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Bio-based Plastic Circular Economy

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Abstract**—*****Plastics is already an integral part of man's daily lives. Whatever man is doing, wherever man is moving, he will use plastic. The versatility and physical properties of plastics make it superior over other materials like papers, and metal containers. The affordability and availability of plastics lead us to a throw-away culture, that results to severe plastic pollution both in grounds or in waters. In the Philippines alone, 163 million plastic sachet packets, 48 million shopping bags, and 45 million thin film bags is used daily, in which around 0.28 – 0.75 million tons/year are thrown into the ocean. Plastics cannot be totally replaced with other materials. Transporting goods contained in other containers like metals becomes too heavy, adding costs to transportation cost. In well populated cities and countries with lesser natural resources, replacing plastics with organic materials like papers poses worse environmental footprints. To mitigate the problems on plastics, there are lots of international projects and collaborations that aims to developed technologies and system that will replace fossil-based plastics with biodegradable, recyclable, bio-based plastics and create the circular economy of plastics. ASEAN partners with European Union to acquire pilot projects from the collaboration, that can be utilized in the region to answer the call on plastic waste management. But more than the industry-state-industry cooperation, every individual has big part in the waste management. Changing our lifestyle with plastics can make our world more sustainable.***

I. INTRODUCTION

Plastic offers the most convenient ways in handling many things. It is more durable and longer lasting, and lighter compared to papers in wrapping things up. In comparison to glasses as containers, plastic is also more flexible, not fragile, lighter and more durable. This makes plastics a better choice in containing things including edible ones, like foods and water. Plastic is also shatterproof, which makes it less vulnerable especially in shipping products from one point to another, while glass when broken can create messy situation and product loss. The weight is also a big deal, making plastic jars and containers cheaper to move things to different places. Plastic is also easy to carry and can be used everywhere and any moment (comar.com, 2018).[1] As the world fight and strive against Covid 19, the need of plastic increased exponentially due to increased consumption of masks, sanitizer bottles and online delivery packaging.

The physical properties of plastics and the convenience it offers hide its hazard potential and led the world to a throw-away culture. The hazard is not hidden already but plastic pollution presents an ever-increasing problem that threatens the environment. The growing production and usage of disposable plastic products surpasses the world's ability to manage the disposal properly, recycling, and handle the problem, that arose from the plastic disposals (PARKER, 2019).[2]

Plastics are built to last forever. Most plastics are obtained from a simple chemical component of petroleum, the propylene. Decades of evolution in the manufacturing processes of plastics, make the production so efficient and the product invincible. The monomers of propylene are heated up with a catalyst to produce a strong carbon-carbon bondage, leading to the development of polypropylene (Wolchover, 2011).[3] This polypropylene is almost indestructible. There are seven types of plastics available for daily use, each of them has their own characteristics, and all of them are non-biodegradable because plastics are nor organic. Qualitylogoproducts.com identified seven types of plastic as shown in table 1, with their respective symbol for identification, uses, and recyclability (Mertes, 2020)[4] typical thickness to determine the time of decomposition (Ali Chamas, 2020)[5] when they come to the environment. Plastic bags are the products that have the shortest decomposition time at 20 years while disposable diapers and plastic toothbrush can last up to 500 years. Though plastic bags contribute only a small percentage to our plastic waste, they are a serious threat to wildlife especially to marine animals, since they are easy to break. There are 3.5 billion tooth brushes sold worldwide each year. Old toothbrush was never reused or recovered. These plastics normally end up in landfill (https://www.wwf.org.au, 2018).[6] National Geographic reported that half of plastics manufactured since its discovery have been made in the last 15 years; that around 8 million tons of plastic from coastal nations ended into the oceans.

