Asia-Pacific Economic Cooperation

USAID FROM THE AMERICAN PEOPLE

PROMOTING COMPOSTABLE BIOPLASTICS IN THE APEC REGION

POLICY FRAMEWORKS TO ENABLE TRADE, INVESTMENT AND INNOVATION

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CONTENTS

ACRONYMS

APEC	Asia-Pacific Economic Cooperation
BCG	Bio-circular green economy
BCNF	Bacterial cellulose nanofiber
CAGR	Compound annual growth rate
CTI	Committee on Trade and Investment (APEC)
EGS	Environmental goods and services
EPR	Extended producer responsibility
EU	European Union
IEC	International Electrotechnical Commission
ISO	International Organization for Standardization
MOU	Memorandum of understanding
MSW	Municipal solid waste
OFWG	Ocean and Fisheries Working Group
PLA	Polylactic acid
R&D	Research and development
SMM	Sustainable materials management
TBIA	Thai Bioplastics Industry Association
TBT	Technical Barriers to Trade
USAID	United States Agency for International Development
USDA	United States Department of Agriculture
WTO	World Trade Organization

EXECUTIVE SUMMARY

The growing market for compostable bioplastics products presents Asia-Pacific Economic Cooperation (APEC) economies with an opportunity to harness the potential of a growing circular economy to address the increasingly harmful societal impacts associated with plastic pollution. To capture this opportunity, economies must provide the policy and market conditions that enable increased commercialization by producers and widespread use by consumers. This study examines the current commercial landscape for compostable bioplastics, as well as the related policy and market conditions, to provide a compendium of best practices to guide economies' efforts in the trade and investment of compostable bioplastics products while reducing plastic pollution throughout the APEC region.

The study focuses on four main drivers that are essential to promoting compostable bioplastic products in a more circular economy in the APEC region. First, economies must create policy environments that enable the commercialization, scaling, and marketing of these products while providing incentives for innovation. These may include developing standards, technical regulations, labeling requirements and regulatory structures that facilitate product differentiation from traditional plastics, market certainty for producers, and interoperability with markets in other economies. Second, education and awareness campaigns are needed to promote the benefits of compostable bioplastics and the market opportunities these products provide. Third, there is a need to develop the necessary infrastructure that compostable bioplastic products require at end of life for processing. This may require changes to long-standing recycling and solid waste management practices as well as changes to well-established supply chains that favor petroleum-derived, single-use plastics that support traditional plastic re-use and recycling infrastructure. Finally, to scale up the potential market impacts and environmental benefits of compostable bioplastics, economies must cooperate to provide compatible, interoperable markets to facilitate trade and investment. By promoting alignment of standards and technical regulations across jurisdictions, economies can greatly expand markets for compostable bioplastics, while incentivizing investment and competition to spur continued innovation. Taken together, the policies and practices discussed in this study are intended to guide economies that seek to promote increased market penetration and more widespread use of compostable bioplastics.

This study is a key deliverable under the United States' self-funded APEC project entitled, Promoting Compostable Bioplastics in the APEC region. To initiate the project, an economy-level stock-taking survey was conducted among members of the APEC Committee on Trade and Investment (CTI) in September of 2022 to gauge current policies and practices related to compostable bioplastics management. The survey results help to establish a baseline understanding of the current policy environment that can generate ideas among economies about best practices in the APEC region and diagnose opportunities for future capacity building needs. The United States also led efforts to facilitate policy discussions amongst APEC government officials, including by holding a capacity building workshop on Promoting Sustainable Solutions for Compostable Bioplastics in the APEC region in February 2023. The workshop discussed recent developments in compostable bioplastics policy and management efforts throughout the APEC region, bringing together private sector and government representatives to discuss their experiences and challenges in the areas of standards, labeling, certification, infrastructure, and commercialization. This study discusses the results of the economy-level survey, key insights from the workshop, and several case studies from APEC economies that demonstrate innovations in compostable bioplastics promotion and adoption. The study concludes with recommendations to help guide policymakers and practitioners in APEC economies in developing more robust markets for compostable bioplastics at home and abroad.

BACKGROUND

APEC has been active in advancing trade and investment in environmental goods and services since 2011, when the leaders of member economies committed to reducing tariffs on environmental goods and services (EGS) and "promote regulatory coherence and cooperation in areas affecting environmental goods.[1]" As a follow up to these commitments, APEC launched a series of public-private partnership dialogues to explore concrete pathways to reducing non-tariff barriers to trade and investment in EGS. This work led to a 2016 initiative under the APEC Committee on Trade and Investment's (CTI) Regulatory Cooperation Advancement Mechanism (ARCAM) to facilitate trade and investment in Sustainable Materials Management (SMM) Solutions (i.e., source reduction, recycling, composting, waste-to-energy). This initiative helped facilitate further dialogue among APEC economies about trade and investment solutions in SMM products and services, culminating in the APEC publication, *Facilitating Trade and Investment in Sustainable Materials Management Solutions in the APEC Region: Promoting an Enabling Regulatory Environment.* The report outlined key recommendations to determine how the region can best address barriers to trade in SMM solutions and prioritize actions for further work by APEC economies.[2]

This initial APEC work related to SSM and EGS trade and investment promotion laid the groundwork for broader commitments within APEC to promote circular economy approaches to waste management and specifically to reduce plastic pollution and marine debris. The 2019 APEC Roadmap on Marine Debris recognized the severity of the marine debris and plastic pollution problem in the Asia-Pacific and outlined a series of recommendations for promoting shared solutions. Specifically, the Roadmap defined collective actions and recommendations related to policy development and coordination, capacity building, research and innovation, and financing and private sector engagement that member economies can leverage to address the problem.[3] The work undertaken to implement the Roadmap is managed under APEC's Oceans and Fisheries Working Group (OFWG) and the Virtual Working Group on Marine Debris, which report progress made on annual workplans to the Steering Committee on Economic and Technical Cooperation.

APEC's Putrajaya Vision 2040 and the actions set out in the Aotearoa Plan of Action (APA) emphasized trade and investment promotion and sustainable, inclusive growth as priorities supported by effective governance frameworks for effective implementation and regional cooperation. The 2022 Bangkok Goals on Bio-Circular-Green (BCG) Economy expanded on this vision to emphasize key areas of cooperation for APEC economies to approach shared environmental and resource management challenges. The Bangkok goals specifically emphasized the promotion of the BCG economy model that integrates economic approaches where technology and innovation are used to create value, reduce waste, advance resource efficiency, and promote sustainable business models. This prior APEC work demonstrates the sustained commitment of APEC member economies to pursue collaborative solutions to sustainable economic development challenges and innovative approaches to promoting a more circular economy.

This study builds on important APEC groundwork to advance trade and investment in SMM and EGS to explore how increased trade and commercialization of compostable bioplastics can promote

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[1] Asia Pacific Economic Cooperation (APEC), 2011, "2011 Leaders' Declaration." Web Resource. November. https://www.apec.org/meeting-papers/leaders-declarations/2011/2011_aelm

[2] Asia Pacific Economic Cooperation (APEC), 2017, Facilitating Trade and Investment in Sustainable Materials Management Solutions in the APEC Region: Promoting an Enabling Regulatory Environment" October. https://www.apec.org/docs/default-source/Publications/2017/11/CTI-Annual-Report-2017/TOC/Appendix-7-Facilitating-Trade-and-Investment-in-SMM-Solutions-in-the-APEC-Region.pdf

[3] Asia Pacific Economic Cooperation (APEC), 2019, APEC Roadmap on Marine Debris, Web Resource. August. https://www.apec.org/Meeting-Papers/Annual-Ministerial-Meetings/2019/2019_AMM/Annex-B

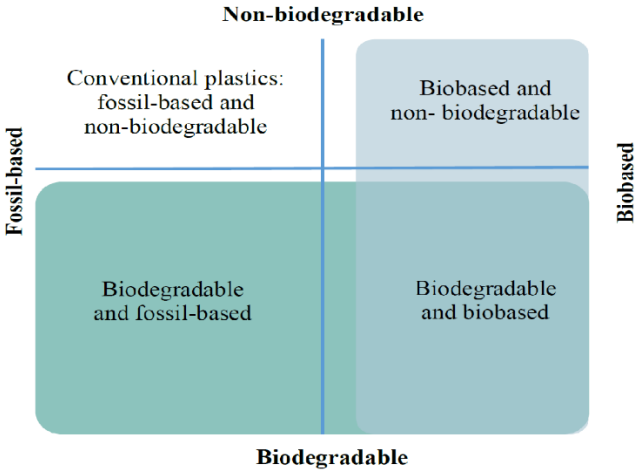
circularity in the APEC region. In the sections that follow, the study will explore the commercial landscape for compostable bioplastics, the results of recent APEC workshops and consultations, policy frameworks to enable trade and investment, economy-level case studies and recommendations for enabling increased commercialization, trade and investment in the region.

INTRODUCTION TO COMPOSTABLE BIOPLASTICS

Compostable bioplastics products have tremendous potential to help reduce plastic pollution and promote more circular economies by providing substitutes for single-use plastics that biodegrade easily in the natural environment, while potentially providing a valuable commodity as a byproduct. Made from sustainable biomass feedstocks, compostable bioplastics can displace petroleum feedstocks for ubiquitous plastic products. At the same time, compostable bioplastics reduce plastic pollution while diverting traditional plastics waste streams from landfills. At the end of their useful lives and given the right conditions, these products can potentially be processed into organic compost, a valuable commercial product that can generate additional economic benefits for communities and the natural environment.

Compostable bioplastics form a subset of a much larger category of biobased plastics (Figure 1), which are distinguished from conventional plastics by being either fully or partially made from biological raw materials as opposed to fully petroleum based raw materials used in conventional plastics. However, not all biobased plastics are the same in terms of their lifecycle environmental impacts and there is significant confusion among end-use consumers about these differences. To properly contextualize these different categories of bioplastics, it is necessary to consider the properties of the bioplastic material as well as the environmental conditions and amount of time they require to decompose into organic material.

Figure 1: Alternatives to Conventional Plastics



Source: European Commission (2022), European Union Policy Framework on Biobased, Biodegradable and Compostable Plastics.

