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*Review*

# A Review of Circular Economy Development Models in China, Germany and Japan

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**Abstract:** The circular economy (CE) concept is gaining traction as a sustainable strategy for reducing waste and enhancing resource efficiency. This concept has been adopted in some countries such as Denmark, Netherlands, Scotland, Sweden, Japan, China, and Germany while it is being considered by others including England, Austria, and Finland. The CE has been employed in the manufacturing, agricultural, textile, and steel industries but its implementation varies. It is against this backdrop that this study seeks to identify CE implementation in three pioneering countries (China, Japan, and Germany). A critical review and analysis of the literature was conducted. The results revealed enabling and core policies/laws for the development of the CE concept. It also identified the implementation structure of the CE in China, Germany, and Japan. In conclusion, the findings of this study are expected to serve as a guide for developing and implementing the CE concept in various sectors of the economy.

**Keywords:** China; circular economy; Germany; implementation; Japan; resource efficiency; waste management

## 1. Background of the Study

The linear economy is a waste-generating model. It is a system where resources become waste due to production and consumption processes [1]. The linear economy model is a "take-make-waste" approach [2,3] that extracts raw materials to manufacture products, which are disposed of by consumers after use. This suggests that linear material processing presents challenges such as resource depletion and pollution [4]. Therefore, the linear economy model can be described as problematic [5], ecologically inefficient, and economically viable in the short-medium term [1], which makes it unsustainable.

Several authors [6–11] have argued that the CE is a sustainable development concept that mitigates unsustainable material production and consumption. The CE is seen as an alternative to the linear economy model. It is described as a "resource-product-waste-regenerate resource" model that utilises resources and effectively protects the environment [12]. With the CE, pollution is reduced, and waste is minimised owing to efficient use and re-use of resources and recycling [13]. It is understandable that the CE focuses on product use rather than production processes, which implies taking care of existing products through re-use and recycling instead of producing new ones [14].

The CE is "an economy system which is characterized by principle of sustainable growth and depends less on depletion of natural resources than traditional economies through the mechanism of recycling the waste output of its system" [15]. In practice, it depends on economic development by reducing resource consumption and emissions of pollutants, reuse of waste, and recycling of materials [10]. CE seeks to harmonise development between sustainability's triple bottom line (social, economic, and environmental). Socially, job opportunities are expected to be created [16,17] and strong cooperation among various actors in society is expected [5]. It offers enormous business

opportunities economically [10,16–18] and ecologically, it lowers demand for resources and improves the ecosystem [5,12].

The CE is gaining more and more attention by researchers, policy makers, and governments. It has evolved over time and has been adopted by some organisations and sectors in their activities and operations. As a sustainable model, the CE could be applied to any sector of the economy. However, while the CE has been acknowledged as a potential alternative to the linear economy in the literature, it is yet to be applied in some countries, particularly those in Africa. Lack of awareness of the implementation processes [19–23] and information [11,24] may be responsible for its non-adoption. The implementation of CE varies but requires the support of all stakeholders at all levels. Likewise, some policies or legislations are required to effectively implement the CE [25,26]. This paper sets out to summarise and create awareness about the CE in three pioneer countries—China, Germany, and Japan. A study of the implementation process and concepts/strategies including policies or legislations adopted in these countries were presented. Though, the implementation involved some processes that cannot be mechanically copied to each country because of their uniqueness [27]. This paper specifically identifies such policies and laws that were used by the pioneer countries. It intends to make several contributions to the literature and policy. The main contributions of this review relate to providing a summary of the CE implementation, enabling laws and policies, and serves as a guide for countries planning to introduce the concept.

## 2. Research Methodology

The goal of this study was to determine the implementation methods of the CE concept in three pilot countries. A desktop study review of the development of CE in China, and similar concepts in Japan and Germany were conducted. China was selected based on its track record in the development and implementation of the CE concept. Japan and Germany were included due to their effective waste management strategies, which are closely related to the CE concept being the pioneers. The review has been systematically approached and Figure 1 summarises the process.

