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Exploring the Circular Solutions for Plastic Reduction: Case Studies of New Transition Journey

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Abstract

We live in the plastic age, producing over 300 million tons of plastic every year globally. Plastic is a fundamental commodity in the global economy, but with low rates of reduction, reuse and recycling. A circular economy (CE) stands as a viable solution to the increasing global demand for plastic and other resources, and their worldwide impact on climate change and the environment. The purpose of this study is to shed light on possible solutions for reducing plastic usage in our daily lives under a circular economy paradigm by reduction, reuse and recycling in the public and private sectors, and the role of government in promoting circular economy initiatives. This analysis makes clear the intent and result of circular economy policies. Their goal is to enable a transition to a circular economy to avoid waste and reduce plastic, while maintaining their value in the economy.

Keywords

Circular Economy, Plastic Waste, Recycling, Policy, Governance, Case Studies

1. Introduction

Governmental organizations report increasing pressure on our global resources and climate due to human activity (WBCSD, 2011). According to the European Commission (2015), a circular economy approach is viewed as a promising means to help reduce global sustainability pressures. For example, the European Commission (2015) associated the move towards a circular economy with strategies such as: boosting recycling and preventing the loss of valuable materials; creating jobs and economic growth; showing how new business models, eco-design and industrial symbiosis can move Europe toward zero-waste; and

reduce greenhouse emissions and environmental impacts.

A circular economy (CE) is one where resources coming into the economy are not allowed to become waste or lose their value. Instead, those resources are recovered for productive use for as long as possible (Benton et al., 2014). Plastic is a precious resource, and plastic pollution can be prevented by applying a waste hierarchy to the plastic economy in order to enormously upscale the reduction, reuse and recycling of plastic waste. When lost to the environment plastics degrade in quality, so many higher-value opportunities for reuse and recycling are lost. Many plastics are designed for single use without planning for potential after-use pathways of reuse, recycling, or composting. As such, they are inconsistent with a circular economy and fail to account for their end-of-life phase. In addition, according to Watkins et al. (2017), many products contain toxic chemical additives or contain composite materials, rendering them difficult or impossible to recycle—meanwhile, the costs of inaction are high. The impact of plastic pollution on the oceans alone is at least US$ 8 billion per year, based on natural capital costs, the costs of action can be significant but have the potential to create value, especially when considering upstream activities such as plastic packaging design that enables high quality recycling. Downstream ocean clean-up is generally extremely costly, largely too late and only addresses part of the problem, because clean-up action comes only long after plastics have broken down into smaller fragments which become widely dispersed, causing pollution that damages ecosystems and health. Therefore, clean-up must be a last-choice intervention (UNEP, 2015).

Circular economy is considered a possible solution to assuage problems such as the increasing global demand for resources, climate change and worldwide pollution. Kirchherr et al. (2017) defined CE as: "an economic system that is based on business models which replace the 'end-of-life' concept with reducing, alternatively reusing, recycling and recovering materials in production/distribution and consumption processes, with the aim to accomplish sustainable development, which implies creating environmental quality, economic prosperity and social equity, to the benefit of current and future generations." Thus, CE aims to maximize the use of resources and minimize green energy emissions and waste until zero waste is achieved. Under the principle that no item is wasted and every product can be newborn and process a long-life output are maximized by preserving products for as long as possible.

Although regularly discussed and described in practice-based circular experience projects, there is still little academic research and literature on the systematic understanding and nature of plastic pollution and how policy and industry practices can be aligned to incentivize the adoption of circular economy principles in the plastic industry.

The study highlights the importance of transitioning to a circular economy as a means to address global sustainability pressures, particularly focusing on the issue of plastic pollution. The research gap and potential research questions can be identified as follows:

RQ1: How can circular economy principles be effectively applied to the plastic economy to promote reduction, reuse, and recycling, considering the current challenges and barriers in the industry?

RQ2: How can policy frameworks and industry practices be aligned to incentivize the adoption of circular economy principles in the plastic industry?

RQ3: What are the potential regulatory and economic instruments that can facilitate this transition?

The remaining of the study is structured as follows, we review the relevant literature, which will lead us to have a better understanding of its theoretical background, practices and policies across governmental organizations in a global context, and the research design was centered on the comparison of two case studies.

2. Literature Review

2.1. Theoretical Background—Linear to Circular Approach

George et al. (2015) presented a theoretical model incorporating the concept of circular economic activities by constructing a circular economy model with two types of economic resources: a polluting input and a recyclable input. There are countries that have made an effort to implement circular economy models in the plastic packaging industry, such as Austria (Van Eygen et al., 2017), the United States, Sweden (Singh & Cooper, 2017), Finland (Dahlbo et al., 2017) and The Netherlands (Brouwer et al., 2017). **Figure 1** below outlines the linear nature of plastic management. The greatest challenge in managing plastic waste in the country has been the end-of-life-cycle phase. Such waste from the public and industrial/private sector is managed formally by country environmental departments through the collection, disposal in designated places and incineration. Hence, linear business models result in many environmental challenges as resources become depleted, ending up as waste and emission since they rely on virgin resources (Wagner, 2017).

