAINABLE DECOMMISSIONING

With increased environmental awareness and the rising costs of material fabrication, the recycling and reusing of fixed offshore platforms are being examined carefully in view of sustainability feasibility. On average, an offshore platform is constructed out of 1000 – 20,000 t or more of steel (depending on the type of platforms).

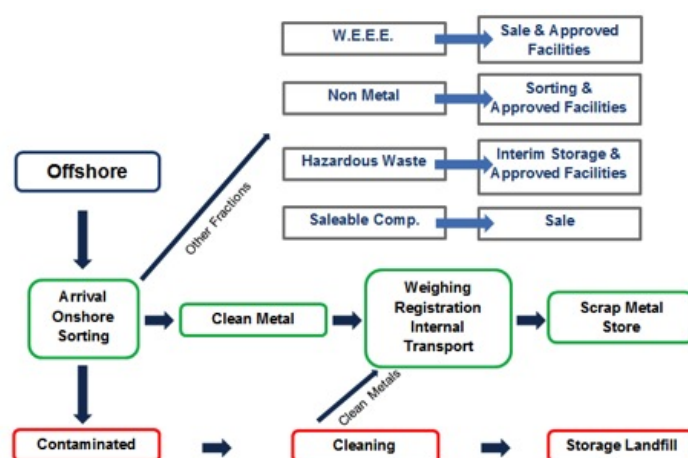


Figure 1 above illustrates the material flow of a typical decommissioned platform. Abandoning these weathered yet possibly functional massive steel structures out in the ocean would be a waste of resources. In 2008 alone, about 475 x 106 t of steel scrap were recycled worldwide. This number tops the combined reported total for other recyclable materials such as glass and paper<sup>11</sup>. Moreover, steel recycling and reusing account for significant raw material and energy savings as well as CO2 emissions reduction. If 475 x 106 t of hot rolled steel were produced purely from scrap steel, the total CO2 savings is approximately 811 x 106 t a year<sup>11</sup>.

Reuse takes place when end-of-life steel is reclaimed and reused, mostly retaining its original state of material. The embodied energy of steel is saved and the environmental impacts of creating new steel would be reduced. Reusing offshore platforms potentially removes thousands of tonnes of steel from the waste stream and reduces the input energy required for reprocessing or recycling. Taking salvaged steel as an instance, in 2007 the emissions cost of recycling over reuse cost the UK the energy equivalent of the output of two power stations<sup>12</sup>. Reuse is an important aspect of sustainability as the energy used for remanufacture or refurbishment is relatively small compared to the energy of the recycling process.



Figure 2. The new European 5-Step Waste Hierarchy which classifies waste management strategies according to their desirability<sup>14</sup>

As illustrated in Figure 2, reuse is the second most viable option in the new European Waste Framework Directive (2008/98/EC) aimed at promoting recycling among EU member states<sup>13</sup>. The framework applies to all materials, but the durability nature of steel makes reuse particularly pertinent. Thus, from an environmental,

and often economic, point of view it is desirable that as many components of an offshore structure as possible are extracted from the waste stream for reuse at the end of their useful life. Although reuse has primarily been used in the Gulf of Mexico, as artificial rigs, the trend is picking up in other locations, such as the North Sea<sup>14</sup> and Southeast Asia<sup>1</sup>.

The potential of reusing the bare structure or components of the platforms is theoretically boundless. For instance, the steel column from the Frigg platform is now a breakwater while the topside is utilized as a training centre for offshore personnel<sup>6</sup>. These platforms also could be used as bases for search-and-rescue operations or centres for waste processing and disposal.

### REUSING OF OFFSHORE PLATFORMS

Decommissioned offshore platforms have also long been recognized as a component of artificial reefs (AR) in the Gulf of Mexico. In fact, the Louisiana artificial reef program (LARP) is the largest rigs-to-reef program in the world. To date, it covers over 83 sites with approximately 120 decommissioned platforms<sup>15</sup>. The rigs-to-reefs programme is said to have improved biodiversity of the Gulf of Mexico, where flat and sandy sea beds create minimal shelter for sea creatures. These decommissioned platforms are ideal as artificial reefs as their open design attract fish<sup>16</sup>. Additionally, the platforms increase the amount of available hard substrate needed for coral communities, which are natural fish habitats. This important feature results in a more complex food chain, leading to better fishery exploitations. Fish densities surrounding the artificial reefs have been found to be an amazing 20 to 50 times higher than in open water<sup>17</sup> (this number is highly site dependent).