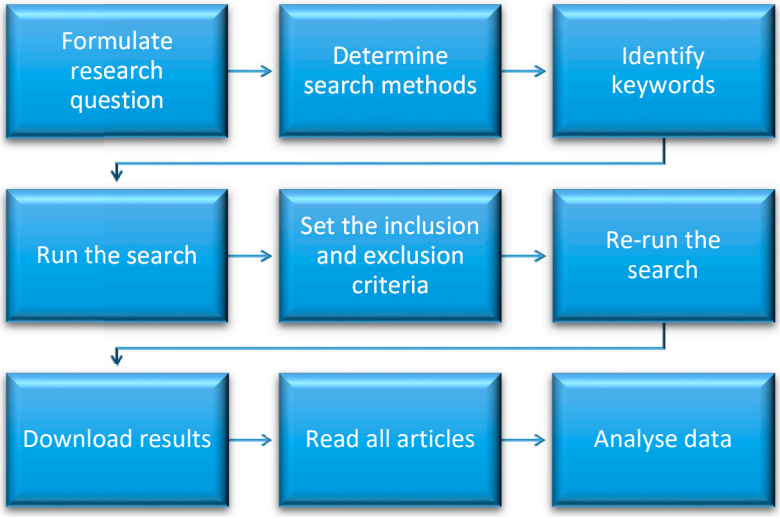


**Figure 1.** Desktop review process.

Following the development of the research question, electronic databases including Google Scholar, Web of Science, and Scopus were identified as data sources due to their wide coverage of published and unpublished articles. In addition, government databases were also included. Keywords such as "circular economy", "waste", "resource efficiency", "waste management", "waste management policies", and "waste disposal" were introduced to find relevant studies while Boolean notation (e.g. "and", "or") was used with the keywords to expand the search. For instance, more than a thousand articles were generated by the search entry—circular economy "and" China. The inclusion

criteria—year of publication (2000 to 2019) and language (English)—were determined in order to collate relevant and current data on CE and waste management in the three pilot countries. A re-test was then conducted and the results (i.e., relevant articles) were subsequently downloaded. Using a narrative synthesis approach, data were analysed.

## 3. Findings and Discussion

### *3.1. China*

There has been rapid industrial and infrastructural development in China over the last two decades. However, this has resulted in daunting environmental problems such as desertification, water depletion, land degradation, loss of biodiversity, and pollution [11]. Several authors (see, for example, [1,11,28–31]) have reported serious health, social, and environmental challenges in the aftermath of heavy industrialisation, hasty urbanisation, change of consumption patterns, and population growth. An intervention that decouples economic growth from environmental ruin, builds an environmentally friendly community as well as resource saving society was sought. The CE concept was identified as one such potential method [29] and according to Dajian [32], it was suggested and presented in 1998 by scholars to the central government who approved it in 2002. Being a potential strategy for sustainable development (SD), CE was accepted and an ambitious program for its effective implementation was developed [31,33]. It has since been further developed [11] and chosen as a national policy for SD [31].

The concept was promoted by the State Environmental Protection Administration (SEPA) in 2002 with specific guidelines for its development, planning, and operation [34]. The State Council appointed the National Development and Reform Commission (NDRC) in 2004 to take over its implementation and promotion [33]. In furtherance of the development strategies, eight initiatives to facilitate implementation of CE were announced by NDRC, including: "initiation of legislation procedure, pilot projects, the application of economic instruments, research and development (R&D) efforts, industrial restructuring, performance indicators, financing mechanism, and training and education" [11]. Research on CE development in the urbanisation process was conducted by the Chinese Academy of Engineering and findings were presented in 2005. The first list of pilot models to develop CE including 56 enterprises, 13 industrial parks, 7 provinces, 5 cities, and 1 town were announced by NDRC. The second list, for 178 enterprises, was announced in 2007 [35]. The standing committee of the Chinese 11th National People's Congress in a meeting held on August 29 2008 passed the CE law which was signed by Hu Jintao (former president) and took effect in 2009 [36].

The CE was incorporated into the medium-term focus (11th five-year plan (2006–2010) and 12th five-year plan (2011–2015)) of the government for national economic and social development supported by decrees/laws created to stimulate cleaner production, pollution prevention, and waste control [8]. China's CE was significantly informed by policies and approaches adopted from Germany and Japan [1,8,11,18,35,37]. However, China's CE law "is the world's first national law proclaiming an economy model different from the mainstream linear "raw materials in" at one end and "waste out" at the other end—a model that still implicitly dominates mainstream economics, as if natural limits simply did not exist" [1]. In a counter claim, Su, Heshmati, Geng, and Yu [11] referred to China's CE law as the world's third claiming that Germany and Japan had laws related to CE. Murray, Skene, and Haynes [8], however, argued that Japan and Germany only had recycling and waste management laws, respectively, which differs from CE law. Before the CE law was promulgated, some enabling and core policies were instituted to support it. These policies/laws are presented in Table 1.

