China in transition towards a circular economy: from policy to practice

Yuhong Zhao
Faculty of Law, The Chinese University of Hong Kong, Hong Kong

Received 2 March 2020
Revised 16 June 2020
27 June 2020
Accepted 28 June 2020

Abstract

Purpose – The purpose of this paper is to examine China's approach to circular economy (CE) and investigate how the foreign concept of CE has been turned into a national strategy for implementation in production, circulation and consumption. This study aims to highlight the Chinese characteristics in the implementation of CE from central to local levels including the "trial and test" by pilot schemes and the role of local governments in CE transformation of industrial parks and in building CE cities. Based on what has been achieved, this paper aims to identify the gaps to be filled in the next stage of CE implementation.

Design/methodology/approach – This paper engages in critical analysis of state policies, plans, laws and regulations and case studies of Suzhou New District and Shanghai city in the building CE-oriented industrial park and CE city, respectively.

Findings – China has taken a top-down approach to CE characterised by strong government involvement in both policy and plan making and implementation at local levels. The government's financial investment and administrative assistance proved to be crucial in the early stage of CE implementation to close the loop at industrial parks and in cities. In comparison, participation by enterprises and individuals is still weak and limited, which should be the focus of the next stage of CE implementation.

Originality/value – There is an absence of legal literature that studies circular economy in China. This paper fills the gap by examining the development of CE law and policy as well as CE implementation at local levels from industrial parks to cities.

Keywords Circular economy, Resource conservation, CE pilot schemes, Waste reduction, Industrial parks, Reduce reuse recycle

Paper type Research paper

1. Introduction

As a closed-loop system, the circular economy (CE) promotes the restructuring of industrial processes so that one manufacturer's waste output becomes the material input for another (Pearce and Turner, 1990). It thus provides a sustainable alternative to the traditional linear economy in which resources are extracted, transformed into products, consumed and then disposed as waste. This linear take-make-dispose approach generates wastes, causing pollution and environmental degradation. CE instead reduces resource consumption through reuse, recycling and recovery of products at their would-be end-of-life and thereby abates pollution discharge and waste disposal. Because of these perceived benefits, China formally adopted the concept of CE into state policy in

This article is based on a paper presented at the Conference on Rethinking Property Approaches in Resources for the Circular Economy hosted by Coventry University in June 2019. The author is most grateful to Dr Katrien Steenmans for inviting him to participate in the conference and for her assistance and support in editing the paper for publication. He also appreciate all the comments and questions of the conference participants and anonymous referees that have helped him in writing this article.

Journal of Property, Planning and Environmental Law
Vol. 12 No. 3, 2020
pp. 187-202

2514-9407
DOI 10.1108/JPPEL-03-2020-0014

2005 to address the tension between its accelerating industrialisation and the constraints of natural resources and environmental carrying capacity (State Council, 2005). In 2008, the Circular Economy Promotion Law [1] (CEPL) was promulgated to demonstrate strong political commitment to CE and provide the statutory foundation for the development and implementation of policy measures and market-oriented instruments.

Following intensive industrialisation and fast economic growth in the 1980s and 1990s, China faced unprecedented pressure of rapid depletion of natural resources and serious environmental degradation. The concept of a CE was therefore appealing to the Chinese government, as it promotes resource conservation and environmental protection by reducing, reusing and recycling resources and wastes from production to consumption, instead of China's previously existing development model characterised by energy-, resource- and pollution-intensive and low resource efficiency industrial operations compared to international standards. For example, its consumption of steel, copper, aluminium, lead and zinc per unit of gross domestic product (GDP) was four–five times the world average (Xie *et al.*, 2009). The combination of high resource consumption and low resource efficiency resulted in significant waste generation and serious pollution discharge; during the mid-1990s, the annual economic cost of air and water pollution was estimated at USD24–54bn, approximately 3.5%–7.7% of China's GDP depending on different methods of calculation: human capital and willingness to pay. The human capital approach values mortality and morbidity impacts as lost productivity and out-of-pocket expenditures, whereas the willingness-to-pay approach measures the value of human life and health in the market (i.e. the amount people are willing to pay to reduce the risk of injury or death) (Johnson *et al.*, 1997). By 2003, the total cost of pollution was ¥362bn or 2.68% of GDP by human capital approach, and the cost went up to ¥781bn or 5.78% of GDP by willing to pay approach (World Bank and State Environmental Protection Administration, 2007). The official conservative estimate of the cost of environmental degradation reached ¥511.8bn in 2004, accounting for 3.05% of its GDP (State Environmental Protection Administration and State Bureau of Statistics, 2006) [2]. The Chinese Central Government acknowledged the urgent need to change its resource and pollution intensive growth path at the start of the 21st century by formally endorsing CE in 2005 to build a resource-saving and environmental-friendly society (State Council, 2005). CE, as defined in the CEPL, generally covers activities that reduce, reuse and recycle materials in production, distribution and consumption processes.