The controversy as claimed by conservative environmentalists is that the practice is viewed as a simple and easy excuse to dispose of the used oil rigs into the ocean. The end-of-life oil rigs as artificial reefs would inevitably lead to a certain degree of habitat damage, localized contamination and spreading of hydrocarbon invasive<sup>18</sup>, <sup>19</sup>. Malaysia holds much potential in rig-to-reef programmes due to its relatively shallow water depths. This is because the performance of AR as fisheries habitat was found to be highly dependent on the depth of deployment. This is due to the vast changes in temperature, salinity, turbidity and light across a vertical water column, which in turn affects the changes in plankton components with influences the plentiful presences of marine life<sup>20</sup>. The success of this practice in shallow waters of the Gulf of Mexico where around 200 platforms have been converted so far is a great motivator<sup>14</sup>.

There have only been two major rigs-to-reef programmes in Malaysian waters to date. BARAM-8, now more known as the Kenyalang Reef, was one of the first rigs-to-reef in this region. BARAM-8 was a single well 3-legged wellhead with a protection jacket located 8 nautical miles from Tanjung Baram of Miri. Decommission first started in 2001 after intensive consultation with external stakeholders (local fishermen, local councils, etc.) and approval of PETRONAS<sup>21</sup>. A series of marine surveys showed that the sunken BARAM-8 platform was housing dendronephthya soft corals and fish were in fact using the rig as migratory points. Additionally, in Brunei, there was a marked difference between the 1996 and 1999 surveys indicating significant increase in marine life<sup>10</sup>.

### CONCEPTUAL FRAMEWORK FOR DECOMMISSIONING IN MALAYSIA

Ocean colonization is another potential platform reuse option. Conceptualized and even practiced since the 1980's, Seastead is a concept of self-sustaining permanent dwellings at sea. Mega cruises and ships resembling cities are the closest floating cities there is in reality. However, they are not designed for permanent stays and self-sustainability. The notion of seasteading is now refined by Patri Friedman, executive director of The Seasteading Institute (STI). STI describes their mission as creating "next generation governance" at sea, outside the jurisdiction of any nation and the idea has \$1.25 million in backing from Peter Thiel, the PayPal co-founder. STI has already drawn up plans for the construction of a homestead on the Pacific Ocean off San Francisco<sup>22</sup>. The prototype was described as similar to a cruise ship and was loosely designed based on oil rigs, but with important modifications<sup>23</sup>.

According to TSI's official website<sup>24</sup>, seasteads run on diesel-fueled-generators for electrical power. Instead of being self-sustaining resource-wise immediately, seasteads are to specialize in industries where they have a competitive advantage (such as aquaculture) and trade for goods which are produced more resourcefully onshore.

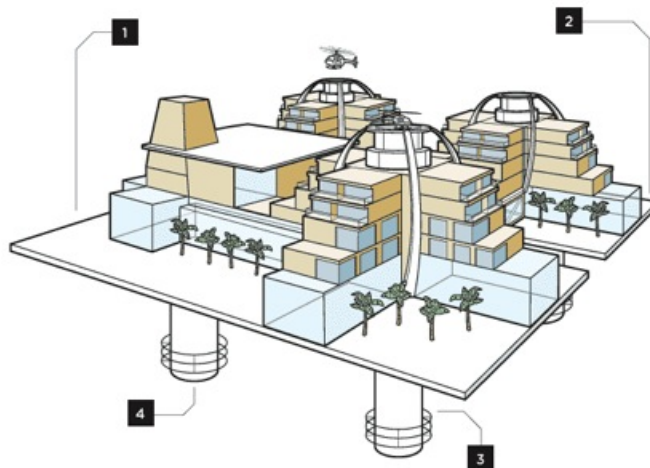


Figure 3. Conceptual design of the un-named seastead off San Francisco waters<sup>21</sup>