The Philippines is an archipelago with more than 7,000 islands and a coastline of about 36, 289 km. The country's coastal economy contributes to 7% of the national GDP in 2015. A report by Global Alliance for Incinerator Alternatives (GAIA) shows that the country is using more than 163 million plastic sachet packets, 48 million shopping bags, and 45 million thin film bags daily. From those used plastics, Philippines throws around 0.28 – 0.75 million tons/year of plastic into the ocean making the country, 3rd largest contributor of marine plastic pollution. Marine and coastal ecosystem of the Philippines and of the world is facing multiple threats including plastic pollution (sea-circular.org, 2020).[7] This paper aims to identify the threats posed by plastics pollution in the environment, more specifically the ocean or marine environment; to identify the gaps and close the loop of plastic wastes management. It also aims to identify the technologies that can be used to minimize, if not eliminate plastic pollution entering into the environment both the land fill and the ocean.

II. METHODOLOGY

Plastics have been part of human's daily life, in every activity, in every event, from all walks of life and from every person. These can be found anywhere and anytime. The versatility, the strength, and the usability of plastic make it a reliable part of our life. Eliminating the use of plastic is impossible. It can be replaced in some cases but it can't be totally eliminated. In countries like Singapore, where there are not enough natural resources like water, replacing plastic with paper or other organic materials poses more serious problems. Nanyang Technological University, Singapore (NTU Singapore) scientists revealed in their cradle-to-grave impact model that in cities like Singapore, Tokyo, Hongkong, and Dubai, which densely populated metropolitan areas but with strong waste management structures and similar end-of-life incineration facilities, reusable and single use plastics are more eco-friendly than paper and kraft bags considering their environmental footprints.

Technology Policy

The 3 R's is a failure when it comes to plastic waste management. The United States of America popularized the 3R's method in 1970 by an environmental movement with an aim of curbing plastic problems. But this globally adopted process is inadequate to resolve problems on plastic waste especially on less developed countries (Dayrit, The Management of Plastic: The 3Rs are Not Enough, 2019).[8] These countries are the worst users of sachets, used for retailed products like shampoos and the likes, but these countries are also the one's with less and/ or weak plastic waste management laws.

As plastics have been manufactures for already several decades, billions of tons of plastic have accumulated in the ocean. Plastics have deleterious effects on the environment both physically and chemically. Physical effects include habitat destruction, marine animals' entanglement, facilitation of invasive species across habitats, depositing in sediments, leading to potential impacts on the animals that live and forage in the benthos, and blockages of plastic in the digestive tracts of marine animals when consumed. Ingestions of microplastics and macro plastics pose serious chemical impacts globally. Toxic pollutants like heavy metals and plasticizers and chemicals adsorbed by plastics from the surrounding environment are efficiently delivered to several places. This can lead to potential human health hazard, because humans consume an estimated 39,000 to 52,000 microplastic particles per year from food and beverages alone. One solution is the development of technologies that could prevent entrance of plastics in waterways or collect marine and riverine plastic pollution (Emma Schmaltza, 2020).[9]

Plastic waste management's global concern led each nation to treat the problem seriously on national levels. The European Union-ASEAN tied up for the implementation of technologies and projects to resolve the issues on plastics. The EU-ASEAN webinar series' "GreenTech & Innovation Mapping Dialogue: Green Technologies for Plastic value Chain Management" shows how serious every nation in looking for ways in effectively dealing with plastics. Assessments have been made on the current status of plastic manufacturing, consumption, and waste management. Indonesia adopted international laws like UNCLOS, MARPOL, LC&P, and even ASEAN laws on Marine plastic pollution regulation in their national, regional and local implementation. In Thailand, more than 40 private companies tie up with the government in the Thailand public-private partnership for plastic waste management. The project deals with using residual plastics as an alternative fuel in co-processing. The Philippines also uses the same approach via Ecoloop. Ecoloop is the first technology for the production of gas from waste materials that can replace fossil fuels on an industrial scale in an economical, ecological and efficient manner. A report by Republic Cement stated that even the pandemic did not stop Pampanga LGU's to go for a more sustainable and environmental recovery and disposal process of residual plastics. The company launched the Ecoloops' Cement-for-Trash Program where the LGU's get cements in exchange of collecting, segregating, and qualifying residual plastics wastes for co-processing at the Republic Cement plants. With the project, The Pampanga LGU's diverted the equivalent of around 100 dump trucks or about 120 million plastic wastes which includes sachets, plastic cutlery, grocery bags, food packaging, and straws among others, from landfills (Cement, 2021).[10]