**Table 1.** Enabling and core policies/laws in China for circular economy (CE).

| Area | Policy/Law | Year |
|---|---|---|
| Cleaner production | Cleaner production promotion law | 2002 |
| | Methods of cleaner production audit and review | 2004 |
| Pollution and waste management | Law for environmental pollution of solid waste | 2004 |
| | Amended law on pollution prevention and control of solid waste | 2005 |
| | Laws and regulations for reuse and recycling specific solid waste | ongoing |
| | Amended law of the prevention and control of environmental pollution by solid waste | 2016 |
| | Environmental Protection Tax law | 2018 |
| Energy conservation | Law for energy conservation | 1997 |
| | Medium- and long-term plan for energy conservation | 2005 |
| | Law for renewable energy | 2005 |
| Circular economy | Circular economy promotion law | 2009 |

Source: Adapted from Li, Bao, Xiu, Zhang, and Xu [38] and Su et al. [11].

The main objective of the China's CE promotion law is to improve the efficiency of resource use and to decouple economic growth from the use of natural resources such as water and land. According to Ghisellini, Cialani, and Ulgiati [39], the CE in China resulted from a top-down approach. This implies a system of command and control from the government to the people. Liu, Li, Zuo, and Zhang [35] decried the inadequate integration of both market-based solutions and public involvement in the whole plan of CE. Zhijun and Nailing [30] described the implementation of CE as following vertical and horizontal approaches. The former implies that CE shifts from micro (such as consumer or company) to meso (eco-industrial parks) and macro (provinces, regions and cities) while the latter suggests a link between industries, infrastructure, environment, and social consumption systems [30]. Table 2 shows the three-layer implementation structure of CE in China as described by Su et al. [11]. It gives concise details of both vertical and horizontal approaches described by Zhijun and Nailing [30].

**Table 2.** Implementation structure of CE in China.

| Areas | Micro (Enterprise) | Meso (Inter Firms) | Macro (Provinces, Region, State and Cities) |
|---|---|---|---|
| Design | Eco-design | Environmentally friendly design | Environmentally friendly design |
| Production | Cleaner production | Eco-industrial park | Eco-city<br>Eco-municipality<br>Eco-province |
| Consumption | Green purchase and consumption | Environmentally friendly park | Renting service |
| Waste management | Product reuse and recycle system | Waste trade market<br>Industrial symbiosis | Urban symbiosis |

Source: Adapted from Su et al. [11].

At the micro/enterprise level, eco-design is incorporated in the early stages of product design to ensure that energy consumed throughout the product life cycle is reduced. Eco design principles that are applicable at this level includes design for reuse and recycling, design for disassembly, design for maintainability, design for energy efficiency, and design for flexibility. The core of CE implementation at this level is cleaner production [40]. It includes reuse of resources and recycling of by-products to

achieve dual environmental and economic performance goals, reduction of toxic materials and resource consumption, efficient use of energy, and reduction in emission of pollutants and waste [40–42].

At the meso/inter firm level, environmentally friendly designs that ensure resource efficiency, life cycle thinking, and upgradability of products are encouraged to improve industrial symbiosis. Likewise, reuse and recycling of resources within industrial parks and clustered industries is essential for the implementation of the CE [41]. This is to ensure effective circulation of resources within the region. An eco-industrial park is "a community of manufacturing and service businesses seeking enhanced environmental and economic performance through collaborating in the management of environmental and resource issues" [43]. Ren [40] revealed that activities of eco-industrial parks are of two types: New park construction and incorporation of 3R principles into existing parks. These activities can be achieved through two approaches—eco-industrial chain development among enterprises in the park and shared infrastructural systems for common supplies [40]. Examples of eco-industrial park projects in China includes Guigang national demonstration EIP, Nanhai national demonstration EIP, Tianjin economic development area, Suzhou Industrial Park, Sichuan Tuopai brewing EIP, Xi'an high-tech zone, and Yantai development zone EIP. Within these EIPs, waste from participating companies serves as raw materials or part of materials for others. According to Shi and Yu [44], these EIPs have been successful in implementing waste exchanges including ash, sludge, plastics, wood, and paper. For instance, copper is being recovered from sewage in Suzhou Industrial Park [45]. Within the Tianjin economic development area, symbiotic relationships among firms such as electronics, automobile, food, and biotechnology have been successfully implemented [46]. Likewise, there have been synergies between automotive, manufacturing, cement, and recycling companies within the Xi'an high-tech zone [44].