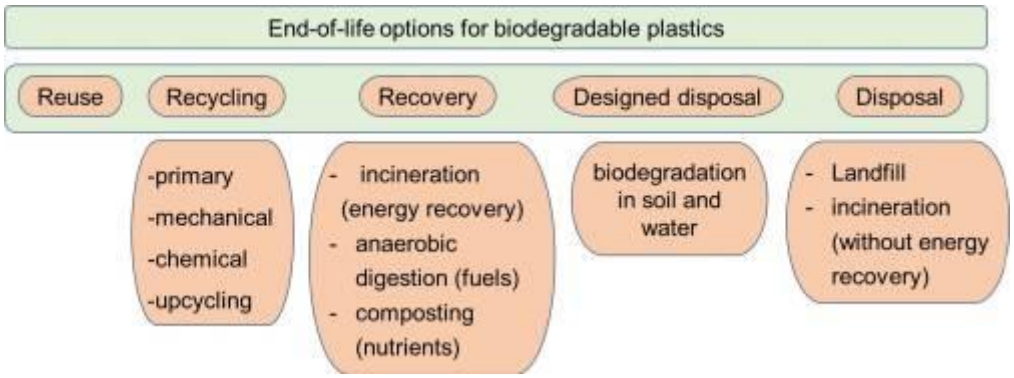
Biobased plastics are derived from renewable biomass feedstocks such as sugarcane, cereal crops, oil crops, or non-food sources like wood. Other sources include organic waste and byproducts, such as used cooking oil, bagasse, and tall oil.[4] However, just because these plastics are made from biobased

[4] European Commission, 2022, European Union (EU) Policy Framework on Biobased, Biodegradable and Compostable Plastics, 30.11.2022 COM(2022) 682 final, Brussels, https://environment.ec.europa.eu/system/files/2022-12/COM_2022_682_1_EN_ACT_part1_v4.pdf.

substances does not necessarily mean they are biodegradable. Notably, biodegradable plastics can be both biobased and fossil-based.

In general, plastics are considered biodegradable if they decompose into organic materials relatively rapidly (months, not years) when they are disposed of. However, not all biodegradable products are suitable for composting (Figure 2). Broadly speaking, a product identified as compostable will ideally break down in the same or a similar time frame to completely organic material and result in no negative effects on the resulting compost (i.e., be nontoxic). This breakdown needs to involve biodegradation—the actual molecular transformation by microbial activity of a material—not just disintegration.[5]

Figure 2: Overview of End-of-life Options for Biodegradable Plastics



Source: Gioia, C. et al. (2021), "End of Life of Biodegradable Plastics: Composting versus Re/Upcycling." ChemSusChem 14(19): 4167–75.

Compostable bioplastics are a subset of biodegradable plastics designed to biodegrade under controlled conditions, typically though industrial composting in special facilities for composting or anaerobic digestion.[6] It should be noted that some compostable bioplastics can be decomposed naturally in home gardens or other non-industrial settings. In-situ composting has lower environmental impacts compared to large scale industrial composting because it does not require transportation of waste streams or large capital costs to implement. Often large-scale facilities must be located outside of urban centers where the sources of waste occur because of zoning considerations. This creates the need for significant investments in transportation infrastructure and results in higher lifecycle greenhouse gas impacts compared to in-situ methods.

However, if viewing this issue through the lens of a more circular economy, industrial processing at scale has the potential to produce organic compost as a value-added biproduct that can provide additional benefits for economies. This study focuses on describing the policy and market conditions that would facilitate this circular economy approach.

COMPOSTABLE BIOPLASTICS MANAGEMENT AND INFRASTRUCTURE

For compostable bioplastics to fulfill their potential as drivers of a more circular economy, two fundamental conditions must be met. First, economies must help facilitate market conditions that incentivize investment in their production. Secondly, economies must create incentives to divert

[5] H. Nageler-Petritz, 2023, 'Bioplastics and Composting: Not a Love Match," WEKA Industrie Medien, March 15, https://waste-management-world.com/resource-use/bioplastics-and-composting/.
[6] European Commission, 2022, EU Policy Framework on Biobased, Biodegradable and Compostable Plastics.

organic waste from municipal solid waste landfills and develop composting infrastructure to expand and scale markets for the value-added by-product (organic compost) that compostable bioplastics generate after use. This section focuses on the infrastructure needed to process organic waste at scale generated from widespread commercial use of compostable bioplastics.

One critical input central to the feasibility of infrastructure needed to support a circular economy approach to compostable bioplastics, is waste segregation. Generally, it is much cheaper and more effective to separate organic waste from non-organic waste before it is transferred to processing sites. Once co-mingled, waste is delivered to a processing site and it becomes extremely costly to segregate into organic and non-organic material. Additionally, on-site segregation is not as effective because cross-contamination is extremely difficult to avoid and costly to mitigate.

Most economies undertake some form of waste segregation at the source. In developing economies, there is a robust informal sector associated with the recycling and upcycling of waste materials destined for landfills because of the economic value of these materials. According to the International Labor Organization, 15–20 million people worldwide earn their living from recycling municipal solid waste (MSW). Known as waste "picking," this informal recycling economy helps reduce a significant amount of waste destined for landfills. If done with the welfare of the waste pickers in mind, it could potentially be leveraged in certain economies to contribute to the infrastructure challenge associated with segregation of compostable bioplastics at the source for commercial composting operations. In fact, several economies have undertaken efforts to incorporate waste pickers into the formal waste management economy. For example, in 2008, waste pickers in Peru formed the National Movement of Waste Pickers of Peru (MNRP) and in 2009, together with the Ministry of Environment, and several NGOs, helped draft and pass a new recycling law (No. 29419) formalizing the pickers into the municipal solid waste management infrastructure.[7] As discussed later in the case studies, Chile has implemented a similar approach and Malaysia also plans to do so. However, introducing compostable bioplastics programs at scale is needed to facilitate widespread commercialization. This requires significant investments in physical infrastructure for industrial processing, education and awareness campaigns to institutionalize segregation practices for consumers, and clearly defined labeling requirements to facilitate informed segregation.

COMPOSTABLE BIOPLASTICS INFRASTRUCTURE

The degradation of compostable bioplastics into organic compost can only occur in favorable environmental conditions of high temperature and humidity and in the presence of appropriate microorganisms. Industrial aerobic composting is the most common and effective way to process compostable bioplastics into organic compost. This process is characterized by distinct, consecutive phases:

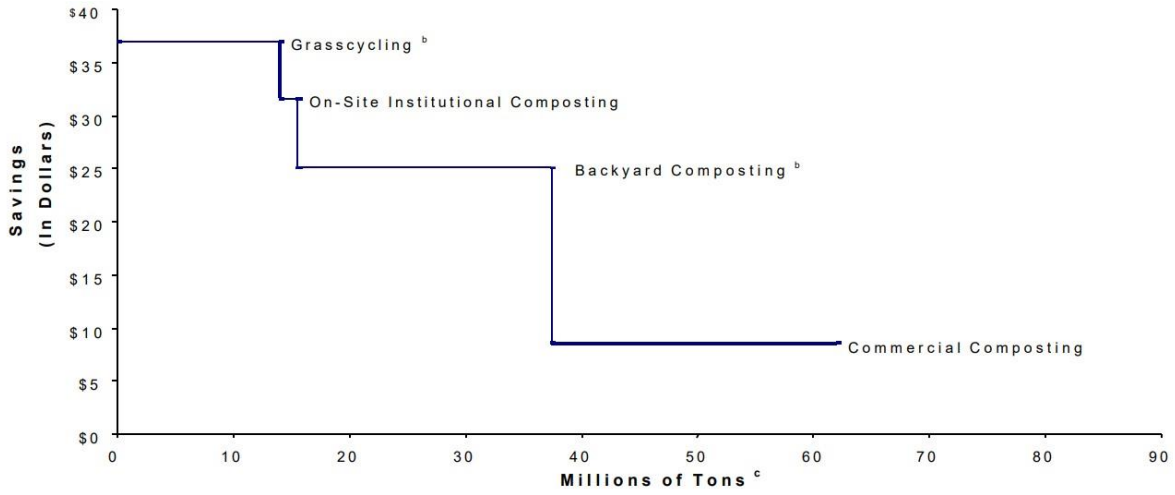
i. One or more mechanical pretreatments of the waste
ii. A phase of few days during which the biological process starts
iii. A thermophilic (high temperature treatment) phase of almost three weeks with temperature ranging between 55 and 60°C
iv. A maturation phase with duration between 1 and 2 months with cooling down to room temperature
v. A final refining with sieves of millimetric mesh to obtain acceptable compost quality

[7] Mélanie Rateau and Luisa Tovar, "Formalization of wastepickers in Bogota and Lima: Recognize, regulate, and then integrate?", EchoGéo [Online], 47 | 2019, posted April 21, 2019, accessed June 27, 2023. http://journals.openedition.org/echogeo/16614

The costs associated with construction and operation of a high-quality industrial composting facility can be quite high. Here we define a high-quality compost facility as one that produces compost for soil amendment and landscaping purposes and for use on farms, and in nurseries and mines (for mine reclamation). This is opposed to low-quality compost facilities that produce partially composted MSW for either landfill cover or direct landfilling.

A report compiled by the United States Environmental Protection Agency in 2000 estimated that it would cost approximately USD49 per ton (in 1998 dollars) for a high-quality compost facility.[8] These costs are obviously outdated and would be expected to be significantly higher in today's dollars when adjusted for inflation. This cost does not include preprocessing operations that remove recyclables and non-compostable items from waste streams prior to treatment. Although the initial capital costs and ongoing operating costs can be high for commercial composting facilities, the benefits can outweigh those costs in terms of avoided costs of landfill disposal, which is much more expensive than composting on a cost per ton basis in the United States. Figure 3 illustrates this cost curve for several different organic waste composting scenarios by comparing the savings per ton associated with composting versus conventional landfill disposal. Depending on the type of waste and method of composting selected, average domestic savings over conventional disposal vary from USD9 to USD37 per ton.[9] Although this United States specific example may not be representative of many developing economy scenarios because of the high cost of landfill disposal, it does illustrate how diverting organic waste from landfills can produce long run cost savings.

Figure 3: Savings Per Ton of Organic Diversion (Compost Strategies Savings Curve)[10]



Notes:
[a] These savings are from the viewpoint of local government and assume that any additional labor required from citizens is donated at no cost to society .
[b] To be conservative, we assume no savings in collection costs. The tonnage in these composting programs is not reduced significantly enough to affect the cost of collection.
[c] Based on the applicable portion of the organic waste stream available for composting using existing strategies and technologies.

Source: US Environmental Protection Agency (1999), Organic Materials Management Strategies

[8] United States Environment Protection Agency, 2000, *Life Cycle Inventory and Cost Model for Mixed Municipal and Yard Waste Composting*, June, https://mswdst.rti.org/docs/compost_model_ocr.pdf
[9] United States Environment Protection Agency, 1999, *Organic Materials Management Strategies*, July, https://archive.epa.gov/wastes/conserve/tools/greenscapes/web/pdf/omms.pdf
[10] Ibid.

Preprocessing infrastructure for compostable bioplastics includes the systems, processes, physical infrastructure, and transportation services required to segregate and process compostable bioplastics and other organic waste from non-organic waste streams. Generally, this infrastructure involves providing households, businesses, and public spaces with designated containers for collecting and segregating different categories of waste. This container system interlinks with the MSW transportation system that collects waste from these sites in a manner that maintains the integrity of the segregated waste streams and delivers them to processing sites. Often in cases where waste is segregated at the source to facilitate industrialized recycling and composting, different transportation vehicles for each designated waste stream are required. Although the cost of preprocessing infrastructure is not trivial, it is relatively low if there are existing transportation infrastructure systems in place to support waste collection and segregation for recycling.

