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Circular Economy (CE): A Framework towards Sustainable Low Carbon Development in Pengerang, Johor, Malaysia

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Under the Malaysia's National Key Economic Area (NKEA), Pengerang is set to become the largest regional petroleum refinery and trading hub in South East Asia and will be the focus centre in Asia and globally. This paper relates the basic theory of CE with Pengerang's background, which is in the construction phase towards becoming the centre of integrated petrochemical refinery industry in Johor, Malaysia. CE in the petrochemical industry in Pengerang is briefly exposed in terms of overall constitutional framework, industrial management, energy cycle usage, and wastewater and sludge treatment. This paper outlines the reviews of current movements for Circular Economy (CE) based on the work of literature gathered in 2000 till 2017, its definitions, current best practices, and policy framework towards its implementation especially in highly industrialised petrochemical refinery industries in Europe and China. These mechanisms of CE are then synthesised and implementation framework for CE in Pengerang is produced. Despite this early investigation and literature exposure of CE in Pengerang, there is a need for further specific research to be conducted extensively, to acquire more understanding especially in the context of potential implementations, stakeholders' involvement and awareness towards low carbon development in Pengerang, Johor, Malaysia via CE implementation.

1. Introduction

Pengerang is located in the Southern Eastern tip of Peninsular Malaysia, in the State of Johor. The Johor State Government has selected Pengerang as a catalyst project for rural transformation program. The area has seen an increase of investments and development over the past few years which are sourced from the Pengerang Integrated Petroleum Complex (PIPC). PIPC is a mega project planned under the Malaysia's National Key Economic Areas (NKEA), which was announced in 2011. With strategic location of shipping lanes from the Middle East- Singapore – China (see Figure 1) and is adjacent to Singapore, PIPC will be a big step in creating value for the downstream oil and gas value via petrochemical refining industry in Johor and Malaysia.

PIPC with area of 80.94 km^2 single plot will comprise of oil refineries, naphtha crackers, petrochemical plants as well as liquefied natural gas (LNG) import terminals and a regasification plant, upon its completion in 2019 (JPDC, 2016) (see Figure 2). To ensure the oil and gas refinery and storage hubs are well managed and administered, a newly dedicated Federal Government agency, Johor Petroleum Development Corporation (JPDC) was created as a subsidiary of Malaysia Petroleum Resources Corporation (MPRC). Current development in the whole of Pengerang other than PIPC, comprises of agriculture land (palm oil and rubber), forestry, seashore, hinterland, local villages (FELDA and rural areas) as well as the new uprising township developments.

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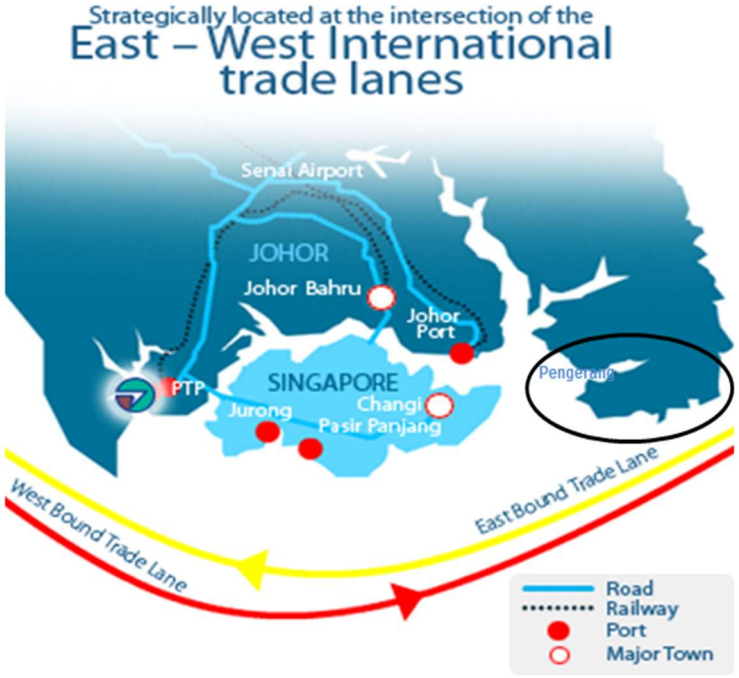

Figure 1: Location of Pengerang, Johor, Malaysia (JPDC, 2016)