At the macro level, product collection, processing, storage, and distribution systems at regional, municipal, provincial, or city is key to developing environmentally friendly production and consumption systems and energy savings [40,41]. Similarly, Su et al. [11] revealed that at the production area, all-inclusive co-operative networks between industries and industrial parks from primary to tertiary sectors exist. "The 3R principles are achieved by the redesign and rearrangement of city's infrastructure and industrial layout according to regional characteristics, as well as phase-out of the heavy polluting enterprises, while supporting high-tech industries" (p. 217). Ren [40], however, identified the categories of activities at the macro level to include:

- Development of industry for waste reuse, recycling and safe treatment;
- Development of eco-farming, which has had a long history in china and is rich in diverse models such as planting-livestock breeding/fishery-food manufacturing model and livestock-methane-fertilizer model and the eco-food and organic food base;
- Activities for environmentally friendly consumption, including public green procurement, energy saving in governmental offices and households, green communities, green hotels and restaurants, green buildings, and certifications for environmentally friendly and energy saving products.

Some cities and districts including Shenzhen in Guangdong, Wuhan Huashan in Hubei, Zhenjiang Guantang in Jiangsu, Kunming Chenggong in Yunan, Sanming in Fujian, and Zhuhai Hengqin in Guangdong were proposed as low-carbon cities. The objectives of establishing these low-carbon cities are to reduce carbon emission (e.g., carbon dioxide and methane) while maintaining economic growth [47], manage and collect data on greenhouse gas (GHG) emission, and encourage green consumption among residents [48]. The Chinese government outlined the thresholds for low-carbon cities to include economic growth, energy consumption, urban construction, government support, and residential consumption [48]. Figure 2 illustrates the benchmark and maximum index score for a low-carbon Chinese city.

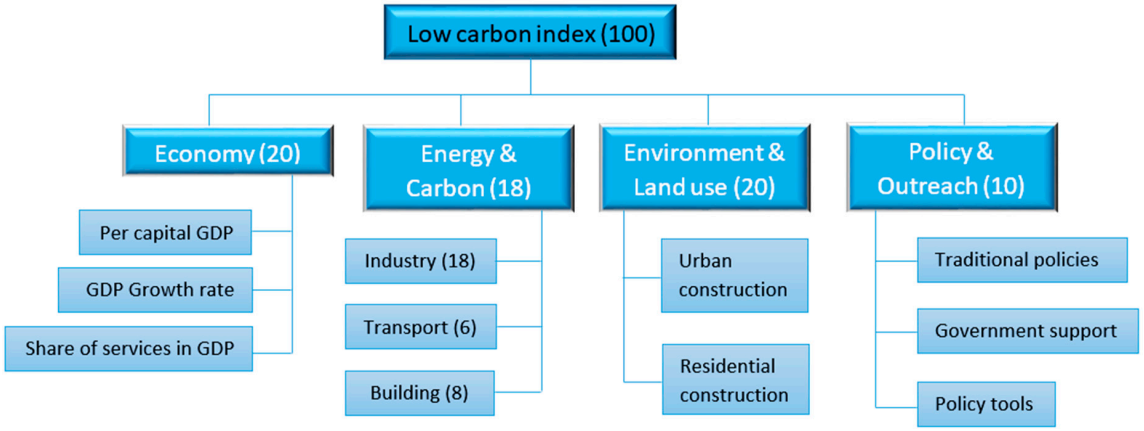


**Figure 2.** Benchmark and low-carbon city index in China. Source: Adapted from Ohshita et al. [49]; Hu et al. [48].

The CE has been adopted, implemented, and passed into law (CE law) in China. Nevertheless, some problems have been identified with the concept. For instance, Geng, Zhu, Doberstein, and Fujita [50] recognised the high cost of CE activities, few industry incentives for green activities, and low public awareness of CE activities. Su and Zhou [51] identified inadequate financial support while Li, Bao, Xiu, Zhang, and Xu [38] acknowledged the absence of CE evaluation criteria to measure its development. Weak guidelines for planning, a lack of understanding, experience, and knowledge among local officials and others about CE projects' implementation, and lack of clarity between the concept and other standard environmental protection planning concepts were recognised by Shi, Xing, Bi, and Zhang [10] as some of the challenges of CE in China.

### *3.2. Germany*

Germany witnessed massive oil crises and recession between 1974 and 1978 [52], which led to economic diversification. This resulted in additional environmental issues and to protect the environment from further degradation, the first waste law was enacted in 1972 [53]. In 1971, the Federal government developed a holistic action plan and environmental programme with guiding principles of precautionary protection of the environment, causal responsibility, and co-operation, which eventually led to the waste disposal act of 1972 [52]. Sensitivity about effective waste management including collection methods, sorting, and reuse options characterised the period between 1978 until the end of the 1980s [52,53]. Although Germany's waste management was effective, a shift to the CE model was necessary because it incorporates all principles of SD [54].