This paper reviews and analyses the Chinese Government-led top-down approach to CE over the past 15 years from law and policy making by the central government to implementation and practice at local levels. For this purpose, Section 2 discusses the socio-economic context in which China embraced CE and turned it from a concept into a national development strategy by promulgating CE policies, plans and legislation. Section 3 examines the implementation of CE law and policies through pilot projects supported by local governments. Section 4 criticises the delayed implementation of the extended producer responsibility (EPR) scheme. Section 5 emphasises the urgency to extend CE from production to consumption and to implement CE in the wider society.

2. Top-down approach to circular economy: policies, plans and law

China's economic growth, evidenced by an average annual GDP growth in excess of 10% between 1981–1995 and 2001–2010, has been achieved predominantly as a result of economic activities by resource-intensive and pollution-intensive heavy industries (Qi *et al.*, 2016). The following sections explore how adopted CE policies, plans and law aim to offer China a path for long-term sustainable development by alleviating the increasing tension between shortage of resources and China's ongoing industrialisation and urbanisation.

2.1 State policies on circular economy

In 2004, the National Development and Reform Commission (NDRC) hosted the first national working conference on CE to promote CE as an economic growth model in line with sustainable development, with reduced resource consumption and emissions as well as increased resource efficiency through the principle of reduce, reuse and recycle (3Rs). It represents a fundamental departure from China's economic growth pattern characterised by "massive production, massive consumption and massive waste generation" (Ma, 2004). A year later, the State Council issued "Several Opinions on Accelerating CE Development" (Several Opinions) to mobilise government's efforts to adopt CE from central to local levels (State Council, 2005). Since then, NDRC has been the state agency in charge of implementing CE pilot programmes in major industries, sectors, industrial parks and cities and provinces (NDRC *et al.*, 2005). China's approach to CE has thus been top-down government-led. The central government formulates state policies and national laws, sets targets and standards and allocates tasks and quota for local implementation.

The State Council has a leading role in CE promotion and it identified five key areas for CE implementation in its Several Opinions:

(1) resource exploration;

(2) resource consumption by key industrial and agricultural sectors;

(3) waste generation as a result of production and consumption;

(4) waste recycling including waste sorting, collection, recovery and remanufacturing; and

(5) green consumption, including government green procurement focussing on energy and water conservation and waste reduction at source (State Council, 2005).

Based on its several opinions, the State Council promulgated the "CE Development Strategy and Short-Term Action Plan" (State Council, 2013) to launch the 10–100-1000 initiatives (see Section 3). The NDRC issued the "2015 Plan on the Promotion of CE" (NDRC, 2015) to clearly stipulate the respective responsibilities of the central government's ministries and departments and a detailed "Leading Action on CE Development" (NDRC *et al.*, 2017) in collaboration with 13 other state departments. The central government has taken the lead to adopt and promote CE by state policies and plans to set targets, create incentives and monitor performance of the industry, as discussed later.

2.2 Circular economy priority in the five-year plans

Implementation of CE requires long-term commitment and state support to achieve industrial restructuring, clean production and development of relevant sectors, including resource recycling and recovery, to close production and consumption loops. In China, five-year plans (FYPs) are the most important government plans that lead and guide both market stakeholders and government administration by clarifying national strategic plans and stipulating key targets, tasks and measures to be taken for each five-year period. The FYPs are prepared by the NDRC and presented to the National People's Congress (NPC) for approval and promulgation. Local governments adopt local FYPs to implement the tasks and achieve the targets set by the national FYPs. To ensure policy stability for the promotion of CE, it was therefore an important signal to stakeholders that the central government included CE as one of the major strategic tasks in the 11th FYP on the National Socio-Economic Development (11th FYP) (2006–2010). It proposed a circular resource utilisation system through the promotion of combining economic development with resource conservation in accordance with the 3Rs (Part VI ch 22).

