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The guideline handbook for

CE PRODUCT VERIFICATION

LANCANG-MEKONG REGION COUNTRIES FOR APPLICATION

Project Title: Circular Economy (CE) Capability Building in the Lancang-Mekong Region: Product Verification of Plastics Packaging in Supply Chains

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1 Introduction

1.1 Background and purpose of the guideline handbook

The importance of the guideline handbook for CE product verification implementation for plastics packaging in supply chains cannot be overstated, particularly for the Mekong Region countries, which are currently facing a plastic waste crisis.

By providing clear guidance on how to implement CE product verification techniques, the handbook can help organizations in the plastics packaging supply chain reduce their environmental impact, promote sustainable practices, and contribute to a circular economy. This is particularly important given the negative impacts of plastic waste on the environment, human health, and the economy.

Moreover, the guideline handbook can serve as a valuable tool for the Mekong Region countries as they strive to achieve their sustainability goals and transition to a circular economy. The handbook can provide guidance on how to integrate CE product verification into existing processes, identify suitable products for verification, and measure and track progress.

The handbook can also help to standardize CE product verification practices across the region, promoting a more consistent and effective approach to circular economy implementation. This can, in turn, help to address the plastic waste crisis in the Mekong Region and contribute to the global effort to promote sustainable development.

Overall, the guideline handbook for CE product verification implementation for plastics packaging in supply chains is an important tool for organizations in the Mekong Region countries, as well as for the global community as a whole, as we work together to address the plastic waste crisis and promote sustainable development.

1.2 Importance of a circular economy approach to reduce plastic waste

The importance of a circular economy approach to reduce plastic waste cannot be overstated. In a linear economy, products are manufactured, used, and then discarded as waste, resulting in a significant amount of plastic waste being generated. This waste often ends up in landfills or in the natural environment, where it can take hundreds of years to decompose and have negative impacts on wildlife, water quality, and human health.

In contrast, a circular economy approach aims to keep resources in use for as long as possible, through strategies such as reuse, repair, and recycling. This approach can help to reduce the amount of plastic waste generated by the plastics packaging industry, while also conserving natural resources and reducing greenhouse gas emissions.

In a circular economy, plastic waste is not seen as a problem but as a valuable resource that can be reused and recycled. By using circular economy principles, it is possible to reduce the amount

of plastic waste generated by the plastics packaging industry, as well as to create new opportunities for innovation and job creation.

Furthermore, a circular economy approach can provide economic benefits by reducing the reliance on virgin materials and creating new markets for recycled plastics. This can help to reduce the environmental impact of plastic production and consumption, while also contributing to economic growth and development.

A circular economy approach to reduce plastic waste is not only vital to stop plastic pollution, but it also offers strong economic, social, and climate benefits. By 2040, a circular economy has the potential to reduce the annual volume of plastics entering our oceans by 80%, reduce greenhouse gas emissions by 25%, generate savings of USD 200 billion per year, and create 700,000 net additional jobs[1].

A circular economy considers every stage of a product's journey – before and after it reaches the customer. To create a circular economy for plastic we must take three actions: eliminate all problematic and unnecessary plastic items, innovate to ensure that the plastics we do need are reusable, recyclable, or compostable, and circulate all the plastic items we use to keep them in the economy and out of the environment [1].

Overall, the importance of a circular economy approach to reduce plastic waste lies in its ability to reduce environmental impact, conserve natural resources, and promote economic development. By adopting circular economy principles, the plastics packaging industry can move towards a more sustainable and resilient future, while also contributing to the global effort to address the plastic waste crisis.

1.3 Overview of the plastics packaging supply chain and the need for CE product verification

The plastics packaging supply chain is a complex network of organizations and processes involved in the design, production, distribution, use, and disposal of plastic packaging materials. This supply chain includes various stakeholders such as plastic manufacturers, packaging converters, brand owners, retailers, consumers, waste management companies, and recyclers.

The need for CE product verification in the plastics packaging supply chain arises from the significant negative impact of plastic waste on the environment, human health, and the economy. The use of plastic packaging has been on the rise due to its convenience, durability, and cost-effectiveness, but this has led to a surge in plastic waste generation. A large amount of plastic waste ends up in landfills, oceans, and other natural environments, where it can take hundreds of years to decompose, harming wildlife and ecosystems, and creating health hazards for humans.

To address this issue, it is important to promote a circular economy approach in the plastics packaging supply chain. CE product verification is a critical component of this approach, as it involves the identification and verification of products that have been designed, produced, and used in a way that promotes circularity.

There are several types of plastic packaging commonly used in supply chains. Some of the most common types include:

1) Polyethylene Terephthalate (PET): This type of plastic is commonly used for beverage bottles, food jars for condiments and jelly, and microwave meal trays [2,3].
2) Polyvinyl Chloride (PVC): This type of plastic is commonly used for juice, beer, and other beverage bottles as well as bottles for mouthwash [3].
3) Polypropylene (PP): This type of plastic has a high melting point and chemical resistance, making it perfect for holding hot liquids. It is commonly used for medicine bottles, syrup bottles, yogurt containers, take-out and deli food containers, and bottle closures and caps [8].
4) Polystyrene (PS): This type of plastic is commonly used for packaging that requires heat sealing, garbage bags, plastic bags, coatings on beverage cups and cartons, stretch film and shrink wrap, squeezy condiment bottles, fresh and frozen produce bags, flexible lids, wires and cables[3].
5) High-Density Polyethylene (HDPE): This type of plastic is translucent, tough, and chemical and solvent resistant. It has high tensile strength and is able to withstand higher temperatures than other plastics. It is commonly used for bottles for beverages and liquids, cosmetic bottles such as shampoo and conditioner, domestic cleaning containers, grocery bags, liners for cereal boxes [3].

These are just some examples of the different types of plastic packaging used in supply chains. Each type has its own properties and typical applications.

There are many supply chains of plastic packaging used in the world. Plastic packaging is used in a wide range of industries and products, including food packaging, appliances, smartphones, car parts, exercise equipment, and roller skates [4]. However, there are also challenges and risks associated with the use of plastic packaging in supply chains. For example, only around 15% of the total plastic produced is recycled today, and about 11 million metric tons of plastic leak into the ocean annually [5].

If you're looking for more specific information about supply chains of plastic packaging used in the world, you can check out resources such as the World Business Council for Sustainable Development [5] or the United Nations-supported Principles for Responsible Investment [6], which provide information and analysis on sustainable plastics and packaging value chains.

The concept of circular plastic packaging in supply chains refers to the idea of transitioning towards a more sustainable and circular use of plastic packaging. This involves prioritizing resources and capabilities along the supply chain to reduce waste and increase the use of recycled materials [7].

Open-loop recycling of plastic refers to a recycling process where plastic materials are converted into both new raw materials and waste products. Typically, materials recycled through open-loop recycling go on to be used for purposes different from their former, pre-recycled purpose [8]. This means that the input into the recycling process is converted to a new raw material, which can be used as an input into another manufacturing process.

A common example of open-loop recycling of plastic is when plastic bottles are recycled into sleeping bags or fleece jackets [9]. Another example is when HDPE bottles are recycled to make plastic pipes [10]. These pipes can have a lifespan of many decades, keeping this material in use for a longer period of time.

Open-loop recycling processes usually involve processing various types of products of similar material makeup and change the properties of the material itself (through heat, chemical reactions, or physical crushing). Open-loop recycling is often associated with a degradation of the material being recycled, and a loss of attached materials that are not being recycled (such as bottle labels and adhesives). Open-loop recycling is also referred to as down cycling or reprocessing [11].

CE product verification helps to ensure that plastic products are designed for circularity, that they are produced using sustainable and eco-friendly processes, and that they are used in a way that reduces their environmental impact. Furthermore, verification provides a means to measure and track progress towards circularity and sustainability goals, which can help to drive continuous improvement and innovation in the supply chain.

The CE mark is probably the most widely used and recognized marking required by the European Union for product verification. The placement of the CE mark on a product serves as the manufacturer's declaration that the item meets all EU regulatory requirements (typically related to safety, health, energy efficiency, or environmental concerns) for marketing that item in the European Economic Area.

The CE mark is primarily recognized within the European Union and European Economic Area. However, many countries outside of the EU have similar regulatory requirements and may accept products with a CE mark as meeting their own standards. For example, Turkey sometimes requires certain products to have a CE mark. In other countries, certain aspects of the CE mark process – such as EN standards – are recognized [12].

Overall, the plastics packaging supply chain plays a crucial role in the global effort to address the plastic waste crisis. By promoting a circular economy approach and implementing CE product verification techniques, the supply chain can reduce its environmental impact, promote sustainable practices, and contribute to a more sustainable and resilient future.

2 CE product verification techniques

CE product verification is an essential process for ensuring that products meet specific requirements, including quality, safety, and environmental standards. The use of CE product verification techniques in the supply chain has become increasingly important in recent years due to the growing demand for sustainable and environmentally friendly products. These techniques help ensure that products are produced in compliance with specific standards and regulations, such as those related to environmental sustainability and social responsibility.

There are various CE product verification techniques that can be used in the supply chain, including the use of certification schemes and product labeling. These techniques provide assurance to consumers and stakeholders that products meet specific requirements, and they also help companies to demonstrate their commitment to sustainability and social responsibility.

This guide will provide an overview of the different CE product verification techniques that can be used in the supply chain, including certification schemes, product labeling, and other verification methods. It will also highlight the importance of implementing these techniques and provide guidance on how to do so effectively.

2.1 Techniques

CE product verification techniques are a set of methods used to ensure that products meet the criteria for circularity and sustainability. These techniques include:

- Life cycle assessment (LCA): LCA is a comprehensive technique that evaluates the environmental impacts of a product over its entire life cycle, from raw material extraction to disposal. LCA can identify opportunities for improvement in terms of resource efficiency, carbon footprint reduction, and waste reduction.
- Material traceability: Material traceability involves tracking the origin of raw materials used in the production of a product, as well as the destination of the product after use. This technique can ensure that products are produced using sustainable materials and that they are recycled or disposed of properly at the end of their life cycle.
- Eco-design: Eco-design involves designing products with sustainability in mind. This includes using eco-friendly materials, minimizing waste during production, and designing products that are easily disassembled and recycled.
- Certification schemes: Certification schemes are third-party programs that provide a stamp of approval for products that meet certain sustainability criteria. Examples include the International Sustainability and Carbon Certification (ISCC) and the Forest Stewardship Council (FSC).
- Upcycling and recycling: Upcycling involves converting waste materials into products of higher value, while recycling involves turning waste materials into new products. Both techniques can help to reduce the environmental impact of products and promote circularity in the supply chain.

- Closed-loop supply chains: Closed-loop supply chains involve designing the supply chain in such a way that waste is minimized and resources are kept in use for as long as possible. This can be achieved through techniques such as product take-back programs, reuse of materials and components, and the creation of circular networks of suppliers and customers.
- Product labeling: Product labeling provides consumers with information about the environmental performance of a product. This can include information about the materials used, the energy consumed during production, and the product's end-of-life options. Labels such as the Energy Star label and the Green Seal label can help consumers make more sustainable purchasing decisions.
- Product standards: Product standards provide guidelines for the design and production of products that promote sustainability and circularity. Examples include the Cradle to Cradle certification and the Global Recycled Standard.
- Waste-to-energy: Waste-to-energy involves converting waste materials into energy. This can be done through techniques such as incineration or gasification. While this technique can help to reduce the environmental impact of waste, it should be used as a last resort after other techniques such as recycling and upcycling have been exhausted.
- Extended producer responsibility (EPR): EPR is a policy approach where producers are held responsible for the end-of-life management of their products. This can encourage producers to design products that are more easily recycled or upcycled.

Overall, there are many different CE product verification techniques that can be used to promote sustainability and circularity in the plastics packaging supply chain. Organizations can choose the techniques that are most relevant to their products and supply chains to ensure that they are operating in a more sustainable and circular manner.

By implementing these CE product verification techniques, organizations can ensure that their products meet the criteria for circularity and sustainability, and contribute to a more sustainable future.

2.2 Upcycling

Upcycling, also known as creative reuse, is the process of transforming by-products, waste materials, useless, or unwanted products into new materials or products perceived to be of greater quality, such as artistic value or environmental value [12]. The goal of upcycling is to prevent wasting potentially useful materials by making use of existing ones. This reduces the consumption of new raw materials when creating new products. Reducing the use of new raw materials can result in a reduction of energy usage, air pollution, water pollution and even greenhouse gas emissions [13].

The methodology for upcycling varies depending on the materials being used and the desired end product. However, the general principle involves assessing the potential of waste materials and finding creative ways to repurpose them into something new and valuable. This can involve

disassembling and reassembling materials, combining different materials together, or simply finding a new use for an existing item.

The theory of upcycling plastic is based on the idea that plastic waste can be transformed into new materials and products with a higher value or functionality than the original waste. This is achieved by taking advantage of the inherent properties of plastic, such as its durability and versatility, and transforming it into a new form that can be used in different applications.

The upcycling process typically involves transforming plastic waste into a new material, such as a composite material or a 3D printing filament, or into a new product, such as a piece of furniture or a fashion accessory. This is done by combining the waste plastic with other materials or by using specialized techniques to reshape and reform the plastic into a new form.

The theory of upcycling plastic is based on the principles of the circular economy, which seeks to minimize waste and maximize the use of resources by creating closed-loop systems in which waste materials are reused and repurposed. By upcycling plastic waste, organizations can reduce their environmental impact, conserve resources, and create new business opportunities.

Overall, the theory of upcycling plastic is grounded in the belief that waste can be turned into a valuable resource if we approach it with creativity and innovation, and that by doing so, we can create a more sustainable future for ourselves and for the planet.

Here is the example of upcycling: A company can upcycle used plastic bottles into new products such as tote bags or pencil cases, and verify the percentage of recycled material used in the final product.

2.3 Return-to-refill

The theory and principles of Return-to-Refill are based on the circular economy concept, which aims to keep resources in use for as long as possible and minimize waste. The key principle of Return-to-Refill is the reuse of materials and containers, which involves the following:

- Designing durable and reusable containers: To support the Return-to-Refill approach, containers must be designed to be durable, strong, and capable of withstanding multiple uses.
- Establishing a closed-loop system: Return-to-Refill involves establishing a closed-loop system where empty containers are collected, cleaned, and refilled with the same product for reuse. This closed-loop system minimizes the need for new containers to be produced and reduces waste.
- Reducing the environmental impact: Return-to-Refill reduces the environmental impact of plastic waste by minimizing the amount of plastic that ends up in landfills, oceans, and other natural habitats. By reusing containers, fewer resources are needed to produce new ones, resulting in lower carbon emissions and reduced energy consumption.
- Promoting a sustainable business model: The Return-to-Refill approach promotes a sustainable business model by reducing costs associated with producing new containers and providing customers with a more cost-effective and environmentally friendly option.

- Extended Producer Responsibility (EPR): EPR is a concept that holds producers responsible for the entire lifecycle of their products, including post-consumer waste management. In the context of Return-to-Refill, EPR requires producers to take responsibility for collecting, cleaning, and refilling empty containers.
- Cradle-to-Cradle (C2C) Design: C2C design is an approach that aims to create products that can be recycled or repurposed at the end of their useful life. In the context of Return-to-Refill, C2C design principles can be applied to the development of containers that are designed to be reused or recycled.
- Sharing Economy: The sharing economy is a concept that promotes the sharing of resources, such as products and services, to reduce waste and maximize the use of existing resources. In the context of Return-to-Refill, the sharing economy can be applied to the sharing of reusable containers between multiple users, such as within a community or among businesses.
- Product as a Service (PaaS): PaaS is a business model that involves offering products as a service, rather than selling them as a one-time purchase. In the context of Return-to-Refill, PaaS can involve offering refillable containers as a service, where customers pay for the use of the container and the product it contains, rather than owning the container outright.

Overall, the principles of Return-to-Refill aim to promote a circular economy, reduce waste, and encourage businesses to adopt more sustainable practices.

Here is an example of Return-to-Refill: A beverage company can introduce reusable glass bottles and implement a deposit-return system to encourage customers to return the bottles for refilling. The verification can ensure that the bottles are properly cleaned and sterilized before reuse.

2.4 Reuse

Reuse is the practice of using an item more than once, extending its lifespan and reducing waste. The theory of reuse can be approached from different perspectives, including economic and environmental.

From an economic perspective, an economic model of reuse has been developed to analyze the effect of reuse activity on the amount of waste in the economy and the welfare of consumers. The paper adapts the theory of durable goods and second-hand markets. There is only one type of good, a durable good, which lasts two periods. A durable good is called ‘new’ in the first period and ‘used’ in the second period [14].

From an environmental perspective, reuse is an important component of waste reduction and resource conservation. By reusing items instead of discarding them, we can reduce the amount of waste that ends up in landfills and reduce our consumption of new resources.

The theory of Reuse is based on the idea that products and materials can be used multiple times before they are disposed of, thus reducing waste and conserving resources. The principles of Reuse include:

- Durability: Products should be designed and manufactured to last, with materials and components that can withstand repeated use, repair, and refurbishment. This may involve

using higher quality materials or designing products to be more easily repaired or upgraded.

- Modularity: Modularity refers to the design of products in a way that allows for easy disassembly and repair. Modular design can also enable the reuse of components in different products, reducing waste and enabling more efficient reuse.
- Standardization: Standardized components and materials can be reused in different products, reducing waste and enabling more efficient reuse. This principle can be applied to both the design and manufacturing of products, as well as the systems for collecting and redistributing reusable components.
- Compatibility: Reusable products and components should be compatible with a range of systems and applications, making them more versatile and easier to incorporate into existing processes. This can include compatibility with different types of machinery or software, as well as compatibility with different types of packaging or storage systems.
- Reverse logistics: Reverse logistics is the process of managing the collection, cleaning, and redistribution of reusable products and components. Effective reverse logistics systems are essential for successful reuse, and may involve partnerships with logistics providers, waste management companies, or other stakeholders.
- User behavior: Reuse requires changes in user behavior, including increased awareness of the benefits of reuse and responsible use of reusable products. This may involve education and outreach campaigns, as well as the design of products and systems to encourage responsible use and disposal.