For the integrated management system required for a circular economy approach to compostable bioplastics to function as designed, educating the public about the system design and its benefits is essential. This involves educating consumers about how to categorize and segregate different waste streams and instituting appropriate fee structures for waste collection. If compostable bioplastic products are not properly segregated or if composting facilities cannot accept them because they are contaminated with other waste, they will end up in landfills. Often recycling or composting programs charge lower fees for collection and transportation than for traditional landfill waste streams to incentivize wider participation. While these scenarios may require government subsidies to be viable, this type of support is often needed to develop new waste management programs. Making sure that consumers are aware of how fee structures are tied to the end-of-life destinations of their respective waste streams helps generate buy-in for these programs.

Education and awareness campaigns should also accompany robust product labeling programs that support the integrity of compostable bioplastic products and allow consumers to make informed choices. For labels on compostable bioplastic products to be credible, they should reference relevant international standards to provide consumers with confidence in the materials' claims. A labeling program can support the integrity of waste segregation systems and functionality of industrial composting processes, while allowing compostable bioplastics producers to credibly market their products to consumers. It should be emphasized that labelling requirements should be as least trade restrictive as possible and that adherence to the obligations under the World Trade Organization's (WTO) Technical Barriers to Trade (TBT) Agreement could facilitate this. Compostable bioplastic product labeling requirements should also incorporate market surveillance programs to provide a mechanism to address claims of fraud, misuse or manipulation that could occur in the rapidly evolving market. Labeling, standards, technical regulations, and other policy tools to facilitate more widespread commercialization of compostable bioplastics are discussed in more detail later in this study.

CURRENT GLOBAL COMPOSTABLE BIOPLASTICS MARKET CHARACTERIZATION AND OUTLOOK

Although bioplastics currently comprise a minuscule share of the global plastics market (accounting for less than 1 percent of the more than 367 million tons of plastic generated annually), its market share is expected to grow significantly, as is global production capacity (Figure 3). The global bioplastics market size was estimated at USD11.2 billion in 2021 and is expected to grow to approximately USD46.1 billion by 2030, registering growth at a compound annual growth rate (CGAR) of 17.02 percent between 2022 and 2030. This growth is largely driven by consumer demand for products that minimize adverse environmental impacts. Lower production costs may also play a significant role. High fossil fuel prices, particularly within economies that lack crude oil

deposits, can drive consumer product manufactures towards less expensive, renewable, biobased feedstocks in lieu of petroleum-based plastics. The growing demand for bioplastics is fueling innovation in an increasing number of new product applications as manufacturers focus increasingly on corporate social responsibility and reputation management.

Packaging is by far the most dominant application for bioplastics within the market segment, accounting for more than 63 percent of total revenue for the sector. Consumer preference for ecological or "green" packaging is driving manufacturers to incorporate bioplastics into a wide variety of packaging applications including food and beverages, personal care packaging, and household care goods. Food packaging applications are by far the most common, with bioplastics commonly used in the production of bottles, jars, and containers as well as fresh food packaging. The foodservice and hospitality industries are particularly well suited for compostable bioplastic single-use products such as cutlery, cups, and takeaway containers. Because traditional plastic single-use products are often contaminated by food waste, they are often not recycled because the recycling facilities cannot process them easily. Compostable packaging allows food waste and packaging to be composted together.

The agricultural sector is an additional high-demand application for bioplastics. Biodegradable bioplastics are increasingly being used in nursery, farming, and garden applications such as seedling growth containers, mulching, and row covers for crops. Commercial growing of renewable biomass feedstocks for bioplastic product manufacturing will increase in lockstep with consumer demand. In addition, the agricultural sector is poised to absorb demand for the compost generated after end-of-life processing of compostable bioplastic products. Agriculture's role throughout the bioplastics value chain embodies the principles of the circular economy more than perhaps any other sector.

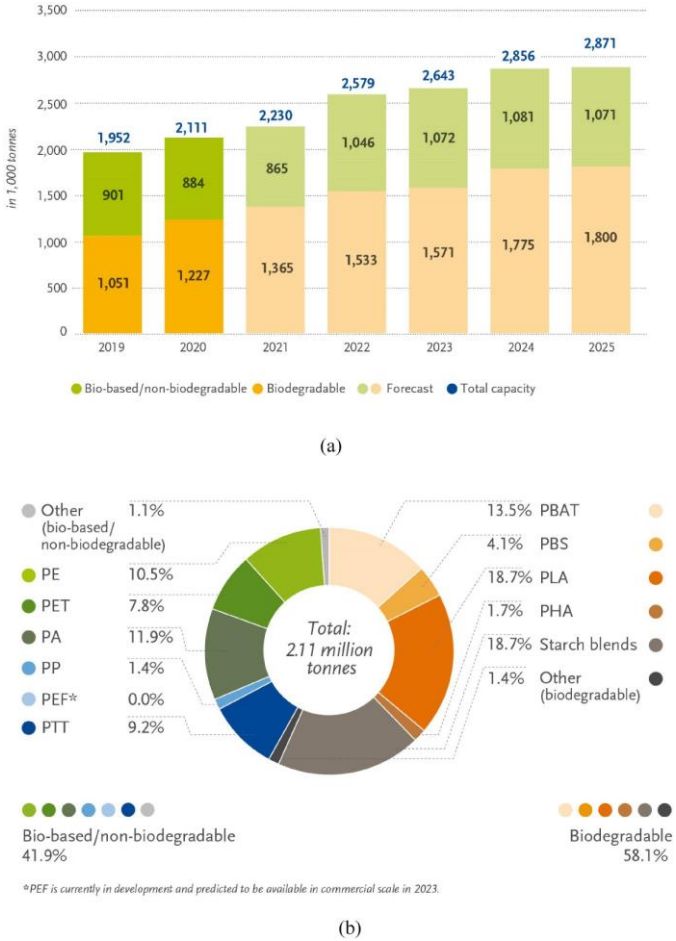
As the bioplastics market continues to grow, innovation will drive the diversification of product applications. The automotive and consumer electronics industry are two sectors expecting significant growth in bioplastic products. Vehicle interiors, wiring harnesses, and even engine covers are all made of bioplastics today. Toyota, Fiat, Mercedes Benz, and Mitsubishi are industry leaders in bioplastic product use, with each devoting significant research and development (R&D) resources to continue the innovation. Much of the potential new growth in bioplastic products is predicated on the functionality of these products to meet more technically sophisticated applications. For the automotive sector, exacting standards for safety and performance are paramount and the bioplastics industry is rapidly increasing its market share of the sector, which has been driven largely by industry-led R&D.

Consumer electronic goods make up a significant portion of the plastics market. Today, casings, circuit boards, and data storage are made of plastic to ensure the appliances are light and mobile while being tough and, where necessary, durable. Consumer electronics are also large contributors to plastic waste. However, an increasing range of bioplastic products are being introduced in the fast-moving consumer electronics sector: for example, touch-screen computer casings, loudspeakers, keyboard elements, mobile casings, vacuum cleaners, or laptop mice. As consumers continue to demand more environmentally friendly products, the share of consumer electronics produced with bioplastic materials will continue to grow and the sector will be a key driver of innovation going forward.

The Asia-Pacific region is poised to experience significant bioplastics market growth, driven largely by the packaging sector. With a well-established food and beverage sector, strong demand for packaging for e-commerce applications, and a ready supply of renewable biomass feedstocks, the Asia-Pacific is expected to grow at a projected CAGR of 12.46 percent from 2022 to 2031. Although

the availability of cheaper alternatives to bioplastics hinders potential growth in the Asia-Pacific bioplastics market, government policies are helping to drive growth in the sector. Details of some of these key policy drivers across the APEC region are discussed in more detail later in this study.

Figure 4: Global Production Capacity of Bioplastics in 2020.[11] (a) Total Production of Biodegradable and Non-biodegradable Plastics and Forecasts (2019–2025 compared); (b) Production Capacities by Material Type



Source: European Bioplastics (2022), "Bioplastics Market Data."

The COVID-19 pandemic had a mixed influence on the market for bioplastics in the Asia-Pacific region. The packaging industry saw significant growth in bioplastics production, with increased demand for single-use food service products and pharmaceutical products as well as packaging for e-commerce applications. At the same time, other sectors such as construction, automotive, and consumer electronics experienced significant slowdowns in production due to supply chain disruptions and containment measures instituted by governments in response to the pandemic. With supply chains rebounding in the post-pandemic economic recovery, these growth impediments are subsiding and bioplastics markets in Asia are poised for dramatic growth.

[11] PlasticsEurope (Association of Plastics Manufacturers), 2021, *Plastics – The Facts 2020. An Analysis of European Plastics Production, Demand and Waste Data*, Brussels, https://plasticseurope.org/wp-content/uploads/2021/09/Plastics_the_facts-WEB-2020_versionJun21_final.pdf.

ECONOMY-LEVEL SURVEY ON PROMOTING COMPOSTABLE BIOPLASTICS IN THE ASIA-PACIFIC REGION

An economy-level survey on compostable bioplastics policies and practices was conducted among APEC Committee on Trade and Investment (CTI) members in October of 2022. In total, 10 different economies participated in the survey: Australia; Chile; Hong Kong, China; Indonesia; Japan; Mexico; Papua New Guinea; Peru; Russia; and Thailand. The purpose of the survey was to collect up-to-date information about the policy frameworks and management infrastructure supporting the use of compostable bioplastics at the economy-level. The survey focused on gathering primary data and context-specific information related to the following core areas of compostable bioplastics management:

- The existing policy and legal frameworks that support more widespread use of compostable bioplastics, including standards and labeling and certification requirements as well as regulations governing the management and disposal of organic waste. The survey also solicited information on whether economies had specific mandates for compostable bioplastics for specific consumer end-use applications.

- Current compostable bioplastics management capacities and practices related to organic waste diversion from landfills, composting initiatives and waste segregation dynamics, and plans for increased production of compostable bioplastics. The survey also solicited information about consumer and commercial demand for compost generated from compostable bioplastics.

The survey was designed to generate information from economies about current capacities to support compostable bioplastic production, consumer use, and infrastructure management. The information generated from the survey is useful to establish a baseline understanding of conditions across APEC economies to support more widespread use of compostable bioplastics and to diagnose potential future capacity building needs.