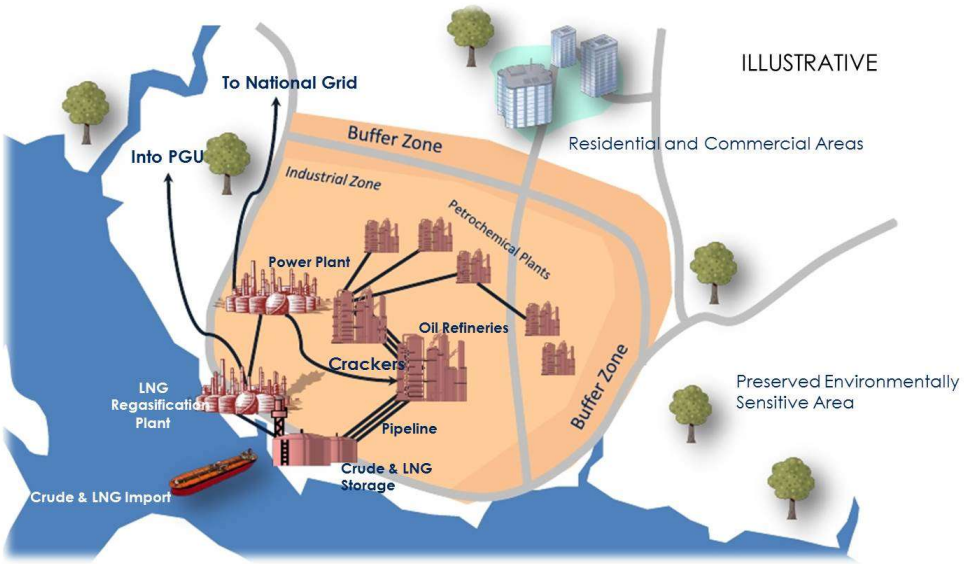

Figure 2: Pengerang Integrated Petroleum Complex (PIPC) (MPRC, 2017)

In conjunction with PIPC project in the plan, Pengerang Local Authority has signed a 1.1 M RM Memorandum of Understanding (MoU) with Universiti Teknologi Malaysia (UTM) to conduct four research projects to develop a framework for sustainable development in Pengerang. The MoU involves the preparation of the Pengerang Low Carbon Society Blueprint 2030 (PLCSBP 2030) and other master plans such as tourism, business and geographic information system (GIS). The outcome of the research projects is to spur ideas in planning and shaping development which will bring optimum benefits to the community in Pengerang (Shahizatul, 2017). There is a potential of managing resources in Pengerang, especially in the petrochemical refining industry using the concept of CE towards its vision of “Smart, Clean, Green and Smart Pengerang” by 2030.

2. Circular Economy (CE)

Circular Economy (CE) refers to an economic system that leaves no waste to be landfilled and that keeps all material flows in the economy loop through reuse, redesign, material recovery or energy recovery (European Commission, 2015). Current practices have seen CE concept to be embraced in the policy of the developed as well as the developing countries during previous few years (WM&R, 2017). Mihelcic et al. (2003) explains that CE concept extends the conventional waste and by-product utilisation and recycling by emphasising the utilisation of the value embedded in materials in as high-value applications as possible. The current concept of CE is shown in Figure 3. In J. Korhonen et al. (2017) suggests that CE provides a win-win potential situation for sustainable development as it contributes to all three dimensions of sustainable development, economic, environmental and social. It also adds that CE should adapt to the natural cycles and utilise these in economic cycles by respecting the reproduction rates (see Figure 4).

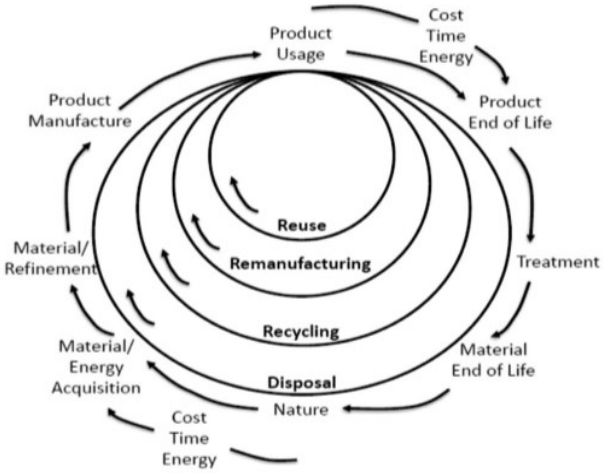

Figure 3: The current concept of CE (Milhelcic et al., 2003 via Korhonen et al., 2017)

