Industry Symbiosis: Essential for the circular economy and achieving net zero carbon emissions

On the sidelines of the National Chemical Engineering Symposium (NACES) 2022, IChemE's POPSIG (Palm Oil Processing Special Interest Group) organized on 22/11/22 a webinar forum "Circular Economy - Exploring the Industry Symbiosis Within and Outside the Palm Oil Industry". Three process experts were invited to share what their organisations have achieved and what further needed to be done.

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Many industries today are non-sustainable in nature. Production is in large quantities using cheap and easily accessible raw materials with little attention paid to the waste produced. Economic profitably is the driving force and industry is constrained by social and ecological environment. How then do we create a circular economy? Application of industrial symbiosis allows materials to be used in a more sustainable way. The core idea of industrial symbiosis follows the study of industrial ecology, which is to imitate the functioning of ecological systems. When it is implemented correctly, industrial symbiosis creates an interconnected network where materials and energy are utilized continually with minimum generation of waste. Materials used remain economically valuable for a longer period. In its sustainability journey the palm oil industry is already practicing reduce, reuse and recycle within its sub-sectors and even across sub-sectors.

Industry symbiosis dates as far back as 1970s and it is the mutually beneficial exchange of waste and by-products between three or more parties. We are looking at
1. By-product exchange
2. Utility and infrastructure sharing
3. Common service sharing
So where is the palm oil industry in industry symbiosis?

Hemavathi Silvamany in her overview reviewed the importance of palm oil in our daily lives and shared that the palm oil processing value chain is similar to the oil and gas industry with upstream, midstream and downstream. In upstream (estate) and midstream (mill) she showed the enormity of palm biomass that is wasted. For example, of the 179 million tons of biomass generated in 2019, 25 million tons of EFB (empty fruit bunch) were unused and 14 million tons of fibre and 6 million tons of PKS (palm kernel shells) were underused, potentially missing out at least RM10 billion in revenue annually (see Fig. 1).

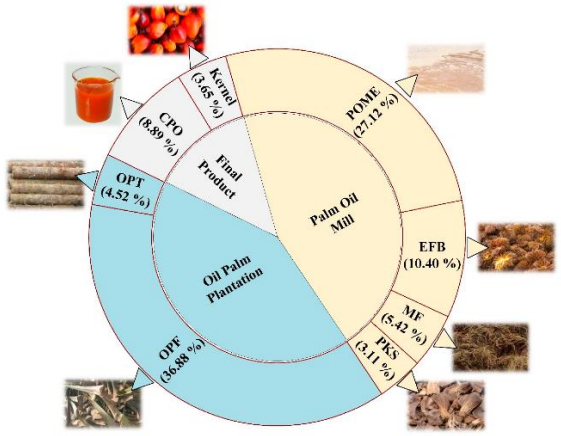

Fig. 1 Typical composition of oil palm biomass (%) in the Malaysian palm oil industry
Source: https://doi.org/10.3390/su12198081

- Equivalent of 5 ton FFB processing
- Every ton of CPO can be associated with 9 tons of biomass.
- Largest contribution is POME and OPF.
- Approximately, 179 mil tons of biomass was generated in 2019.
- The palm oil industry has contributed up to 77% of the total agricultural wastes in Peninsular Malaysia.
- Unused resources: 25 mil ton of EFB, 70 mil tons of POME, equivalent of 4 mil ton coal, 800 mil USD
- Underused resources: 14 mil tons of fibre, 6 mil ton PKS, equivalent of 8.35 mil ton coal, 1670 mil USD

Silvamany identified many opportunities for a circular economy, many of which are already practiced in Sime Darby Plantations (see Fig. 2). They are also investigating co-digestion of biomass in POME treatment to use up more biomass as well as generate more biogas.