SURVEY RESULTS

The results of the survey (Table 1) demonstrate that facilitating more widespread use of compostable bioplastics is a priority for almost all economies (90 percent) and each of these economies has some programs in place for diverting organic waste from municipal solid waste disposal sites. Additionally, most of the economies surveyed (80 percent) currently produce compatible bioplastics domestically and 70 percent of economies have plans to increase that production. These results demonstrate that there is a strong foundation to support more widespread commercialization of compostable bioplastics and that existing solid waste management systems can support a circular economy approach towards that goal.

The survey results were mixed related to the policy environment supporting compostable bioplastics and the industrial waste management and composting infrastructure needed to facilitate economic circularity for the sector. For example, 60 percent of economies have some form of federal government-promoted standard related to compostable bioplastics and about half of the economies have labeling and certification schemes in place. Only 40 percent of economies have mandates in place requiring the use of compatible bioplastic in specific commercial applications. These data indicate that economies can do much more to help develop more robust markets for compostable bioplastics. For example, the lack of a coherent policy framework disincentivizes investment for prospective market entrants. Standards and labeling requirements help distinguish the market niche for compostable bioplastics, providing incentives for producers to invest in new markets and

increased certainty for consumers regarding product integrity. More robust regulatory frameworks regarding specific commercial applications of compostable bioplastics and organic waste diversion from landfills create incentives to promote economic circularity in the market for both producers and consumers. A later section of this study discusses in more detail how economies can harness these policy tools to advance more widespread production and use of compostable bioplastics.

In nearly every economy, there is significant demand for industrialized commercial compost and nearly all economies require segregation of organic waste at the source, prior to disposal. However, most economies (70 percent) do not have restrictions for disposing of organic waste in landfills. This indicates that there is a lack of infrastructure in place to support industrialized commercial composting operations. Although systems are in place to support segregation at the source, incentives are lacking to divert organic waste from landfills. As a result, industrialized composting is not widespread and compostable bioplastics would currently likely be disposed of in landfills with other solid waste.

Several economies have ambitious plans to accelerate organic waste recovery within their solid waste management plans. For example, Australia's National Waste Policy Action Plan has committed to recover 80 percent of its organic waste materials and to halve the amount of organic waste sent to landfill for disposal by the year 2030. Hong Kong, China's Waste Blueprint for Hong Kong 2035 establishes a vision to achieve waste reduction, resources recirculation, and zero landfilling, setting a goal of 55 percent recovery of waste materials by 2035. Chile's National Organic Waste Strategy aims to increase the recovery of organic waste generated at the municipal level from 1 percent to 66 percent by 2040. Linked to its broader climate policy goals, Indonesia's National Mid-term Development Planning includes organic waste management as a priority for 2020–2024. These intentions demonstrate strong political will among APEC economies to prioritize a circular economy approach to waste management. This approach is vital to reducing waste. It is also vital to reducing greenhouse gas emissions because municipal solid waste landfills are one of the largest anthropogenic sources of global methane emissions.

Table 1: Aggregated Survey Results

	Yes (%)	No (%)
Is organic waste management a priority for your economy?	90%	10%
Is composting a priority for your economy?	80%	20%
Does your economy require segregation of organic waste at the source?	90%	10%
Does your economy have standards for compostable bioplastics?	60%	40%
Does your economy have restrictions for disposing of organic waste at landfills?	30%	70%
Does your economy have plans to divert organic wastes from landfills?	80%	20%
Does your economy have standards for compostable bioplastics?	70%	30%
Does your economy mandate the use of compostable bioplastics in particular applications?	40%	60%
Does your economy require special labels for compostable bioplastics?	50%	50%
Does your economy require certification for compostable bioplastics?	60%	40%
Does your economy currently produce compostable bioplastics?	80%	20%
Does your economy have plans to produce more compostable bioplastics?	70%	30%
Does your economy have difficulties selling the compost that is produced?	10%	90%
Does your economy have unmet demand for compost?	10%	90%

APEC CAPACITY BUILDING WORKSHOP: PROMOTING SUSTAINABLE SOLUTIONS FOR COMPOSTABLE BIOPLASTICS IN THE ASIA-PACIFIC REGION

The results of the economy-level survey are complimented by information gathered from a capacity building workshop held at APEC 2023's First Senior Officials Meeting in Palm Springs, California on 20 February 2023. A copy of the agenda is included in Appendix 2. The workshop brought together private sector and government representatives to discuss their experiences and challenges in the areas of standards, labeling, certification, infrastructure, and commercialization. During the workshop, small groups of workshop participants discussed institutional and policy challenges involved in strengthening enabling environments for broader use of compatible bioplastics in their economies. Participants also discussed key financial and resource constraints related to scaling up compostable bioplastic commercial activity and the infrastructure required to support it. See Table 2 below for a summary of key findings.

Table 2: Summary of Key Workshop Findings

TOPIC	FINDINGS
Standards and harmonization	• Local standards align with international standards in many economies • More consumer education is needed • International standards can be used to facilitate harmonization across jurisdictions • Increased harmonization may be detrimental to some economies because of capacity constraints to meet more stringent standards
Labeling and certification	• Improving intuitive labeling for consumers is a priority; QR codes could be a potential innovative solution • Low awareness among consumers about the benefits of compostable bioplastics and the distinctions among other bioplastics • What role can APEC play in facilitating common labeling and certification schemes?
Commercialization and scaling up	• APEC region is rich in sustainable feedstocks for compostable bioplastics • Tax incentives can help drive investment in infrastructure development • Need to promote increased awareness of home composting applications • Creating an APEC roadmap on labeling and infrastructure can help grow the bioplastics market. Look to Thailand's roadmap and Japan's Center of Excellence as examples.
What can APEC do to support increased commercialization?	• Consolidate and disseminate information to help guide research and investment • Engage standards developers and test labs to provide technical assistance • Create APEC Committee on Sustainability • Provide capacity building assistance to interested economies (pilot projects) • Provide guidance on the development of labeling, certification, and standards development

POLICY FRAMEWORK FOR COMPOSTABLE BIOPLASTICS

Although the global market for compostable bioplastics is growing significantly, important market failures and insufficient government interventions to address them inhibit more robust growth. This section of the study describes some of the key policy tools available to economies to facilitate enabling environments for compostable bioplastics markets to prosper and grow. Each of these policy tools are described in the context of how they are designed to address market failures throughout the compostable bioplastics value chain as well as in relation to some of the implementation challenges and opportunities that they present. This section also describes how these policy tools are being applied throughout the APEC region and highlights opportunities for further actions APEC economies can take to develop more robust markets for compostable bioplastics. It should be noted that as economies pursue market development plans in this emerging area, they should consider the work of other economies that have developed policy frameworks to enable the compostable bioplastics industry.

Government policies play a central role in creating the market conditions for innovation and growth in the compostable bioplastics sector. As discussed earlier in this study, for a circular economy approach to compostable bioplastics markets to function as intended, maintaining product integrity throughout the value chain is essential. This requires standards that certify the authenticity of the product's attributes and, if necessary, technical regulations that specify the authorized uses of the product in the economy. Products must be labeled to accurately convey information about their attributes to consumers. Mandates requiring waste segregation and composting of suitably biodegradable bioplastics are needed to the divert these waste streams from landfills. Governments can use procurement policies to generate demand in nascent markets and devote resources for R&D to spur investment. Finally, for markets to function efficiently, policy vehicles that facilitate the convergence of standards and regulations across jurisdictions are needed. Together, these interconnected government interventions can form an enabling environment for compostable bioplastics that promotes consumer welfare, facilitates trade, enables market access and innovation for industry, and provides environmental and economic benefits for communities.

INTERNATIONAL STANDARDS

Standards play a vital role in the development and promotion of compostable bioplastics products. They are generally developed to address specific market needs and are designed to support the uniformity and consistency of products or services within or across markets to reduce information asymmetries between governments, producers, and consumers. The WTO Agreement on Technical Barriers to Trade (TBT) defines a standard as a,

> document approved by a recognized body, that provides, for common and repeated use, rules, guidelines or characteristics for products or related processes and production methods, with which compliance is not mandatory. It may also include or deal exclusively with terminology, symbols, packaging, marking or labelling requirements as they apply to a product, process, or production method.[12]

For the emerging compostable bioplastics industry, standards can help address some of the challenges associated with their commercialization by fostering a common understanding of product

[12] Agreement on Technical Barriers to Trade, Annex 1, para. 2

attributes and claims for producers and consumers. This allows compostable bioplastic products to be differentiated from many similar products within the vast plastics market.

Plastics standards can either be developed at the economy-level by standard setting bodies to address domestic market needs, or by non-governmental, multistakeholder standard setting bodies, which are generally referred to as international standards. Economy-specific standards are often developed to support domestic regulations and the process by which they are developed is generally not open to stakeholders outside of the domestic context. As a result, economy specific standards for the same product in different economies can differ from one another, which can result in trade barriers and inhibit innovation because of the lack of product interoperability between markets.

In contrast, international standards are developed through consensus-based processes that incorporate the expertise of a wide variety of stakeholders. The open, transparent, and collaborative process through which international standards are developed and revised contributes to their perception of fairness and market relevance by stakeholders and promotes confidence in their use. The WTO TBT Committee's 2000 Decision on the Principles for the Development of International Standards outlines key feature of the international standards development process, which include (1) openness; (2) transparency; (3) impartiality and consensus; (4) relevance and effectiveness; (5) coherence; and (6) the development dimension.[13] International standards help promote the interoperability of products between markets, which facilitates trade, and incentivizes investment and innovation.

The international standards landscape for compostable bioplastics is nascent but evolving rapidly to meet market specific needs. For example, ASTM International has developed numerous standards related to test methods for biodegradable plastics and labeling specifications for compostable bioplastic end products. Several APEC economies have also developed standards for compostable bioplastic products. See appendix I for more examples. For economies seeking to develop compostable bioplastics industries in their economies, participation in the development of international standards development activities can help ensure that emerging standards for compostable bioplastics are relevant to their domestic needs.

TECHNICAL REGULATIONS

Some economies may develop technical regulations to build a market for compostable bioplastic products. According to the WTO, a technical regulation is "a document which lays down product characteristics or their related processes and production methods, including applicable administrative provisions, with which compliance is mandatory." Technical regulations reference standards while adding requirements specifying how products can be used in the economy.

Technical regulations should be pursued with caution, as mandatory regulations can potentially produce market distortion, and trade restrictive impacts. Therefore, before implementing any mandatory requirements, non-regulatory alternative measures to achieve the desired policy outcome should be considered. These non-regulatory measures could include, among others, product liability regimes, co-regulation, voluntary standards, self-regulation, and codes of practice.[14]

When developing technical regulations, economies should adhere to the principles and guidelines outlined in the WTO TBT Agreement. Specifically, technical regulations should be no more

[13] "Learn More about Standards." NIST, July 3, 2023. https://www.nist.gov/standardsgov/learn-more-about-standards
[14] "Principles & Features of GRP - Asia-Pacific Economic Cooperation." APEC. n.d. https://www.apec.org/docs/default-source/groups/scsc/2023/00_scsc3_016-principles-features-of-grp.pdf?sfvrsn=af764d34_2

restrictive than necessary to fulfill the intended objective, and wherever possible utilize performance-based compliance approaches rather than design or descriptive characteristics. If relevant international standards exist for the regulated sector, the Agreement also states that WTO Member governments "shall use them as the basis for their technical regulations except where such a standard is ineffective or inappropriate to meet that government's legitimate objective." Economies should look to the experiences of other economies when considering technical regulations for compostable bioplastics to observe lessons learned or potential unintended consequences that could result from pursuing technical regulations in lieu of non-regulatory policy options.