There exist various studies and models on how to prolong life-span, reuse and recycle plastic products, more so at the end-of-life phase (Oghazi & Mostaghel, 2018). A circular economy is frequently defined as a combination of reduction, reuse, and recycling activities. Reduction is mostly achieved through policy measures such as bans, restrictions, and taxes. Researchers have analyzed how plastic waste can be recycled and used in the production of other products as a raw material. Circular business models based on remanufacturing and reusing bring about significant cost savings associated with radical reductions in environmental impact. Circular business models are a potential way for industries or companies to profitably achieve a significant increase in resource productivity. Thompson et al. (2009) find that given the decline of fossil fuel reserves, and finite capacity for disposal of waste to landfills, the linear use of hydrocarbons through packaging and other short-lived applications of plastic, will not prove sustainable in the long run (Mwanza & Mbohwa, 2017).

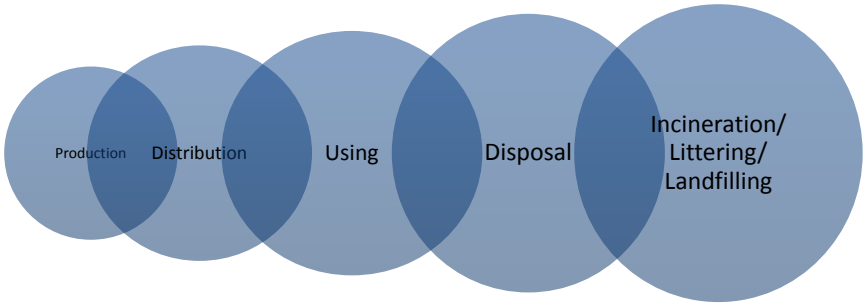

Figure 1. Linear economy model George et al. (2015). Source: The Researcher.

The other problem is that certain types of plastics are unsuitable for recycling. For example, composite plastics with multiple layers of different resin codes (e.g., beverage containers) are highly problematic in recycling. They have little use and must be down-cycled to recover energy from plastic waste. This process emits a considerable amount of air pollutants and deprives plastic of its future utilization possibilities as a material. Hence, it's below recycling on the waste management hierarchy. Nwabue et al. (2017) demonstrate how the recovery of the plastic waste into refuse-derived fuel by incorporation in the production of bio-coal briquettes can be considered as part of waste management options, especially in developing countries.

2.2. Circular Economy Practices across Governmental Organizations in a Global Context

The ongoing transition to a circular economy in many countries has the potential to identify policies that can facilitate global objectives on plastic waste. Previously, commitments to reduce levels of marine litter were not integrated with wider objectives on resource efficiency and waste management. Actions in both the public and private sectors that support a transition to a circular economy provide a framework to enhance the effectiveness of a plastics system through better design, increase its resource productivity and reduction from plastics, including marine litter and its impacts.

Many countries have developed resource efficiency and circular economy strategies that integrate objectives to transform the plastics sector and simultaneously reduce marine litter. The Dutch strategy "A Circular Economy in the Netherlands by 2050" highlights marine litter as a global issue (Dutch Government, 2016). Furthermore, 12 countries have recently joined the International coalition to reduce plastic bag pollution to promote the elimination of single-use plastic bags. The European Union Action Plan for the Circular Economy (European Commission, 2015) commits the European Commission to help reduce the impacts of marine litter while increasing the value of materials in the EU economy. A forthcoming Strategy on "Plastics in the Circular Economy" is expected to become one of the main vehicles for addressing marine litter in the EU, with the reduction of leakage of plastics as one of its three core objectives. Innovative

industries have likewise made commitments to improve the design of their products and packaging, particularly plastics, recognizing the dividends that exist in reducing plastic waste. One of the top five global consumer goods companies has committed to ensuring that by 2025, it is technically possible for 100% of its plastic packaging to be reused or recycled and there are established examples that it is commercially viable for plastics re-processors to recycle the material (ten Brink et al., 2016).

In view of the fact that some circular economy practices are long-established, the majority of these initiatives are still in an immature phase, and plastic reuse and recycling rates remain low in all countries, especially in the case of lower-value products. Whereas some countries are clear leaders in the development of advanced waste management infrastructure, plastic packaging is one of the major mess makers of waste, inefficiency and litter creation within the global economy. Although circular economy thinking has shown closed loop systems can provide greater social and environmental benefits when confined to bottom-up supply chain management systems, advantages of waste governance at multiple spatial levels can also be noted (Ghisellini et al., 2016).