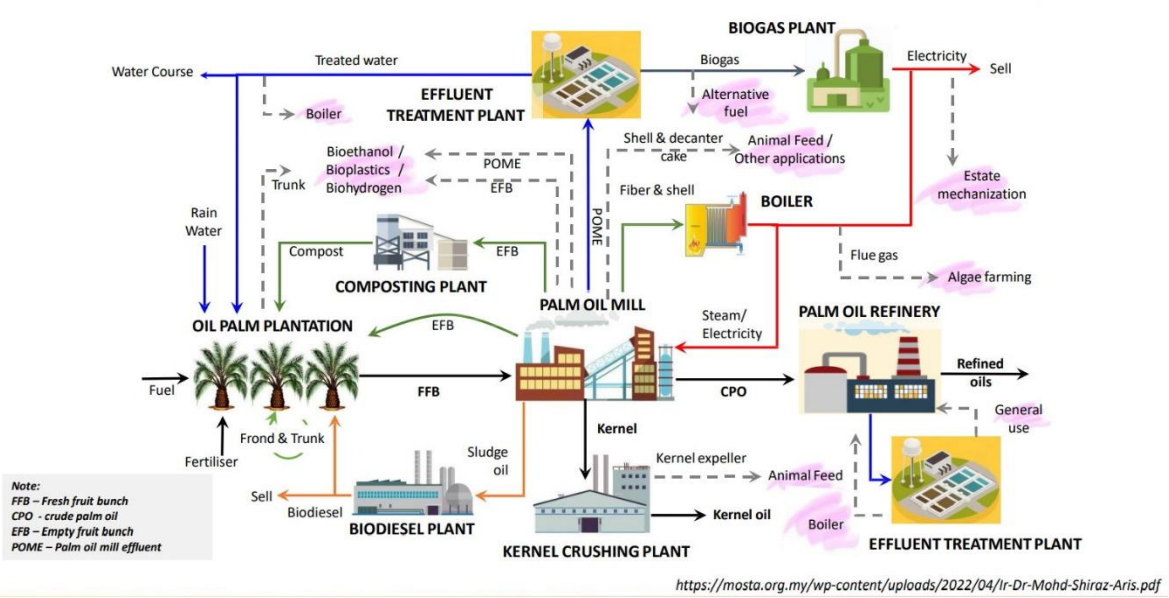

Fig. 2 Circular economy in the Palm Oil Industry: Opportunities

Ir. Shyam Lakshmanan in Sabah runs an integrated palm oil refining complex with 3 refineries, 6 fractionation plants, 3 kernel crushing plants, bulking facility with export jetty and a biomass boiler and power plant. Within the complex, IOI Edible Oils is practicing recover, recycle, reuse and reduce to not only minimize waste, energy and water usage but also generate green steam and power (see Fig. 3).

Its biomass boiler and power plant uses EFB from nearby mills as fuel and the residue boiler ash, being rich in potassium, is sought after as fertilizer in the plantation. This reduces its Scope 1 and Scope 2 GHG emissions. The palm oil mill can be a net exporter of green energy be it electricity, biogas or biomass. This is an example of industry symbiosis between three parties viz estate, mill and refinery.

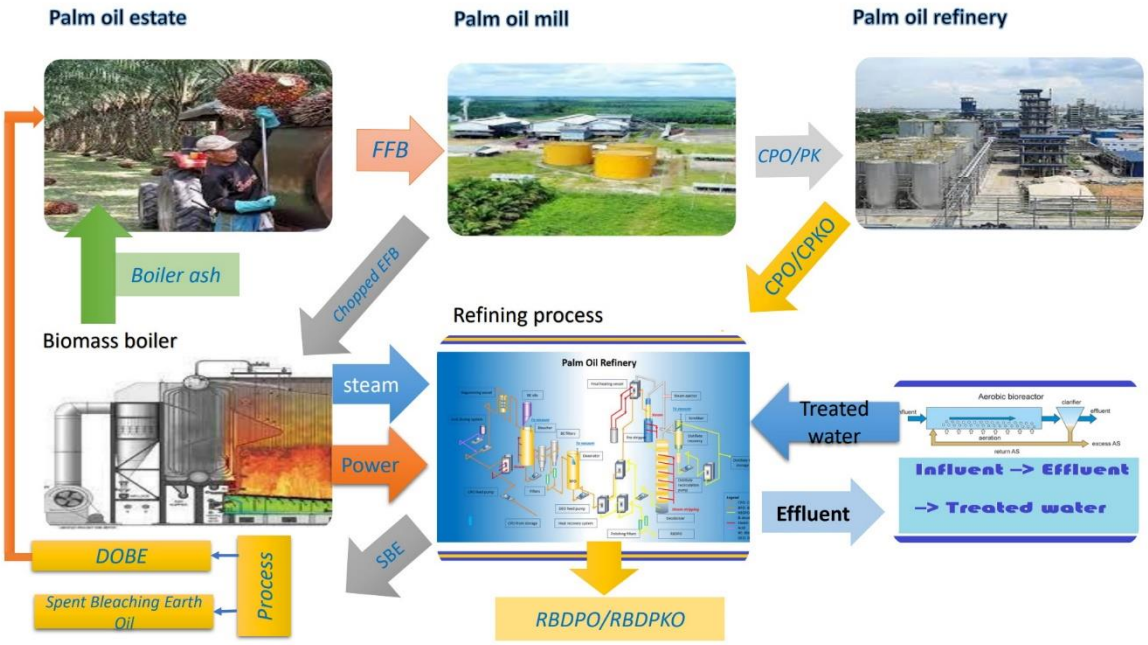

Fig. 3 Circular economy in an integrated palm oil refining complex

The complex has no town water supply, collects rain water, treats its effluent and reuses the treated water in the plant. It sells its spent bleaching earth to a third party that recovers SBEO (spent bleaching earth oil) which has many uses including being a biofuel feedstock. The DOBE (de oiled bleaching earth) can be sent to the plantation as a component of a bio organic fertilizer.