Figure 3 illustrates the conceptual design of a seastead which consists of (1) a 160,000 ft<sup>2</sup> living platform; (2) its water supply systems; (3) its foot tanks which hold the seastead above water and minimize the impact of rouge waves; and (4) the engine room which houses 4 diesel engines. These engines generate electricity and enable the structure to travel up to 2 knots. Instead of producing new steel for such mammoth project, it is feasible that existing oil platforms could be enhanced, structurally and facilities-wise, and re-used as a floating city. Being modular in nature ensures the ease in expansion and design of the cities. With hundreds of oil platforms scheduled to be decommissioned within decades to come, the possibility of decommissioned oil

platforms functioning as liveable hubs may come to realization soon. The winning entry of the 2008 Radical Innovation in Hospitality Awards, designed by Morris Architects, showcased a self-sustaining and eco-friendly hotel offshore. As offshore construction is costly, the architects proposed building prefabricated rooms and transporting them by ship<sup>25</sup>.

A special viewing balcony can be extended from each room and it can be retracted if the weather turns bad. Attractions of the "Oil Rig Resort, Spa and Aquatic Adventure" would no doubt be the various on-water activities and the rich ecosystem which would appeal to eco tourists. John Hardy, president of the John Hardy Group and co-sponsor of the competition, reckoned "the Resort offers a potentially commercially viable solution to an environmental hazard by providing alternative adventure travel opportunities based on a natural setting, simultaneously creating new jobs previously non-existent in the area"<sup>25</sup>. To maximize use of the existing infrastructure, a core of water is placed in the central of the platforms, allowing light to penetrate and acts as ballast in stabilizing the rig<sup>26</sup>.



Figure 4. Conceptual design of the „Oil Rig Resort, Spa and Aquatic Adventure“ design by Morris Architects and the transformation of the modular rooms

Figure 4 shows the conceptual design of an alternative use for decommissioned oil platforms and the mechanisms of its modular rooms.

One of the finalists of the 2011 Skyscraper Competition explored the idea of transforming abandoned oil rigs into livable cities, above and below the ocean level. The general population could reside above waters while specialized researchers work in underwater. The in-between zone will be used as housing and recreational areas. The existing structures are strengthened with the use of exterior steel beams that allow for high velocity wind to filter through the platform<sup>27</sup>. The entry by Malaysian design students Ku Yee Kee and Hor Sue-Wern exploits solar energy harvested with a large roof-top photovoltaic membrane. Wind turbines are located at strategic points along the façade while tidal turbines are installed at the bottom of the installation.

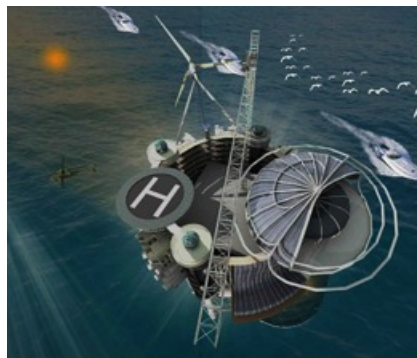


Figure 5 outlines the conceptual design of the „Residential Oil Rig“ with retrofitted facilities.

Closer to home, there is a successful example of the reuse of decommissioned structures. Off the east coast of Sabah, stands a refurbished oil platform, now a hotel for snorkelers and scuba divers. Seaventures Dive Resort, nearby Sipadan Island, houses 25 minimalistic guest rooms. Well known by serious divers all over the world, its main attraction is the diving trips around Sipadan Island<sup>28</sup>.

In view of these realistic concepts, the aging platforms of Malaysia holds potential economic value through more

commercialized yet sustainable decommissioning. Leading contractors and researchers could fit into the picture as an Engineering, Procurement, and Construction Contractor (EPCC) in refurbishing the end-of-production-life platforms, marketing the completed structures, and running the place for a contractual period. Prospective ventures include but not limited to research centres, wind farms, tourist attractions and even as long-term living hubs. Once the agreed upon contractual period is up, PETRONAS as the previous operators, could take over possession of the venture.