Waste is a guaranteed component of any urbanized landscape and the management of waste has existed for centuries. Propelled by an economic philosophy of exponential growth through consumerism, the availability, complexity and rapid manufacturing of consumer products is creating unsustainable levels of "waste" material outputs. These point to the urgent need to remodel the way waste is managed (Rootes, 2009). Waste management has for the most part provided end-of-pipe solutions, whereby increasing amounts of discarded materials are buried, dumped out at sea or turned into ash, creating the need for the extraction of further raw materials. These methodologies do not make the best use of the waste as a resource or do not deliver satisfactory environmental outcomes. The waste industry is now recognized as an underutilized "resource industry" in its own right, with increasing focus on waste having inherent economic value. Formal and informal recycling practices have emerged as a dominant force, central to most waste management programs in the developed world (Karani & Jewasikiewitz, 2007). In addition, increasing focus on circular economy and economic innovation during recent times of slow international growth has also seen more economic policy focus on waste management.

Cramer (2017) introduces substantive policy innovations in waste management that have emerged over the last decade to address the growing demand for materials and mounting evidence of ecological and societal impacts of our throw-away consumerist economy. Whilst some policies aim at reforming traditional waste management frameworks, others fundamentally re-conceptualize and reframe it altogether. The world of waste management is moving away from conventional landfills and recycling of both municipal and industrial waste towards an integrated waste policy. Programs involving zero waste targets and 100% diversion from landfills are increasingly noted with rising urban densities

and land prices in major cities across the world. Sustainability outcomes, sustainable production, consumer behavior and circular economy programs all underpin new standards in governance structures and waste policy intervention. Likewise, environmental regulations, material cost and material poverty are creating an awareness of eco-design benefits in linking end-of-life waste materials as recycled/returned inputs to earlier production stages (UNEP, 2011).

Governments and legislators should develop standards and definitions to provide clarity to producers, linking the design of products and packaging to the collection, sorting and recycling of these items. Confusing definitions of what is waste and what is a resource can inhibit the reuse of otherwise valuable materials. Products with notable externalities should be regulated and where appropriate banned. The United States has legislated for a nationwide ban on the manufacture of rinse-off microbeads from 2017 (Congress, 2015).

2.3. Developing Policy for a Circular Economy of Plastic Waste

Schweitzer et al. (2018) indicate that plastic production must be decoupled from primary raw materials, and over-packaging or unnecessary applications of plastics must be avoided where sustainable or less material-intensive alternatives exist. Plastics are predominantly produced from fossil raw materials, so wasting plastic drives pollution and plant energy losses. Alternative raw materials exist for plastics, including those based on biomass. However, these can have major sustainability impacts (on land and water use, biodiversity, indirect greenhouse gas emissions and creating competition with food production) and with current technologies cannot be scaled up to meet more than a fraction of the potential demand.

Recycling can supply secondary material, but there are often challenges to recycling (mechanical, material and chemical) depending on the type of plastics. To increase the uptake, quality and economics of recycling, concerted efforts are needed on upstream design and on downstream collection, sorting and reprocessing. This will also contribute to wider de-materialization of economic growth. Markets continue to favor primary raw materials over recycled materials, and until the costs of negative externalities are internalized, unsustainable applications of plastics remain financially viable (PBL, 2012).

Upstream and design-led approaches to reducing plastic waste and pollution are cost-effective ways to implement a waste hierarchy. Without redesign many plastic products cannot be reused or recycled, currently, as much as 30% of packaging products are destined for landfill or incineration (EMF, 2014). All products should be designed with an after-use pathway in mind in order to facilitate the reuse of plastics in the circular economy. Innovative solutions should address those products that have functional added value in the economy but cannot currently be recycled. This includes exploring alternative materials or products where they exist, for example, using natural alternatives to plastic micro beads in personal care products or for ship-blasting. Designers and produc-

ers should avoid creating products that are inherently single-use or inevitably destined for landfill. Furthermore, voluntary industry commitments can provide leadership for sector wide action. One of the big five global personal care product manufacturers pledged in 2017 to switch from plastic to paper-based cotton bud sticks, recognizing that their product contributed to plastic marine litter (Cottonbud Project, 2017).

Special attention needs to be given to designing plastics without toxic chemical additives, as this undermines their potential for secondary uses as well as creating health and ecological risks. Chemical regulations need implementation and reform to phase out toxic chemicals through substitution and circular economy solutions. For some applications, non-plastic materials may provide innovative, cost-effective and competitive alternatives with beneficial outcomes. Such substitutions and alternatives should be explored, researched and developed, alongside the re-design of old-generation plastic products to improve their reparability and recyclability. The cycling of materials should be the focus of innovation, but further research is needed to understand the potential role of alternative raw materials, for example, bio-based plastics and their potential for CO_2 capture and other impacts, both positive and negative (UNEP, 2015).