Plastic manufacturing also has its share on plastic value chain management. Bioplastics represent only one percent of the more than 368 million tonnes of plastic produced annually. But the European Bioplastics sees the increase of global bioplastic production capacities from 2.11 million tons in 2020 to around 2.27 million tons in 2025, due to rising global concerns on plastic wastes, innovation of sophisticated biopolymers, applications and emerging products. Polylactic Acid (PLA), bio-based polypropylene (bio-based PP), and polyhydroxyalkanoates (PHA's) which are results of innovations in biopolymers continue to grow in production and commercial scales show that in 2025, production will be more than quadrupled. Of this bioplastics, biodegradable plastics including PLA, PHA and starch blends account for almost 60% of the global production capacities. This is over 1.2 million tons and is expected to increase to 1,8 million tons in 2025. The non-biodegradable bioplastics which include bio-based polyethylene (PE), bio-based polyethylene (PET), and bio-based polyamides (PA) make up for just above 40% of global production. Their production is expected to decrease to just over 37 percent or around 1 million tons in 2025. The production of bio-based PET is expected to have rapid decline as focus has shifted to the development of polyethylene furanoate (PEF), which is expected to enter the global market by 2023. PEF is anew polymer that has the same feature with PET but it is 100 percent bio-based, with superior barrier and thermal properties; an ideal material for packaging drinks, food and non-food products (European-bioplastics, 2020).[11]

Technology Strategy

The 3Rs approach to address plastic waste problem failed because, first, most developing countries has weak, if not no system to efficiently recover plastic wastes and secondly, many plastics are not recyclables. Turning plastic waste management into a circular economy is seen to help the global approach to plastic pollution. Circular economy is a model of production and consumption, which involves sharing, leasing, reusing, repairing, refurbishing and recycling existing materials and products as long as possible. This contradicts the traditional linear economic model, the take-make-consume-throw away pattern in dealing with plastics. With this approach, wastes are reduced to the minimum level. Whenever the products reached its end life, the materials are kept anywhere possible within the economy. The materials are then used again and again productively (Parliament, 2015). [12] The concept of circular economy is applied to plastic value chain management by looking at the problems in the waste collection and recycling programs in the ASEAN States. After identifying the gaps, effective processes on waste collection and recycling are suggested. On the side of the economy, technologies on making plastics from sustainable feedstocks, elimination of non-essential uses of plastics, shifting from single-use products to reuse options, and designing plastic products to be durable, reusable, and easily recyclable (Lewis AKENJI, 2019)[13].

The weakness of the 3Rs approach paved way to the proposal of 5R, which is more consistent with the trend towards circular economy. The proposal added two additional crucial components, 'R-edesign' and 'R-ecovery' to reduce, reuse, and recycle approach.

Redesign refers to the modification of activities in the development, usage, and end-of-life approach of plastics. The process requires the involvement from the industry down to the consumers. The consumers need to modify activities in order to decrease plastic consumption, change lifestyle like using reusable tumblers to bring water, instead of usually buying bottled water, then throwing the bottle anywhere; and eliminate non-essential plastic products. Retailers may assist manufacturers in re-designing plastic products, as they are the ones who can see the advantages and disadvantages, the market analysis of plastic life all around. The government and the industries should work together in research and development and come up in the development of new biodegradable polymers and plastics that can be re-used and recycled more readily, replace harmful additives, and eliminate non-essential plastic products (Dayrit, The Challenges of Plastic Waste: Legislation, regulation and Management Strategies, 2019).[14]

Recovery refers to the new strategies in efficiently redirecting end-of-life plastic products towards new purpose in the economy. There are four paths of plastic recovery and regeneration. Primary recovery is the reprocessing of the scraps and by-products of the same plastic material produced during the processing of finished products or extrusion process. This is known as re-extrusion process.