By applying these principles, products can be designed, manufactured, and used in a way that maximizes their reuse potential, reducing waste and conserving resources. Additionally, successful reuse systems can provide economic and environmental benefits by creating new markets for reusable components and reducing the need for virgin materials.

Here is an example of reuse: A company can develop a system to collect used plastic containers and refurbish them for reuse in their own production processes. The verification can ensure that the containers are properly cleaned and inspected before reuse.

2.5 Examples of products that can be verified using these techniques

Here are some other examples of products that can be verified using the techniques mentioned:

- Biodegradability: A manufacturer can develop biodegradable plastic packaging and verify the biodegradability rate and safety of the end-product.
- Recycling: A recycling facility can verify the percentage of recycled content in their plastic pellets and ensure that they meet certain quality standards for use in new products.
- Repurposing: A furniture manufacturer can repurpose discarded plastic materials, such as plastic bags, into new furniture products, such as chairs or tables. The verification can ensure that the repurposed material meets certain quality and safety standards.
- Eco-design: A consumer goods company can use eco-design principles to create products that are durable, repairable, and recyclable. The verification can ensure that the product design meets specific criteria for eco-friendliness and sustainability.

- Closed-loop systems: A company can implement a closed-loop system, where products are designed to be reused or recycled at the end of their life cycle. The verification can ensure that the closed-loop system is functioning properly and that the products are being reused or recycled as intended.
- Life cycle assessment: A company can conduct a life cycle assessment of their plastic packaging to determine the environmental impact of the product at every stage of its life cycle, from raw materials extraction to disposal. The verification can ensure that the life cycle assessment is accurate and that the company is taking steps to reduce the product's environmental impact.
- Carbon footprint: A company can measure the carbon footprint of their plastic packaging and take steps to reduce it, such as using renewable energy sources or reducing transportation emissions. The verification can ensure that the carbon footprint measurement is accurate and that the company is taking effective steps to reduce their impact on the environment.

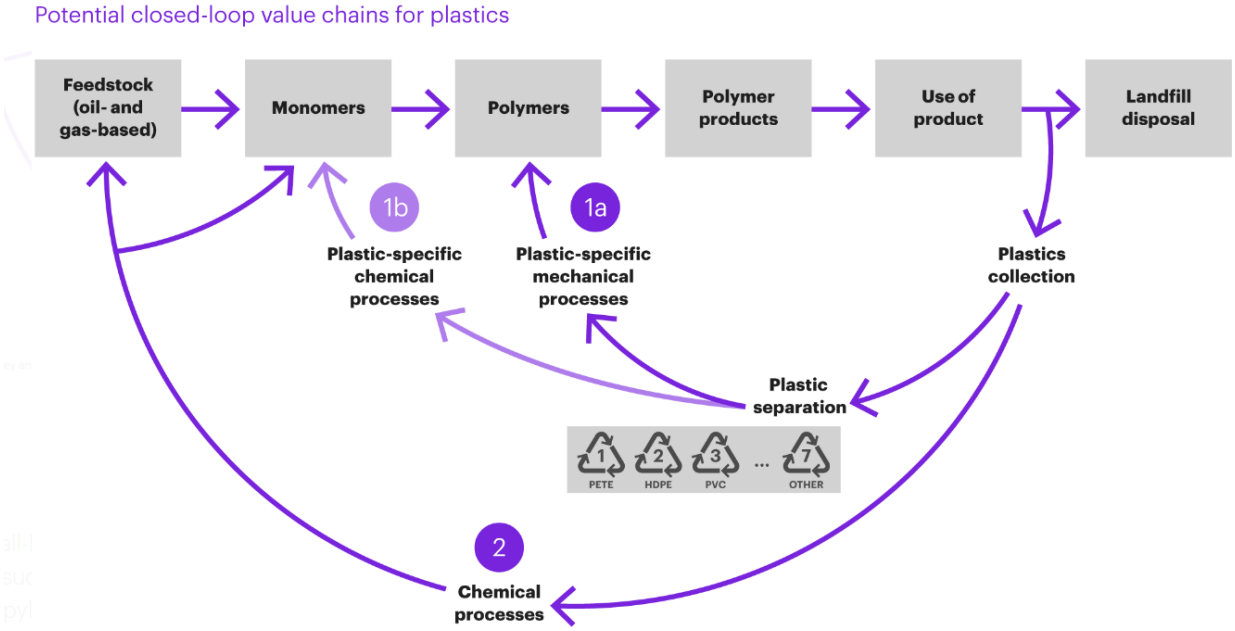

Figure 2-1 Chain of plastic packaging waste

3 Standards and certifications

The concept of Circular Economy (CE) is gaining importance in the supply chain due to its potential to reduce waste and improve resource efficiency. CE product verification is an important aspect of ensuring that products meet certain sustainability standards throughout their life cycle. To achieve this, various standards and certifications have been developed that aim to address environmental, social, and economic impacts of products.

In this context, the implementation of CE product verification in the supply chain requires careful planning and consideration of relevant standards and certifications. This involves assessing the supply chain for potential risks and opportunities for improvement, selecting appropriate standards and certifications, and developing a verification program to ensure compliance.

This guide provides an overview of the various standards and certifications related to CE product verification and their relevance in the supply chain. It also outlines key steps that companies can take to prepare for implementing CE product verification in their supply chain.

3.1 ISCC Plus

The ISCC (International Sustainability and Carbon Certification) standard is relevant for CE (Circular Economy) product verification, particularly in the case of plastic waste material. ISCC provides a system for certifying sustainable biomass and bioenergy supply chains, which includes plastic waste as a feedstock. By certifying the entire supply chain from feedstock to end product, ISCC ensures traceability and transparency, making it a useful tool for CE product verification. Additionally, the ISCC standard addresses environmental and social sustainability issues, which are critical aspects of CE. Therefore, utilizing the ISCC standard in CE product verification for plastic waste material can contribute to a more sustainable and transparent circular economy.

ISCC (International Sustainability and Carbon Certification) supports recycling and the development of the circular economy with its certification approach. The ISCC PLUS standard covers all types of waste and residues, including plastic waste material. Both pre- and post-consumer waste are covered.

ISCC PLUS certification provides traceability along the supply chain and verifies that companies meet environmental and social standards. For companies using the mass balance approach, ISCC PLUS certification verifies that the mass balance accounting follows predefined and transparent rules.

The mass balance approach is a method used to trace the flow of materials through a complex value chain. It is based on verifiable bookkeeping and allows for the tracking of the amount and sustainability characteristics of circular and/or bio-based content in the value chain. This approach makes it possible to gradually increase the share of bio-based and/or circular feedstocks in the production process. In addition, the calculated share of bio-based and/or circular feedstocks can be attributed on an equivalent basis to one or several outputs. On this basis, the ISCC PLUS mass balance approach allows system users to make credible claims [15]

The mass balance approach helps with recycling plastic waste material by allowing companies to track the amount and sustainability characteristics of circular and/or bio-based content in the value chain. This approach makes it possible to gradually increase the share of bio-based and/or circular feedstocks in the production process. In addition, the calculated share of bio-based and/or circular feedstocks can be attributed on an equivalent basis to one or several outputs. On this basis, the ISCC PLUS mass balance approach allows system users to make credible claims about their use of recycled materials.

One example of a company using the mass balance approach is Solvay, a global market leader in specialty materials. Solvay has successfully earned independent third-party mass balance chain of custody accreditation under the widely recognized International Sustainability and Carbon Certification (ISCC-PLUS) scheme for its Marietta, Ohio (USA) site, producing polysulfone (PSU) and polyphenylsulfone (PPSU). The products – Udel PSU ReCycle MB and Radel PPSU ReCycle MB – are the first ISCC-PLUS mass balance compliant sulfone materials in the market and commercially available worldwide [16].

3.2 ISO/IEC 17029

Designing a verification and validation scheme for CE product verification implementation for plastics packaging in supply chains as per standard requirement of ISO/IEC 17029 involves the following steps:

1) Define the verification and validation requirements: This step involves identifying the specific requirements for the verification and validation of CE products. This includes the performance criteria, testing methods, and acceptance criteria.
2) Develop a test plan: A test plan should be developed to describe the testing methods, sampling procedures, test conditions, and equipment needed for the verification and validation of the CE products. The test plan should also specify the number of samples required for testing.
3) Conduct the testing: The CE products should be tested according to the test plan. The testing should be conducted by qualified personnel using calibrated equipment and standard testing procedures.
4) Analyze the results: The results of the testing should be analyzed to determine if the CE products meet the performance criteria and acceptance criteria specified in the test plan.
5) Document the verification and validation process: The verification and validation process should be documented in detail, including the test plan, testing procedures, results of the testing, and conclusions.
6) Evaluate the effectiveness of the verification and validation process: The effectiveness of the verification and validation process should be evaluated to determine if it meets the requirements of ISO/IEC 17029. This includes evaluating the quality of the testing, the accuracy of the results, and the completeness of the documentation.
7) Continually improve the verification and validation process: The verification and validation process should be continually improved based on the evaluation of its effectiveness. This includes identifying areas for improvement, implementing corrective actions, and monitoring the effectiveness of the changes made.

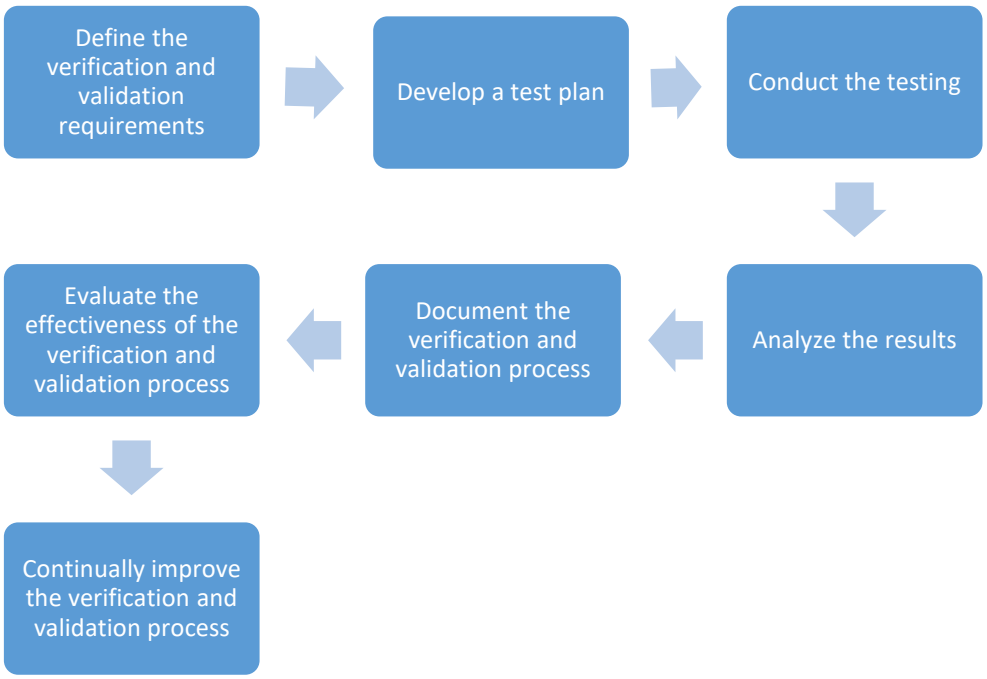

Figure 3-1 General steps in Designing a verification and validation scheme for CE product verification implementation for plastics packaging in supply chains as per standard requirement of ISO/IEC 17029

By following these steps, a comprehensive verification and validation scheme can be developed and implemented for CE product verification implementation for plastics packaging in supply chains as per the standard requirements of ISO/IEC 17029.

On the other hand, the seven steps in Figure 3-1 could be revised into five steps in Figure 3-2. The following these steps, a comprehensive verification and validation scheme for CE product verification implementation for plastics packaging in supply chains as per standard requirement of ISO/IEC 17029:

Step 1: Define Verification and Validation Requirements

- Identify the regulatory requirements for CE product verification for plastics packaging in the supply chain, including any relevant standards such as ISO/IEC 17029.
- Determine the scope of the verification and validation activities, including the products, processes, and supply chain stages to be covered.
- Specify the acceptance criteria for CE product verification, including performance requirements and quality standards.

Step 2: Develop a Verification and Validation Plan

- Develop a detailed plan for conducting the verification and validation activities, including the testing methods, sampling procedures, and data analysis methods.

- Specify the personnel responsible for carrying out the verification and validation activities, as well as the necessary resources, equipment, and facilities.
- Define the timeline for the verification and validation activities, including the start and end dates for each phase of the process.

Step 3: Conduct Verification and Validation Activities

- Conduct the verification and validation activities according to the plan developed in Step 2, using the specified testing methods and sampling procedures.
- Collect and analyze the data generated during the verification and validation activities, ensuring that the acceptance criteria are met.
- Document the results of the verification and validation activities, including any deviations or non-conformities that were identified.

Step 4: Review and Report Results

- Review the results of the verification and validation activities, ensuring that they are accurate and complete.
- Prepare a report summarizing the verification and validation activities, including the results, conclusions, and recommendations for any corrective actions or improvements.
- Submit the report to the relevant stakeholders, including regulatory agencies, customers, and suppliers.

Step 5: Implement Corrective Actions and Continual Improvement

- Implement any corrective actions or improvements identified during the verification and validation activities.
- Conduct regular reviews of the verification and validation process to identify opportunities for continual improvement, ensuring that the process remains effective and efficient over time.

By following these steps, a comprehensive verification and validation scheme can be designed and implemented for CE product verification for plastics packaging in supply chains, in accordance with the requirements of ISO/IEC 17029.

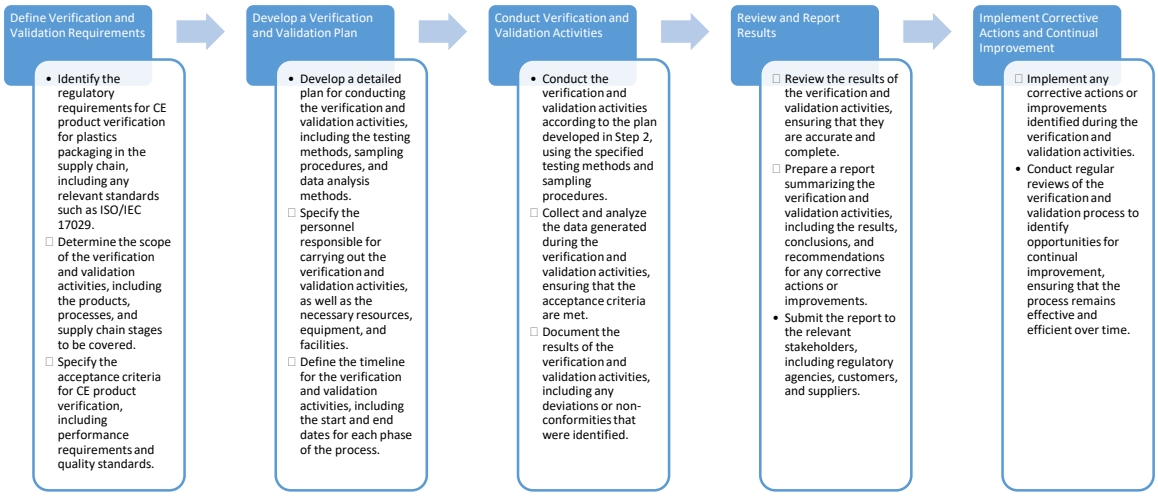

Figure 3-2 Steps in Designing a verification and validation scheme for CE product verification implementation for plastics packaging in supply chains as per standard requirement of ISO/IEC 17029

3.3 Cradle to Cradle Certification

The Cradle to Cradle Products Innovation Institute is a non-profit organization that is dedicated to powering the circular economy through products that have a positive impact on people and planet. Through the Cradle to Cradle Certified® Products Program, the Institute sets the global standard for products that are safe, circular and responsibly made [7]. The Institute is headquartered in San Francisco, California and Amsterdam, The Netherlands [7].

3.4 EU Ecolabel

The EU Ecolabel is a voluntary labeling scheme that promotes environmental excellence by certifying products that have a reduced environmental impact throughout their life cycle. The criteria for the EU Ecolabel include requirements for raw material extraction, manufacturing, packaging, and disposal, as well as limits on the use of hazardous substances.

In the context of CE product verification, the EU Ecolabel can be relevant for plastic waste material as it sets standards for sustainable production and consumption. The use of plastic waste material in products can contribute to reducing the demand for virgin plastic and promoting the circular economy, but it is important to ensure that the recycled material is produced in an environmentally sound manner. By meeting the EU Ecolabel criteria, products made from recycled plastic can demonstrate their environmental performance and contribute to the transition to a more sustainable economy.

The EU Ecolabel criteria are a set of environmental and performance requirements that a product must meet in order to be certified with the EU Ecolabel. The criteria cover a range of categories such as energy efficiency, water conservation, waste reduction, and hazardous substances. For plastic waste materials, the criteria may include requirements related to the use of recycled content, the reduction of hazardous substances, and the promotion of sustainable production and consumption practices. In addition to the product criteria, the EU Ecolabel also includes requirements for the labeling and communication of the environmental information related to the certified product.

The EU has implemented several measures to tackle plastic waste. Under its new Plastics Strategy, the EU aims to make recycling profitable for business, curb plastic waste, stop littering at sea, drive investment and innovation, and spur change across the world [16]. The EU has also passed a law in 2019 to ban the most common single-use plastic items such as plastic cutlery, stirrers and straws [17].

Specific rules and targets apply to certain areas, including single-use plastics, plastic packaging, microplastics, and soon bio-based, biodegradable and compostable plastics. The EU's plastics strategy outlines specific actions in more detail [18].

3.5 Standard and certification and how they relate to CE product verification for plastics packaging

ISO 14001: This standard specifies the requirements for an environmental management system (EMS) that a company can use to enhance its environmental performance. The ISO 14001 standard can be used by companies in the plastics packaging industry to identify and manage their environmental impacts, including waste management, energy efficiency, and reduction of greenhouse gas emissions.

Forest Stewardship Council (FSC): The FSC is an international certification system for forests and forest products. This certification ensures that the products come from responsibly managed forests that provide environmental, social, and economic benefits. FSC certification is relevant to CE product verification for plastics packaging because many companies use paper-based packaging materials that require responsible sourcing.