3. Methodology

To comprehensively examine policy developments in enhanced plastic and waste management within the context of the circular economy, a structured methodological approach was employed. The research design centered on the selection of two case studies: 1) the Recycling Regulations in Taiwan region and the 4-in-1 Recycling Program, and 2) Japan's Sound Material-Cycle Society Plan. These cases were chosen to highlight alternative approaches into circular economy principles, governance structures, and policy outcomes in the context of enhanced plastic and waste management.

The rationale behind the selection of these particular case studies lies in their status as representative exemplars that provide a nuanced understanding of the multifaceted dimensions of enhanced plastic and waste management policies. Taiwan region's Recycling Regulations and the 4-in-1 Recycling Program exemplify a concerted effort to integrate circular economy principles into local, regional, and national waste management initiatives. The selection of Japan's Sound Material-Cycle Society Plan adds an additional layer of diversity, presenting an opportunity to explore alternative approaches to enhanced plastic and waste management on an international scale.

The research process entailed an in-depth review of existing academic literature and authoritative assessments conducted by prominent government bodies and researchers. This comprehensive literature review serves as a foundation for establishing an understanding of how circular economy principles are being applied in each case. Key documents, such as political materials, policy instruments and programs, industry reports, and published quantitative results, were subject

to meticulous document analysis. The comparative analysis seeks to draw attention to the varying governance structures and policy outcomes, providing insights into the effectiveness of different strategies in achieving enhanced plastic and waste management goals. Each case serves as an illustrative example of local, regional, and national policy programs dedicated to advancing circular economy practices in the context of waste management.

The comparison highlights of the increasing value attributed to governmental actions and public policy management of waste as a resource within the circular economy framework. The study illustrates how the role of governments in shaping policies not only address environmental concerns but also enhance the potential economic and social value inherent in waste materials. In essence, the methodology employed in this study combines a subtle case selection process with a robust literature review and document analysis. This approach aims to contribute meaningful insights into the intricacies of enhanced plastic and waste management policies, facilitating a deeper understanding of the global landscape and paving the way for informed recommendations and future research directions in the realm of circular economy practices.

3.1. Research Process

A review of existing academic literature as well as governmental assessments provide a balanced understanding of how a circular economy is being applied in each case. Document analysis includes, policy instruments and programs, industry reports and published quantitative results. The research process is shown as below in Figure 2.

3.2. Case Selection Criteria

A set of discerning criteria was employed to judiciously select two illustrative case studies. First and foremost, the chosen cases were required to exemplify a steadfast commitment to the principles of the circular economy, with an emphasis on the reduction, reuse, and recycling of plastics and waste materials. This foundational criterion ensured a thematic alignment with the overarching global imperative of sustainable resource management.

Consideration was given to the diversity in governance structures represented by the selected cases. This encompassed variation in regulatory frameworks, institutional arrangements, and the mechanisms employed for policy implementation. By incorporating this criterion, the analysis looks at distinct impacts of governance models on the outcomes of enhanced plastic and waste management policies.

Figure 2. Research process. Source: The researcher.

In selecting cases, a global context and applicability criteria were paramount. The chosen cases were assessed not only for their local relevance but also for their potential applicability to diverse socio-economic and cultural contexts on a global scale. This strategic consideration was aimed at ensuring that the insights gleaned from the analysis could transcend geographical boundaries and contribute to the formulation of universally applicable strategies for enhanced plastic and waste management. Integral to the selection process was the identification of cases demonstrating policy innovation and effective implementation strategies within the realm of enhanced plastic and waste management. This criterion enabled an in-depth exploration of successful policy interventions, shedding light on the intricacies of their design and the implications for the broader adoption of circular economy practices.

Additionally, the cases were selected based on their multilevel impact: at local, regional, and national levels. This criterion facilitated an understanding of the scalability and transferability of successful policies across different geographical scales, and the potential for broad societal transformation. The temporal dimension was addressed through the inclusion of a longitudinal criterion, which mandated that the selected cases offer insights into the evolution of enhanced plastic and waste management policies over time. This longitudinal lens enabled the identification of trends, challenges, and opportunities for sustained circular economy practices in a historical context.

Finally, stakeholder engagement emerged as a necessary criterion, requiring active participation and collaboration among governmental bodies, industries, research institutions, and the public. This criterion acknowledged the multifaceted nature of policy implementation and sought to capture diverse perspectives and interests, thereby contributing to a more comprehensive and distinct analysis.

4. Comparable Case Studies

4.1. Recycling Regulations in Taiwan Region and the 4-in-1 Recycling Program

Taiwan region is a circular economy pioneer and is known for its high recycling rate, bubble milk tea industry, and hardware plants that feature advanced technology. Taiwan region is now experimenting with circular economy, humanity's potential saving grace. Often misperceived as "just recycling," circular economy is both an idea and a system focused on maximizing the effectiveness of resources and minimizing waste. To transform theory into practice, circular product design is key. "When we try to design a product, before we produce it, it should be evaluated throughout the life stage of the product to make sure that no energy or material is wasted throughout its life cycle," explains Dasdy Lin, Sustainability Consultant at Taiwan region's Plastics Industry Development Center, a government-supported plastics think tank.