In terms of metocean characteristics, South China Sea is relatively calmer than other prominent hydrocarbon producing regions. The North Sea is frequently plagued by severe extratropical cyclones, which bring torrential rain and winds. Hurricane Bawbag in 2011 experienced winds up to 264 km/h<sup>29</sup>.

While tidal currents are quite insignificant in both the Gulf of Mexico and the South China Sea, severe tropical storms affect both basins<sup>30</sup>. However, it is quite established that destructive tropical cyclones are very rare in the near equatorial zone<sup>31</sup>. Due to the diminishing Coriolis effect, the belt 300 kilometers on either side of the equator has been generally considered to be tropical cyclone-free<sup>32</sup>. Hence, Malaysia is relatively shielded from the incidences of cyclones. Save for Typhoon Vamei, which developed near the south of Peninsular Malaysia in 2001. It was the first of its kind recorded within 1.5 degrees of the equator and is estimated to have a return period of once every 100-400 years<sup>32</sup>.

Conditions of the Gulf of Mexico (GOM) are less advantageous, given the likelihood of intense tropical cycles striking anytime. Circa the 60s, Hurricanes Hilda, Betsy and Camille caused severe damages to 50 out of 1500 platforms. Forty years onwards, hurricanes Ivan, Katrina and Rita destroyed 130 of 4000 fixed platforms along the Gulf<sup>33</sup>. Moreover, the GOM is also affected occasionally by strong oceanic currents caused by the Loop Current and its anti-cyclonic eddies<sup>30</sup>. Given the little information available on the comparisons of metocean data of the three seas, an evaluation of the respective platform design guidelines would illustrate the extent of environmental loads of the respective oceans.

**TABLE 1. COMPARISON OF MAXIMUM AND SIGNIFICANT DESIGN WAVE HEIGHTS FOR OFFSHORE PLATFORMS OF DIFFERENT REGIONS**

| Area                       | Standard Guidelines              | Hmax<br>(m) | Hs<br>(m) |
|----------------------------|----------------------------------|-------------|-----------|
| Gulf of Mexico<br>( GOM )  | API RP-2A (2005) <sup>34</sup>   | 21.5        | 10.75     |
| North Sea                  | DNV OS E301 (2004) <sup>34</sup> | 23.8        | 11.9      |
| South China Sea<br>( PMO ) | PTS 20.073 (2005) <sup>35</sup>  | 6.6         | 3.3       |

Table 1 demonstrates the variation in maximum design wave height (Hmax) and significant design wave heights (Hs) for the GOM, the North Sea and Peninsular Malaysia. The difference between these values clearly depicts the environmental conditions of the three oceans. The relatively calmer waters of Malaysian waters are a plus point in terms of safety and ease of the refurbishment of the decommissioned rigs. The crux of the matter would be coming up with the most optimal engineering and economics scheme in realizing this innovative vision. Once the appropriate platforms are identified by the operators, retrofitting works could be done to structurally strengthen the platforms and to integrate sustainability elements. Incorporating the key criteria of the Green Building Index or other equivalent indexes, the refurbished platform houses a coexistence of humans and nature. By improving on the efficiency of mechanical and electrical systems as well as incorporating good passive designs together with proper sustainable maintenance regimes, significant reductions in operational energy and emissions can be realized. For instance, having adequate harvesting of natural lighting, an efficient storm water management and proper control of air flow would greatly reduce carbon footprint and incur long-term savings. Similar to the design by Morris Architects, wind turbines, wave energy generators and photovoltaic panels could be mounted for alternative energies. As for desalination works, Thermo-Ionic technology is implemented. This novel technique applies salinity gradients using low-temperature energies such as sunlight or waste heat, significantly reducing operational and material costs.

## VI. CONCLUSION

With the impending rise of regional decommissioning of offshore platforms, it is important for all stakeholders to plan for a sustainable and profitable scheme. Being second in the waste hierarchy, reusing steel has been proven to incur less environmental impact relative to recycling the same amount of steel. Through extensive sustainability and technical comparisons, reusing an end-of-production-life platform can be feasible. The proposed approach of decommissioning as a Build-Operate-Transfer (BOT) commercial project is attainable with the fitting technology.