Sustainable Forestry Initiative (SFI): This certification program ensures that the products come from forests that are managed sustainably, considering social, economic, and environmental factors. The SFI certification is relevant to CE product verification for plastics packaging because many companies use paper-based packaging materials that require responsible sourcing.

Global Recycled Standard (GRS): This is a voluntary product standard for tracking and verifying the content of recycled materials in a product. The GRS evaluates products based on input material, traceability, environmental practices, social requirements, and chemical restrictions. GRS can be relevant for CE product verification for plastics packaging as it ensures that the recycled materials used in the packaging meet environmental and social standards.

Carbon Trust Certification: This certification verifies the carbon footprint of products, services, and organizations. It can be relevant for CE product verification for plastics packaging as it can help organizations reduce their greenhouse gas emissions, which can include measures such as using more sustainable materials or reducing waste.

Overall, these standards and certifications are relevant to CE product verification for plastics packaging because they promote sustainability throughout the product lifecycle, from the sourcing of raw materials to disposal. By meeting the requirements of these programs, companies can demonstrate their commitment to environmental responsibility and provide consumers with more sustainable packaging options.

4 Implementing CE product verification in the supply chain

Implementing CE product verification in the supply chain can be a challenging task, especially when it comes to ensuring the environmental sustainability of plastic packaging. It requires a thorough understanding of the relevant standards and certifications that can guide the implementation process. Selective standard and certification can help in meeting the regulatory requirements, minimizing the environmental impact, and improving the overall sustainability of the product.

In this guide, we will provide an overview of the relevant standards and certifications related to CE product verification for plastics packaging. We will also discuss the implementation process and the steps required to ensure compliance with these standards. By following these guidelines, companies can establish a sustainable supply chain for plastic packaging, meeting the expectations of both the regulators and the consumers.

4.1 Step-by-step guide for implementing CE product verification in the supply chain

ISO 17029 provides a globally recognized standard for the accreditation of conformity assessment bodies that perform product certification. By following ISO 17029, companies can ensure that their CE product verification process is reliable, consistent, and meets international standards. The standard provides a framework for the design and implementation of conformity assessment schemes, including requirements for validation and verification methodologies, traceability, and risk management. Adhering to ISO 17029 can also increase confidence and trust in the products and services of a company, which can ultimately lead to improved market access and competitiveness. Therefore, by following ISO 17029, companies can demonstrate their commitment to quality and compliance, and ensure that their CE product verification process is efficient and effective. Step-by-step guide for implementing CE product verification in the supply chain:

1) Basic Data: Collect data on the types of plastics used in the supply chain, their sources, quantities, and destinations.
2) Management System: Implement a management system to manage the CE product verification process, including roles and responsibilities, procedures, and documentation.
3) Traceability: Establish a traceability system to track the flow of plastic waste and recycled material throughout the supply chain. This includes documentation of the origin and composition of the plastic waste, as well as the processes used for recycling and manufacturing.
4) Mass Balance: Implement a mass balance system to ensure that the amount of recycled material used in the production of plastic packaging is accurately accounted for.
5) Physical Segregation: Establish a physical segregation system to ensure that recycled plastic is kept separate from non-recycled plastic throughout the supply chain.
6) Greenhouse Gas Emissions: Establish a system for measuring and reporting greenhouse gas emissions associated with the production and transportation of plastic packaging.

7) List of Best Practices: Develop a list of best practices for implementing CE product verification in the supply chain, including guidelines for selecting suppliers, verifying compliance, and managing nonconformities.
8) Nonconformities: Establish a system for identifying and managing nonconformities related to CE product verification in the supply chain.
9) Measures: Establish measures for monitoring and evaluating the effectiveness of the CE product verification process in the supply chain.

By following these steps, a company can ensure that its plastic packaging products meet the CE product verification requirements and contribute to a more sustainable and circular economy.

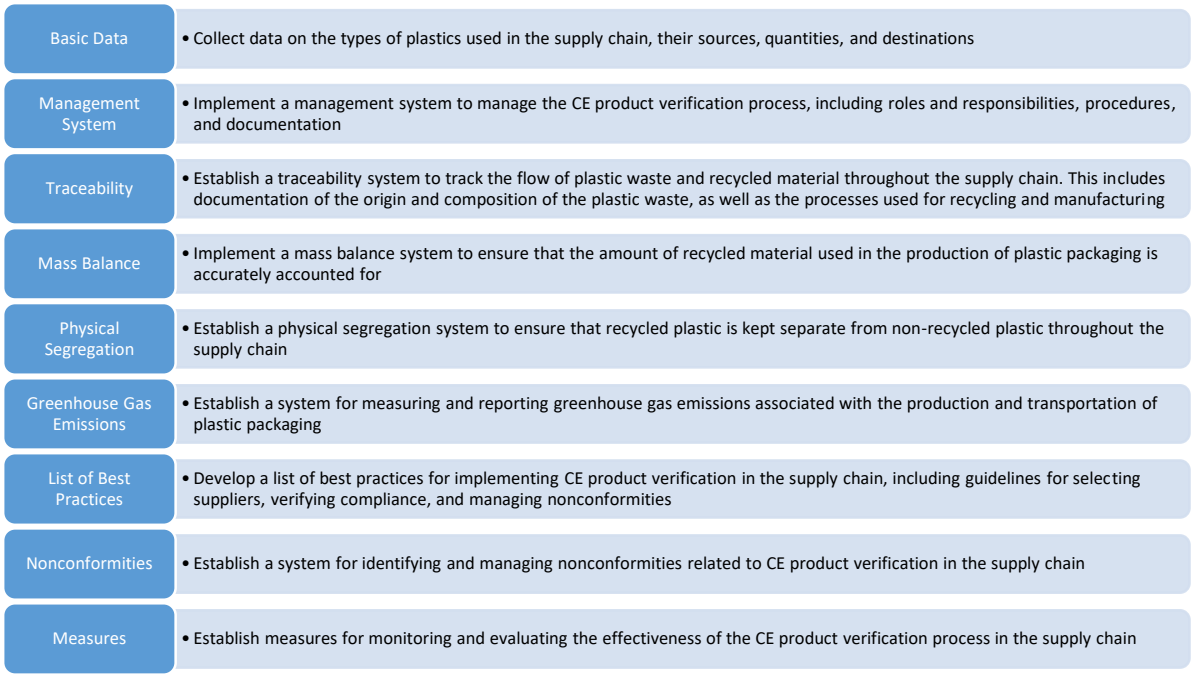

Figure 4-1 Step-by-step guide for implementing CE product verification in the supply chain

4.2 Identifying products suitable for verification

The activities for identifying products suitable for verification:

1) Conduct a risk assessment: Evaluate the potential impact on the environment and human health of products within the supply chain. Identify products with high risk factors that require verification.
2) Review regulatory requirements: Determine which products are subject to regulatory requirements for verification, such as those related to safety or environmental standards.
3) Analyze customer requirements: Identify products that require verification based on customer demands or preferences, such as those related to sustainability or ethical sourcing.
4) Evaluate production processes: Assess production processes to determine which products are more likely to have quality or safety issues that require verification.

5) Consider product complexity: Take into account the complexity of the product and its components to determine the appropriate verification methods.
6) Prioritize products: Prioritize the products based on the above criteria to determine which products should be verified first.

These activities can help companies identify which products are suitable for verification and ensure that they are focusing their resources on the most critical products within their supply chain.

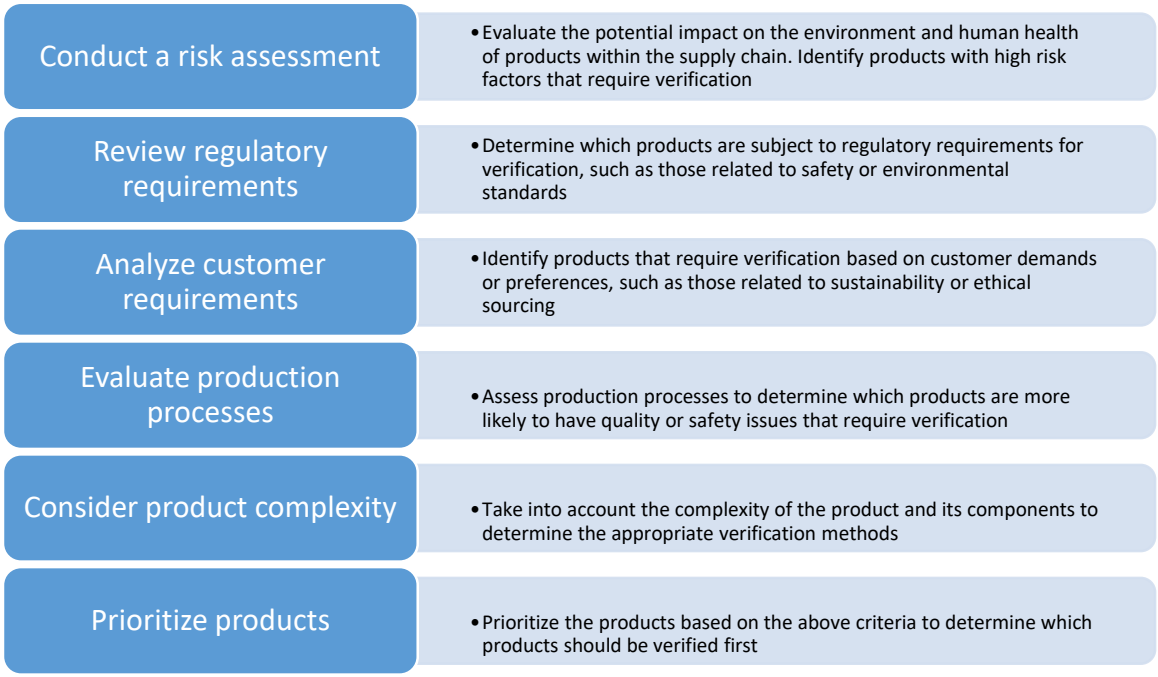

Figure 4-2 Step-by-step activities for identifying products suitable for verification

4.3 Selecting the appropriate verification techniques

Possible activities for selecting the appropriate verification techniques:

1) Identify the regulatory requirements and industry standards for product verification in your region and sector.
2) Determine the specific performance and safety characteristics that need to be verified for each product.
3) Review the available verification techniques and methods, including testing, inspection, and certification.
4) Evaluate the advantages and limitations of each technique, taking into account factors such as cost, accuracy, and reliability.
5) Consider the complexity and feasibility of each technique, including the equipment and expertise required.
6) Determine the most appropriate verification technique(s) for each product based on the above criteria.
7) Develop a verification plan that outlines the chosen techniques, procedures, and timelines for each product.

8) Train staff on the selected verification techniques and ensure that they are properly equipped and certified to perform them.
9) Continuously monitor and evaluate the effectiveness of the verification techniques used, and make adjustments as necessary.

By following these activities, you can ensure that the appropriate verification techniques are selected for each product, and that the verification process is effective and efficient.

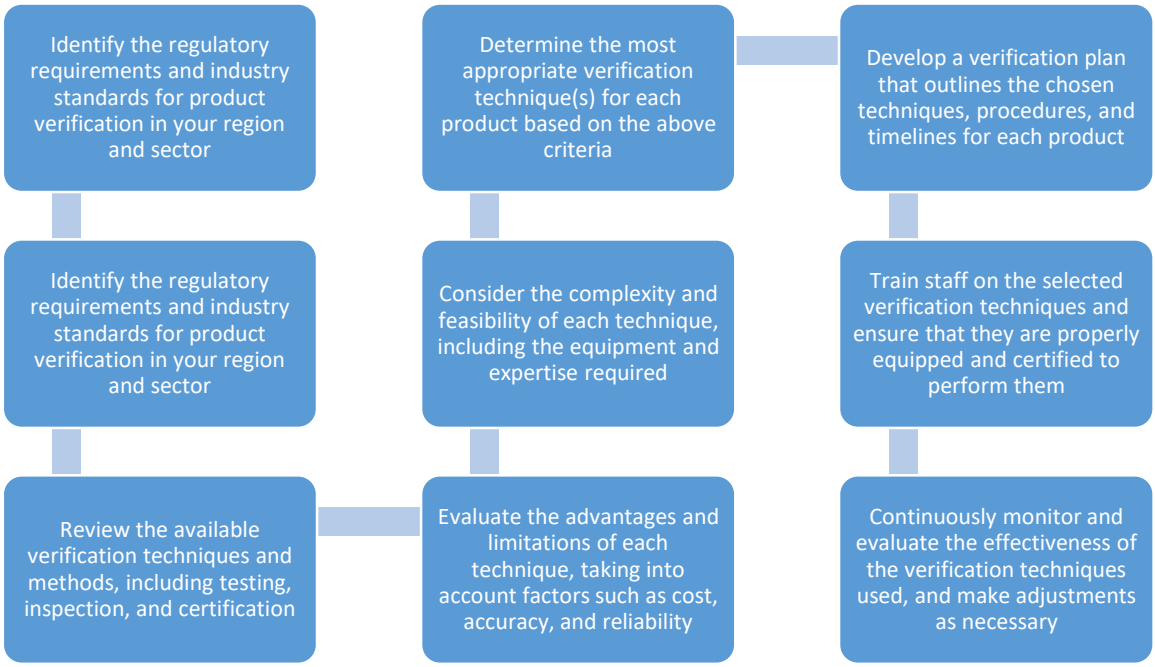

Figure 4-3 Activities for selecting the appropriate verification techniques

4.4 Integrating verification into existing processes

Integrating verification into existing processes can involve several activities, including:

1) Conducting a process audit: Evaluate existing processes to identify areas where verification can be integrated, and determine the resources required to implement verification activities.
2) Identifying the key checkpoints: Determine the key stages in the production process where verification activities should be integrated to ensure compliance with regulations and standards.
3) Developing verification procedures: Develop procedures for conducting verification activities at each key checkpoint, including clear instructions and documentation requirements.
4) Training personnel: Train personnel responsible for conducting verification activities to ensure they understand the procedures and can carry out the activities effectively.
5) Conducting verification activities: Conduct verification activities at each key checkpoint, including sample collection and analysis, testing, and inspection.

6) Documenting verification activities: Record the results of verification activities, including any deviations from established procedures and the corrective actions taken.
7) Reviewing and updating procedures: Regularly review and update verification procedures to ensure they remain effective and up-to-date with changing regulations and standards.

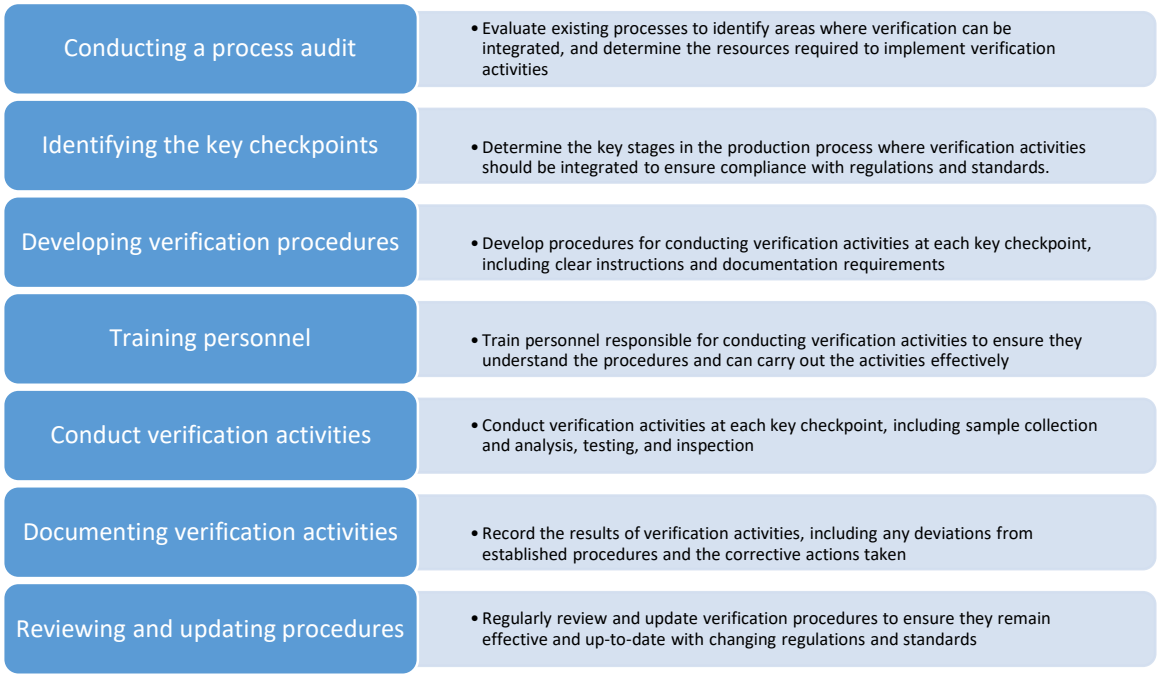

Figure 4-4 Activities for Integrating verification into existing processes

4.5 Making Use of the Developed Project Standard

To implement the standard developed for this project, it is important to follow the guidelines and requirements outlined in the standard. The first step is to familiarize oneself with the standard and understand its purpose and scope.

Once this is done, the next step is to identify the relevant stakeholders and communicate the requirements of the standard to them. This includes manufacturers, suppliers, distributors, and other parties involved in the production and distribution of the product.

It is important to establish a system for tracking and verifying the source of materials used in the production of the product, as well as the production process itself. This may involve implementing a traceability system, conducting regular audits, and ensuring compliance with relevant regulations and standards.

Finally, it is important to establish a mechanism for verifying compliance with the standard and maintaining records of this compliance. This may involve third-party certification, internal audits, or other methods of verification.

By implementing these steps, CLMV can ensure that the standard is effectively implemented and that CE product verification is conducted in a transparent and reliable manner, promoting greater trust and confidence in the products being produced and sold in the region.

The implementation of a standard developed for the CLMV region in the context of CE product verification. The standard is outlined in an Annex 1 (CHAIN OF CUSTODY MLC STANDARD FOR RESPONSIBLY PLASTIC WASTE MATERIALS) in this guidebook. The goal is to provide guidance on how to implement the standard to ensure product conformity and compliance with CE regulations. The implementation of this standard can bring significant benefits to the CLMV region in terms of increased trade and improved product quality.