Under Taiwan region's 4-in-1 Recycling Program, public and private sectors

obtain industrial and household plastic and recycle them into new forms. Materials are then put back into the industrial production stream in an effective end-of-life sorting process, meeting the ultimate goal for circular economy: preventing waste. Circular economy is part of the innovative industries initiative, a national development strategy aimed at revitalizing the economy of Taiwan region while supporting environmental sustainability.

Recycling Regulations in Taiwan region

Three amendments to the Waste Disposal Act (WDA) make up the foundation of the recycling system in Taiwan region:

• In 1988, Article 10-1 of the WDA required for the first time in Taiwan region that manufacturers and importers bear financial responsibility for recycling by forming associations to fund recycling.

• In 1997, the requirement changed with another amendment to the WDA that established the 4-in-1 Recycling Program. Instead of forming associations to fund recycling, manufacturers and importers now had to pay a recycling fee to the Environmental Protection Administration Taiwan region (EPAT) and offer collection of waste for recycling from consumers. The fees feed into the Recycling Fund, which subsidizes collection and recycling by licensed enterprises and is the key element of the 4-in-1 Recycling Program. The Fund's establishment marked a milestone in the history of Taiwan region's recycling regulations. This amendment also led EPAT to create the Recycling Fund Management Board (RFMB) to operate the Recycling Fund.

• In 2001, the Waste Disposal Act was revised again, expanding regulations under Article 10-1 to clarify responsibilities of manufacturers, importers and recyclers under the 4-in-1 Program.

The 4-in-1 Recycling Program:

Before 1997, although the Waste Disposal Act had required manufacturers and importers to recycle Regulated Recyclable Waste (RRW), the collection channels were not coordinated, so the collection rate was low. Furthermore, manufacturers and importers did not invest in recycling facilities due to underdeveloped regulations and incentives. In 1997, EPAT created the "4-in-1 Recycling Program" to better connect all parties involved in RRW collection channels, including community residents, recyclers and collectors, local governments, and the newly established Recycling Fund. Through the incentives associated with the Fund, the 4-in-1 Recycling Program has increased recycling rates and reduced the amount of solid waste sent for disposal. The structure of the 4-in-1 Recycling Program is illustrated in **Figure 3**.

Components of the 4-in-1 Recycling Program:

• Waste Generators: To form community-based recycling organizations and promote the separation of wastes and recyclables.

• Community Residents: Community residents make up the foundation of the 4-in-1 Recycling Program. Residents who deposit their waste at local collection points serviced by municipal collection teams must separate their recyclable,

non-recyclable, and organic wastes. Except for community residents, there are many citizen groups and charity organizations that work to increase recycling in communities and schools. These groups conduct recycling education programs, collect RRW for charities and donation for reuse, and collect RRW for sale to recyclers.

As of 2011, there were a total of 3200 communities and 3500 schools carrying out recycling. Through requirements and voluntary actions, RRW collection points have been installed in public places such as national parks, scenic spots, public transportation stations, as well as chain stores and supermarkets. These expanded collection channels make it convenient for citizens to send RRW for collection and recycling (Environmental Protection Administration, Executive Yuan, 2014). The Management Structure of the 4-in-1 Recycling Program is shown as below in **Figure 4**.

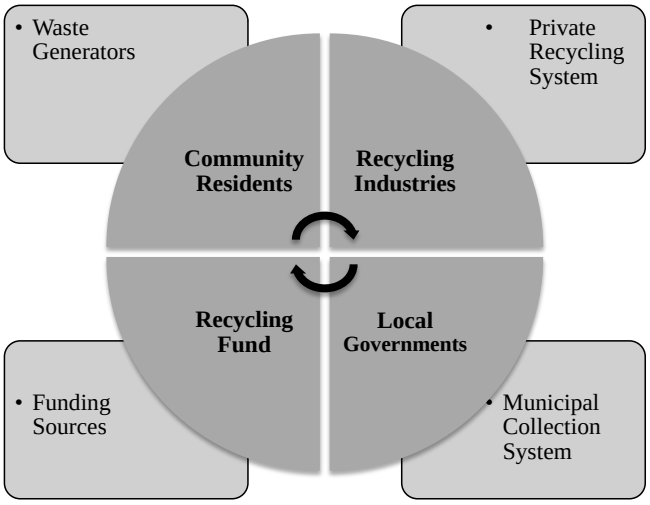

Figure 3. The 4-in-1 recycling program. Source: The researcher.