In 1994, a model of sustainable development was incorporated into the German constitution and was adopted into the regional planning act and building code in 1998 [52]. This was an offshoot of the government's commitment to save natural resources, protect the environment, reduce soil sealing, conserve biological diversity, and promote sustainable use of resources [55]. Included in the SD model were special nature conservation laws, renewable energy and energy-saving regulations, and environmental information law [52]. These laws provided the platform for the shift towards circularity. The German parliament passed the law on "*kreislaufwirtschaft*" (circular economy) in 1996 [11,37,52,53]. This law, according to Geng, Sarkis, Ulgiati, and Zhang [37], seeks to reduce land for waste disposal based on waste hierarchy of avoidance and closed-loop recycling. It also shifts product responsibility to producers meaning that their products have to be designed to minimise waste, ensure waste recovery, and reuse both in production and use [52,53]. Based on this policy, Germany could be referred to as the role model in resource recovery.

Several laws, polices, and regulations (Table 3) were implemented to ensure the circularity of materials. For example, all old electrical and electronic appliances are to be returned and producers are obligated to accept them free of charge starting from March 2006 [52]. Similarly, the government

placed a ban on landfill dumping in 2005 aimed at encouraging the total phase out of landfills by 2020 and improve recycling and reuse of waste [52]. As a result, about 50% of waste is recycled while zero municipal waste has been sent to landfill for disposal since 2009 [56]. In implementing European Union's guidelines, including improved environment, climate, and resource protection, the German CE and waste laws were revised and further developed in 2012 [53].

**Table 3.** German laws, policies, and acts for CE.

| Laws, Polices and Acts | Year |
|---|---|
| Waste Disposal Act | 1972 |
| Federal Emission Control Act | 1974 |
| Producer Responsibility for Packaging waste | 1991 |
| Closed Substance Cycle and Waste Management Act ("kreislaufwirtschaft") | 1996 |
| Battery Ordinance | 1997 |
| Ordinance on Bio waste | 1998 |
| Packaging Ordinance | 1998 |
| Renewable Energy Law (Erneuerbare-Energien-Gesetz EEG) | 2000 |
| Ordinance on environmentally compatible storage of waste from human settlements | 2002 |
| End-of-Life Vehicles Act | 2002 |
| Ordinance on the Management of Waste Wood | 2002 |
| Landfill Ordinance | 2002 |
| Ordinance on the management of municipal waste of commercial origin and certain construction and demolition waste | 2002 |
| Stowage Ordinance | 2002 |
| The Waste Storage Ordinance | 2005 |
| Electrical and Electronic Equipment Act | 2006 |
| Circular Economy Act ("kreislaufwirtschaftgesetz KrWG") | 2012 |
| Amended renewable energies act | 2017 |

Source: Adapted from Heck [52].

### 3.3. Japan

Japan, an island with a high population and large mountainous terrain, explored the concept of CE after the global financial crisis some decades ago [27]. The path to circularity in Japan was driven by a lack of landfill space due to rocky topography, limited domestic metal and mineral resources despite being a major industrial producer, and stagnating industries [57,58]. The move to circularity started far back as 1870 [27] but only yielded results when the law for effective utilization of recyclables was implemented in 1991 [39]. Japan became the first country to enact CE legislation. The strategies employed were to reduce oil dependence and high energy consumption industries, adjust energy structure, improve efficiency of energy utilisation, and develop knowledge-intensive industries [27].

In 2007, 98% of Japan's metals were recycled [59] and just 5% of its waste were landfilled. An enforced consumer's responsibility for returning electrical equipment resulted in the recovery of about 74%–89% of the materials [59]. Transition to the CE in Japan has been characterised by effective collaboration between consumers and manufacturers [57,60]. This started with the development of high technology and the advancement of technological knowledge, which decoupled use of non-renewable resources from production and created avenues to explore alternative energy and use of renewable resources [27]. This has provided a firm foundation for Japan's CE system and according to Ji, Zhang, and Hao [27], Japan built a CE society by integrating its people, economy, and social system through optimum utilisation of non-renewable resources and strategic changes for renewable resources.

The implementation of the CE concept in Japan followed a top-down approach, using legislation and regulations [11,27]. The government developed an all-inclusive legal framework for transition to a CE society [11], which later became a national living pattern [27]. Important steps taken by the Japanese government to ensure circularity in all sectors include:

- Creation of educational courses on awareness of environmental issues in schools, companies, and communities, which is the foundation for CE development.
- Provision of recycling laboratories in schools.
- Provision of enterprises' circular trading markets.
- Provision of incentives, enhancing public collaboration, and creating customer-friendly collection of old appliances.
- Provision of waste recycling station [27].