5 Monitoring and evaluation

Monitoring and evaluation are critical components of ensuring the effectiveness and success of CE product verification in the supply chain. Through proper monitoring and evaluation, organizations can identify gaps, track progress, and make informed decisions to improve their product verification processes.

The monitoring and evaluation process involves collecting and analyzing data on various aspects of the product verification process, including compliance with standards and certifications, the effectiveness of product testing methods, and the overall impact on the environment. This data can then be used to identify areas for improvement and develop strategies to address them.

Proper monitoring and evaluation also ensure that the product verification process is transparent and accountable. By providing stakeholders with clear information on the performance and impact of CE product verification in the supply chain, organizations can build trust and credibility with customers, regulators, and the wider public.

In this context, this guide will explore the importance of monitoring and evaluation in CE product verification in the supply chain and highlight some of the key tools and techniques that can be used to achieve these goals.

5.1 Importance of monitoring and evaluating CE product verification implementation in the supply chain

Monitoring and evaluating the implementation of CE product verification in the supply chain is of utmost importance. It is a crucial step that helps ensure that the CE product verification system is functioning as intended, and it is achieving its desired outcomes. The following are some of the key reasons why monitoring and evaluating CE product verification implementation is essential.

Firstly, monitoring and evaluation provide valuable feedback on the effectiveness of the CE product verification system. By tracking the performance of the system and evaluating its impact, it is possible to identify areas that need improvement and make adjustments accordingly. This feedback helps to ensure that the CE product verification system is continuously improving and delivering its intended outcomes.

Secondly, monitoring and evaluation provide an opportunity to measure the effectiveness of the CE product verification system against its original goals and objectives. This helps to ensure that the system is delivering the intended outcomes and that it is aligned with the broader sustainability goals of the organization.

Thirdly, monitoring and evaluation provide an opportunity to identify and address any issues or challenges that may arise during the implementation of the CE product verification system. By tracking the system's performance and analyzing the data, it is possible to identify potential problems early on and take corrective action before they become significant issues.

Fourthly, monitoring and evaluation help to ensure that the CE product verification system is transparent and accountable. By tracking and reporting on the system's performance, stakeholders can be confident that the system is operating as intended and delivering its promised outcomes. This transparency and accountability are critical for maintaining stakeholder trust and support for the CE product verification system.

Finally, monitoring and evaluation provide an opportunity to communicate the results and impact of the CE product verification system to stakeholders. By sharing data and information on the system's performance, it is possible to build stakeholder support and demonstrate the value and impact of the system.

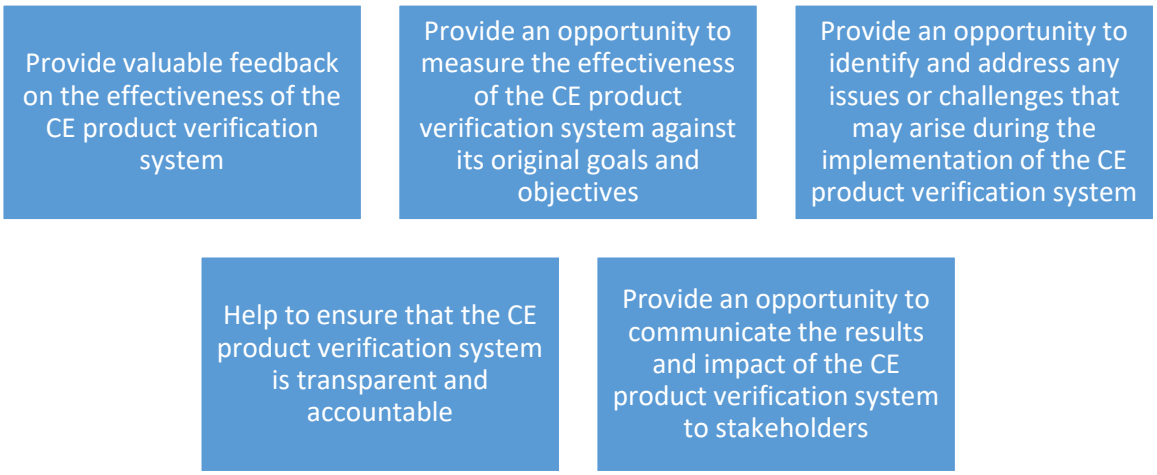

Figure 5-1 Key reasons highlight the importance of monitoring and evaluating CE product verification implementation

In conclusion, monitoring and evaluating CE product verification implementation in the supply chain is essential. It provides valuable feedback on the effectiveness of the system, measures its impact against its original goals and objectives, identifies and addresses issues and challenges, ensures transparency and accountability, and communicates results and impact to stakeholders. By monitoring and evaluating the CE product verification system, organizations can ensure that they are delivering sustainable products and contributing to a more sustainable future.

5.2 Guidance on measuring and tracking progress

Monitoring and evaluating the implementation of CE product verification in the supply chain is crucial to ensure its effectiveness and to identify areas for improvement. By measuring and tracking progress, companies can identify successes and challenges, make necessary adjustments, and ensure that the program is meeting its intended goals.

There are several key steps to measuring and tracking progress of CE product verification implementation:

1. Set clear and measurable goals: Companies should define clear and specific goals for their CE product verification program. These goals should be measurable and should align with the company's overall sustainability objectives. For example, a company may set a goal to reduce the amount of non-recyclable plastic packaging used in their supply chain by 50% within a year.
2. Establish key performance indicators (KPIs): KPIs are specific metrics used to evaluate progress towards achieving the goals. These metrics should be relevant, measurable, and easy to track. For example, a KPI for the above goal could be the percentage reduction of non-recyclable plastic packaging used in the supply chain.
3. Collect data: Data collection is essential to tracking progress towards achieving the goals and KPIs. Companies should establish a process for collecting data on a regular basis, such as monthly or quarterly. The data collected should be reliable and accurate, and should align with the KPIs established.
4. Analyze and report on progress: Once data has been collected, it should be analyzed to determine progress towards achieving the goals and KPIs. Companies should report on progress regularly, such as monthly or quarterly. Reports should be transparent and easy to understand, and should highlight successes and areas for improvement.
5. Make necessary adjustments: Based on the progress reports, companies should make necessary adjustments to the CE product verification program to ensure that it remains effective and aligned with the company's sustainability goals.

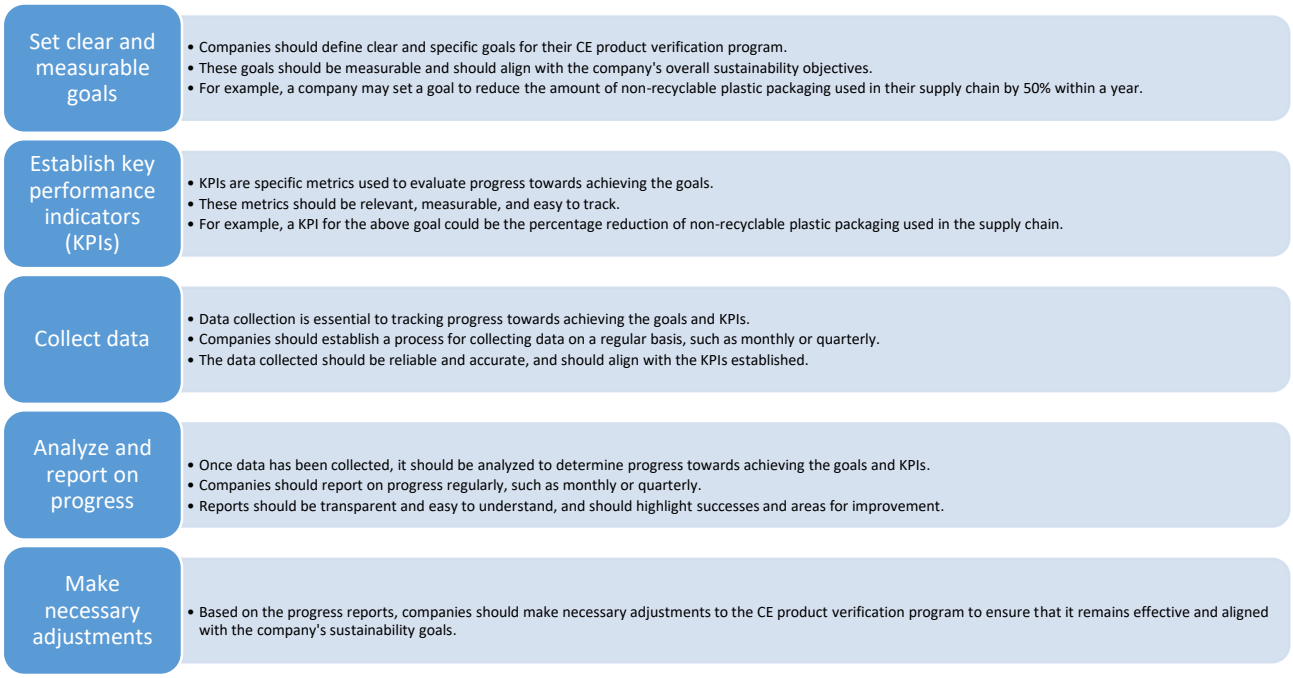

Figure 5-2 Key steps to measuring and tracking progress of CE product verification implementation

By following these steps, companies can effectively measure and track progress towards achieving their CE product verification goals and ensure that the program is effective and aligned with their overall sustainability objectives.

5.3 Making adjustments as necessary

Implementing CE product verification in the supply chain is a continuous process that requires ongoing monitoring and evaluation. This means that adjustments and improvements must be made as necessary to ensure the effectiveness and success of the verification program.

One important aspect of making adjustments is to regularly review the performance of the CE product verification system. This can be done through a variety of methods, including data analysis and stakeholder feedback. By identifying areas where the verification system may not be working as intended, adjustments can be made to improve its effectiveness.

Another important aspect of making adjustments is to stay up-to-date with relevant regulations and standards. As regulations and standards change over time, the CE product verification system must be adapted to ensure compliance. Failure to make adjustments in response to regulatory changes can result in non-compliance and potential legal or reputational risks.

Additionally, it is important to stay informed of emerging technologies and best practices in CE product verification. As new technologies and methods become available, they may be more effective or efficient than current methods. Staying informed and making adjustments as necessary can improve the efficiency and effectiveness of the verification system.

Finally, it is important to communicate any adjustments or changes to stakeholders in the supply chain. This includes suppliers, customers, and any other parties involved in the CE product verification process. By communicating changes effectively, stakeholders can better understand their roles and responsibilities in the verification process, and can provide feedback on the effectiveness of any adjustments made.

In summary, making adjustments as necessary is a crucial aspect of implementing CE product verification in the supply chain. By regularly reviewing performance, staying up-to-date with regulations and best practices, and communicating changes effectively, the verification system can be improved and adapted to ensure its ongoing success.

Figure 5-3 Important aspect of making adjustments

6 Case studies and examples

Implementing CE product verification in the supply chain is becoming increasingly important for companies to ensure they meet sustainability goals and customer demands. The process involves selecting standards and certifications, implementing techniques, monitoring and evaluating progress, and making adjustments as necessary. One useful way to understand the process is through case studies and examples. In this section, we will explore some case studies and examples of CE product verification in the supply chain to provide insight into successful implementation strategies.

6.1 Examples of organizations that have successfully implemented CE product verification for plastics packaging in their supply chains

This guideline handbook for CE product verification implementation for plastics packaging in supply chains, it may be helpful to include case studies and examples from companies or organizations that have successfully implemented circular economy principles in their supply chains. This can provide real-world context and practical guidance for readers of the handbook.

Additionally, it may be beneficial to include information on the potential economic and environmental benefits of implementing circular economy principles in supply chains, such as cost savings through reduced waste and increased resource efficiency, as well as improved environmental sustainability and reduced greenhouse gas emissions. This can help to further emphasize the importance and relevance of the guidelines outlined in the handbook.

CIRC-PACK is a research project funded by the European Union under the Horizon 2020 program. The project aims to develop more sustainable and efficient plastic packaging for the food and beverage industry by adopting circular economy principles. The project focuses on improving the design of packaging to facilitate its reuse, recycling, and upcycling, as well as developing new materials and technologies for the production of circular packaging.

The project is focused on the development of new, sustainable packaging materials and products that are designed for a circular economy. This includes the development of new biodegradable and compostable materials, as well as innovative recycling and upcycling technologies. The CIRC-PACK project also includes research on the environmental impact of plastics packaging and the potential for reuse and recycling in various supply chains.

The CIRC-PACK project involves a consortium of 22 partners from across Europe, including universities, research institutions, and companies involved in the packaging industry. The project runs from 2017 to 2021 and has a budget of €7.7 million. The ultimate goal of the project is to reduce the environmental impact of plastic packaging while promoting a more sustainable a There are several companies involved in the packaging industry that are part of the CIRC-PACK project consortium. Here are lists of them:

1) AIMPLAS (Spain)
2) AR Packaging (Sweden)

3) Bemis Europe (Netherlands)
4) Britton Group (Ireland)
5) CP Packaging (UK)
6) Danone (France)
7) Ecoembes (Spain)
8) ECOINNOVA (Spain)
9) European Bioplastics (Germany)
10) Fraunhofer ICT (Germany)
11) Iberchem (Spain)
12) ITENE (Spain)
13) Klockner Pentaplast (Germany)
14) Mondi Consumer Packaging Technologies (Austria)
15) Nestle (Switzerland)
16) Polymeris (France)
17) RISE Research Institutes of Sweden (Sweden)
18) SABIC (Netherlands)
19) Sealed Air (France)
20) Tomra Sorting (Norway)
21) University of Leeds (UK)
22) Werner & Mertz (Germany)nd circular economy.

The ultimate goal of the CIRC-PACK project is to help the packaging industry transition to a more sustainable, circular economy by providing new and innovative solutions for plastics packaging.

The CIRC-PACK project aims at creating a more sustainable, efficient, competitive, integrated and interconnected plastic packaging value chain with less dependence on fossil fuels. The project is working on developing, testing and validating better system-wide economic and environmental outcomes by decoupling the chain from fossil feedstocks [20].

6.2 Case studies highlighting the benefits of CE product verification for plastics packaging

There are many companies and organizations that have successfully implemented circular economy principles in their supply chains. Here are some examples [18]:

- IKEA has recently started a buy-back scheme, allowing old furniture to have a new lease of life.
- Adidas has developed a shoe made from sustainable materials such as coconut husk and sugar cane, and even recycled plastic bottles.
- Burger King has also embraced the circular economy by investing in it.

The Coca-Cola Company: In 2013, The Coca-Cola Company launched a sustainable packaging campaign, pledging to recover 75% of their bottles and cans by 2020. They implemented a tracking and monitoring system, which included partnering with suppliers to improve their environmental

practices and providing training to employees on sustainable packaging. The company achieved their 75% recovery goal in 2019, one year ahead of schedule.

Patagonia: Outdoor clothing and gear company Patagonia has implemented a product verification system called the Footprint Chronicles, which tracks the environmental and social impact of their products throughout the supply chain. They also use third-party certifications such as Fair Trade Certified and Bluesign to ensure the sustainability of their products.

Dell: Computer manufacturer Dell implemented a closed-loop recycling system, which allows them to use recycled plastic from their own products to create new products. They also developed a tracking and monitoring system that allows them to trace the recycled plastic back to its source and ensure it meets their sustainability standards.

Nike: Nike has implemented a sustainable materials index, which assesses the environmental impact of their materials and helps them select more sustainable options. They also use third-party certifications such as the Better Cotton Initiative and the Leather Working Group to ensure the sustainability of their products.

Unilever: Consumer goods company Unilever has implemented a Sustainable Living Plan, which includes a goal of sourcing 100% of their agricultural raw materials sustainably. They use third-party certifications such as the Roundtable on Sustainable Palm Oil and the Rainforest Alliance to ensure the sustainability of their raw materials.

Conclusion:

These case studies and examples demonstrate the importance of implementing CE product verification in the supply chain and provide valuable insight into successful implementation strategies. Companies can learn from these examples and tailor their own implementation plans to meet their specific sustainability goals and customer demands. By selecting the appropriate standards and certifications, implementing effective techniques, monitoring and evaluating progress, and making adjustments as necessary, companies can achieve their sustainability goals and contribute to a more sustainable future.

7 Best practice in circular economy product and in waste management

7.1 Best practice in circular economy product case studies for plastic packaging in Thailand and other countries: value chain of plastic packaging waste management

The management of plastic waste in Thailand begins with household waste management. Most household waste is sent to collection points in different locations, depending on the residential situation. For instance, in condominiums, the collection point is often located at the bottom of the building and is called the waste collection room. In villages, it may be in the community's waste bin area, or some neighborhoods may have waste bins in front of individual houses. Meanwhile, offices and most shopping centers usually have housekeepers who collect waste and store it in a designated waste collection room until local government agencies come to pick it up. This collection typically occurs during the early morning or late evening each day.

Once the waste is collected and prepared for pickup, it is often sorted again to separate valuable and recyclable materials. These recyclables are then sold to scrap shops. Commonly sorted materials during this phase include clear plastic water bottles and opaque plastic bottles, as they have minimal contamination and higher market value. Those involved in this sorting process are often janitors responsible for maintaining the premises or dedicated waste sorters who oversee recycling at various waste collection points in condominiums, villages, or offices.

When the staff come to pick up the garbage from the garbage collection point, most of the garbage is sorted again at the garbage truck of the garbage collector. A lot of the waste is recyclable waste and other plastic waste that can be recycled, such as plastic scrap from electrical appliances, water bottles, and oil bottles. Colored plastic buckets and bottles are used to contain chemicals Once the garbage is sorted by the garbage truck staff, the remaining waste is loaded into the truck and compressed for further loading and unloading at a central garbage collection station where garbage will be properly managed such as being sent to a landfill.

The plastic waste sorted in the first round is collected and sold to small and medium-sized sorting hubs. Some sorting hubs may drive to pick up their trash. Some of them open shops for ‘saleng’, three-wheeled motorbikes with a cart, and people who sort plastic waste to come to and sell the waste. In most cases, the prices paid by the sorting hubs are higher than the prices paid at the pick-up garbage collection points because the sorting hubs do not have to bear the cost of transportation. This makes it possible to pay a higher price.