CONFORMITY ASSESSMENT

Conformity assessment is a procedure used to verify that the characteristics and features of products or services meet the requirements of standards or technical regulations. According to the International Organization for Standardization (ISO), conformity assessment refers to "techniques and activities that ensure a product, process, service, system, installation, project, data, design, material, claim, person, body or organization, or any combination thereof, fulfills specified requirements."[15] To avoid unnecessary obstacles to international trade, economies should ensure that their conformity assessment procedures are prepared, adopted and applied in a non-discriminatory manner. Whenever possible, conformity assessment procedures should utilize risk-based approaches that embrace the idea that the risks associated with non-compliance should be proportional to the system design. Such approaches should recognize that overdesign of conformity assessment procedures can be costly and potentially trade restrictive while under-designed processes reduce confidence in the results.

One important resource for economies developing conformity assessment procedures for compostable bioplastics is the CASCO toolbox developed jointly by the ISO and the International Electrotechnical Commission (IEC).[16] The CASCO toolbox includes international standards and guides for conformity assessment procedures that can be used by APEC economies to support their compostable bioplastic policy objectives. Use of the standards in the CASCO toolbox can also be a basis for mutually accepting trading partners' products and services and avoiding unnecessary barriers to trade.

GOVERNMENT PROCUREMENT POLICY

Government procurement policies can play a vital role in generating demand for compostable bioplastics in nascent markets. Typically, governments employ their purchasing power when seeking to boost innovation capacity in sectors with strong societal demand for innovation such as the health, environment, and energy sectors. Often these preferential purchasing programs are coupled with regulations that establish the policy goals of the program and standards to facilitate knowledge and technology transfer. Together, these demand-side innovation policies are designed to lower barriers to the market introduction and diffusion of innovations.[17]

One prominent example of an integrated demand-side innovation procurement policy for compostable bioplastics is the BioPreferred program of the United States Department of Agriculture

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[15] CASCO (ISO Committee for Conformity Assessment), n.d., "Conformity Assessment," `resource, https://casco.iso.org/conformity-assessment.html.

[16] "Toolbox." ISO, January 5, 2021. https://casco.iso.org/toolbox.html. https://casco.iso.org/toolbox.html

[17] E. Uyarra et al., 2014, "Barriers to Innovation through Public Procurement: A Supplier Perspective," *Technovation* 34(10): 631–45, DOI:10.1016/j.technovation.2014.04.003.

(USDA). Established through federal legislation in the 2018 Farm Bill, the program works to increase the purchase and use of biobased products through federal procurement and a certification and labeling initiative. The program helps federal agencies meet statutory mandates to increase the specification and purchase of biobased products, including compostable bioplastics, where applicable.

Notably, the BioPreferred program requires the use of the American Society of Testing and Materials (ASTM) standard D6866 as the only accepted standard for determining the biobased content of products as well as for labeling a product with the USDA Biopreferred logo showing biobased content. Two other ASTM companion standards provide detailed specifications for labeling of end-use items that incorporate plastics and polymers as coatings or additives with paper and other substrates designed to be aerobically composted in municipal or industrial facilities:

- Standard specification for labeling of plastics designed to be aerobically composted in municipal or industrial facilities (D6400).
- Standard specification for labeling of end items that incorporate plastics and polymers as coatings or additives with paper and other substrates designed to be aerobically composted in municipal or industrial facilities (D6868).

These standards are designed to help manufacturers develop next-generation plastic polymer materials for packaging and other disposable products. At the end of their useful life, these plastics can be safely and efficaciously treated along with food, paper, and biodegradable organic wastes in industrial composting. These standards provide much needed clarity and credibility for acceptance in the marketplace and by regulatory bodies in states of the United States that have mandates in place for compostable bioplastics such as California, Connecticut, Minnesota, Rhode Island, and Washington. The United States BioPreferred program is an example of a government procurement policy to promote compostable bioplastics that other APEC economies could potentially model to jump-start the industry in their jurisdictions.

RESEARCH AND DEVELOPMENT PARTNERSHIPS

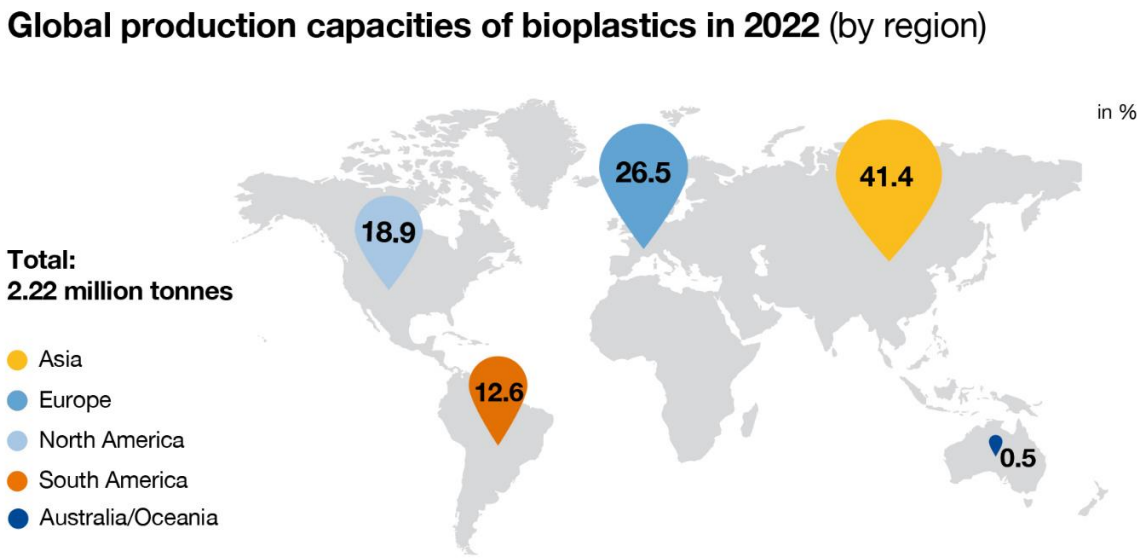
Although the current market for compostable bioplastics is small, it is growing rapidly, with many new products and applications emerging from intensive R&D efforts. However, significant R&D investments are needed to improve material efficiency and optimize the use of promising new biomaterials to generate more useful and less expensive bioplastics. In terms of next generation developments, the techniques of synthetic biology to produce innovative polymers are already being applied to bioplastics production, at least in the laboratory. These developments may make industrial scale production more controllable, more scalable, and more cost-effective. While increased public funding can help bridge the gap between research initiatives and public mechanisms designed to support commercialization of compostable bioplastics, there is also scope for leveraging private sector investment via the creation of public-private partnerships. Additionally, partnerships involving government, academia, and the private sector have proven effective in economies like Japan and Thailand which have invested significantly in these types of initiatives.

APEC POLICY CONTEXT

Compostable bioplastics have a promising future in the APEC region. Economies throughout the Asia-Pacific are increasingly focused on addressing plastic pollution, which has become extreme in many cases, with significant spillover effects. Already the dominant regional producer of bioplastics (Figure 4), the Asia-Pacific is well suited to lead further innovation and market development in the sector. With political will, an abundant labor supply, a robust packaging manufacturing base, and wide

availability of renewable biomass feedstocks, the APEC region has all the right ingredients. However, more robust policy frameworks at the economy-level are needed to unlock this potential.

Figure 5: Global Production Capacities of Bioplastics in 2022



Source: European Bioplastics (2022), "Bioplastics Market Data."

Several APEC economies have adopted policies to promote the widespread commercialization of bioplastics. In these economies, plans to develop the bioplastic industry are tied directly to sustainable development goals and international commitments such as the Paris Agreement, a legally binding international treaty on climate change. Significant planning to systematically analyze the most appropriate pathways for introducing bioplastics as well as sequencing reforms and infrastructure investments has greatly aided these efforts. Initiatives to integrate aspects of the informal waste management value chain into the new bioplastic economy have also been central to several economies' approaches. Research partnerships amongst government, industry, and academia are helping establish linkages between human capital needs and technological advances to create foundations that ready domestic bioplastics industries to compete globally. Creating enabling environments for bioplastics by relying on international standards to maintain product integrity for producers and consumers, offering economic incentives to industry, educating consumers, and overcoming regulatory barriers are key to the viability of these nascent industries.

CASE STUDIES

The final section of this study examines case studies of APEC economies that have implemented policies and practices to commercialize compostable bioplastics. It should be noted that each economy faces distinct political, social, and economic factors influencing its ability to deploy these policies and practices effectively. The intention behind discussing these cases is to provide examples of promising policy approaches in the APEC context that may provide inspiration for other

economies to adopt or innovate from. Given the strong market fundamentals and commercial potential for compostable bioplastics in the APEC region, there are also significant opportunities for economies to develop regional and global manufacturing hubs in the future.

CHILE

Chile has set ambitious goals towards a sustainable, circular economy. A major focus of these efforts centers around improving waste management practices, in particular the diversion of organic wastes from landfills. Although Chile differs from Thailand and Malaysia in that it is not seeking to become a major producer of bioplastics, its approach to transforming the MSW infrastructure provides an important example of downstream measures needed to achieve economic circularity in the waste management value chain.

The integration of informal waste pickers into the MSW management system is a key aspect of Chile's sustainability and circular economy goals. Domestically, it is estimated that some 60,000 waste pickers live and work in Chile,[18] and these workers can play a vital role in implementing the National Organic Waste Strategy 2040 (discussed in more detail below). In 2010, the Ministry of the Environment released the Policy for the Inclusion of Waste Pickers, 2016–2020, which aims to facilitate the integration of these informal workers into the formal waste management sector to help meet the targets established in the organic waste strategy. In addition, the 2016 Extended Producer Responsibility (EPR) Law (Law 20.920) recognizes waste pickers as integral to the policy, providing a pathway for informal workers to get training and certification to integrate within the formalized MSW sector. The law establishes a hierarchy in waste management that prioritizes prevention of waste generation and establishes "cradle-to-grave" responsibility for the disposition of end waste, meaning it begins at the initial moment of waste generation and continues to its recovery or disposal. Together, these and other mandates included in the EPR law create important incentives to produce alternatives to single-use plastic products, including bioplastics and compostable bioplastics. The Policy for the Inclusion of Waste Pickers and the EPR law also provide an important foundation to begin establishing the necessary infrastructure to support more specific initiatives targeting the economic circularity of waste management in Chile.