Given the concerns with MOSH (mineral oil saturated hydrocarbons) and MOAH (mineral oil aromatic hydrocarbons) contamination in palm oil the refinery has switched from fossil based mineral lubricants to using its own palm based bio-lubricants viz palm olein.

The site had a problem disposing of its used plastic membrane filters from the dry fractionation process but eventually found a processor in Peninsular Malaysia to recycle this special material. Finally he shared that in a remote location of Kunak in Sabah, trucks for transporting FFB and crude oil are successfully using compressed biogas from their own POME plants.

Dr. Calvin Chok described an oleochemical complex as a chemical engineering playground where there are many processes and product from one plant becomes the feed to another plant allowing for circularity. All the products and by-products including waste can find buyers.

Fig. 4 Into the future: KLK Oleo's commitment to sustainability

In the corporate video (Fig. 4) he showed establishes that oleochemicals are used in many applications that are not obvious to the layman. At the same time it emphasized KLK Oleo's commitment to sustainability standards.

Palm Oil Industrial Cluster (POIC)

The purpose of the POIC is to supply material to adjacent industries. There is Sawit POIC in Sandakan but it is not yet as developed as the one in Lahad Datu. It has one refinery that has been there for many years. IOI Edible Oil was on the original site but the POIC was shifted across the hill due to land acquisition issues.

The other one in Sabah is the POIC Lahad Datu where there are many industries related to palm oil. One of the companies operating there is Ecooils Sdn Bhd that recovers SBEO. Shell has acquired all Ecooils five plants in Malaysia and Indonesia to drive its low carbon fuels ambition. Another existing SBEO company there, Gamalux Oils Sdn Bhd, will set up a new oleochemical plant. So the cluster is developing well.

While there are no similar clusters elsewhere in Malaysia there are industrial parks. KLK Oleo operates in such a park. Its hydrogen supply is provided by a third party plant on their land and they realise GHG emissions savings as hydrogen does not need to be transported by trucks. Further KLK utilizes the waste steam from the hydrogen generation plant.

Sime Darby Plantations works across their entire supply chain as a cluster. For example their biodiesel plant takes in sludge oil, waste oils and high ffa oils from their supply chain.

Geographic proximity

Geographic proximity is said to be a key characteristic of the resource reuse and recycling practice. We have our plantations and mills around the country but the refineries, oleochemicals and biodiesel plants are located near to port. The panelists say that geographic proximity is not a barrier for circular economy.

A composting plant located central to a number of mills that send in their EFB can be cost effective. When refineries were smaller it was possible to be close to mills but as the size of refineries increased tremendously it is near impossible for the large refineries to be supplied by a few mills located closeby. The mill has to be located close to the plantation as they are handling a large volume of FFB to produce just 22% of oil. For refineries near to ports it is possible to ship the refined oil by barges which is more efficient than road transport.

Circular economy does not imply that it has to be local but where a material gets reused as much as possible and there is a value is using that material. So circular economy will still work whether it is regional, national and even global.

Energy: Palm biomass and hydrogen

From the ports, biomass such as PKS is exported to Japan as it is much sought after. In many of the power plants if they are using solid fuel, coal predominantly, then PKS makes an ideal mixture with the coal for co-firing. It allows them to reduce their GHG footprint. There are companies that take EFB and make EFB pellets to export to Japan and Korea. In 5 to 10 years when there is a sufficiently attractive price due to carbon pricing, mills may no longer be interested to export as there will be demand by industries in Malaysia further downstream.

There are challenges in producing bio-hydrogen from palm biomass. There are many routes like gasification of biomass, reforming of biogas and pyrolysis. The proven process today is hydrolysis of water using solar electricity on a large scale and therefore favoured over processing methods. Also

favoured is wind and hydro electricity to produce green hydrogen. However it is still an expensive way to produce hydrogen. The palm industry has been looking at this for many years and viability depends on the volume and the price point that the market can take.