As stated earlier, CE development in Japan is characterised by effective collaboration that requires the public or consumers and manufacturers to play their part. Benton and Hazell [57] identified the role of the public to include source separation of recyclables, prompt payment of recycling fees, and protecting their right as consumers. Manufacturers' roles are use of more recycled materials, production of long-lasting products, and design for repair, reuse, and recycling. Three levels of implementation including enterprises (the main implementing body), industrial parks (waste from one enterprise are transformed into raw material for another), and society (recycling society) were developed [27].

The CE in Japan was developed in such a way that old materials or products are easily collected; the cost of return and recovery have been added to a product's cost when new and all companies are compelled to recycle their products [57]. The CE practically became a lifestyle, making it not only an economic behaviour, but a social one [27]. Recycling systems aimed at zero emission were developed, which consist of "life cycle assessment system, waste minimisation system, resource recycling system, the industry chain of waste recycling and the recycling, transport and trading system of waste" [27]. These systems were supported by legislation and regulations. Heck [52] identified eight laws in Japan that supports the CE while other researchers [27,37,39] identified fundamental and enabling laws (see Table 4) for the development of CE in Japan. "The ultimate purpose of circular economy is to achieve the coordinated development of economy and resources" [27]. The CE concept has been effective in Japan except for some challenges in its waste and recycling market, which Yolin [60] identified as lack of understanding and acceptance of the concept by local companies and lack of waste.

**Table 4.** Fundamental and enabling laws for circular economy development in Japan.

| Fundamental and Enabling Laws | Year |
|---|---|
| Waste disposal law | 1970 |
| Resource efficient law | 1991 |
| Environmental law | 1993 |
| The law of separate collection and recycling of container and packaging | 1995 |
| Special household machine cycle law | 1998 |
| Sound material cycle society law | 2000 |
| Building construct recycling law | 2000 |
| Polychlorinated biphenyl waste properly handle special measures law | 2001 |
| Vehicle recycling law | 2002 |
| Recycling based society law | 2002 |
| Revision of the waste management act | 2010 |
| Small home appliance recycling act | 2013 |

Source: Adapted from Geng et al. [37]; Ghisellini et al. [39] and Ji et al. [27].

### *3.4. Comparison of the CE Implementation in China, Germany, and Japan*

The purpose of the CE concept is to decouple economic growth from environmental degradation, enhance resource efficiency, and reduce waste. Figures 3–5 summarise the CE development models in China, Germany, and Japan, respectively. The CE is commonly implemented at the design, production, consumption, and waste management stages [30]. In China, eco design and environmentally friendly designs are introduced at the design stage to protect the quality of the environment. Manufacturers in Germany are responsible for identifying design measures suitable to mitigate environmental degradation, while producers in Japan are encouraged to embrace high-tech designs for repair, reuse,

and recycling [57,60]. This finding implies that manufacturers/producers need to adopt lifecycle thinking during product design to ensure that proper consideration is given to the environmental impacts of such products.