Secondary recovery or mechanical recovery is the reprocessing of plastic scraps by physical means, turning the scraps into recyclates. The process involves conversion of the scraps into pellets, flakes or powders and contaminant separation. Mechanical recovery follows the method of plastic recovery without changing the chemical structures and properties (Karmakar, 2020).[15]

Tertiary Recovery or the chemical feedstock recovery involves catalytic cracking, steam degradation and liquid – gas hydrogenation for the production of various monomers. The process involves depolymerization using pyrolysis produce oil and gas fractions. The process can be applied in wider application than the mechanical recovery but poses worse environmental impacts.

Quaternary recovery or process engineered fuel consists of converting plastic wastes into an industrial fuel that meets the market specifications. Incineration and combustion technologies, which burns plastic wastes alongside with solid wastes, providing heat energy to converted to hot water, steam and electric energy, which are then used to power many of industries like cement factories.

III. RESULTS AND DISCUSSION

Technology Transfer

Coalition between the government and the industries, between private and public companies and cooperation of manufacturers, retailers, and consumers will define the technology transfer of plastic value chain management into circular economy. ASEAN States in partnership with the European Union for the multinational partnership to form Bio-economy, green economy and circular economy to mitigate plastic pollution and prevent plastics in ending up in landfills and water bodies. It is seen ASEAN countries are in strategic location to be manufacturing hubs of environmentally sound, resource and energy efficient products using green technologies, as answer for the growing mass of plastic wastes. Europe is a natural strong partner for the development and upgrade of world class research and innovation system plus a strong, innovative enterprises. EU has been a constant source of green technologies for the development of new and more sustainable products from sustainable feedstock. Green technology transfer and capacity building became possible through EU-ASEAN collaboration.

Greentech aims at contributing to sustainable green growth through postering EU-ASEAN Technology transfer, research cooperation and capacity building in sustainable technologies. It is a project of the enhanced Regional EU-ASEAN Dialogue instrument (E-READI), funded by the European commission and implemented in cooperation with ASEAN. Technology upgrade for sustainable green growth and innovation in ASEAN economy is the main objective of the technology transfer partnership between the two regions. The implementation consists three pillars; [1] create awareness and commitment, [2] prove feasibility in different pilot projects, and [3] extend to all interested ASEAN Member States and sectors (Braun, 2021).[16]

The feasibility involves three pilot projects. Project 1 focuses on plastic wastes with an objective of reducing plastic waste and mitigate plastic waste effects though technology transfer for avoiding, managing and mitigating plastic wastes which expect to produce biodegradable plastic substitutes. The second pilot project aims to support transition to sustainable manufacturing through transfer of resource-efficient and environment-friendly manufacturing technologies. Complete bio-based, sustainable and circular economy manufacturing lines are expected on this pilot project. The third pilot project deals with COVID 19 related plastic waste warfare. The objective is to initiate research cooperation on diagnostic and protective technologies. EU-ASEAN R&D projects which will manufacture green and bio-based protective masks, shields and other single protective device and equipment against COVID 19 virus are expected through matched EU-ASEAN researches and researchers, technology transfer and capacity building.

Technology transfer via the EU-ASEAN partnership will cover the entire plastic economy, from the raw material, feedstock, processes and waste management. There are areas within the plastic economy, that need redesign and or restructuring. From raw material production to polymer production, there's a need to replace pollution intensive plastic to reduce waste load. This will introduce and transfer technologies to enhance biodegradable plastic surrogates, which can be based on Suedzucker technology approach approach (Sebastian Kunz, 2020). [17] There's also a need restructure from "single use and dispose" platform to circular economy, which will enable technologies that supports bio-based and circular approaches like the Genomatica-Novamont-Aquafil and other green company partnership (project_effective, 2018). Retailers, movers and consumers need to improve waste management efficiency which will give opportunity for the introduction of both frugal and advanced technologies and community programs for plastic waste collection, logistics, separation and recycling. For the waste management companies, promotion of higher value recycling from dumping waste or low value-added recycling is needed to encourage communities, consumers, and users to participate in plastic segregation (Braun, 2021).[16]