When plastic waste is brought into the sorting hub, the sorting hub will conduct a more thorough sorting to increase the value of plastic waste, such as separating caps and labels from plastic bottles. When sorting each type of plastic waste, most sorting hubs load it in pickup trucks and sell it to plastic mills and recycling plants.

When plastic waste from old collection points is sent to the plastic recycling factory, the plastic waste must undergo random sample assessment to determine its quality. The factors that affect the quality of plastic waste include:

1. Moisture content.
2. Cleanliness of the plastic waste.

Plastic waste that fetches a higher purchase price is generally plastic waste with minimal contamination and no odor. If the purchased plastic waste is contaminated and has an odor, the purchase price will be significantly reduced. This is because using contaminated and odorous plastic waste can affect the quality of the recycled plastic pellets.

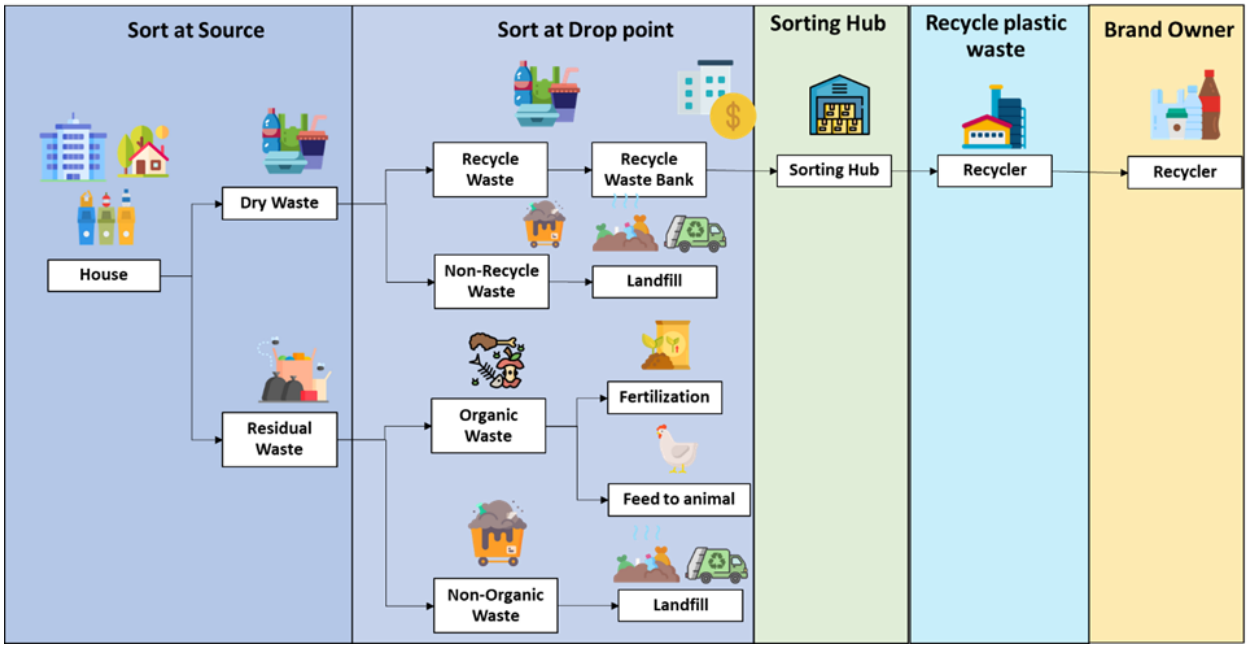

Figure 7-1 Chain of plastic packaging waste

7.2 Best Practice of Plastic Packaging Waste Management in the Community

Sorting at Source: At present, to solve the problem of plastic packaging waste, it is necessary to start managing it at the source which generally means at the household or community level. It starts by separating dry plastic packaging waste from other wet waste. Plastic trays, food bags, plastic cups, etc.

- Separate plastic packaging waste from organic or wet waste.
- If the waste is contaminated, it should be washed and dried thoroughly before collection to reduce mold and unpleasant odors.
- Separate plastic packaging waste by type of plastic packaging.

Sorting at drop point: The sorted plastic packaging waste will be collected at various drop points. Drop points vary from location to location, for example, if you live in a condominium, they are usually collected in the recycling room. Village waste is usually collected at village waste banks or near village waste collection sites. Once the plastic packaging waste is collected at the drop point, the plastic packaging waste will be sorted. At present, plastic packaging waste is usually separated into 5 categories:

- Clear plastic bottles

- Opaque plastic bottles
- Colored plastic bottles
- Plastic bags
- Plastic combinations
- Drop Point Success Factors
- Providing common areas for collecting garbage both wet and dry and general waste and recyclables.
- Having strong community leaders and group members working together to solve waste management problems.
- Generating income or benefits for waste and waste sorters to incentivize people in the community to sort waste and participate more in plastic packaging waste management activities in the community.
- Educating people in the community about sorting plastic packaging waste which makes it possible to add value to waste as well.

Example of a drop point: Ban Eua Artorn Rayong Community Center (Wang Wa) Wang Wa subdistrict, Klaeng district, Rayong province, Thailand

In the past, Ban Eua Artorn Rayong Community Center (Wang Wa) was a community that had a large waste problem that affected the environment in the village, such as the problem with the bad smell coming from the garbage, the problem with flies attracted to the garbage, and the problem of insufficient garbage storage space. Therefore, community leaders and some residents collaborated to manage waste generated in their communities.

Figure 7-2-1 Waste Bank, Ban Eua Artorn Community Center Rayong (Wang Wa) (source: https://www.bangkokbiznews.com/advertorials/biz2u/Corporate-Moves/3501)

Figure 7-2-2 Multipurpose yard for waste processing, Ban Eua Artorn Rayong Community Center (Wang Wa)

Plastic Packaging Waste Management Ban Eua Artorn Rayong Community Center (Wang Wa) has a village waste bank set up by village community leaders (as shown in Figure 2-1) where villagers bring sorted plastic waste to the waste bank to exchange for supplies prepared by the waste bank. Recycled plastic waste is collected every Sunday at 5.30 p.m. The objective is to provide residents with waste separation management before disposal and generate income from plastic waste, as well as income to the village fund for organizing activities such as scholarships for young children, money for trips to doctors, training, and education by community leaders and private agencies who provide knowledge and equipment for increasing plastic waste such as plastic waste compactors.

In addition, the community has added value to plastic packaging waste management by using plastic packaging waste to make various products, such as construction bricks made from plastic scrap, creation of weaving machines from plastic scrap, etc. The remaining plastic is collected and sorted to wait for a collection truck to pick up. This collected plastic waste, which includes such things as plastic bottles, will be sorted, separated by color, and pressed by a plastic press machine into formed lumps. This saves space for storing plastic waste.

Figure 7-2-3 Bricks made from Plastic Scrap Ban Eua Artorn Community Center Rayong (Wang Wa)

Sorting at sorting hub: The sorting hub is another important stakeholder in the plastic packaging waste cycle. That is, buying recyclable waste from sorters such as 'saleng', three-wheeled motorbikes with a cart, and garbage trucks, collecting from smart kiosks for collecting recyclables, or villagers collecting garbage for sale at the Sorting Hub. Waste that comes directly from domestic sorters is usually cleaner because it is separated at the source before being contaminated with organic waste.

Once the waste is delivered to the Sorting Hub, the staff will weigh and evaluate the price to pay the person who brought the waste to sell. After that, the waste will be sorted either by manual labor or using an automated sorting process. Once each type of recyclable waste has been sorted, it is collected, formed into bales, and sent to the recycling plant or plastic mill.

Sorting Hub Success Factors

- Good communication and cooperation amongst waste producers at the source (residents of condominiums, shops, offices) in separating general waste, recyclables, and wet waste from the source, allowing the waste collection company to use the waste quickly without with little or no need spend lots of time and money on garbage cleaning, which increases the cost of processing the waste.
- Smart kiosks for recycling storage are available. This makes it more convenient for people to sort recyclables and can even allow waste producers to accumulate points to use as discounts on purchases of new products. This creates more incentives for people to separate waste.
- Having a safe and comprehensive waste transportation system. The waste collection company has an enclosed truck to carry recyclables. The recyclables are put in well closed and secured sacksl, reducing the amount of waste that usually ends up in the environment. In addition, the company's large number of recycling trucks provides better coverage and makes it easier and faster to transport raw materials.
- Recording the source of garbage through QR codes nowadays is very important so that we know the source of recyclable waste. Currently, many recycling plants will support the use of more recycled waste from consumers. Therefore, if the waste sorting company can confirm the source or record the source, including the amount of garbage and the date and time that the garbage was collected, this will make the company's sorted waste more reliable and desirable to buyers.
- The presence of a sorting belt that separates the types of recyclable waste with separate sorting belts for plastic, foam, and paper. This result results in recyclables that are less mixed and allows faster production capacity.
- The installation of a garbage compactor that is directly connected to the belt of each type of recyclable, reducing the transportation process from one waste collection point to another waste collection point. It takes less time to compact, and once compacted, the volume of waste decreases. This allows for more waste storage space.
- Zoning which places each type of waste in separate locations. This makes it easier to load and transport to recycling plants.

- Storing raw materials indoors makes it possible to control odor problems. Most of the odors generated from waste in buildings are absorbed for treatment before being released into the environment. At the same time, the wastewater generated by compression can also be treated before being discharged into the city's main sewer. At the same time, storing raw material indoors also helps to preserve the quality of plastic waste from moisture and other contaminants. This makes it easy to further recycle.

Example of Sorting Hub

LoveRe Sorting Hub, People's Republic of China: LoveRe is a private company that has acquired the right to bid for waste management in Putong province.

1. Storage

Recyclable and dry waste storage is handled by automated waste receivers.The operation of the machine is as follows:

- Select the type of recyclable waste to put on your device and scan it to register it in the app on your mobile phone.
- Put recyclable waste into the garbage collection bay, which must be dry waste and not prohibited waste according to the company. Do not insert hazardous waste.
- Press the confirmation button on the screen of the junk receiver. The reward points will automatically be credited in the application on the phone.

Figure 7-2-4 LoveRe Smart Bin

2. Collect waste by truck

Waste sorted from residents or shops is sorted at drop points prepared at each location, such as on the ground floor of a condominium. At the hotel's garbage collection room or behind shops, trucks from the waste collection company pick up and load the waste into the company's sacks. After that, they record the source of the waste and make a QR code sticker that is attached to each

sack. Once the sacks of recyclable waste are filled up, they are delivered to the company's sorting center. When the truck arrives at the sorting center, the sacks containing recyclables are scanned to collect data from where they came from, weighed, and other data is recorded. After that, the recyclable waste is removed from the sacks and loaded onto a conveyor belt. It is then processed through a Manual Sorting Point where there are 6-8 full-time employees sorting recyclables according to the following categories:

- Paper box
- PE-type plastic bag
- PP-type plastic bag
- Garment
- Foam box
- Bottle HDPE (opaque bottle)
- Clear plastic bottle (except oil bottle)
- HDPE plastic bottle (chemical bottle)

Once sorted by type of recyclable, recyclables such as paper and plastic bottles will be baled and stored at the warehouse. This is in preparation for transportation to the recycling plant.

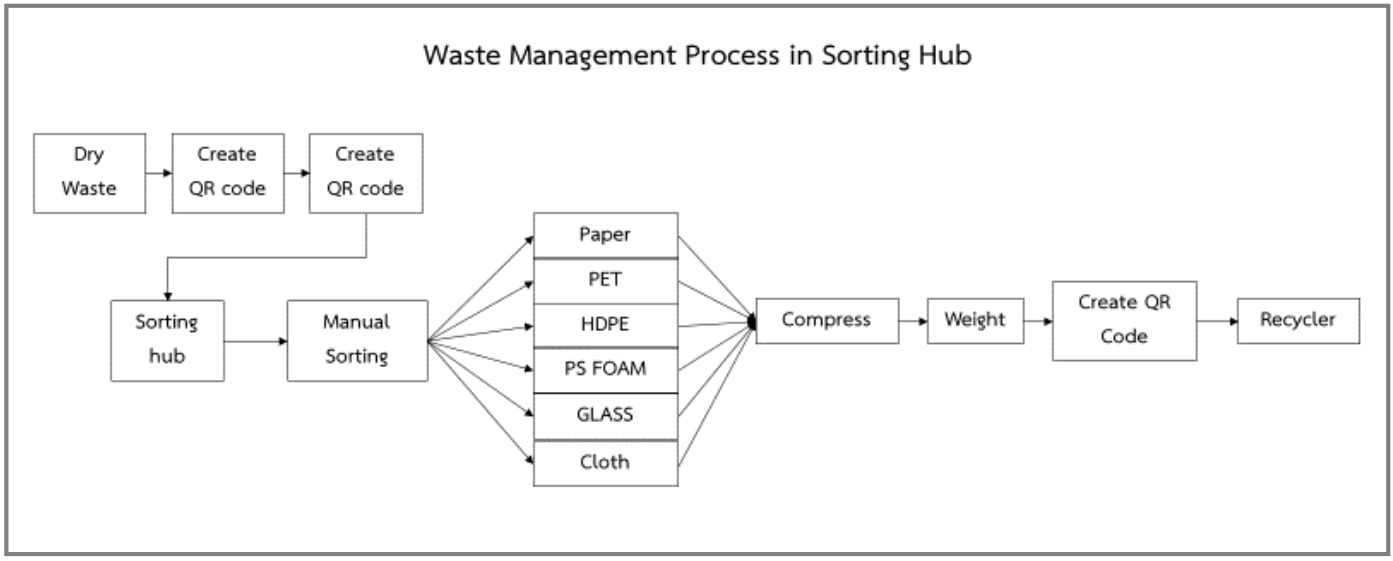

Figure 7-2-5 Work Flow at LoveRe Smart Bin

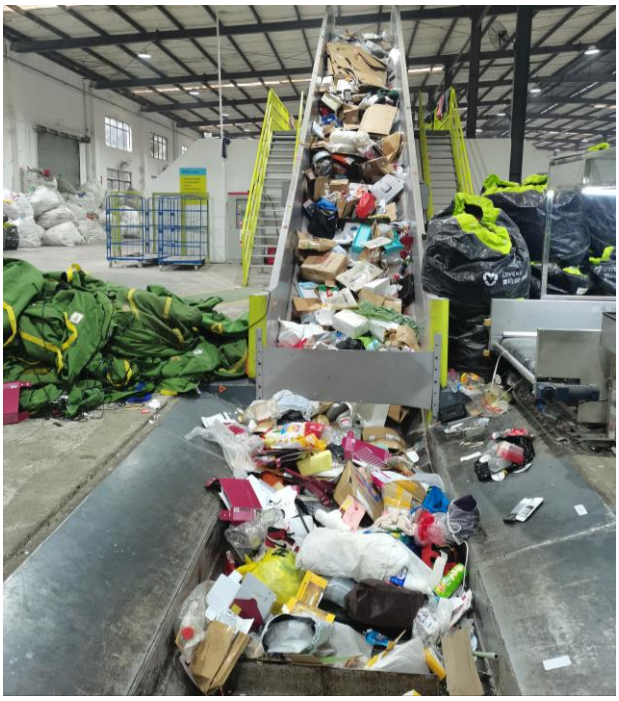

Figure 7-2-6 Loading and unloading waste onto the conveyor belt for manual sorting preparation (Source: https://endplasticwaste.org/en/our-work/innovation-through-collaboration/lovere)

Example of Sorting Hub: Baiyangwan Sorting Center, People's Republic of China

Baiyangwan Sorting Center is a government-owned waste sorting station. At this station, recyclables are only accepted from the surrounding communities, shops, and offices.

Baiyangwan Sorting Center's garbage pickup is commonly done by large trucks and smaller three-wheeled motorcycles with onboard storage that collect recyclables at the drop points. Drop points are defined by each community. In addition, people can also bring recycled waste directly to sell at Baiyangwan Sorting Center.

Figure 7-2-7 Three-wheeled trucks and motorcycles for unloading local recyclables

Baiyangwan Sorting Center's waste management process starts with vehicles carrying recyclable waste going through the weighing gate at the factory entrance. After the incoming weight is recorded, the recycling truck must be driven to unload the recyclable waste at the bulk yard of the sorting station. The officer then inspects the waste. Once all the recyclables have been removed from the vehicle, the unloaded vehicle is weighed again at the scale so it can then be paid for the recyclables by the staff that were purchased by the center.

Figure 7-2-8 Waste Disposal Process at Baiyangwan Sorting Center

After the recyclables are piled up in the factory's dump yard, the staff sorts out the basic waste types such as paper, plastic, and foam. Each type of recyclable waste is then be taken to its belt through loading with trolleys or using forklifts.

Figure 7-2-9 Cart for moving local recyclables

Plastic waste is sorted into 5 categories: clear bottle plastic, colored bottle plastic, opaque white bottle plastic, colored clear plastic, and other plastics. After that, it is stored in a stack in the warehouse area.

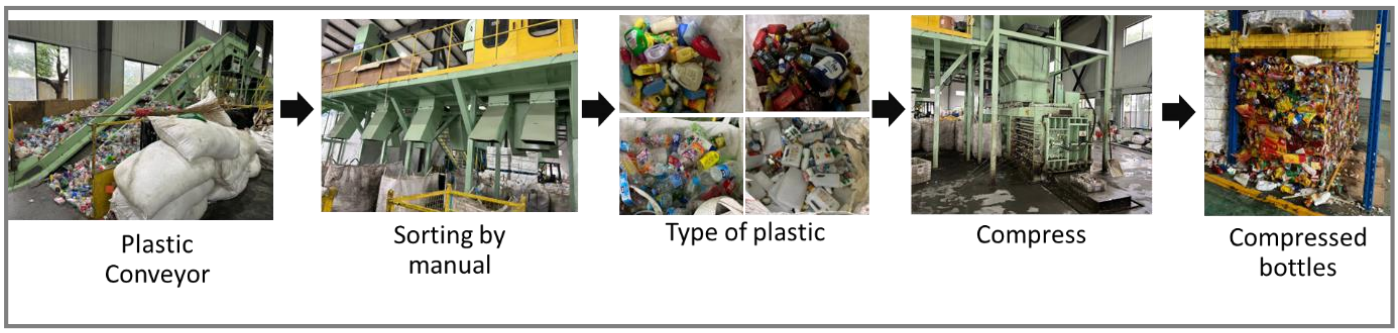

Figure 7-2-10 Plastic Waste Management Process at Baiyangwan Sorting Center

Foam plastic waste is collected at a foam drop point, melted in a foam crusher, and rolled out into square bales for easy collection and transportation to recycling plants.