In 2021, Chile launched its National Organic Waste Strategy 2040, an ambitious plan that aims to dramatically increase municipal organic waste recovery from the current one percent to 66 percent by 2040, with an intermediate goal of recovering 30 percent by 2030.[19] Chile plans to achieve these targets by composting and reducing food waste (Figure 7). The plan is to have composting carried out in 500,000 homes, to create 5,000 composting educational centers, have 500 neighborhoods collectively composting, and have 50 percent of public institutions separating their waste.[20] Chile also plans to implement a gradual fee for household waste collection and a gradual tax on industrial waste disposed at landfills to incentivize mitigation. Together, these measures are intended to dramatically reduce the Chile's greenhouse gas emissions in line with its Nationally Determined Contribution (NDC) for its Paris Climate Accord commitments by diverting organic waste from landfills thereby reducing associated methane emissions.

In May of 2021, Chile passed a law (21.368) that bans all single-use products in the food and beverage sector—the first domestic law of its kind in the world. The law covers plastic products as

[18] International Labor Organization, n.d., "Promoting Green Jobs through the Inclusion of Informal Waste Pickers in Chile," online article, https://www.ilo.org/wcmsp5/groups/public/---ed_emp/---emp_ent/documents/publication/wcms_216961.pdf.
[19] Ministry of Environment, Government of Chile, 2020, National Organic Waste Strategy – Chile 2040, https://economiacircular.mma.gob.cl/wp-content/uploads/2022/03/Estrategia-Nacional-Residuos-Organicos-Ingles.pdf
[20] Ibid.

well as carboard and poly-coated paper products. It also requires that disposable plastic bottles must be composed of a percentage of plastic that has been collected and recycled in Chile. The Chilean Ministry of the Environment plans to enforce and regulate this process through a plastic certification process. However, the exact percentage or what qualifies as "recycled" material remains unclear. Like other laws of its kind, it will take time for citizens and businesses to adjust to the new changes, but Chile has clearly signaled its commitment to pursing alternatives to single-use plastics.

Chile is an example of an economy that has prioritized downstream management of organic waste as a starting point to advance economic circularity for waste management. Although Chile is not poised to become a major producer of bioplastics or compostable bioplastics more specifically, it has positioned itself well to incorporate these products into the economy with the necessary infrastructure in place to appropriately manage their widespread use. At the same time, Chile's ambitious plans for reducing plastic and other nonorganic waste are an important compliment to advancing economic circularity of its waste management economy.

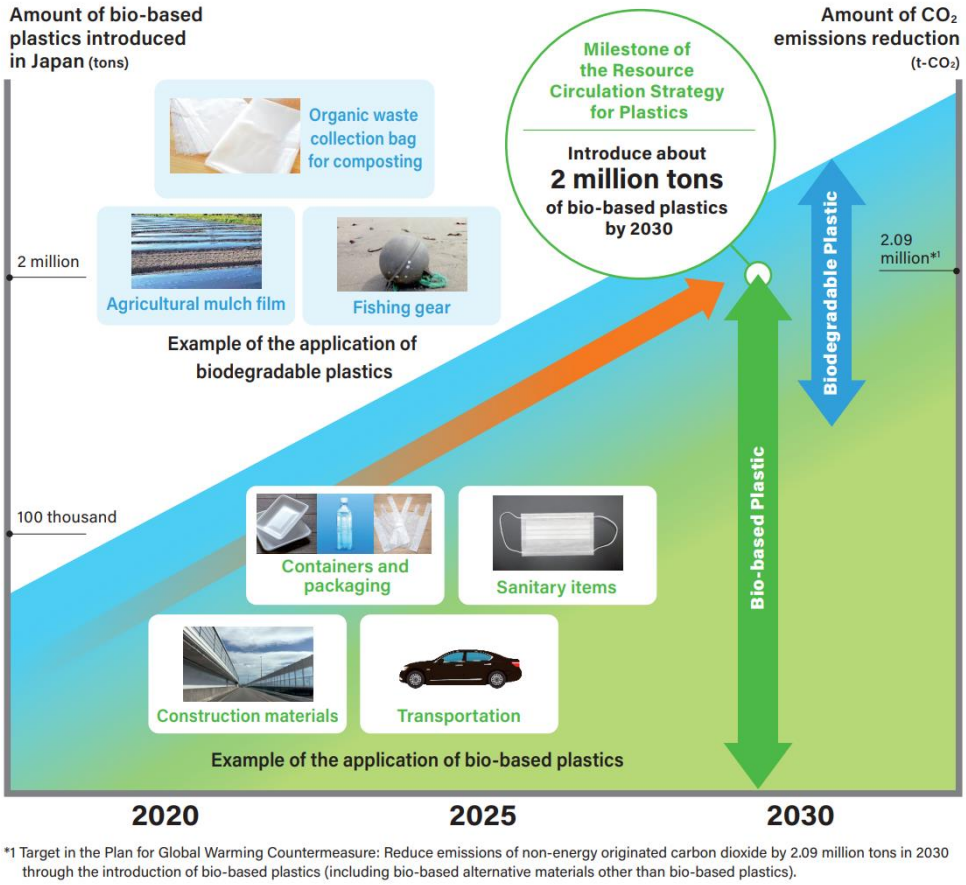
JAPAN

Recognizing the impact of plastics on resource and waste problems, marine plastic litter issues, and climate change, Japan formulated the Resource Circulation Strategy for Plastics in May of 2019. The strategy identifies key initiatives to improve the sustainability of the plastics sector, including prioritizing the increased commercialization of bioplastics in the Japanese economy. To this end, the strategy aims to introduce approximately two million tons of new bioplastics products into the economy by 2030, complimented by educational and awareness raising campaigns for the public about beneficial uses and appropriate end of life treatments.[21] Finally, the strategy recommends a comprehensive roadmap to guide implementation of these strategic goals.

In January of 2021, Japan released its Roadmap for Bioplastics Introduction, which summarizes the status, and challenges for achieving more widespread production and use of bioplastic products in Japan.[22] It also presents details directions and recommendations for the introduction and expansion of bioplastics into the economy, taking total life cycle impacts into account. These recommendations are intended to stimulate innovation in manufacturing, recycling technologies and systems, inform consumer choices, and to serve as a basis for the sustainable increase of demand and supply of bioplastics. The bioplastics roadmap outlines specific principles and measures for the introduction of sustainable bioplastics. Starting with basic principles, it discusses the need to expand non-food domestic biomass supply, further develop the domestic bioplastic manufacturing base, lower the costs of bioplastics products through government support and procurement, expand uses for bioplastic products, and ensure the compatibility of bioplastic products with existing recycling and end-of-life processing infrastructure. The roadmap goes on to provide details of principles and measures related to the introduction of bioplastics for manufacturers, plastics-using companies, retail and service providers, consumers, academic and research institutions, and local governments. Finally, the roadmap outlines specific principles for the introduction of bioplastics in different plastic product areas, including containers and packaging; electrical and electronic equipment; construction materials; transportation; and agriculture, forestry, and fisheries. It identifies specific bioplastic types suitable as substitutes for current plastic products and uses, providing a detailed mapping of how bioplastics can and should be applied throughout the economy. Figure 8 below depicts the timeline for introducing bioplastics.

[21] Government of Japan, 2021, Roadmap for Bioplastics Introduction, January, https://www.env.go.jp/recycle/mat21030210_1.pdf.
[22] Ibid.

Figure 6: Schematic of the Timeline for Introducing Bioplastic Products



Source: Government of Japan (2021), Roadmap for Bioplastics Introduction.

Bioplastics are recognized as a central part of the solution to combating Japan's plastic pollution. However, questions remain about their recyclability and biodegradability and the energy used to produce bioplastics, which is one of the reasons a series of teams at different Japanese companies are tackling bioplastics from many angles as part of a project called COI-NEXT, launched in 2020. COI stands for Centers of Innovation, an industry-academia partnership that promotes R&D in strategic sectors aimed at addressing Japan's sustainable development goals.[23] Biotechnology is one of these strategic sectors and Japanese researchers supported by the COI-NEXT program are focused on developing bioplastics that rapidly biodegrade in natural environments. Known as bacterial cellulose nanofiber (BCNF) composites, which are designed to replace a variety of current common plastic packaging products. Composites made of BCNF and other substances such as plant cellulose, are more durable than glass, carbon, and other non-biodegradable synthetic fibres. The

[23] Japan Science and Technology Agency, 2021, "Report: COI-NEXT Kick-off Symposium," article, June 16, https://www.jst.go.jp/report/2021/210726_e.html#:~:text=COI%2DNEXT%20was%20established%20in,%E2%80%93academia%20co%2Dcreating%20system.

composites can be recycled many times without losing their strength.[24] Another advantage of these compounds is that their production involves few hazardous chemicals and does not require a lot of energy.[25] Research on BCNF compounds and other innovative compostable bioplastics in Japan is drawing interest from the automotive industry, the fisheries sector, and other Japanese industries seeking more environmentally sustainable alternatives to traditional inputs to their production value chains.

Japan provides an example of an economy that has taken a systematic approach to policy planning for the widespread commercialization of bioplastics. The Roadmap for Bioplastics Introduction provides policymakers, industry, and consumers with vital information about how to plan for and introduce bioplastics in lieu of traditional plastics wherever possible. Japan's policy planning efforts, combined with its intensive focus on R&D partnerships with industry and academia, place it on a pathway to achieve its ambitious goals for advancing bioplastics in its economy.