The 12th FYP (2011–2015) endorsed CE development and implemented the "fundamental state policy" of resource conservation and environmental protection (Part I ch 2). It reiterated the 3Rs, prioritising reduction and promoted CE in production and consumption to achieve improved resource productivity (Part VI ch 23). It set the targets for 2015 including a comprehensive utilisation rate (i.e. rates of reuse, recycling and recovery) of 72% of industrial solid waste and raising resource productivity (economic output per resource units used) by 15% (Part VI ch 23 *s* 1). Further targets are set by State Council to increase energy productivity by 18.5%, water and land productivity by 43% by 2015 as compared to 2010 (State Council, 2013, ch 2). Tables 1 and 2 illustrate improvement in resource productivity and rates of reuse, recycle and recovery from 2010 to 2020.

CE targets are set by reference to key indicators of resource productivity and rates of resource reuse, recycling and recovery (NDRC *et al.*, 2007a). Scientific indicators are valuable metrics for evaluating the effectiveness of CE measures and providing feedback for decision-makers to improve policy instruments. Resource productivity refers to the amount of production value generated per unit of major resources, energy, water and land. A higher ratio indicates higher efficiency of resource consumption. The resource comprehensive utilisation rate examines utilisation rate of industrial solid waste, reuse rate of industrial water and reuse rate of treated wastewater from urban wastewater treatment facilities. The indicators have thus been developed based on the 3Rs.

2.3 Circular economy promotion law

During the 11th FYP period, the state legislature promulgated CEPL to build a regulatory infrastructure for the transition to CE. The law was amended in 2018 subsequent to the

Table 1. Resource productivity (economic output per unit resources used)

Resources	Unit	2010 (actual)	2015 (actual)	2020 (target)	Target (%) improvement 2020 over 2015
Major resources	Yuan/ton	Nil	5,994	6,893	15
Energy	Yuan/ton of coal	12,400	14,028	16,511	17.7
Water	Yuan/m^3	66.7	97.6	126.8	29.9
Land for construction	Yuan/hectare	Nil	154.6	200.4	29.6

Source: Adapted from State Council (2013); NDRC *et al.*. (2017)

Table 2. Rate of reuse, recycling and recovery

Solid wastes and wastewater	2010 (%) (actual)	2015 (%) (actual)	2020 (%) (target)
Recycling of major wastes		47.6	54.6
Comprehensive utilisation of crop straws	70.6	80.1	85
Comprehensive utilisation of industrial solid waste	69	65	73
Reuse of water resources by industrial enterprises	85.7	89	91
Recycling of major recyclable resources	65	78	82
Recovery of kitchen waste in cities		10	20
Reuse of treated wastewater from urban wastewater treatment facilities	<10	Nil	20

Source: Adapted from: State Council (2013); NDRC *et al.*. (2017)

institutional state reform in March of the same year. CEPL aims to improve resource efficiency and environmental protection for long-term sustainable development (Article 1). The law defines CE as a generic term for "the reducing, reusing and recycling activities conducted in the process of production, distribution and consumption" (Article 2[1]). The 3Rs are thus the central theme, with reduction in energy and resource consumption, waste generation and pollution discharge prioritised (Article 3). Reduction requires decreasing the input of primary energy and raw materials through improving production efficiency. Reuse refers to the use of one enterprise's unprocessed by-products and wastes as input for another enterprise's production process. This entails using products to their maximum capacity with regular maintenance and repair to prolong the products' durability. Recycling is a process where recyclable materials are made into new products so that consumption of virgin materials can be reduced. Six major mechanisms are found in CEPL:

(1) government planning;
(2) total control of resource consumption and pollution discharge;
(3) evaluation and appraisal of CE;
(4) extended producer responsibility (EPR);
(5) special supervision over heavy polluting enterprises; and
(6) incentive and support mechanisms. Some of these are discussed below.

CEPL emphasises the important leading roles to be played by central to local levels of government in promoting CE and imposes primary obligations on key enterprises to take measures to reduce energy and resource consumption, waste generation and pollution discharge and to promote the 3Rs (Article 9). As for citizens, they are "encouraged" to conserve resources, protect the environment and engage in rational consumption (Article 10).

CEPL requires both FYPs and annual plans to address CE development (see previous section on FYPs discussing how CE has been addressed in FYPs). In addition, central to municipal levels of governments have to formulate CE implementation plans, which are specialised plans setting clear targets for the 3Rs to improve energy and resource efficiency, key tasks to be accomplished and measures to be adopted (Article 12). By incorporating CE into all of its government development plans, China shows its determination to transition towards a CE. To achieve reduction in consumption of energy and resources and abatement of waste and pollution, local governments shall adjust the industrial structures in accordance with the "total control targets" for pollution discharge, land used for construction and total water consumption as decided by the governments of a higher level. Any new, modified or expansion projects shall comply with the relevant total control targets (Article 13). The biggest challenge in CE promotion has been to change the attitude and mentality of local government decision-makers who are used to prioritising fast economic growth at all cost. To address the potential resistance at local levels, a target responsibility and performance appraisal mechanism was adopted to set targets for local governments to take measures to promote CE covering, *inter alia*, planning, finance, investment and government procurement (Article 8).