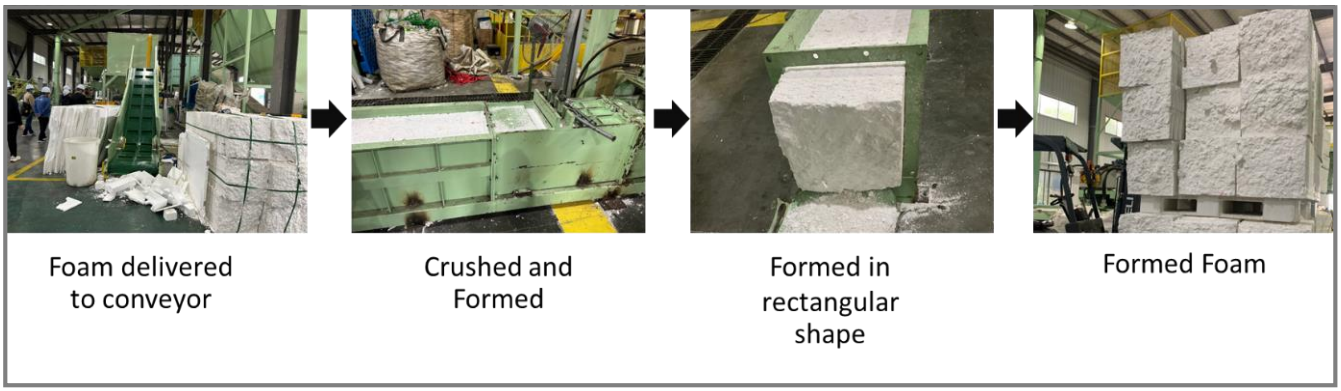

Figure 7-2-11 Foam Plastic Waste Management Process at Baiyangwan Sorting Center

Paper recycling management starts with collecting waste paper in the hopper for loading paper onto the conveyor belt. It is pulled up along the belt where it is sorted by different types of paper, such as crate paper, white paper, and color composite paper.

Figure7- 2-12 Paper Type Recycling Waste Management Process at Baiyangwan Sorting Center

Recycler: Recycling plants are a very important part of reprocessing plastic packaging waste so that plastic packaging waste can be reused again in the form of recycled plastic pellets. Having a process to manage plastic packaging waste at the source reduces contamination. Separating the types of plastic packaging waste will further improve the efficiency of recycling plant production of plastic pellets.

Plant Recycler Success Factors

- Encouraging separation at waste origin with communities results in good quality plastics, income distribution, and sustainability.
- Quality control of incoming plastic packaging waste improves the quality of pellet production and makes for more efficient recycling
- Modern production technology makes it possible to produce recycled plastic pellets in large quantities.
- For example, the use of Solid State Polymerization (SSP) technology enables the production of recycled plastic pellets that have been certified as food contact grade by the Food and Drug Administration of Thailand, allowing them to increase the value of recycled plastic pellets.
- Having a closed raw material storage warehouse to be able to sell the waste at a good price as the price of plastic packaging waste sometimes fluctuates. A covered warehouse to store raw materials will reduce the damage to raw materials such as by moisture from rain, soil contamination, and dust.

Examples of Successful Recycler: ENVICCO LIMITED, Thailand

ENVICCO LIMITED is a recycling plant in Thailand that produces food contact grade recycled plastic pellets approved by the Food and Drug Administration of Thailand (PET Recycled Plastic Pellets). PET has been used mainly by consumers or Post Consumer Recycle to produce recycled plastic pellets that can be reused into PET plastic bottles with the production process as shown in Figure 2-14.

There is a process to check the quality of waste before it enters the production line, including waste received from vendors with clear verification of the origin of the waste and waste bought from surrounding communities with clean waste separation. As a result, the quality of the factory's rPET resin has been higher and it can be confirmed that it is waste that comes from real consumers. In addition, the plant has a Solid-State Polymerization procedure that makes it possible to increase the strength and viscosity so that it is suitable for plastic resin molding by injection blow-molding as well as extrusion process.

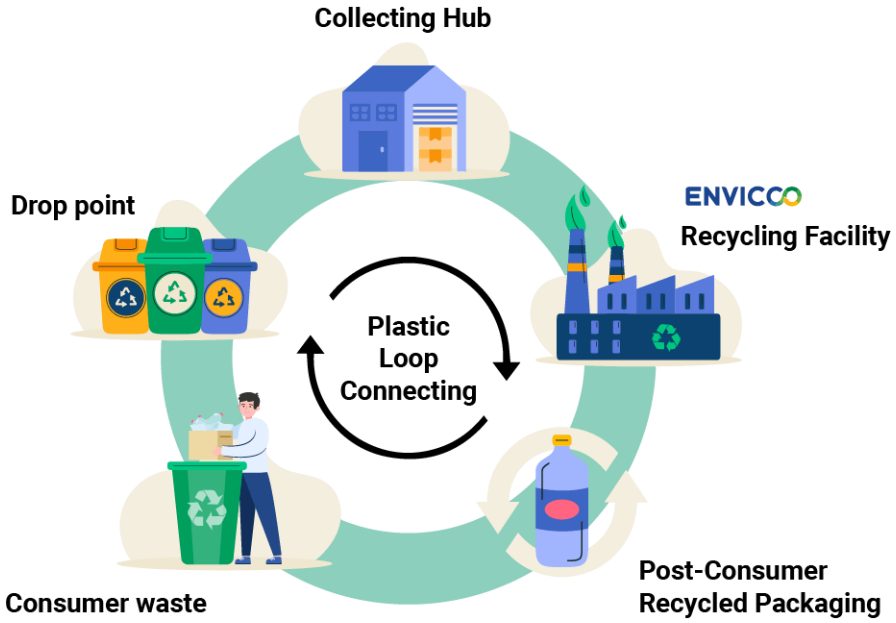

Figure 7-2-13 Envicco's Circular Economy Concept (source: https://envicco.com/en/about)

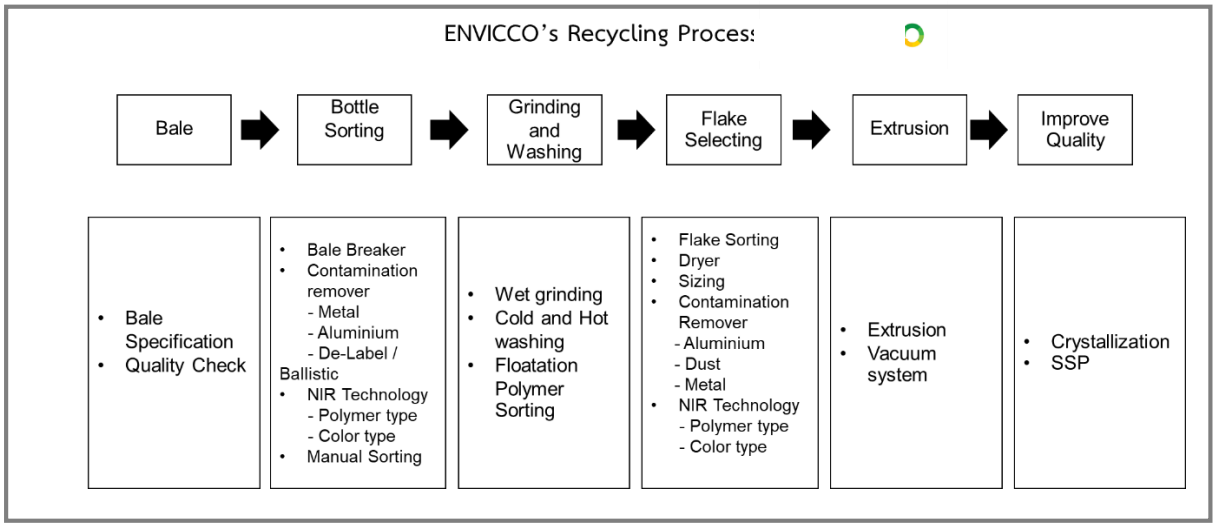

Figure 7-2-14 Envicco's Recycling Process (source: https://envicco.com/th/products)

7.3 Summary of best practice

There are four key stages in managing plastic waste from packaging:

- Source Collection: This is where the waste originates. It's crucial to control the separation of different types of waste from the beginning. Separating wet waste, general waste, and

recyclable waste at the source allows plastic waste from packaging to be recycled and reused most efficiently and economically.

- Drop Points: At waste collection points, clear and well-labeled bins with knowledgeable attendants are essential. They educate people on proper waste disposal and ensure that waste is correctly sorted at this stage.
- Sorting Hubs: Modern sorting equipment and proper training for waste sorters at sorting hubs both play a vital role. This ensures that plastic waste is effectively separated and prepared for recycling.
- Recycling Facilities: When recycling facilities receive sorted plastic waste, they conduct quality checks and use state-of-the-art processes to produce high-value, high-quality recycled plastic pellets. These pellets often have traceability data, allowing them to meet the growing demand in the market, especially from brand owners who support the circular economy (CE) concept and want to reuse materials.

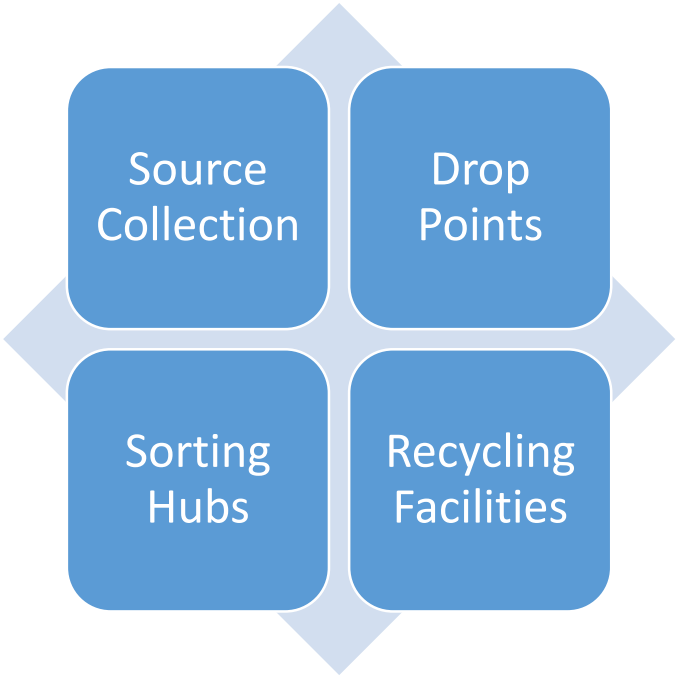

Figure7-3-1 Four key stages in managing plastic waste from packaging

At present, Brand Owners, who are clients of the recycling industry, tend to demand a significant quantity of recycled plastic pellets. This trend is driven by the increasing environmental awareness among consumers, which affects their purchasing choices.

Starting the management of plastic waste from packaging in all sectors can be initiated and successfully accomplished through several key factors:

1. Building Knowledge, Understanding, and Awareness: Educating and creating awareness about the proper separation of various types of plastic packaging waste is essential.
2. Data Collection on the Source of Plastic Packaging Waste: Collecting data on the origin of plastic packaging waste, such as from condominiums or communities,

enables confirmation that the recycled plastic pellets indeed come from previously used plastic waste.

3. Support, Regulations, and Policies: Support and regulations from government bodies play a crucial role in expediting the management of plastic waste from packaging.

These factors collectively contribute to a more effective and sustainable approach to plastic waste management and recycling.

Additionally, if all sectors start to manage plastic packaging waste correctly and efficiently this can lead to an improvement in the quality of plastic waste generated from consumption that enters the production process. This can reduce the amount of plastic waste sent to landfills and result in more environmentally friendly waste management.

However, the move towards a circular economy (CE) must be driven by actioning throughout the whole system to include producers, entrepreneurs, and consumers. We must work together to make changes for a sustainable future by:

1) Make: Produce products with minimal raw resources, starting from product design and innovation that reduces raw resource consumption and uses as much recycled or reused resources as possible.
2) Use: Use products in a cost-effective manner to their fullest extent of use and dispose of them properly so that those materials can be reused or recycled.
3) Return: Reuse materials in the production process or use them to create other benefits to maximize value.

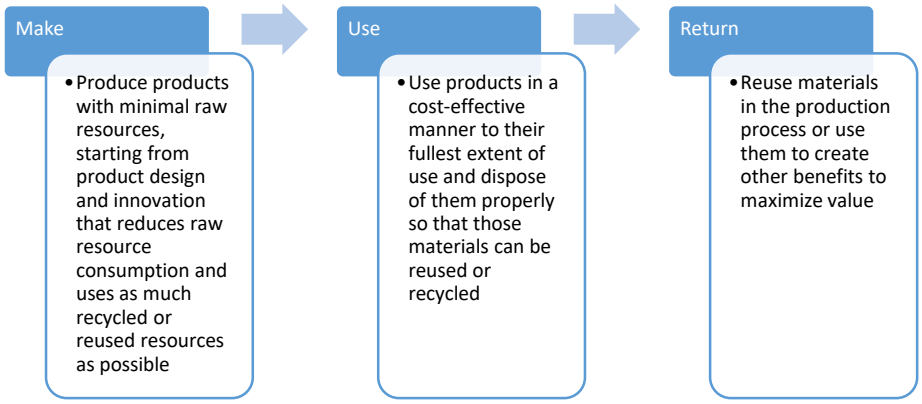

Figure7-3-2 Moving towards a circular economy

The most important thing is to understand where the organization stands in the Circular Economy (CE) process and then start by making changes to what is currently being done. This includes improving production efficiency, promoting renewable energy, smart design choices, selecting alternative materials, and embracing circular economic concepts. Sustainable development, widely accepted worldwide, has become the forefront idea, leading various companies globally to

practically implement circular economic concepts in their operations more and more. This is to pave the way for the organization's sustainability in the future.

8 Conclusion

The guideline handbook for CE product verification on Lancang-Mekong Region Countries has been developed to assist organizations in implementing sustainable practices in their supply chains. The handbook provides comprehensive guidance on the requirements of CE product verification, including the relevant standards and certifications, monitoring and evaluation, and case studies of successful implementation.

Through the implementation of CE product verification, organizations can ensure that their products are produced sustainably, and they are not contributing to environmental degradation or social injustices. The handbook outlines the importance of monitoring and evaluating the implementation of CE product verification in the supply chain, providing guidance on measuring progress and making necessary adjustments.

The case studies and examples included in the handbook provide real-world examples of how organizations have successfully implemented CE product verification, highlighting the benefits and challenges of the process. Overall, this guideline handbook serves as a valuable resource for organizations in the Lancang-Mekong Region Countries seeking to implement sustainable practices in their supply chains through CE product verification.

8.1 Summary of key points in the guideline handbook

The guideline handbook for CE product verification in Lancang-Mekong Region Countries serves as a comprehensive guide for businesses looking to implement sustainable practices in their supply chain. Throughout the handbook, various standards, certifications, and techniques were discussed to aid in the implementation process.

One key takeaway is the importance of choosing the appropriate standard or certification for the business and the product being produced. Each standard and certification has its own set of criteria, and it is essential to choose the one that aligns with the company's goals and values. Additionally, monitoring and evaluating the implementation process is crucial to ensure that the intended goals are being met and to make any necessary adjustments.

The guideline handbook also provides guidance on measuring and tracking progress, as well as making adjustments as necessary. This involves setting measurable goals and regularly monitoring progress to identify areas that require improvement. By doing so, businesses can ensure that they are continuously improving their sustainability practices and meeting their commitments.

The handbook also includes several case studies and examples of successful implementation of CE product verification in the supply chain. These case studies serve as inspiration and provide a real-world example of how businesses can successfully integrate sustainable practices into their supply chain.

Overall, the guideline handbook for CE product verification in Lancang-Mekong Region Countries provides businesses with a comprehensive guide to implementing sustainable practices in their

supply chain. By following the guidelines outlined in this handbook, businesses can reduce their environmental impact and promote sustainability while also improving their bottom line.

8.2 Importance of CE product verification for achieving a circular economy

CE product verification is an important step towards achieving a circular economy, which aims to minimize waste and maximize the use of resources. The circular economy model is based on the principles of designing out waste and pollution, keeping products and materials in use, and regenerating natural systems. CE product verification is an essential tool for ensuring that products are designed and manufactured according to these principles and that they meet the standards and certifications required for environmental sustainability.

CE product verification involves monitoring and evaluating the entire supply chain, from raw material sourcing to end-of-life disposal or recycling. By implementing CE product verification, businesses can ensure that their products meet the highest environmental standards and are manufactured in a sustainable and socially responsible manner. This can lead to cost savings through reduced waste, improved resource efficiency, and increased customer loyalty and brand reputation.

In order to achieve a circular economy, it is essential to implement CE product verification across all sectors, including plastics packaging, textiles, electronics, and more. By doing so, businesses can reduce their environmental impact, minimize waste, and create a more sustainable future for all.

Overall, CE product verification is a crucial aspect of achieving a circular economy and creating a more sustainable world. By implementing the guidelines and best practices outlined in this handbook, businesses in the Lancang-Mekong Region Countries can play a leading role in driving the transition towards a more sustainable and circular economy.

8.3 Additional resources and references for further reading

CE product verification is an essential aspect of achieving a circular economy, and it is becoming increasingly relevant for businesses and organizations to adopt this practice in their supply chains. To support the implementation of CE product verification, there are various resources and references available for further reading.

One useful resource is the Ellen MacArthur Foundation, a leading organization in the circular economy field that provides valuable insights and guidance on CE product verification. Their website offers a range of resources, including case studies, reports, and toolkits, that can help businesses and organizations understand and implement CE product verification in their operations.

Another useful reference is the ISO 14024 standard for Type I Environmental Labeling, which provides a framework for certifying and labeling environmentally friendly products. This standard is widely recognized and can help businesses verify their sustainability claims to consumers and stakeholders.