Technology Project Management

The ASEAN Member States unite to collaborate with the European Union for the adaptation of projects originated from the EU. The cooperation of the two state unions sees the launching of pilot projects in the ASEAN region, as the region is regarded to be in the strategic geographic location, because ASEAN nations are emerging economies, populations are increasing, and most of them are coastal regions, who are most affected with plastics ending in the water streams. ASEAN countries are home to long standing networks and international businesses that can offer services above the world's best can offer. They are also homing young workforce, well-educated, and growing middle class. The EU-ASEAN Dialogue on Green Tech & Innovation Mapping: Green Technologies for Plastic Value chain Management is a good partnership which aims to amplify awareness and create platforms on technology markets and transfer for plastic waste management.

Mutual benefits are good indicators of successful technology management in multi-company, multinational consortium. In the case of Project PEFerence, Avantium is the center of technology for the whole supply chain of FDCA/PEF-based product manufacturing. Partnership throughout the PEF value chain also validates the commercial production and drives the commercialization.

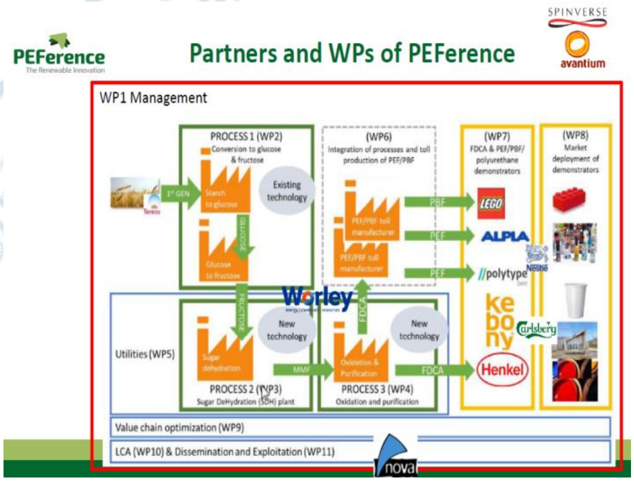

Fig. 1 Technology management of project PEFerence source: Ed De Jong, Avantium

Shown in figure 1, are the technology project management plan areas with corresponding partner companies. Work Progress 1 (WP1) is the overall conceptualization of the management performed by Avantium, to oversee the whole operation of the project. Tereos, a cooperative of conglomerate, specialized in processed agricultural materials secures the feedstock requirements of the value chain (Tereos). Process 1 (WP2) is the conversion of starch to glucose, then to fructose, using the existing technology. Process 2 (WP3) utilized the sugar dehydration plant

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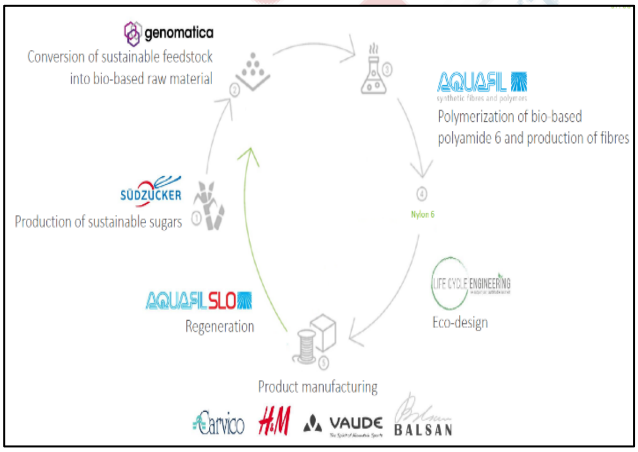
developed by Worley, worldwide team of consultants, engineers, construction workers and data scientists, design machines, processes and process flow for the supply chain (Worley, n.d.). The product of sugar dehydration is Methoxymethylfurfural (MMF). The next process, process 3 (WP4) is the oxidation and purification of MMF which results to furan dicarboxylic acid (FDCA). In WP6, the resulting FDCA will proceed to the integration of processes and toll production of polyethylene furanoate (PEF)/ furandicarboxylate (PBF). FDCA, PEF, and PBF are three bio-based products that are used in the production of different biodegradable, recyclable plastic products (WP7). The products are then deployed and demonstrated to the market for testing and utilization.