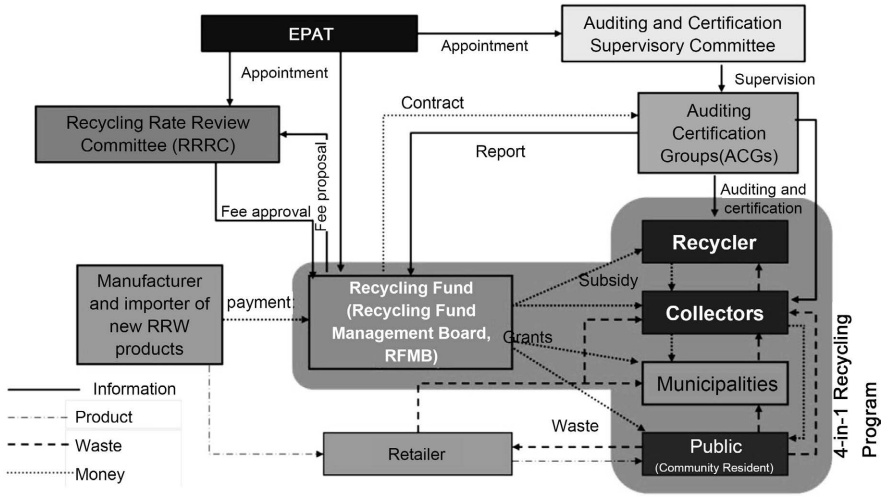

Figure 4. Management structure of the 4-in-1 recycling program. Source: Environmental protection administration taiwan region.

• Private Recycling System: To purchase wastes from the public, communities and local governments.

• Recycling Industries: Private recyclers and collectors buy waste materials, including Waste Electrical and Electronic Equipment (WEEE), from residents, communities, commercial enterprises and others in order to recover commodities from these wastes and generate revenue in the process.

• Municipal Collection System: To transport wastes and recyclables separately, and part of the revenue is given to the general public.

• Local Governments: Authorities such as municipalities and local governments organize municipal collection teams to collect Regulated Recyclable Waste (RRW) and other wastes from community collection sites. They sell RRW and other Municipal Solid Waste (MSW) of value to private recyclers and give a portion of the income back to the local government in order to fund grants for community waste collection sites.

• Funding Sources: To be paid by responsible enterprises as well as to subsidize the collecting and recycling system.

• Recycling Fund: The Recycling Fund fuels the 4-in-1 Recycling Program because it subsidizes municipal RRW collection as well as private collectors and recyclers who meet EPAT's environmental and safety standards. Under the 4-in-1 Recycling Program, manufacturers and importers of new RRW products, including electrical and electronic equipment, are required to pay fees to EPAT depending on the number of items they put on the market. These fees feed into the Recycling Fund, which is managed by The Recycling Fund Management Board (RFMB).

Summary of Recycling Regulations in Taiwan region and the 4-in-1 Recycling Program

The 4-in-1 recycling system not only created a high recycling rate of Polyethylene terephthalate (PET) bottles, but also enabled the recycling of 67 product items from 13 categories. The recycling rate was 58% in 2016, 10 times that of 1998.

Taiwan region strives to turn wastes into resources and promote circular economy, so as to achieve the goal of total resource recycling and sustainable materials. The authorities and local governments are now focusing on recycling organic wastes for renewable energy, hoping to create reuse value with recycling technology, and turning in-organic wastes into cement additives and construction materials, as well as recovering precious metals for reuse.

4.2. Japan's Sound Material-Cycle Society Plan

Japan's recycling initiatives date back to the late 1970s. The urbanization of Japan's municipal cities in the mid-1980s combined growing economic influence, high-density population and mass-consumption, creating difficulties for Japanese municipalities to resolve and manage waste and recycling problems. Responding to these changes, Japan experienced a policy transition in waste and re-

cycling management towards a nation wide framework founding—a "Sound Material-Cycle Society". Three essential plans were produced and published by the Ministry of the Environment Japan (2013). Japan's Sound Material-Cycle Society Governance Structure is shown as below in **Figure 5**.

The 3Rs (Reduce, Reuse and Recycle) guiding Japan's National Policy towards a Sound Material-Cycle Society:

The policy logic of the waste hierarchy (reduce, reuse, recycle, recovery, and disposal) prioritizes the reduction and reuse of materials ahead of recycling and disposal solutions in order to reduce mass-consumption and waste generation. Consequently, Japan's Sound Material-Cycle Society (SMCS) plan incorporates reduce and reuse principles to enhance the existing recycling, recovery and disposal treatment processes (EEA, 2014). The use of the term "society", presents a new philosophy in policy direction with a focus of societal aspirations and community engagement. This suggests that SMCS moves beyond an objective focused on waste and material management, yet it is rather more encompassing.

Japan's vision to establish a "Sound Material-Cycle Society", originated in 2000 through the successive development of the first essential plan, initiated by the re-structured Ministry of Environment, Japan (MOEJ). By 2008 a second essential plan for Establishing a Sound Material-Cycle Society was published addressing goals for the end of 2015. Following that, a third essential plan was published in 2013, which revised the plans in light of the 2011 East Japan earthquake disaster, setting goals to 2020. The principles guiding the plan focused on the 3R concept (Reduce, Reuse and Recycle). The policy required focused government supervision in order to input a legal framework to ensure compliance and provide consolidated subsidization for the disclosure of high-tech materials management infrastructure nationwide.