In addition to these resources, there are numerous organizations and initiatives focused on promoting sustainable practices and circular economy principles. For example, the Global Reporting Initiative (GRI) provides guidance on sustainability reporting, including reporting on circular economy practices. The Sustainable Packaging Coalition (SPC) is another organization that offers guidance and resources for businesses looking to implement sustainable packaging practices.

Other resources that businesses and organizations can consult include academic articles, industry publications, and government reports on circular economy practices and CE product verification. These resources can provide valuable insights and best practices for implementing CE product verification in various supply chain contexts.

In conclusion, there are numerous resources and references available for further reading on CE product verification, including the Ellen MacArthur Foundation, ISO 14024, the GRI, the SPC, academic articles, industry publications, and government reports. By consulting these resources and implementing CE product verification in their supply chains, businesses and organizations can contribute to a more sustainable and circular economy.

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Annex 1

CHAIN OF CUSTODY MLC STANDARD FOR RESPONSIBLY PLASTIC WASTE MATERIALS

1. Introduction

1.1 Purpose

The MLC Chain of Custody Standard for plastic waste material was developed to provide the base-level requirements for traceability for any plastic waste material from its source through the downstream chain of custody to the end consumer.

The Chain of Custody Standard for plastic waste materials will, as needed, be supplemented by Annexes specifying additional guidance for specific plastic waste supply chains. In addition, this Standard has been developed to work in harmony with existing and emerging traceability services and technologies (e.g., blockchain, plastic ID scanning, testing, etc.), and be used to help validate key systems and documentation through on-site audits that are associated with secure ledgers and testing results. It is also intended to be compatible with other standards programs forwarding responsible sourcing and recycling of plastic waste materials downstream of the source and will work to adapt expectations when coordinated with these and other systems working to a common goal to convey value for responsible practices at the source level down the chain to consumer-facing products.

1.2 The CoC Standard aims to:

a) Provide organizations in the chain of custody with a common standard for handling and making claims regarding MLC-conformant responsibly plastic waste materials in their possession and their products.

b) Establish requirements that can be independently audited to provide objective evidence for the flow of MLC-conformant responsibly plastic waste materials.

1.3 Scope and methodology of evaluation

The MLC Chain of Custody Standard outlines requirements for "Organizations" involved in the plastic waste material supply chain, including those who process, handle, or use the material. To make market claims about MLC-conformant plastic waste materials, each Organization taking legal custody of the material back to MLC-recognized plastic waste material must be certified against this Standard. The scope and methodology of evaluation are defined by this Standard.

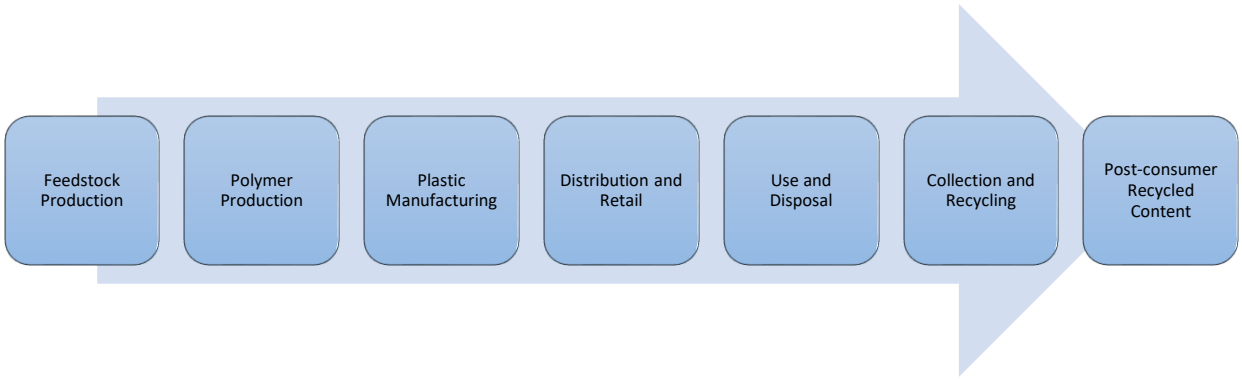


Figure A1 an illustration of the plastic value chain

1) Feedstock Production: The plastic value chain begins with the production of feedstock, such as crude oil or natural gas, which is used as the raw material for plastic production.

2) Polymer Production: The feedstock is then processed in a petrochemical plant to produce plastic resins, such as polyethylene, polypropylene, and polystyrene.

3) Plastic Manufacturing: The plastic resins are transported to plastic manufacturing facilities, where they are molded or extruded into various plastic products, such as packaging materials, automotive parts, and consumer goods.

4) Distribution and Retail: The finished plastic products are distributed to retail stores or directly to consumers.

5) Use and Disposal: The plastic products are then used by consumers, and eventually discarded. Depending on the disposal method, the plastic waste may end up in landfills, oceans, or incinerators, contributing to environmental pollution and degradation.

6) Collection and Recycling: To reduce the environmental impact of plastic waste, some of the plastic products may be collected and sent to recycling facilities, where they are processed into new plastic products or other materials.

7) Post-consumer Recycled Content: The recycled plastic may then be used as post-consumer recycled content in new plastic products, completing the plastic value chain loop.

Nature of organization	Mandatory requirements	
Plastic value chain	**Clause**	**Applicability**
Feedstock	2	All
	3	Only applicable to sites that source PWM from other PWM
	4	4.1 All 4.2,4.3 are only applicable to sites that source PWM material from other PWM
	5	All
	6	All
Polymer Production, Plastic Manufacturing	All	All
Distribution and Retail, Use and Disposal, Collection and Recycling, Post-consumer Recycled Content	2	All
	3	All
	4	4.3 is exception for Distribution and Retail
	5	All
	6	All

1.4 Application and certification

Certification to the MLC Chain of Custody Standard provides independently verified assurance that plastic waste materials traded or sold with an MLC-related claim are traceable to an MLC recognized (PWM). Organizations certified against the MLC Chain of Custody Standard are audited by an MLC-approved third-party auditor (i.e., certification body) and are subject to annual surveillance audits over the three-year term of an MLC Chain of Custody Certificate.

1.5 Terms and definitions

1.5.1 Accounting Period

The time period during which materials going through a particular stage in the supply chain (i.e., incoming and outgoing material) are accounted for. In this case, the period is at minimum 3 months.

1.5.2 Batch

A specific quantity of plastic waste material identified using a unique identifier (e.g., bar code, unique reference number, RFID tag or other identifier). A batch may be in bulk or contained in a bag, box, pallet, or other container.

1.5.3 Chain of Custody

The sequence of organizations who have had physical possession of the plastic waste material along its journey from its source to the end point to which it is tracked, including any processing or transformation steps. This is necessary for ensuring traceability and transparency in the supply chain of plastic waste materials.

1.5.4 Conversion Factor

The change in quantity of a specific material that occurs due to processing of the respective material at a specific site.

1.5.5 Documented Information

Data that are required to be controlled and maintained by the organization, and the medium in which it is contained. (ISO 9001:2015).

1.5.6 Eligible Inputs

MLC materials that carry an MLC Chain of Custody certification claim. In future this is intended to be combined with appropriate tracking of recycled materials that also meet appropriate standards that assure responsible practice metrics.

1.5.7 MLC Accounting System

Organization's system(s) for planning, controlling, handling and accounting for the acquisition, manufacturing, storage, and sale of MLC-conformant material.

1.5.8 Identity Preserved

a system for traceability and chain of custody is necessary to ensure segregation throughout the supply chain, enabling the tracking of plastic waste back to its original source. This system should allow for the identification of the specific source of the plastic waste material

Plastic waste material-to-market chain of custody: The documented process of tracking the movement and ownership of plastic waste material from the point of sale(PoS) or distribution to customers or clients, ensuring traceability and accountability for the material throughout the supply chain.

Plastic waste material-to-product chain of custody: The documented process of tracking the movement and ownership of plastic waste material from the point of transformation (PoT) into a finished product to the point of sale(PoS) or distribution to customers or clients, ensuring traceability and accountability for the material throughout the supply chain.

1.5.9 MLC-Conformant material

Conformant plastic waste material would therefore be plastic waste that has been verified to meet these standards and can be traced through a chain of custody from its source to its end point of use or disposal.

1.5.10 Mass Balance

An accounting of the input, output and distribution of a substance between streams in a process or stage. Mass Balance within this Standard is a system of accounting that allows physical inputs of MLC and non-MLC materials to be mixed during manufacturing processes as long as specific rules are met. Only the volume- equivalent of MLC-conformant material inputs can be claimed as MLC outputs, minus any manufacturing losses.

Mass Balance within the context of plastic waste refers to a system of accounting that allows for the mixing of MLC-conformant plastic waste materials and non-MLC plastic waste materials during manufacturing processes, as long as specific rules are met. This system allows for the physical inputs, outputs, and distribution of the plastic waste material between different stages of the process to be accounted for. Only the volume-equivalent of MLC-conformant plastic waste material inputs can be claimed as MLC outputs, minus any manufacturing losses.

1.5.11 PWM Site

The source of a plastic waste material and the point of extraction (PoE) of the plastic waste material, to the greatest possible specificity.

1.5.12 Garbage

Plastic is primarily produced through a manufacturing process using petrochemicals derived from oil and natural gas. However, plastic waste can be collected and recycled or repurposed through various methods such as mechanical recycling, chemical recycling, and energy recovery.

1.5.13 Extraction

Extraction of plastic waste material refers to the process of obtaining plastic waste from various sources such as households, businesses, and industries. This process involves collecting, sorting, and processing plastic waste in order to recover useful materials and divert waste from landfills or the environment.

1.5.14 On-Site Assessment

An evaluation of conformance to MLC standards conducted at the organization's site by an MLC authorized third party assessor.Organization

Participant in the plastic waste materials chain of custody that processes, handles, or uses MLC-conformant plastic waste materials.

1.5.15 Responsible waste management (RWM)

Responsible waste management practices are also important in ensuring that plastic waste is not harmful to human health or the environment. This includes reducing plastic waste generation, promoting recycling and reusing plastic products, and safely disposing of plastic waste. RWM of plastic material aim to minimize harm to the environment and promote sustainable practices.

1.5.16 Segregation

Refers to the practice of keeping all waste materials strictly separated from other materials throughout the supply chain, from the point of generation to their final disposal. This helps to ensure that plastic waste material is properly sorted and managed, reducing the risk of contamination and increasing the likelihood of effective recycling or disposal.

1.5.17 Supply Chain

A network between a company and its suppliers to produce and distribute a specific product to the final buyer.

1.5.18 Third-Party Assessment

A formalized evaluation of an organization's operations and/or products carried out by an authorized, independent party against the requirements of a Standard or set of criteria, typically resulting in a report containing specific findings. For the purpose of this Standard, the term "assessment" is used to cover any type of assurance, audit or certification engagement.

1.5.19 Traceability

The ability to verify the history of a material and its processing from one point to another.

2. Management system requirements

The minimum requirements for an Organization's management system to comply with the standard. Management systems refer to the policies, procedures, roles, responsibilities, and structures that an Organization establishes and utilizes to ensure compliance with the standard. It is possible to modify existing environmental management systems, such as ISO 9001 and ISO 14001, to include the traceability requirements specified in this standard.

2.1 Sourcing Policy and Commitment

2.1.1 The Organization shall establish and implement a publicly available sourcing policy aligned with this Standard for procurement and sale of plastic waste materials. The policy shall include the following components:

- **Definition of scope** : The policy describes the plastic waste materials covered.
- **Commitment** : The policy states a commitment to conform to this Standard.
- **Grievance mechanism** : The policy includes a formal process for stakeholders and interested parties to file grievances regarding an Organization's adherence to this Standard, along with time-bound actions the Organization will take, and how it will report back findings.

2.1.2 The Organization shall communicate its policy to employees, suppliers, customers, and other interested stakeholders.

2.2 Designation of Responsibility

2.2.1 The Organization shall designate individual(s), including senior management, who will be accountable for meeting the requirements of this Standard, which include:

- Making sure that the management system complies with this Standard.
- Reporting on the performance of the management system, which includes identifying opportunities for improvement and non-conformities, implementing corrective actions, and tracking and monitoring the progress of risk mitigation efforts.
- Ensuring that the management system's integrity concerning this Standard is maintained whenever significant changes occur in the Organization.

2.3 Documented Processes and Procedures

2.3.1 The Organization shall establish, implement, and maintain management systems related to the traceability conducted on MLC inputs.

2.3.2 The Organization's internal management systems and procedures with respect to this Standard shall be formalized and documented. This documentation shall, at a minimum, contain the following elements:

- A site map that shows material flows, processing equipment and steps;
- Organizational structure, responsibilities, and authorities with respect to the chain of custody;
- Procedures ensuring the traceability and accounting procedures in compliance with this Standard for MLC-eligible inputs from purchase to the final sale of Products made with MLC-conformant material,
- Develop and apply the criteria and methods – including monitoring, measurements, and related performance indicators – needed to ensure the effectiveness of the tracking and control systems.

2.4 Record Keeping and Document Control Systems

2.4.1 The Organization shall ensure appropriate identification and description (e.g., a title, date, author, or reference number), format and approval for suitability and adequacy with respect to the requirements of this Standard when creating and updating documented information.

2.4.2 The Organization shall ensure that documented information related to the management systems and associated procedures are available and suitable for use, where and when they are needed. Additionally, the Organization shall ensure that adequate protection measures are in place to prevent loss of

confidentiality, improper use, or loss of integrity of the documented information.

2.4.3 Upon request during an MLC Chain of Custody audit, the Organization shall provide records demonstrating a clear link between incoming eligible inputs and outgoing products made with MLC-conformant material. The records that the Organization shall maintain include:

- Plant operation permit, including layout plan and capacities of storage facilities.
- Lists and contracts with all suppliers and customers of products made with MLC-conformant plastic waste materials.
- Incoming and outgoing products containing MLC-conformant plastic waste material.
- Inventory reports on opening and closing stock for incoming and outgoing products containing MLC-conformant plastic waste material.
- Internal processing records for products containing MLC-conformant plastic waste material, including the respective yields and conversion factors.
- Lists and contracts with subcontractors and service providers related to the processing of products made with MLC-conformant plastic waste material.
- Records of internal audits, non-conformities with this Standard, and related corrective actions taken.

2.5 Training

2.5.1 The Organization shall ensure that staff responsible for the chain of custody system are competent and trained to carry out their responsibilities effectively.

2.5.2 Records of training provided to staff shall be maintained by the Organization.

2.6 Internal Evaluation System

2.6.1 The Organization shall establish, implement, and maintain an internal evaluation program to assess the effectiveness of its chain of custody system in ensuring ongoing conformance with this Standard.

2.6.2 The Organization shall ensure that competent evaluators are selected to conduct assessments of its chain of custody system, ensuring objectivity.

2.6.3 The Organization shall establish and maintain an internal evaluation program to ensure the ongoing conformance of its chain of custody system. Competent evaluators shall be selected to conduct assessments, ensuring objectivity. The results of evaluations and corrective actions shall be reported to relevant management, used to determine and implement corrective actions without undue delay, and documented and retained.

3. Sourcing and receiving eligible inputs

This section outlines the fundamental sourcing requirements that a product must meet in order to be eligible to carry a chain of custody claim recognized by MLC.

3.1 Confirmation of Sources

3.1.1 The Organization shall maintain complete and current records for all suppliers of plastic waste materials conformant to MLC, which include:

- Supplier company name, location, contact information, and supplied material;
- Details of supplied materials (eligible inputs), including volume, mass, composition, and form (e.g., PET,PVC,HDPE), along with the MLC-related claim associated with the material;
- The supplier's valid chain of custody registration number.

3.2 Confirmation of MLC-Conformant Plastic waste materials

3.2.1 The Organization shall have policies and procedures in place to ensure that all MLC inputs are purchased and received from MLC-certified suppliers, which shall include:

a) Verification of the validity of the supplier’s MLC certification on the MLC website prior to ordering;

b) The Organization shall include the requirement for MLC-conformant plastic waste materials as a stipulation in purchase contracts or purchase orders.

c) Verification of delivered products against shipping documentation upon receipt to ensure that the delivered material corresponds with the purchased material shall include:
- Verification that the shipped material meets the MLC-conformant plastic waste material claim as specified in the purchase order, including MLC 100, 75 or 50, or Transparency;
- Verification that the shipped material is accompanied by documentation that describes the MLC-accounting system used (Mass Balance, Segregation or Identity Preserved);
- Verification of the supplier's valid chain of custody registration number that matches the certification of the supplier.

NOTE: *MLC claim and accounting system information should be on the line item for each product listed on shipping documents unless all products listed have the same claim.*

3.3 General Internal Traceability Requirements

3.3.1 The Organization shall establish and maintain a robust traceability system that enables any product sold with an MLC claim to be traced from the sales invoice back to an MLC ecosystem.

3.3.2 The Organization shall maintain accurate records to link MLC-conformant plastic waste materials at every stage between purchase and sale, including receipt, processing, transport, packing, storage, and dispatch.

3.3.3 The Organization shall ensure that all records related to MLC-conformant plastic waste materials are complete, accurate, and unaltered.

3.3.4 The Organization shall maintain precise records on the weight and quantity of all MLC-conformant plastic waste materials purchased and sold, which demonstrate that the quantities sold, after accounting for manufacturing losses ("conversion factors"), do not exceed eligible inputs received over each 3-month accounting period.

3.3.5 If an Organization uses an MLC Identity Preserved or Segregation accounting system, they shall not commingle MLC-conformant plastic waste materials with non-MLC materials.

4. Accounting and Counting and segregation system requirements

This section outlines the internal tracking and segregation requirements for each of the three (3) MLC accounting systems:

- Identity Preserved,
- Segregation, and
- Mass Balance.

These systems may be used alone or in combination, depending on the needs and limitations within the value chain. The selected system determines the resulting MLC chain of custody claims for products with different input claims.

The requirements in sections 4.1 to 4.3 apply only if the respective accounting system is used.

4.1 Identity Preserved System Requirements

4.1.1 The Organization shall establish and maintain a process to prevent mixing of MLC-conformant waste material from different source to ensure the integrity of the unique source. This process shall include clear identification, separation, and labeling of materials from different waste throughout the value chain, and regular monitoring and verification to ensure compliance.