In the meantime the industry is looking at biodiesel which is well established as a process for transportation and industrial fuel. The blending of biodiesel is progressively increasing at 10% now to hopefully 20% for transportation by the end of 2022. The industry is moving from biodiesel, which is an oxygenated fuel, to HVO (hydrogenated vegetable oil) which is a hydrotreated (hydrogenation and hydrocracking) and deoxygenated fuel. HVO is a drop in diesel fuel and can be blended as SAF (sustainable aviation fuel) into conventional jet fuel. In this evolution hydrogen is the end game. Whilst there is a lot of academic research in bio-hydrogen, the gap is in the scale up and end application. It was pointed out that hydrogen can also be produced from glycerol and as more biodiesel is produced more glycerol will become available as a feedstock.

Limited circular economy

Comment: Circular economy is very attractive in both economic and environmental aspects, but still arguably being implemented on a limited scale in Malaysia. The palm oil industry in practicing circular economy should be able to help Malaysia achieve its target of becoming a carbon-neutral nation by 2050.

The IOI group is committed to significant reduction in GHG emissions and conserving the environment. Lakshmanan pointed out that all his projects, be it energy integration, GHG reduction, particulate matter reduction and even 3MCPDE mitigation, have good payback. When you protect the environment you get your dividends.

The IOI group has committed to net-zero mills. The MPOB requirement as of 1 January 2014 that all new oil palm mills shall have methane gas trapping facilities or emission avoidance is a key licensing requirement that helps not only the mill to be net-zero but makes the electricity grid more green. Using a 60 tonne per hour mill as an example, the biogas from the POME treatment can generate 6MW of electricity. As the mill needs only 1.5MW the excess 4.5MW could be exported to the grid. As a result the mill does not have to burn EFB, MF and PKS which it can sell as biofuel. It does not make sense to send PKS to Japan incurring GHG emissions in shipping when it could be used to make our grid greener eg co-firing our coal power plants and helping Malaysia towards becoming carbon-neutral.

On the question of whether the mill is willing to let go of their biomass and whether outside the palm oil sector are other industries willing to use this excess biomass, Lakshmanan pointed out that the Taiko bleaching earth plant in Indonesia uses biomass. The cement industry use coal and should be happy to use biomass to reduce their GHG foot print.

We can also work as a cluster where several mills send their biomass to a power generator near the grid. Mills are often in remote areas far from the grid and the electricity company is reluctant to lay cables to these mills. The solution is for the mills to send their biomass to the grid, literally, to green the grid. The mills get paid and they help the nation's net-zero aspiration.

Further downstream in oleochemicals most of their by-products whether gas, liquid or solid can be recycled or sold with specifications. For the rest it looks for partners with whom it can process the 'waste' suitable for their use, pricing the by-product accordingly with a win-win arrangement. There is a need to reach out to others outside the palm oil industry, especially to those who support the green initiative. This effort however takes time.

National Energy Policy 2022-2040

This new policy just launched in September to help the country achieve net zero greenhouse gas emissions (GHG) in 2050. Its Action Plan A6 under Strategy 2 of Strategic Thrust 1 is to enhance and unlock potentials of indigenous bio-based energy resources. The Ministry of Plantation Industries and Commodities (MPIC) will be the lead entity in Action Plan A6.

The policy is very much welcomed as it creates the environment to bring together players within the palm oil industry and those outside to move together towards the carbon-neutral goal of 2050.

On biodiesel as the policy aspires for B30 for heavy transport by 2040 it will trigger oil and gas companies in Malaysia to look at it seriously for the uptake of biodiesel. As the EU phases out palm biodiesel this will be helpful for the biodiesel industry in Malaysia.

At IOI they report the GHG emissions for their products streams and where the target has been achieved they will continue to set the target lower to achieve net-zero earlier. The management is very supportive of this.

Final points

Silvamany: I believe technologies are available to shift value chain in the palm oil industry to a circular economy but efforts must continue to be put in to improve the technology to make circular economy more competitive. Policies will also help to make production more responsible.

Laksmanan: Sustainability is the mantra we should all practice and for the students participating today, bear in mind this will be the direction we will be taking in the years to come. Put sustainability and circular economy in the work/thesis you do, so you have a greater selling point when you go for your interview. This way you show you will be able as engineers to hit the ground running in this very wide field.

Chok: In KLK it is very clear that sustainability is something we must do and what is need is greater capability building and better technology that the industry can adopt to produce better products with lesser energy footprint and waste. I hope more chemical engineers will step up into this and look for ways to decarbonize.

Qua: What is clear from our discussions is that leading companies like Sime Darby, IOI and KLK are already practicing circular economy and in some cases already extended this beyond the boundaries of the palm oil industry. This is very encouraging. The new DTN 2022-2024 will help us drive the circular economy even further and with the help of the government extend it outside the palm oil industry. Within the palm oil industry your companies are good examples for the others follow and for the smaller players, companies like yours are needed to show the way by your example. Chemical engineers will have an important role to play too.

Reported by Ir. Qua Kiat Seng