Technology Research and Development

Project Effective

Project Effective is a collaboration of multiple companies with a single purpose; to produce a more sustainable by reshaping the whole value chains on bio-based fibers and plastics for large consumer products. The collaboration involves 12 partner companies from 7 EU countries, and an international partnership from USA, and funded by H2020 framework programme of the European Union, who joint efforts to connect bio-based economy with circular economy on plastic value chain. Each of the 12 companies and American company had their specific part in the value chain of bio-based polyamides and polyesters from the production of renewable feedstock up to large consumer products manufacturing. Figure 2 presents the circular economy of the plastic using in the Project Effective" way, with closed loop on the material cycle. There are two circular bio-based targets; the circular bio-based polyamides, and the circular bio-based polyester. The products from both circular patterns will not find their ways to landfills nor on incinerations because they are developed and designed to be recyclables and compostable at the end of their operational lives.



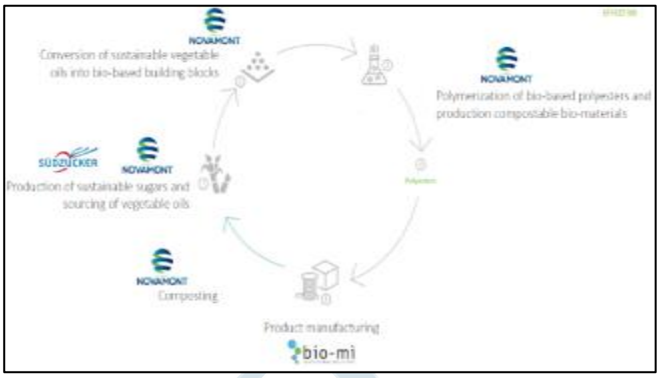


Fig. 2: The model for the circular bio-based plastic production A. Bio-based nylon 6 value chain; b. bio-based polyester value chain source: https://www.effective-project.eu/

The circular process for the production of bio-based nylon 6 starts with the production of sustainable sugar (Suedzucker) as the sustainable feedstock through a brand-new process (suedzucker, 2021). The renewable sugar-based feedstock will be converted to monomers for the production of bio-based polyamides and polyesters (Genomatica). Genomatica harness the power of biotechnology in the polymerization of the bio-based polyamides and polyesters. The collaboration between Aquafil and Genomatica paved for the creation of sustainable caproclatam, a key ingredient in the production of 100 percent sustainable nylon. Genomatica's GENO CPL™ process is a commercially-advantageous bioprocess used to provide an eco-friendly way using plant-based renewable ingredients, including smaller-scale plants to make caprolactam. The product, nylon 6 is fully comparable with nylon, produced from crude oil-derived caprolactam. The biotechnology does not require process adjustments and machine design and specification reconfiguration (Genomatica, 2018). Life Cycle Engineering (LCE) contributed through Ecodesign guidelines and procedures for innovative and sustainable garment and carpet solutions; and the economic analysis including marketability of the bio-based product (lcengineering, n.d.). The companies like Carvico, H&M, Vaude, and Balsan manufacture products from the biobased nylon 6 like carpets, knitted fabrics, apparels, and sustainable sports and outdoor outfits. Aquafil is the one involved in the regeneration of the sustainable materials once they end their operation life, making all the products recyclables and renewables.

The circular economy of the specialty nylon starts with Novamont (Novamont, n.d.) by sourcing of vegetable oil and conversion of sustainable vegetable oil into bio-based building block. The building block served as the raw material used by Aquafil in manufacturing specialty nylon, which is then used by companies like Balsan, Vaude and bio-mi in the production of several sustainable products such as fibers, apparels and a bio-based, biodegradable, and compostable thermoplastic materials (https://nenu2phar.eu/consortium/bio-mi/, n.d.). The products that reached their operational values are then recycled, to be used again in the manufacturing of different bio-based products.