4.1.2 The Organization shall include an “Identity Preserved” claim on documentation accompanying all

purchases and sales of MLC-conformant plastic waste materials. This documentation shall also include the following information (in addition to the sales and shipping document requirements in Section 5 of this Standard):

- Name of the plastic waste of origin;
- First gathering points (FGP) Collecting Point and;
- Points of origin (PoO) for plastic waste MLC-registration number.

4.2 Product Segregation System Requirements

4.2.1 The Organization shall maintain segregation of MLC-conformant plastic waste materials from non-MLC materials throughout production and processing, with safeguards in place at all critical control points.

4.2.2 When MLC-conformant plastic waste materials from two or more source with different levels of recognition are mixed, the Organization shall use the lowest input claim for all subsequent transactions.

4.3 Mass-Balance System Requirements

4.3.1 The Organization shall maintain a record of input quantity and output quantity of MLC-conformant plastic waste materials, by mass.

4.3.2 If an organization is using multiple certification schemes for mass balances, it must maintain records of all mass balances and demonstrate measures to prevent double counting.

4.3.3 The Organization must conduct mass balance calculations at least every three months and keep records of all incoming and outgoing quantities, as well as stock and losses/diversions to recycling, to ensure that the sum of all incoming quantities equals the sum of actual outgoing quantities plus the remaining stock and losses/diversions.

4.3.4 The Organization shall perform mass balance calculations for each batch processing period, which should not exceed three months, to account for the incoming and outgoing quantities of MLC-conformant plastic waste materials. The calculations shall also take into account the amount of material left in stock, losses, and diversion to recycling, and demonstrate that they add up correctly.

4.3.5 The Organization shall not carry over unused and unsold volumes of MLC-conformant plastic waste material to mass balance calculations beyond the following three-month period. Any unused and unsold volumes shall be rolled over to the following three-month calculation period and accounted for accordingly.

4.3.6 Any unused and unsold volumes of MLC-conformant plastic waste material shall be rolled over to the following three-month calculation period and accounted for accordingly. The Organization shall not carry over unused and unsold volumes to mass balance calculations beyond the following three-month period.

4.3.7 The Organization shall ensure that their mass balance calculation is within a 1-5% margin of error and for other as appropriate.

4.3.8 The Organization shall use the lowest level of recognition for PCR inputs when they are from two or more MLC-conformant source carrying different levels of recognition. Additional approved clarifying language can also be included.

5. Sales and shipping requirements

5.1 Documentation

5.1.1 In order to maintain the chain of custody of MLC-conformant plastic waste materials when ownership transfers from one certified organization to another, the following information must be listed in sales and shipping documents:

- "Identity Preserved" claim
- Name of the Point of origin

- Country where the plastic waste is located
- Point of origin's MLC-registration number
- Any additional information required by the certification scheme

5.1.2 The following information is required to be listed in sales and shipping documents of MLC-conformant plastic waste materials to allow the chain of custody to be maintained, when ownership transfers from one certified Organization to another:

- Name of certified seller
- Address of certified seller
- Name of buyer
- Address of certified buyer
- MLC claim associated with each product or material
- Amount of each product or material in weight or pieces
- Amount of material by weight
- MLC Chain of Custody number of seller

6. MLC Claims

6.1 Claims for Segregated versus Mixed Materials

6.1.1 The Organization can make claims related to products and materials made exclusively with MLC-conformant plastic waste material, based on the recognition or certification level of the originating source and the segregation and accounting systems used as part of this chain of custody standard. These claims should incorporate site achievement levels indicating that the products contain responsibly plastic waste materials. The following requirements must be met:

- Identity Preserved means that the material has been tracked throughout the supply chain and can be traced back to a specific source plastic waste.
- MLC Transparency means that information about the plastic waste, including its name, location, and certification level, is shared openly and transparently.
- When material from two or more MLC sources are mixed, the lowest MLC recognition level shall be used. This means that if two or more materials from different source with different certification levels are mixed, the final product can only be labeled with the lowest certification level among the sources used.

6.1.2 Organizations may make claims associated with materials and products made partially with MLC-conformant plastic waste material based on using the mass balance accounting system in this chain of custody standard. Any claims shall include the mass balance according to the following:

- MLC Mixed – Based on Mass-Balance of MLC-Conformant Plastic waste materials
- MLC Achievement Levels shall not be used with mass-balance claims unless meeting particular requirements for clarity on this messaging (see also Appendix 3).

NOTE: Material generated and re-used in the same on-site manufacturing process shall maintain the same claim as the inputs/parent material.

7. References

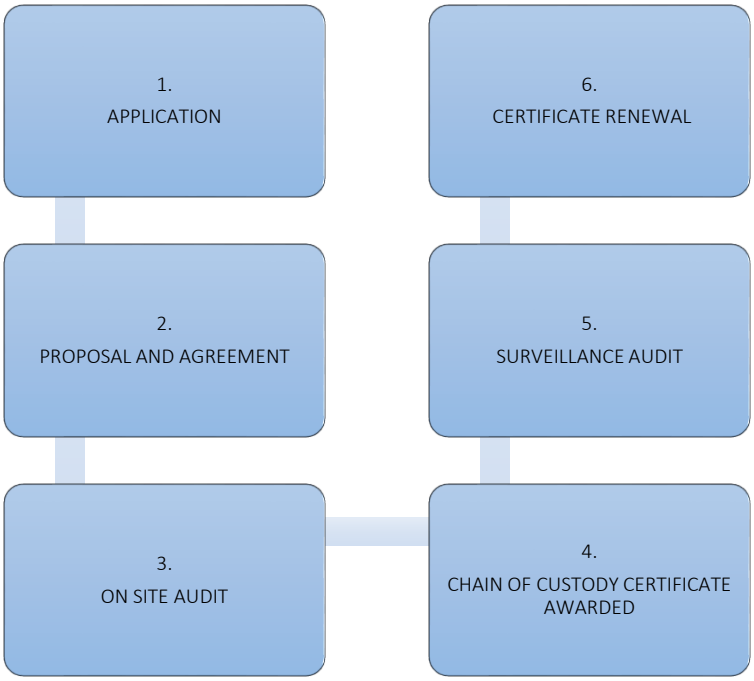
1. ISO 22095:2020 - Chain of custody — General terminology
2. ISO/IEC 17029:2019 - Conformity assessment
3. ISO 9001:2015. Quality Management Systems
4. ISO 14001:2015 - Environmental management systems
5. Forest Stewardship Council. 2017. Chain of Custody Certification Standard, FSC_Std_40_004_V3-0.
6. International Sustainability & Carbon Certification. 2016. ISCC 203 Traceability and Chain of Custody, V3.0.

Annex 1A

(INFORMATIVE)

Chain of Custody certification steps

The steps for MLC Chain of Custody Certification are summarized as follows:



1. APPLICATION – The Organization wishing to process, trade, or use MLC Chain of Custody materials, or to make an MLC-related claim, completes an application for MLC Chain of Custody Certification Audit from an MLC-approved auditing firm (Certification Body). This may be separate from, or alongside, a "plastic site" or "plastic recycling facility" audit for the MLC Standard for responsible mining of plastic waste material.

2. PROPOSAL AND AGREEMENT – The Organization provides documents requested by the audit firm for the development of the proposal and, if agreed by the Organization, the audit firm will enter into an agreement with the Organization to provide auditing services.

3. SITE AUDIT – The audit will mainly involve an on-site assessment of the Organization's management systems, procedures, and other relevant documentation to determine the Organization's conformance to the MLC Chain of Custody Standard to source and/or supply Chain of Custody material for plastic waste material. Non-conformities (NCs) will be identified, and any Major NCs will require the implementation of corrective actions prior to certification.

4. CHAIN OF CUSTODY CERTIFICATE AWARDED – Once the auditor is satisfied that the operating company has implemented corrective actions, if any, and met requirements, the Organization will be issued a Chain of Custody certificate and authorized to begin making claims on invoices and shipping documents regarding the certification or recognition level of MLC-conformant plastic waste material.

5. SURVEILLANCE AUDIT – Annual Surveillance Audits of the MLC certified Organization are required to verify that systems and procedures continue to work effectively. Gaps/Minor NCs identified during the previous audit will be reevaluated during the surveillance audit.

6. CERTIFICATE RENEWAL – The validity of the certificate will be 3 years, after which the Organization will need to undergo a new certification audit if it wishes to continue making MLC certification claims about their products made with plastic waste material.

Annex 1B

(NORMATIVE)

ACCOUNTING AND SEGREGATION SYSTEM GUIDANCE

This Appendix describes three different accounting systems – Identity Preserved, Segregation, and Mass Balance – and the applicable internal tracking and segregation requirements that apply to each system. It also describes conversion factors used to determine the change in quantity of a specific material that occurs due to processing of the respective material at a specific plastic site.

I. Identity Preserved System

The Identity Preserved system in the plastic value chain is one in which materials originating from a specific feedstock source or feedstock type, monomer, polymer, product, use of product, and disposal are physically separated from materials originating from other sources or types. Plastic waste material and products containing unique components wholly made of MLC-conformant plastic waste material can be separated in space or time, at each stage along the value chain (i.e., from the point of collection to final disposal). Identity preservation can be accomplished by either:

1) parallel processes for production, storage and transport, throughout the entire production and distribution process; or

2) sequential (batch) processes at the site of production, storage or transport which separates the MLC-conformant plastic waste materials by type, source, or origin. This enables traceability and accountability of the plastic waste material back to its specific source, providing assurance that the plastic waste material is sustainably sourced and processed.

Table 1 the Identity Preserved system can be mapped to the plastic value chain:

Value chain	Feedstock Production	Polymer Production	Plastic Manufacturing	Distribution and Retail	Use and Disposal	Collection and Recycling	Post-consumer Recycled Content
Source A	materials originating from a specific source A	monomer from a specific feedstock source A	materials originating from a specific polymer source A	storage areas for products made from different polymers A	products made from a specific polymer A	facilitate the collection and recycling of materials originating from a specific polymer or product source or type A	products made from 100% post-consumer recycled plastic can be separated from products made from a lower percentage of post-consumer recycled content.
Source B	materials originating from a specific source B	monomer from a specific feedstock source B	materials originating from a specific polymer source B	storage areas for products made from different polymers B	products made from a specific polymer B	facilitate the collection and recycling of materials originating from a specific polymer or product source or type B	products made from 100% post-consumer recycled plastic can be separated from products made from a lower percentage of post-consumer recycled content.

Feedstock Production: The Identity Preserved system can be applied to the production of feedstock, where materials originating from a specific source or type are physically separated from materials originating from other sources or types. For example, feedstock made from recycled plastic can be sourced from a specific recycling facility that has been certified under the Identity Preserved system.

Polymer Production: The Identity Preserved system can also be applied to the production of polymers, where materials originating from a specific monomer source or type are physically separated from materials originating from other sources or types. For example, a polymer producer can source their monomer from a specific feedstock source that has been certified under the Identity Preserved system.

Plastic Manufacturing: In the plastic manufacturing stage, the Identity Preserved system can ensure that materials originating from a specific polymer source or type are physically separated from materials originating from other sources or types. This can be achieved by using separate production lines for different polymers or by implementing a batch-based system that separates the different polymers during the manufacturing process.

Distribution and Retail: The Identity Preserved system can be extended to the distribution and retail stage, where materials originating from a specific product source or type are physically separated from materials originating from other sources or types. For example, retailers can use separate storage areas for products made from different polymers or products with different recycled content.

Use and Disposal: The Identity Preserved system can also be applied to the use and disposal stage, where materials originating from a specific use or disposal source or type are physically separated from materials originating from other sources or types. For example, products made from a specific polymer can be disposed of separately from products made from other polymers.

Collection and Recycling: The Identity Preserved system can facilitate the collection and recycling of materials originating from a specific polymer or product source or type. This can be achieved by implementing a system that separates the different types of plastics during collection and recycling.

Post-consumer Recycled Content: The Identity Preserved system can also be used to track the recycled content of products. Materials originating from a specific post-consumer recycled content source or type can be physically separated from materials originating from other sources or types. For example, products made from 100% post-consumer recycled plastic can be separated from products made from a lower percentage of post-consumer recycled content.

II. Product Segregation System

The Product Segregation System in the plastic value chain involves physically separating materials originating from different feedstock sources or types, monomers, polymers, products, uses of products, and disposals at specific stages of the value chain. This system requires strict tracking and segregation of materials to ensure that they do not mix with non-conformant materials.

Table 2 in the plastic value chain, the Product Segregation System can be mapped as follows:

Value chain	Feedstock Production	Polymer Production	Plastic Manufacturing	Distribution and Retail	Use and Disposal	Collection and Recycling	Post-consumer Recycled Content
Source A	Different types of feedstocks A	Different monomers and polymers are produced and segregated according to their type and source A	Polymers and other additives are mixed and shaped into different plastic products A+B	Plastic products are physically separated during distribution and retail based on their composition A+B	Plastic products made from virgin materials may be disposed of separately from those made from post-consumer recycled content A+B	The separation of products made from virgin materials and those made from post-consumer recycled content A+B	Materials are used to produce new products with specific levels of post-consumer recycled content A+B
Source B	Different types of feedstocks B	Different monomers and polymers are produced and segregated according to their type and source B					

Feedstock Production: Different types of feedstocks (e.g. crude oil, natural gas, biomass) are sourced and physically separated according to their origin and type.

Polymer Production: Different monomers and polymers are produced and segregated according to their type and source. This includes the separation of polymers made from virgin materials and those made from post-consumer recycled content.

Plastic Manufacturing: Polymers and other additives are mixed and shaped into different plastic products, which are segregated based on their composition and intended use.

Distribution and Retail: Plastic products are physically separated during distribution and retail based on their composition and intended use.

Use and Disposal: Plastic products are used and disposed of in a manner that ensures the segregation of different types of materials. For example, plastic products made from virgin materials may be disposed of separately from those made from post-consumer recycled content.

Collection and Recycling: Post-consumer plastic products are collected and segregated based on their composition and intended use. This includes the separation of products made from virgin materials and those made from post-consumer recycled content.

Post-consumer Recycled Content: Materials containing post-consumer recycled content are physically separated and tracked to ensure that they are not mixed with non-conformant materials. These materials are used to produce new products with specific levels of post-consumer recycled content.

III. Mass-Balance System Requirements

The Mass-Balance system is one in which the total input of feedstock or monomer is matched with the total output of product and waste across the entire value chain. It allows for the mixing of materials from different sources or types at any point in the value chain as long as the total amount of input and output is accurately tracked and recorded.

Table 3 Mass-Balance system requirements for each stage of the plastic value chain are:

Value chain	Feedstock Production	Polymer Production	Plastic Manufacturing	Distribution and Retail	Use and Disposal	Collection and Recycling	Post-consumer Recycled Content
Source A+B	The feedstock can come from multiple sources, conformance source (A+B)	The monomer/polymer can be produced from feedstock from different sources, conformance source (A+B)	The plastic product can be manufactured from polymer produced from different sources, including conformance source (A+B) and non-conformance source (C+D).	The plastic product can be distributed and sold to consumers without differentiation between conformance source (A+B) and non-conformance source (C+D).	The plastic product can be used and disposed of by consumers without differentiation between conformance source (A+B) and non-conformance source (C+D).	The plastic product can be collected and recycled, with separate tracking and accounting for conformance source (A+B) and non-conformance source (C+D) material streams.	The recycled plastic can be used to produce new products with separate tracking and accounting for conformance source (A+B) and non-conformance source (C+D) material streams.
Source C+D	The feedstock can come from multiple sources, non-conformance source (C+D)	The monomer/polymer can be produced from feedstock from different sources, non-conformance source (C+D)					

Feedstock Production: The amount of feedstock produced and used must be accurately measured and recorded.

Polymer Production: The amount of polymer produced must be accurately measured and recorded. The polymer must be identified as being produced from feedstock that meets the Mass-Balance criteria.

Plastic Manufacturing: The amount of plastic produced must be accurately measured and recorded. The plastic must be identified as being produced from polymer that meets the Mass-Balance criteria.

Distribution and Retail: The amount of plastic products distributed and sold must be accurately measured and recorded.

Use and Disposal: The amount of plastic products used and disposed of must be accurately measured and recorded.

Collection and Recycling: The amount of plastic waste collected and recycled must be accurately measured and recorded.

Post-consumer Recycled Content: The amount of post-consumer recycled content in new plastic products must be accurately measured and recorded. The Mass-Balance approach can be used to calculate the amount of post-consumer recycled content in the product.

Illustration of how the input percentage for a given material accounting period can be determined using the mass balance system based on MLC (Material Loss Control) conformant material:

Let's say we have a plastic manufacturing company that uses two sources of MLC (certified) material, A and B, and two sources of non-conformant material, C and D, to produce a specific type of plastic product.

During a given material accounting period, the company uses 100 tons of material to produce this product.

The **input breakdown** is as follows:

- Source A MLC material: 40 tons (40% of input)
- Source B MLC material: 20 tons (20% of input)
- Source C non-conformant material: 30 tons (30% of input)
- Source D non-conformant material: 10 tons (10% of input)

To determine the output breakdown, the company performs a mass balance calculation using the MLC material as the baseline. Let's say that the company has a conversion rate of 90% for MLC material and 80% for non-conformant material.

Using the equation for MLC conformant material, the input of MLC material is calculated as follows:

MLC input = (output of MLC material during accounting period) / (conversion rate of MLC material)

To calculate the output of MLC material, we first need to determine the amount of material lost during production. Let's say that the company has a material loss rate of 5% during the accounting period.

MLC output = (MLC input during accounting period) * (1 - material loss rate)

Using the input breakdown and conversion rates provided earlier, we can calculate the MLC input for the accounting period as follows:

MLC input = (40 tons / 0.9) + (20 tons / 0.9) = 62.22 tons

Then, using the material loss rate of 5%, we can calculate the output of MLC material as follows:

MLC output = 62.22 tons * (1 - 0.05) = 59.11 tons

The output breakdown for the accounting period is then:

- Source A MLC material: 23.64 tons (40% of MLC output)
- Source B MLC material: 11.82 tons (20% of MLC output)
- Source C non-conformant material: 22.74 tons (30% of non-conformant input)
- Source D non-conformant material: 7.58 tons (10% of non-conformant input)

This demonstrates how the mass balance system can be used to track the input and output of different sources of feedstock or monomer, and determine the percentage of each source in the final product.