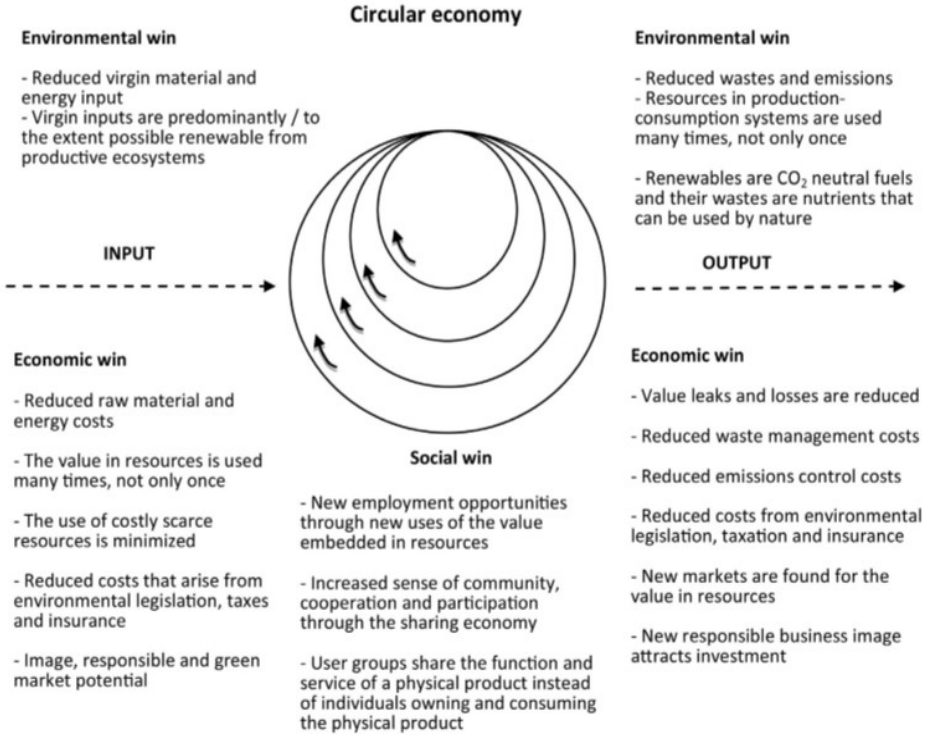

Figure 4: CE for sustainable development (Korhonen et al., 2017)

In comparison, CE is different than the concept of “Industrial symbiosis” and “Nexus”. “Industrial symbiosis” refers to the notions of biological symbiotic relationships in nature where at least two otherwise unrelated species exchange materials, energy, or information in a mutually beneficial manner (Chertow, 2004). Whilst, “Nexus” refers to a scientific enquiry to structure large-scale investments via optimising the system’s performance by treating subsystems as a whole and interrelated in a closed loop interaction within appropriate set of boundary (Howarth and Monasterolo, 2017).

2.1 Current practices of CE

In the perspective of petrochemical integrated industry which consumes extensive energy, it is facing tremendous pressure to save energy (Kangying et al., 2016). Taking Chinese government as an example, via Kangyin et al. (2016) which explains on CE as a sustainable development strategy proposal to be considered in the Chinese petroleum refining industry, the paper calculates the needs of having the petroleum refining industry to be directed towards more focus on resource consumption instead of economic development and cleaner production through integrated evaluation method. The paper also concludes the challenges and policy recommendations for promoting CE in Chinese petroleum refining industry (see Table 1) and described it as far in comparison with other developed countries, such as Germany (Morioka et al., 2005) and Japan (Van Berkel et al., 2009).

Table 1: Challenges and policy recommendations for promoting CE in Chinese petroleum refining industry

Challenges	Policy recommendations for CE in Chinese petroleum refining industry
i. Lack of reliable data; ii. Weak economic incentives; iii. Shortage of advanced technology; iv. Poor enforcement ability of legislation; v. Poor information transparency; vi. Poor leadership and management; vii. A lack of CE awareness; viii. A lack of standard system for CE evaluation.	i. Current industry can use resources and energy circulatory and reduces the industrial wastes effectively on whole; ii. Incorporate CE in the production and management process; iii. Evaluation index system of CE for Chinese petroleum refining industry should be adjusted dynamically; iv. Government should fully consider the proper distribution and strengthen the macro-regulation v. Urgency to carry out science and technology innovation to promote low-carbon green development vi. Petroleum refining enterprises should make full use of opportunities as alternative fuel consumption will display an upward trend in future.