The feedstock materials for bio-based polyester value chain are the bio-based sugar and sourcing of vegetable oils produced by Suedzucker and Novamont. Novamont circular process is used in the production of bio-based polyester. The end product is used by Bio-mi in the manufacturing of bio-based, biodegradable and compostable thermoplastics with TUV certificates.

Project PEFerence: The Renewable Innovation

Project PEFerence: The Renewable Innovation is a five-year flagship project from EU with a total project budget of €24,999,999 contribution from Bio-Based Industries Joint Undertaking (BBI-JU). The project aims to add solution to plastic circular economy by establishing an innovative supply chain for FDCA and PEF. The PEFerence consortium aims to replace a significant number of fossil-based polyesters like PET and polyamide layers in the production of several plastic products with FDCA and PEF, to make end products biodegradable. Aviantum, got the €25 million to initiate the flagship plant, and a total of €150 million for the completion (Kennedy, 2019).

Furan dicarboxylic acid or FDCA is a bio-based building block that can be used to produce high value products and a wide range of chemicals and polymers including polyesters, polyamides, coating resins and plasticizers. It is also used to produce PEF, a 100% bio-based, recyclable, polymers from renewable raw materials (sugar) derived from plants.

PEF exhibits qualities that can replace PET in the manufacturing of multi-layer packaging, and multi-layer small sized PET bottles (https://peference.eu/, 2020).[27] Aviantum spearheaded the research on the properties of PEF in comparison with PET. PEF displays better barrier, mechanical, and thermal properties over PET. The three properties are essential to plastics. PEF exhibits at least 6 times higher barrier than PET when tested with dioxide (0_2), 3 times better with Carbon dioxide (CO_2), and twice with water (H_2O). This property shows that PEF has increased shelf life, avoid barrier layers, and will have better performance in humid areas. PEF has higher T_g(glass transition temperature), lower T_m(melting point) and higher modulus (around 1.6 x) than that of PET. This thermal superiority makes PEF bottles applicable in hot filling environments. The thermal strength makes PEF rigid, lightweight, which can handle higher top load.

The excellent barrier properties of PEF and the calculated cost price (industrial scale) indicates that the bio-based material can replace the traditional packaging products like aluminum cans, multilayer packaging, and small size multilayer PET bottles. The products that can be manufactured out of FDCA-PEF materials include PEF bottles, beverage and water bottles; PEF films, used in packaging; and PEF fibers, which are used in apparels, carpets, home furnishing, disposables commodities, fabrics, diapers, filters and industrial fibers. All of which are 100 % recyclable.

The scale of manufacturability of FDCA-PEF - based product started in 2008 in Amsterdam, with the capacity kgs/annum scale. Several innovative researches are conducted to scale up manufacturability and widen marketability. Technology development led to the pilot project in Geleen that is capable of tons/annum manufacturability scale in 2011 up to present. In 2023, the final investment and implementation will showcase the full operation of the flagship plant of Avantium in Delfzijl, Netherlands, which will increase manufacturing scale of around 5 kilotons/annum. Then in 2024, with a complete value chain, Avantium will be deemed to be technology leader in FDCA manufacturing, giving license to other industrial plants for the same operation. Plants are expected to manufacture at more than 100 kilotonnes/annum/plant.

Prices are expected to decrease as the project focuses on high value application. The collaboration period (2020-2022), which is also the pilot stage, the industry collaborates with customers by providing users with FDCA and PEF for testing and application development. At a manufacturing rate of 10 tonnes/annum, the price of the product is around €0-€1000/kg. Product offtake period (2022-2024) niches the flagship capacity 5 ktons/annum to high-value applications is expected lower the price to €8-€10/kg. 2024 sees Avantium to start licensing other companies/industries on FDCA/PEF product manufacturing. Market anticipates the price to lessen down to €4-€5/kg, with 100 ktons/annum manufacturing capability. Prices of FDCA/PEF product will likely lower to at least €1.5-€2.5/kg as licensing and manufacturability scale increases (Jong, 2021).