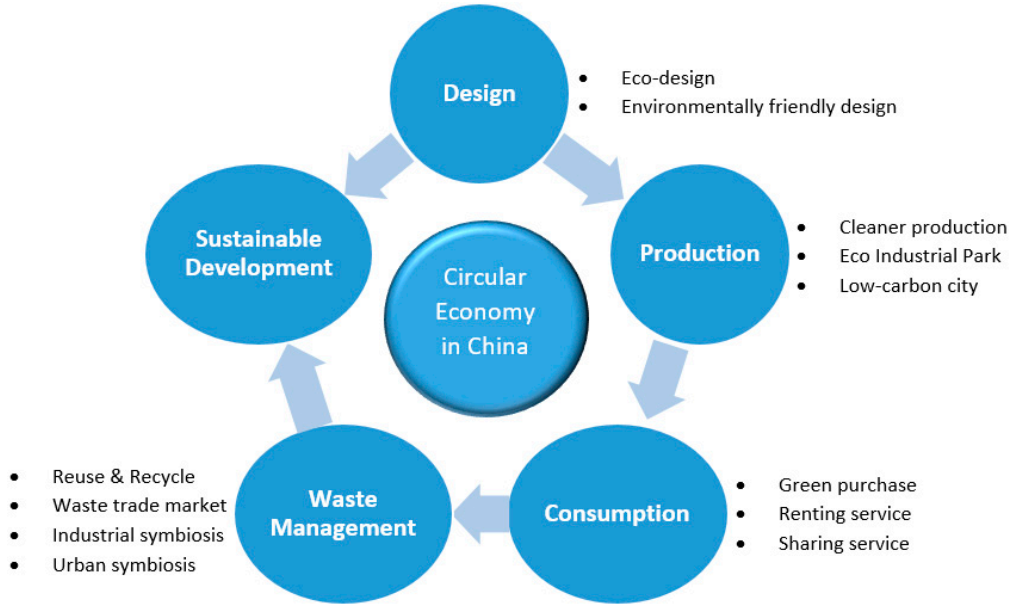


**Figure 3.** Circular economy development in China.

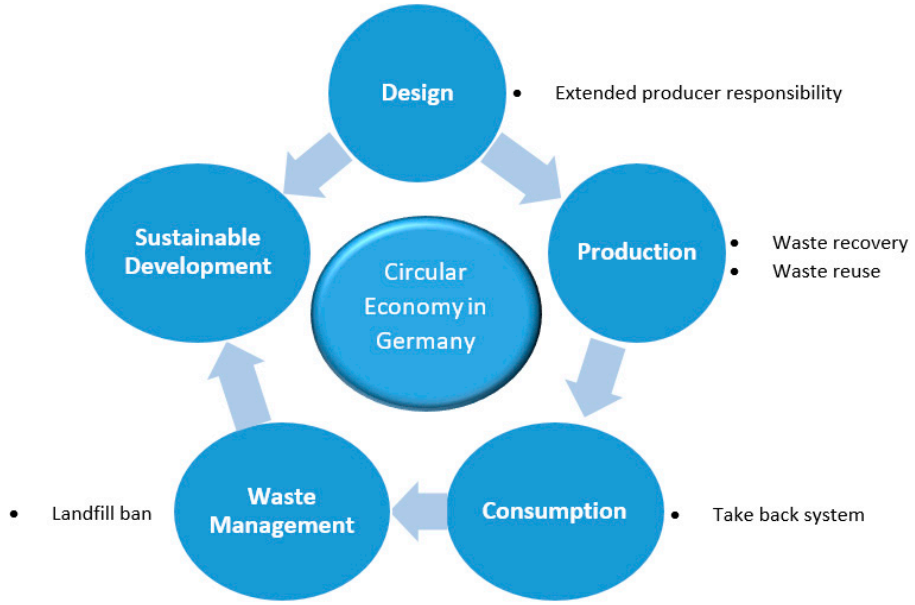


**Figure 4.** Circular economy development in Germany.

In China, cleaner production, eco industrial park, and low-carbon cities are implemented to improve the circularity of products at the manufacturing/production stage. Similarly, actions are being taken in Germany and Japan to recover and reuse waste, use recycled materials, renewable source of energy, and produce durable products. This is to reduce the pressure on raw materials extraction during production and minimise GHG emissions. Consumers play a vital role in ensuring that materials are continually circulated at the end of their useful lives, minimising pollution. To this end, Chinese consumers are encouraged to live a low-carbon lifestyle through green purchase, sharing, and renting services. Likewise, Japan has a national framework for living that offers guidance on waste management for companies and consumers, including sorting, segregation, and recycling [57].

Conversely, manufacturers and retailers in Germany are obliged to implement a take-back scheme, a system that enables consumers to return used or damaged products at no cost. This study's finding implies a win–win–win situation at the consumption stage for consumers, manufacturers, and the environment. For example, the environment benefits from low carbon emission resulting from a shared service, consumers will enjoy improved service quality, while companies benefit from increased efficiency and lower service cost.