MALAYSIA

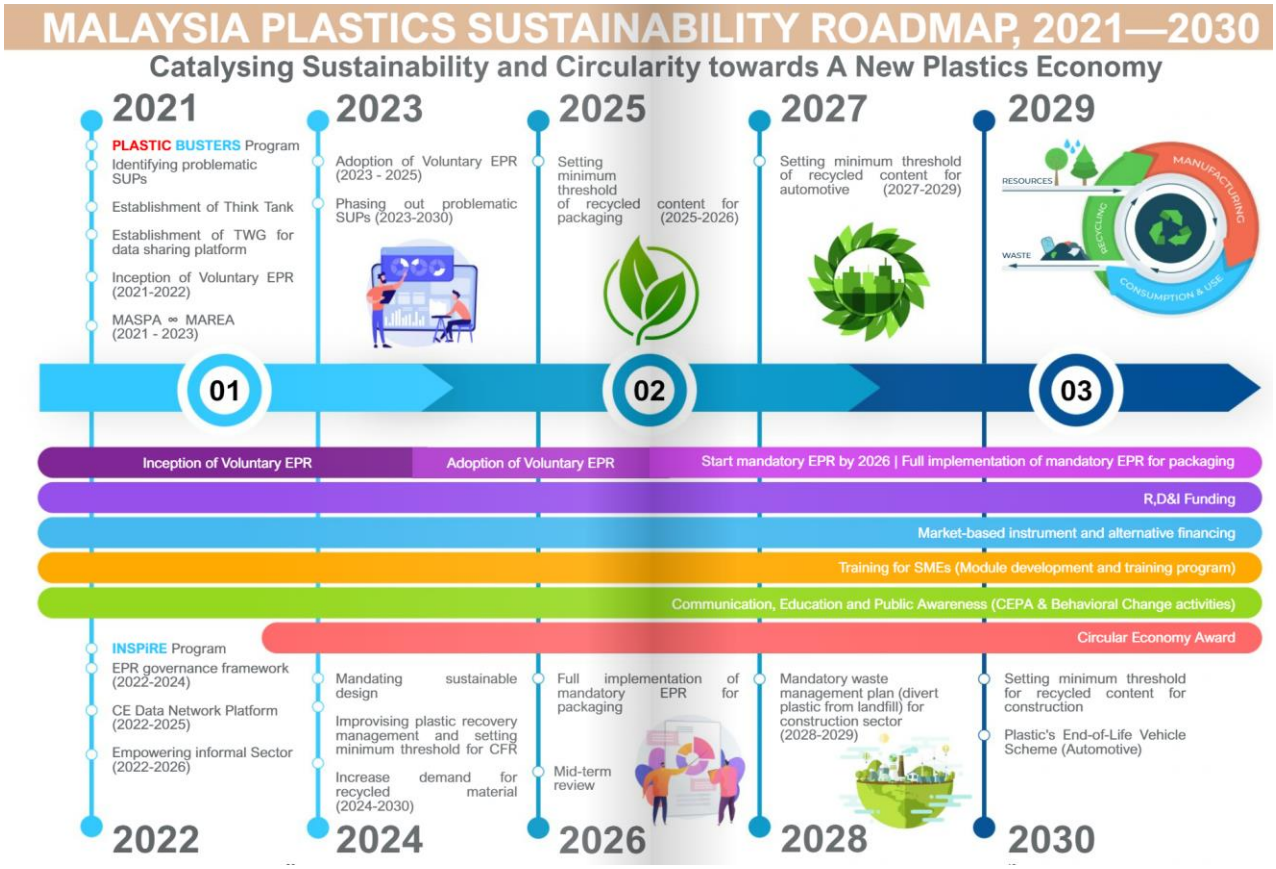
Malaysia has embarked on a similar path as Thailand to promote its bioplastics industry by integrating bioplastics initiatives into domestic planning efforts. Government-wide economic development strategies such as the Twelfth Malaysia Plan 2021–2025 have signaled Malaysia's commitment to a circular economy approach to sustainable development. "Accelerating transition to the circular economy" is one the plan's key strategies for implementing one of its top priorities, namely, "implementing a low-carbon clean and resilient development." According to the plan, the domestic recycling rate of household waste increased to 30.7 percent in 2020, mainly through the implementation of waste separation at the source as well as reduce, re-use, and recycle initiatives.[26] The plan also seeks to increase the share of "green" government procurement to 25 percent. These initiatives have laid the groundwork for a more holistic planning effort to promote a circular economy approach to plastics management.

[24] "Japan Accelerates Hunt for Plastics That Rapidly Biodegrade in the Ocean" Nature news, Accessed January 30, 2024 https://www.nature.com/articles/d42473-023-00087-8

[25] Kanazawa University and Nature Research Custom Media, 2023, "Japan Accelerates Hunt for Plastics that Rapidly Biodegrade in the Ocean."

[26] Economic Planning Unit, Prime Minister's Office, Government of Malaysia, 2021, Twelfth Malaysia Plan 2021–2025, July, https://pulse.icdm.com.my/wp-content/uploads/2021/09/Twelfth-Plan-Document_compressed-1.pdf.

Figure 7: Malaysia Plastics Sustainability Roadmap, 2021–2030



Source: Ministry of Environment and Water, Government of Malaysia (2021), Malaysia Plastics Sustainability Roadmap 2021–2030.

Malaysia has chosen to implement a phased approach that focuses on accomplishing achievable goals first and ratcheting up the scope and impact over time. In 2021, Malaysia developed its Plastics Sustainability Roadmap 2021–2030 (Roadmap) to catalyze sustainability and circularity towards a new plastics economy (Figure 6, above). The Roadmap is aligned with Malaysia's sustainable development goals and aims to inform stakeholders about the opportunities and measures needed to achieve plastics circularity in the economy. The document provides guidance about sustainable business practices to promote plastics circularity and about how to harmonize actions along the plastics value chain through the adoption of a life cycle approach. Malaysia aims to achieve a circular economy approach to plastics management through several key innovation strategies.[27] The first is to focus on improving product design as well as waste collection and sorting outcomes. The development of new standards on biodegradable plastic products is central to this strategy and is similar in approach to Thailand, Malaysia plans to base its national standards on existing international standards from ASTM and ISO. A standardized labeling program will aid appropriate waste collection and separation activities. Here, Malaysia plans to incorporate informal waste picking activities into mainstreamed collection and separation efforts by formalizing workers in this sector. Involving this robust source of human capital could have significant benefits for the system if implemented appropriately. Phasing out single-use traditional plastics, promoting re-use of certain durable

[27] Ministry of Environment and Water, Government of Malaysia, 2021, Malaysia Plastics Sustainability Roadmap 2021–2030, https://www.kasa.gov.my/resources/malaysia-plastics-sustainability-roadmap-2021-2030/28/.

products, and improving the sorting and collection of plastic waste streams are all central to the strategy.

Promoting greater alignment of standards, regulations, and messaging across jurisdictions is another key strategy outlined in the Roadmap. As the Roadmaps states, "harmonized standards are necessary to create conditions for a true circular economy by filling in regulatory gaps on issues like materials efficiency, durability repairability, reusability, and recyclability.[28]"

Finally, the Roadmap aims to implement an extended producer responsibility (EPR) program that seeks to extend financial and/or physical responsibility of plastics producers across the value chain, from product design to treatment or disposal of a producer's post-consumer products. Before moving to a mandatory EPR scheme in 2026, a voluntary program is currently in place from 2023-2025, to allow producers to adjust to the new program.

THAILAND

A combination of abundant biomass feedstocks, a strong agricultural base, high downstream industry demand, and supportive government policies that provide attractive incentives for industry provides Thailand with a competitive advantage in the global bioplastics market. Since 2006, the Thai government has declared the bioplastics industry as a strategic industry for promoting its sustainable development goals. In 2008, the Ministry of Science and Technology developed the National Roadmap for the Development of Bioplastics Industry for 2008–2012, which focused on four main areas: sufficient supply of feedstocks, accelerating technology development and technology cooperation, building industry and innovative businesses, and establishing supportive infrastructure.[29] The plan included over THB60 million for implementation and outlined numerous incentives for bioplastics investment, including corporate income tax exemptions, deductions for infrastructure construction and installation costs, import duty reductions or exemptions for machinery and raw materials, and permission to bring in foreign experts and technicians. These incentives led to investments in several production facilities by domestic and international firms. Since then, the Thai government has updated the National Roadmap to include additional supportive measures to boost investment, including support for additional bioplastics R&D, standardization systems, business and investment privileges, market promotion, and environmental management. Strong government support for the bioplastics industry has positioned Thailand as an industry hub for the Asia-Pacific region.

Thailand is now the world's second largest producer of bioplastics behind the United States, producing around 95,000 tons per year, with planned increases of another 75,000 tons per year according to the Thai Bioplastics Industry Association (TBIA).[30] The top importers of Thai bioplastics products include the European Union, the United States, and Japan, with 90 percent of bioplastic production destined for export. To spur greater investment and innovation in the sector, Thailand developed its first standard for the labeling of compostable bioplastic products in May of 2021. The standard provides detailed guidelines regarding production processes and product specifications for both biodegradable and compostable plastics, using a flexible, performance-based approach that

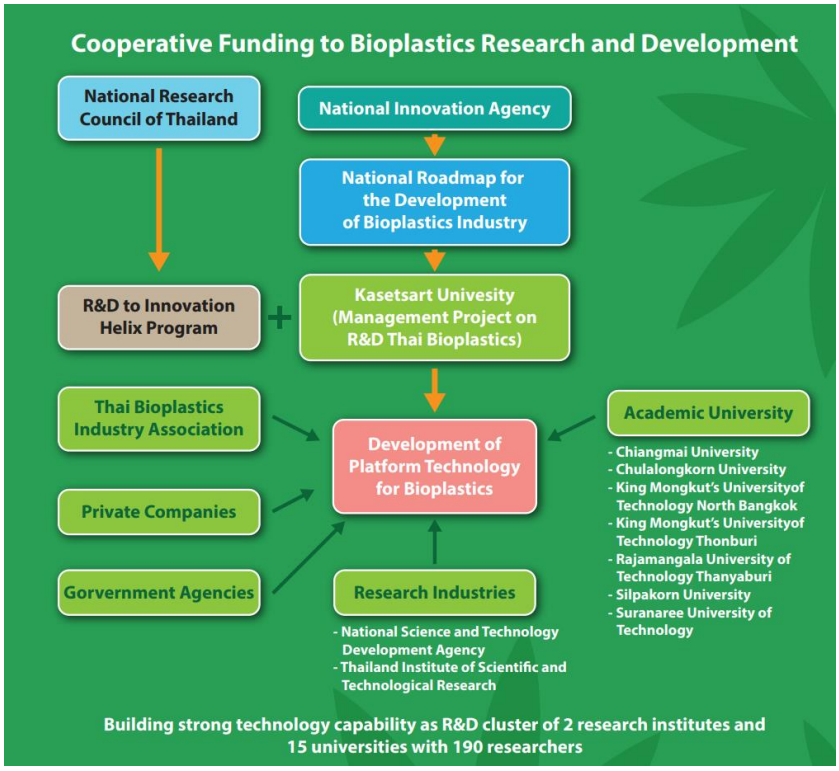
[28] Ministry of Environment and Water, 2021, Malaysia Plastics Sustainability Roadmap 2021–2030.
[29] Ministry of Science and Technology, National Innovation Agency, Thailand, 2008, National Roadmap for the Development of Bioplastics Industry. https://www.researchgate.net/publication/319298055_Bangladesh_Invented_Bioplastic_Jute_Poly_Bag_and_International_Market_Potentials/fulltext/59a17a484585 15fd1fe37abc/Bangladesh-Invented-Bioplastic-Jute-Poly-Bag-and-International-Market-Potentials.pdf
[30] Royal Thai Embassy, Washington, DC, n.d., "Thailand is Now World's Second-Largest Maker of Bioplastics," online article, https://thaiembdc.org/2023/03/09/thailand-is-now-worlds-second-largest-maker-of-bioplastics/.

relies on international standards from the ASTM and the ISO as benchmarks. Three local testing laboratories for compostable bioplastics have been ISO certified to conduct conformity assessment procedures on these products. The TBIA signed memorandums of understanding (MOUs) with several global institutions to further develop harmonized certification and identification programs and scientifically based tests and specifications for bioplastics products.[31] Additional MOUs also promote further cooperation in areas such as technology development, capacity building, joint ventures, and market development to further the global development of the bioplastics industry. The development of standards, domestic lab testing capabilities, and industry alliances have positioned the Thai bioplastics industry well to compete in the global market.