Another great example for CE best practices is Rotterdam. Rotterdam’s CE was developed by the city of Rotterdam with the cooperation with experts and partners in the city. City of Rotterdam focuses on its primary material flows with the cooperation with stakeholders on which the circular principles could add value as the basis for CE opportunities. Gementee Rotterdam (2017) has produced a report, which maps out the long term and short-term goals opportunities towards a more circular business. The challenges and policy framework for assessing Rotterdam CE initiatives are shown in the following Table 2.

Table 2: Challenges and policy framework for assessing Rotterdam CE initiatives

Challenges	Policy framework for assessing Rotterdam CE initiatives
i. Integration of CE within existing municipal programmes and policies; ii. Sufficient support from organisations for CE; iii. Availability of sufficient budget and manpower; iv. Boundaries and limitations raised by existing laws and regulations to allow for new CE solutions; v. Awareness and acceptance of citizens; vi. Traditional ways of procurement based supporting a linear approach; vii. Establishment of efficient balance in responsibilities between the city and its partners.	i. Support the upcoming vision for CE; ii. Fund and initiate research into CE; iii. Have a strong connection with one of the economic clusters; iv. Create prosperity and new green jobs.

Having all of these understandings on the CE concept challenges and policy framework, it is essential to bring the aforementioned theory, principles, and policies from the international champions into the context of Pengerang, Johor, Malaysia.

3. CE in PIPC, Pengerang

With the understanding of CE and background of Pengerang development, there is a need to study on the current petrochemical refining industry in the plan as well as guiding the development through proper planning integration with the CE concept. Wei (2017) exposes on the higher potential of chemical industry to go for circular economy via understanding its circular chain which consider mainly on water chain, energy chain, information chain and other public works as part of a petrochemical refining industry chain. The research also has provided a set of five essential indicators to achieve circular economy in an area with chemical industry which includes (1) resource reduction; (2) emission reduction; (3) resource recycling and reuse; (4) economic output value and (5) investment rate. Meanwhile, the current storage capacity in Pengerang is 1.3 MCM with target storage capacity 5 MCM. In the process of refineries, storage, regasification, power plant and naptha crackers in Pengerang requires an extensive use of energy and water resources. Towards reducing the energy and water consumption in this process, CE concept must be introduced in the industry by reusing the wastewater via complex water treatment plant back into the initial loop and converting the released stream of carbon dioxide (CO_2) to the potential power supply or energy. Within the PIPC non-refining industry planning, there has been hospital and clinic as medical waste resources, waste management centre to treat wastewater and conversion of solid waste to energy (WtE) which have been put in the plan.

CE concept is not just limited to the PIPC industry, it might as well fit for the whole community system in Pengerang which include households, commercials, tourism areas and etc. By taking Rotterdam case as an example, the CE concept has been in plan for the Port of Rotterdam through environmentally friendly oil tank terminals, promoting the use of green technology and ensuring a smarter use of resources (Gemeente Rotterdam, 2017). The potential of converting the conventional system of collect, use, and discard will be adjusted to combat resource scarcity. Among all of the potential CE capability that can be learned from Rotterdam and China are shown in Table 3.

Table 3: Potential CE capability learned from Rotterdam & China

Rotterdam	China
i. Ports function as matchmakers for producing and recycling industries towards reuse energy in chain; ii. Ports accommodates industries in active treatment, collection and shipment of waste in innovation circles; iii. Ports are important crossing points for all kind of waste and industrial flows and act as logistical hubs for the import/export of waste materials; iv. Presence of industrial clusters in ports help to facilitate circular and more sustainable use of waste and resources and offering benefit of existing synergies between industries; v. Example of projects: waste-2-chemicals (synthetic gas and methanol produced from residual waste flows) and Ioniqa (recycling process of plastic bottles into usable chemical raw material for new products) vi. Establishment of “Circularity Center” for further joint-research with local industrial companies for CE initiatives.	i. Resourcing industrial wastes; ii. CE in production and management; iii. Continuous evaluation on CE; iv. Macro-regulation from government on CE; v. Research fund on CE initiatives.

4. Conclusions

From best practices, it is significant for petrochemical integrated refining industry which uses extensive energy and water consumption in Pengerang to be planned and monitored towards the implementation of CE. The CE concept is not just limited with the petrochemical refining industry but it might as well benefits the community in Pengerang as a whole. The question on the feasibility, willingness of local stakeholders and authority, awareness, technology availability must be addressed quantitatively in a further study to understand the local context of CE in Pengerang. A social science research investigation (through a set of questionnaires, interviews and focus group discussions) is needed to be conducted among the professionals, the stakeholders of petrochemical companies on the CE’s current and future initiatives towards reducing energy consumption and emission as well the goal of realising a low carbon city in Pengerang, Johor, Malaysia.

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