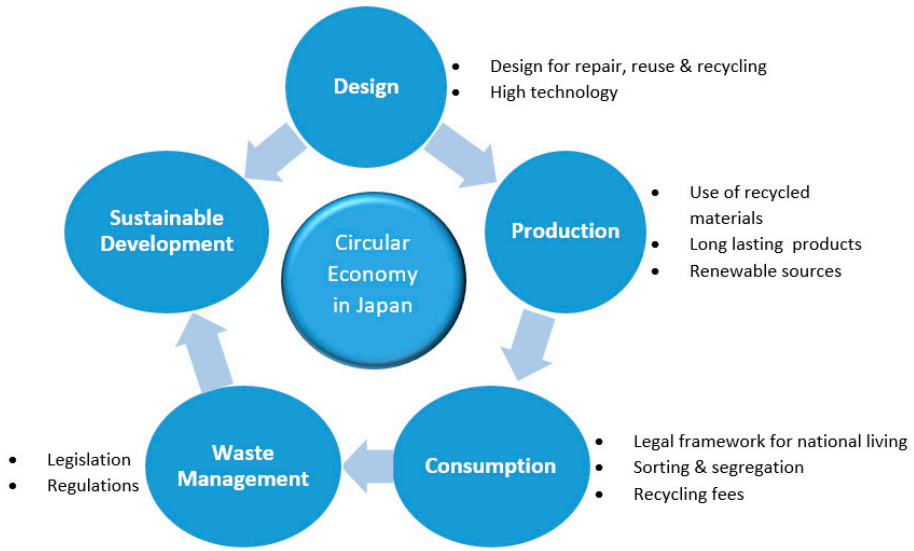


**Figure 5.** Circular economy development in Japan.

With regards to waste management measures, China adopts reuse, recycling, waste trade markets, and industrial and urban symbiosis, which allows waste products to remain in circulation. This is supported by legislation, policies, and regulations. Similarly, landfill ban and legislation are waste management measures in Germany and Japan, respectively. From the review, it is obvious that Japan's resource efficient law and Germany's closed substance cycle and waste management act were postulated to achieve the same purpose as the CE. Therefore, this finding aligns with previous studies [1,8,11,18,35,37] that China's CE was informed by previous policies and laws in Japan and Germany. It is evident from this study that the CE implementation would not have been possible without the enabling policies. This implies that the enabling policies are central to the success of CE in achieving sustainable development. The implication for countries planning to adopt the concept is to first formulate enabling policies such as landfill ban, extended producer responsibility, and take-back schemes.

The findings of this study confirm Japan's resource efficient law as the world's first CE law, which agrees with Su et al.'s [11] claim that China's CE law is the world's third. Table 5 compares the implementation processes of CE in the three pilot countries by answering the question what, why, and how?

It is clear that the common approach to implementing the CE is the top-down approach. It aims at achieving specific goals or objectives through policies. This implies that policies are imperative to implement the CE successfully. In addition, the method of implementation across the three pioneer countries is similar, cutting across individuals, businesses, industries, governments, and the environment. This suggests the need for all stakeholders to support and commit to the CE or waste management policies as shown in Table 5. The implication for countries proposing to adopt the CE concept is to carefully analyse their waste problem and to determine the appropriate country-based implementation approach and method.

**Table 5.** Comparison of the implementation process of the CE and waste management laws in China, Germany, and Japan.

| | **China** | **Germany** | **Japan** |
|---|---|---|---|
| **laws/policies** | Cleaner production/Circular Economy law | Closed substance cycle and waste management act | Resource efficient law |
| **Year** | 2002/2009 | 1991 | 1996 |
| **What prompted it?** | Environmental issues resulting from rapid industrialisation and infrastructure development | Environmental issues resulting from economic diversification | Global financial crises and lack of landfill space due to rocky topography |
| **Why (purpose)?** | To stimulate cleaner production, prevent pollution, and control waste | To reduce land for waste disposal, shift responsibility to producers, and ensure waste recovery and reuse | To reduce oil dependence and high energy consumption. To adjust energy structure To improve efficiency of energy utilisation |
| | The need to reduce reliance on imported raw materials and pressure on domestic resources | | |
| **How (approach)?** | Top-down | Top-down | Top-down |
| **Implementation method** | Vertical approach Micro (Enterprise) Meso (Inter-firms) Macro (Province) Horizontal approach Link between industries, infrastructure, environment, and social consumption systems | Individual Enterprise Administration National | Enterprises Industrial Parks Society |

## 4. Conclusions

This study has reviewed the development of CE concept in China, Germany, and Japan using a desktop study method. Enabling and core policies in these countries to support the CE and waste management policies were identified. According to the study, the CE concept in China was implemented in three layers: Micro, meso, and macro. It has been implemented in the form of legislation, policies, and regulations in Germany and Japan. The CE law was informed in China by resource efficiency while it was based on waste reduction acts in Germany and Japan. China's CE law is similar to the closed substance cycle and waste management act in Germany. Similarly, the resource efficient law of Japan aligns with the CE law of China. These laws, as revealed in the study, were promulgated to reduce land for waste disposal, shift responsibilities to manufacturers, ensure waste recovery and reuse, and improve energy and resource efficiency.

Based on the study's findings, the CE concept is developed in four stages: Design, production, consumption, and waste management. The approaches adopted by the countries under review at these stages are slightly different but similar and aim to achieve sustainable development. The common implementation approach for CE is the top-down approach while the method is similar across the three pioneer countries. Enabling policies and regulations as well as collaboration and support from all stakeholders, especially consumers, are essential for the successful implementation of the CE. This study serves as a guide for countries planning to implement the CE in various economic sectors. It suggests the need for proper planning to identify appropriate implementation method. Future studies may expatiate on the impacts of the legislation, policies, and regulations identified in this review.

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