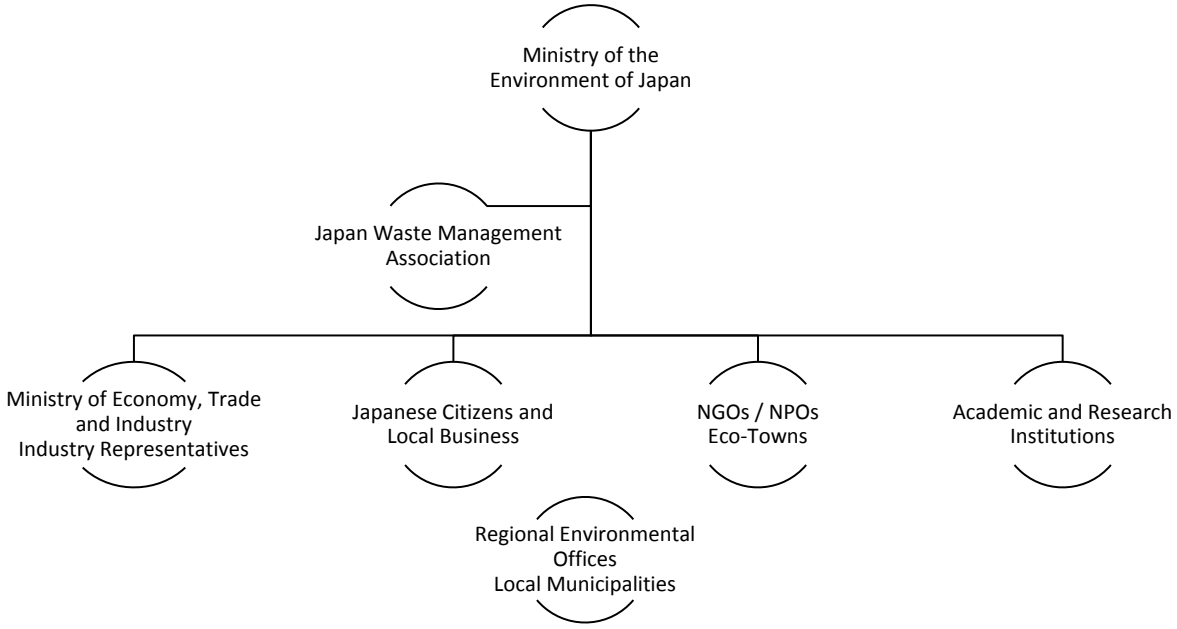

Figure 5. Japan's sound material-cycle society governance structure. Source: The researcher.

1) Reduce

According to Connett (2013), Japan's waste reduction progress does not fully account for materials lost in this process; thus the foundations of the 3R philosophy (Reduce, Reuse, Recycle), especially "reduce" is not sufficiently met, or well developed.

Pariatamby and Tanaka (2014) report 93% of Municipal Solid Waste (MSW) was treated through incineration processes, with only a small number of recycling plants linked to recovered energy in 2010. Reviewing the focal documents associated with the SMCS transition produces similar findings to that of Sustainable Materials Management (SMM) with respect to the importance on the life cycle of materials. It is important to recognize these different variables when weighing waste management policy across geopolitical regions.

2) Reuse

Silva et al. (2016) define reuse as a steady increase in Cyclical Use Rate, which provides an indication of the utilization of existing materials rather than those newly imported. Reuse and recycling mechanisms work closely together to ensure this Key Performance Indicator (KPI) is met. The Essential Plan's (2013) established "Effort Indicators" include power generation and heat utilization from waste within the reuse strategies. However, power and heat recovery through incineration debatably do not align with the reuse concept.

The SMCS Policy framework considers an item recycled only for later re-sale as a resource in the circular market. This policy encourages higher-quality design and disassembly considerations at the manufacturing point (Ongondo et al., 2011). The Japanese government used the concept of Circulative Resources (CR's) as an alternative approach referencing the cyclical and circulative terminology continuously throughout the essential plan is coherent with the more circular economy discourse.

3) Recycle

Hotta (2013) summarizes the existing Japanese government acts for recycling regulations and legislations, which include: Construction Materials (2000), End of Life Vehicles (2002), Container and Packaging (2006), Food Waste (2007) and Home Appliances (2012). To motivate the public to promote SMCS and the 3R's policies, the Ministry of Environment, Japan (MOEJ) collaborated with and subsidized the Eco-Towns program, a grassroots approach to boost recycling performance through Eco-Industrial development in selected towns (Hosomi, 2015). The Japanese plan demonstrates the need to promote the recycling industry and advance the techniques of the recycling processes to achieve circular economy goals.