Recyclability is a good indicator of new plastic materials sustainability. The circular economy of the bio-based nylon 6, specialized nylon and bio-based polyester has no end point. This means that as the end product reached their operational life, the materials can be readily depolymerized, and proceed to [a] feedstock [b] monomers, and [c] polyamides/polyester. This makes the bio-economy of bio-based products circular. FDCA/PEF are fully biodegradable. Once the product is not already recyclable, they will end up in nature both the landfills, and the oceans or water streams. Incineration converts products made of PEF back to atmospheric CO_2. CO_2 is essential to photosynthesis and respiration of plants, after being taken up by grass, weeds and other plants, which can then be used to make more PEF. When in nature, PEF is biodegradable to up to 90% in 60 days, with cellulose reference; 90% biodegradable in 240 days when weathered; and with 90% biodegradation in 385 days when un-weathered.

IV. CONCLUSION

The world had already been awakened with the problem human is facing in saving the environment and the people from plastic wastes. It is accepted that plastic is a great material we can use every day, in every activity and in almost every part of our lives. But the versatility, robustness, strength and other good qualities plastic offer, the mismanagement of its wastes poses serious problems and threats the future more serious problems. The plastics that end in the oceans, rivers, and other water bodies claim lives of marine animals, those that ended in landfills pollutes the air, those that blocks water passages causes floods and other problems. The elimination and removal of plastic usage in our daily lives seems impossible because of the material great properties especially in cities, countries like Singapore, Taiwan, and Japan, where replacing plastics with organic material like papers poses worse environmental footprints. The popular 3Rs framework is not successful in the management of plastic wastes.

To mitigate the problems, several companies go hand in hand with other companies in redesigning plastic production from the feedstock, to processes, to biodegradable products up to recycling and regeneration of plastics. But most of these bio-based, circular programs producing bio-based, biodegradable and compostable plastic products with better economic value are still on the pilot stage and are new in the market. While multi-company are designing circular and bio-economy for plastics, while the governments are localizing international laws such the UNCLOS, MARPOL, LC&P, ASEAN laws, among others, each individual must also do their shares in dealing with plastic problems. Industry and community partnership is also an important part in looking for the solution. Plastic recycling cannot be possible or will be successful when the community see no economic return for their participation. Plastic wastes can be returned to industries by the community in exchange of something with economic value to the community.

In addition to the 5Rs (Reduce, Reuse, Recycle, Redesign, Recovery), another "R" should be considered by every human being living on this earth. The 6th "R" refers to responsibility. The Climate Change Commission (CCC) in Manila warned the public on the surge of plastic pollution as a side effect of the production and usage of single use masks, gloves, PPE's, alcohol and hand sanitizer bottles, and disposable cleaning agents in response to COVID-19. The commission also expressed that breaking old habits and making sacrifices for the climate and the environment is still a big challenge in adopting a more sustainable lifestyle. But by incorporating sustainable practices in our daily activities, the earth, the environment and human will slowly be protected (Commission, 2021).

Sachets and single use plastics are one of the worst pollutants of the environment. Industries use sachets to widen their markets to the economic lower level of the society or the poor populace. They cannot buy large number of commodities so they buy goods like shampoos, foods packed in sachets, or in retail. Practice should be changed, instead of packing commodities in single used plastics, or sachets, stores can sell retails by encouraging buyers to buy containers for the retailed items. Junk foods are also producers of plastic. In fact, the price of the food packed in plastics seem to be cheaper than the price of the plastic used to wrapped the food. Retailers can also practice sustainability by not selling single packed junk foods but by retailing with consumers bringing their own containers. Individual grocers must practice buying commodities in larger amount and bringing their own eco-friendly bags. Buying soft drinks on a nearby store can also be sustainable by drinking on the bottle and not asking to put the drink on plastic and straw.

Plastics are used by individuals, who are members of the community, and part of the country. Thus, everybody is responsible in containing plastic waste in their personal level. Industries do their part to be responsible producers of sustainable plastics by using sustainable materials, which serves as sustainable feedstock, redesigning the process, and restructuring their facilities to be able to produce sustainable, biodegradable, and recyclable plastic products. The circular economy of plastics is also bio-economy and green economy. Being responsible is everybody's best practice to deal with plastic waste.

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