To provide continuous support in improving the investment environment for bioplastics investors, the government has partnered with academic institutions, research centers, and the private sector to provide resources for R&D, human resource training, and dedicated bioplastics faculty in over 20 leading Thai academic institutions (Figure 5),[32] leading to significant foreign investment producing innovative new biotechnology for the Thai bioplastics industry. For example, in 2019, TotalEnergies Corbion inaugurated a new facility to produce up to 75,000 tons per year of Polylactic acid (PLA), a polymer used to produce bioplastics from sugarcane.[33] The plant not only used renewable biomass as feedstock, but its production process is also very low-carbon intensive. Total Corbion conducted a peer-reviewed life cycle impact assessment of PLA that concluded that "from a cradle-to-gate perspective, the Global Warming Potential (GWP) of PLA is confirmed to be only 500-gram CO_2/kg [carbon dioxide per kilogram] of PLA, which is roughly a 75 percent reduction in carbon footprint versus most traditional plastics."[34]

[31] C. Eyre, 2012, "Italian and Thai Bioplastics Groups Sign Agreement," online article, Sustainable Plastics, June 15, https://www.sustainableplastics.com/article/20120615/PNE/306159954/italian-and-thai-bioplastics-groups-sign-agreement.
[32] Thailand Board of Investment, 2017, *Thailand's Bioplastics Industry,* https://www.boi.go.th/upload/content/BOI-brochure%202017-bioplastics-20171114_19753.pdf.
[33] European Bioplastics, 2019, "Total Corbion's New Plant in Thailand Produces Low Carbon Footprint PLA," October 31, https://www.european-bioplastics.org/total-corbions-new-plant-in-thailand-produces-low-carbon-footprint-pla/
[34] TotalEnergies Corbion, 2019, "Low Carbon Footprint of PLA Confirmed by Peer Reviewed Life Cycle Assessment," October 13, https://www.totalenergies-corbion.com/news/low-carbon-footprint-of-pla-confirmed-by-peer-reviewed-life-cycle-assessment/

Figure 8: Cooperative Funding to Bioplastics Research and Development in Thailand



Source: Thailand Board of Investment (n.d.), Thailand Biotechnology: The Gateway to ASEAN.

Thailand's strategy to build and expand the domestic production of compostable bioplastics represents a potential model for the APEC region. From the outset, the Thai government integrated a circular economy approach to bioplastics industry development within an overall framework for strategic economic development. The government of Thailand prioritized the bio-circular and green (BCG) model, encouraging manufacturers to adopt techniques that add value to products and cause little or no impact on the environment. The model is driven by the use of renewable resources for raw materials to produce energy, food, and other value-added products. Through a combination of government incentive programs, the creation of a policy enabling environment rooted in international standards, and the forming of strategic alliances with industry and academic groups, Thailand has positioned itself as a global leader in the bioplastics industry.

RECOMMENDATIONS

For economies seeking to develop circular economy approaches to plastics management through the promotion of compostable bioplastics, the following section outlines a set of key observations to guide planning efforts.

1) Develop policy frameworks that enable trade and investment.

- Voluntary consensus-based international standards are needed to differentiate and maintain product attribute integrity and facilitate the interoperability of compostable bioplastic products across markets among APEC economies. Multi-stakeholder, consensus-based international standards can have several advantages over economy-specific standards. Voluntary consensus-based standards avoid potential technical barriers to trade that can arise from when divergent requirements are set in economy-

specific standards across jurisdictions. They can also be revised more quickly to address market developments than technical regulations, which can become static in the face of technological advances and can be difficult and time-consuming to amend or revise. If technical regulations for compostable bioplastics are employed, performance-based compliance approaches in lieu of design-based approaches are preferred. Performance-based approaches are flexible to accommodate various approaches to compliance, rather than a prescriptive, "one size fits all" design-based approach, which can inhibit market innovation and potentially create trade barriers when requirements diverge across economies.

2) Conduct and promote education and awareness campaigns.

    - Public buy-in and participation is needed to facilitate circular economy approaches to compostable bioplastics management. Separation of compostable bioplastics waste streams at the source is critical to facilitate the commercial composting at scale needed to support widespread commercial use of these products. Educating both compostable bioplastics producers and consumers about the intentions behind, and benefits of circular economy approaches to the management of compostable bioplastic products helps facilitate buy-in to effectuate appropriate management practices throughout the product value chain. Education and awareness campaigns should accompany any compostable bioplastic product labeling requirements to help facilitate product differentiation, increase market penetration, and minimize the potential for greenwashing.

3) Support infrastructure investments.

    - Widespread commercialization of compostable bioplastics requires appropriate investments in waste management infrastructure to achieve economic circularity. Capital investments for commercial composting facilities and operational costs for waste stream management and transport can be costly. Economies can help legitimize and achieve buy-in for costly public investments by providing economic benefits for producers through public procurement programs and incentivizing consumers to participate in composting management programs at the household level. These necessary public investments can be multiplied through public private partnerships, including in some cases, formalizing existing informal waste management infrastructure to perform compostable bioplastic management activities.

4) Promote research and development partnerships.

    - Thailand and Japan provide examples of how partnerships between government and academia have helped facilitated innovation in the bioplastics sector. These innovations have ranged from developing new polymers to enhance the sustainability of existing single use products to developing new product applications in previously untapped economic sectors.

5) Strengthen efforts at regional cooperation.

    - Increased trade and investment in compostable bioplastics in the APEC region cannot be achieved without cooperation. By relying on international standards to develop technical regulations to implement compostable bioplastics management programs economies

permit product interoperability and facilitate trade and investment across jurisdictions. Increasing the compatibility of compostable bioplastic regulations and conformity assessment procedures can help establish the APEC region as a hub for global commercialization of compostable bioplastics.

APPENDIX 1: APEC WORKSHOP SCSC04 2023S ON "ASSISTING POLICY MAKERS WITH MITIGATION AND PREVENTION OF PLASTICS POLLUTION – STANDARDS AS A RESOURCE FOR THE POLICY FRAMEWORK"

For further resources on economy level efforts in this space as well as a preliminary list of standards relevant to the mitigation and prevention of plastics pollution, please see here: https://aimp2.apec.org/sites/PDB/Supporting%20Docs/5069/Completion%20Report/SCSC%2004%202023S_Workshop%20Report_Standards%20and%20Plastic%20Waste.docx

APPENDIX 2: PROMOTING SUSTAINABLE SOLUTIONS FOR COMPOSTABLE BIOPLASTICS IN THE ASIA-PACIFIC REGION WORKSHOP AGENDA

Agenda

Promoting Sustainable Solutions for Compostable Bioplastics in the Asia-Pacific Region

20 February 2023
Smoketree F, Palm Springs Convention Center
Palm Springs, California, United States

SESSION	DESCRIPTION
8:30 – 9:00 am	**Registration and Arrival**
9:00 – 9:10 am	**Welcome Remarks and Opening Address** **Scott Pietan,** Assistant U.S. Trade Representative for Japan, Korea, and APEC (Acting), Office of the U.S. Trade Representative
9:10 – 9:15 am	**Agenda Overview and Participant Introductions** **US-SEGA**
Session 1 9:15 – 9:45 am	**Promoting Compostable Bioplastics** *This session will provide an overview of the policy and regulatory issues that involve compostable bioplastics as a solution to help reduce plastic pollution and promote a transition towards a more sustainable plastic circular economy model. The presentation explores opportunities for a new plastics economy, covering issues involving collection of waste, and compostability in the competitive landscape that includes recycling and reuse options for materials.* **Rhodes Yepsen,** Executive Director, Biodegradable Products Institute
9:45 – 10:15 am	**Tea/Coffee Break**
Session 2 10:15 – 11:30 am	**The Enabling Environment: Labeling, Standards and Certification** *This moderated panel session will discuss the challenges, risks, gaps as well as sound policy responses that support an effective transition towards a regenerative model involving compostable bioplastics. The discussion will cover issues involving appropriate policy practices for organic material composting, developing labeling, standardization, certification and relevant regulatory measures, as well as promoting innovation and commercialization.* *Moderated by:* **Jessica Bowman,** Executive Director, Plant Based Products Council

	Kongsak Dokbua, Vice President, Plastics Market Intelligent Department, Plastics Institute of Thailand **Alyson Fick,** Manager, Standards Development, ASTM International **Yorimasa Suwa,** Visiting Researcher, MEIJI University Center for International Standardization, Japan
11:30 – 1:00 pm	**Lunch**
Session 3 1:00 – 2:15 pm	**Commercialization and Accessing Markets** *This session will examine successful industry-led solutions for sorting and end of life, and best practice options and lessons learned that can be considered in the future to promote compostable bioplastics in the region. This panel will also provide an opportunity for industry representatives to highlight the policy and regulatory obstacles they face in scaling up solutions.* *Moderated by:* **William J. Orts,** Acting Center Director, Research Leader, Bioproducts, U.S. Department of Agriculture Agricultural Research Service **Chris Bradley,** Chief Marketing & Sustainable Design Officer, Orora Packaging Solutions **Andrew Cal,** Director of Innovation, Mango Materials **Adrian Tung Zi Feng,** Co-Founder and CEO, Circlepac **Jon Smieja,** Vice President of Circularity and Senior Analyst, Greenbiz Group
Session 4 2:15 – 3:45 pm	**Interactive Sessions** *These sessions will involve group discussions that are facilitated by experts, on a range of topics that are central to the topic of compostable bioplastics.* *The groups will discuss organic composting methods and waste management and recycling policies; regulatory and legislative issues; standards and certification; the use of compost and circular economy approaches; industrial and municipal composting facilities and infrastructure related issues, and financing aspects, from their economy-level perspectives.*
3:45 – 4:15 pm	**Tea/Coffee Break**

Session 5 4:15 – 4:45 pm	**Report Back** *Each of the groups will report back on the discussions in their groups and present on the three priorities and solutions they arrived at in their groups.*
4:45 – 5:00 pm	**Wrap Up and Next Steps** **Andrew Stephens,** Senior Policy Advisor, Foreign Agricultural Service, U.S. Department of Agriculture

ANNEX 3: REFERENCES

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