Japan's leadership in technology and innovation on an international level is also identified as a motivation for the "Sound Material-Cycle Society" to facilitate Japan's global competitiveness in the emerging "Secondary Raw Materials" industries (Silva et al., 2016). Under the Japanese government's essential plans framework, they carried out a variety of governmental agenda and legislative

policy using KPIs. KPIs include: emissions measurements, number of recycling plans regulated by local governments, average use times of durable consumer goods, resource consumption per capita and reuse and circular market size.

4.3. Findings and Discussions

Table 1 provides a comparative overview of the Recycling Regulations in Taiwan region's 4-in-1 Recycling Program and Japan's Sound Material-Cycle Society Plan, highlighting key aspects such as objectives, waste transformation, resource recovery, global competitiveness, and governmental involvement.

Table 1. Comparison between Taiwan region's 4-in-1 RECYCLING PROGRAM and Japan's Sound Material-Cycle Society Plan.

Aspect	Recycling Regulations in Taiwan region 4-in-1 Recycling Program	Japan's Sound Material-Cycle Society Plan
Objective	Achieve a high recycling rate and promote circular economy principles. Focus on Polyethylene terephthalate (PET) bottles and 67 product items across 13 categories.	Promote a "Sound Material-Cycle Society" to enhance global competitiveness in the emerging "Secondary Raw Materials" industries.
Waste Transformation	Emphasis on turning waste into resources and promoting circular economy. Focus on recycling organic wastes for renewable energy and creating reuse value through recycling technology.	Motivated by Japan's leadership in technology and innovation. Governmental agenda includes emissions measurements, recycling plans by local governments, average use times of consumer goods, and circular market size.
Resource Recovery	Aims to recover precious metals for reuse and turn inorganic wastes into cement additives and construction materials.	Focus on the development of "Secondary Raw Materials" industries, emphasizing resource recovery through emissions measurements and circular market size.
Global Competitiveness	The focus on circular economy principles aligns with global sustainability goals.	Identified as a motivation for the Sound Material-Cycle Society, enhancing Japan's global competitiveness in the emerging "Secondary Raw Materials" industries.
Governmental Involvement and Legislation	Actively involved in recycling initiatives. Focus on legislative policies and local government regulations.	Utilizes Key Performance Indicators (KPIs) for emissions measurements, recycling plans, consumer goods use, resource consumption, and circular market size under a governmental framework.

Source: The researcher.

5. Conclusions

Nowadays, concern regarding sustainability is the reason for changes in the current linear production system, changes that are necessary in order to try to stop climate change and other environmental problems. Circular Economy is considered to be a possible solution to face these problems. Specifically, on December 2015, the European Commission issued a report entitled "Close the Circle: An Action Plan of the European Union for the Circular Economy" seeking a transition towards a more circular economy, where products, materials, and resources are kept in the system for as long as possible while minimizing the generation of waste (European Commission, 2015).

From the study carried out we can conclude that two cases analyzed follow similar approaches regarding the strategic lines and policies established to promote a circular economy. Established policies have found that it is fruitful to promote circular economies on three fronts—economic, social and environmental. The policies follow the wisdom of the 3Rs: reduce, reuse and recycle. The first of these seeks a reduction in energy and water consumption, waste generation and single use plastics. Reuse is focused on the reuse of energy. Recycling is aimed at incentivization, management, separation and classification of waste.

For all the progress made thus far, researchers and practitioners believe Taiwan region's greatest challenge to achieving a circular economy is the lack of a systematized, department-wide policy and a clear definition for all stakeholders of what circular economy actually is. The most effective solution would be to have laws and regulations in place. Many countries have banned the use of plastic bags and plastic containers. France is aiming to stop all production of single-use plastic by 2020. Taiwan region is aiming to ban single-use plastic by 2030. But it's also critical that enterprises work towards a circular economy framework—where they design their operation process to optimizes the use of resources and minimize waste before it takes place. The current economy model isn't sustainable enough especially with the global population growth.

Sustainable alternatives to plastic have to be invented, plastic use is in almost every part of our daily lives after all. It shows that there is a demand for a material more than the plastic. From the government bodies and consumers angle, we can pursue possible solutions for reducing the usage of plastic in our daily life following the 3 R's: 1) reduce—think about ways to reduce our reliance on plastic, use reusable or paper containers, cups, straws, utensils and bags to avoid using single-use plastic; 2) reuse—reuse plastic containers and bags, or find ways to repurpose them; 3) recycle—encourage a social ethic to recycle the plastic through early education and advertising.

Eventually, circular economy has the potential to transform Taiwan region and distinguish it as a leading model for Asia. It takes many volunteers, entrepreneurs, and public and private sectors that are willing to engage in this socio-economic experiment. Some see circular economy as Taiwan region's path to

self-sufficiency while others perceive it as a solution to Taiwan region's identity challenge with resource recycling becoming the front-runner of what Taiwan region is known for.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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