The state has to adopt industrial policies to facilitate CE development (Article 6[1]). In addition to leading and guiding the industrial sector to adopt clean production by promulgating and updating industrial catalogues to encourage, restrict and phase out the use of relevant technologies, production processes, equipment, raw materials and products (Article 18), governments are further required to support and speed up CE development through financial mechanisms to incentivise behavioural change in industry and attract investment in CE. They include the use of special funding (Article 42), public finance (Article

43), tax privileges (Article 44), investments and loans (Article 45), pricing and fee schemes (Article 46) and government procurement (Article 47).

The central government took the lead in offering economic incentives to change the attitudes and set up a special CE fund to support key CE projects and capacity building (State Council, 2013, ch 8 *s* 1). Tax reform since 2004 has included adjustment of the tax rates on some mineral resources, increased consumption tax on refined oil, vehicles with large replacement engines, disposable wooden chopsticks, solid wood floor and adjustment of the value-added tax regimes for some products made from recycled resources and relief of the tax burden of enterprises engaging in waste reutilisation (Ministry of Finance and State Administration of Taxation, 2011). Moreover, the central government encouraged state-owned banks to provide loans for CE projects. CE-related industrial parks and enterprises are given priority for their financing needs in the direct financing market including the stock market and bond market (NDRC *et al.*, 2010).

CEPL has thus promoted CE development by requiring central and local governments to support, foster and invest in CE. One of the key methods of implementation has been by pilot schemes (Section 3). Yet, many important mechanisms established by CEPL, including the EPR scheme (Section 4), have had undue delays in the implementation. The law has successfully promoted CE as an important national development strategy but failed to stipulate specific legal duties and liabilities of relevant parties including the governments, the enterprises and the individuals.

3. Circular economy implementation: pilot schemes

Implementation of CE law and policy started with pilot schemes for designated industrial sectors and regions to test different models and identify best practices for national application. CE implementation involves operation at three levels:

(1) within an enterprise;

(2) among different enterprises of diverse industries (i.e. in industrial parks); and

(3) in wider society covering production, circulation and consumption (Su *et al.*., 2013).

CE at the enterprise level focuses on large-scale process-oriented enterprises including metal smeltery, chemical enterprises and thermal power plants that consume massive volumes of energy and water in the production process (State Council, 2005, Part II *s* 6). Measures are imposed on industrial operators to achieve reuse and recovery of energy and wastewater. In China, more than half of its manufacturing activities are conducted in industrial parks and export processing zones (Mathews and Tan, 2016). CE at the industry level is found in industrial parks where different enterprises join to form an inter-enterprise and inter-industry complex for achieving the 3Rs. Industrial parks are created based on the concept of industrial symbiosis where collective economic and environmental benefits are achieved through cooperative management of resource flow among geographically clustered enterprises. By 2012, those industrial parks accounted for more than 50% of China's GDP (Mathews *et al.*, 2018). Local governments have played a crucial role in building up a platform for the exchange of information on waste and resource recovery and they provide financial investments for the required physical infrastructure to support circular industrial parks. These pilots and the lessons learnt are discussed in more detail the following sections.

3.1 Early circular economy pilots initiated during the 11th five-year plans period (2006–2010)

To implement the State Council's Several Opinions, the NDRC carried out pilot programmes in major industries, industrial parks and cities and provinces. The first set of CE pilot

projects was launched in 2005 to cover seven key industrial sectors (iron and steel, non-ferrous metals, coal, power generation, chemical, construction materials and light industry) with 42 participating leading enterprises across four waste recycling and reuse areas, 13 industrial parks and ten provinces and cities (NDRC *et al.*, 2005). The second set was launched in 2007 to cover more sectors, including agriculture, mining, food, packaging, tannery and textile and more regions (NDRC *et al.*, 2007b). In total, those CE pilot projects involved participation by 178 entities (NDRC *et al.*, 2013).

The pilot participants receive a range of financial and technical support from central and local governments for implementation of CE, and they are expected to demonstrate improved performance by reference to evaluation indicators including:

- resource output indicators (GDP produced per unit of resource consumed);
- resource consumption indicators (resource consumption per unit output of GDP);
- resource comprehensive utilisation indicators; and
- waste and pollution discharge indicators (NDRC *et al.*., 2007a).

From the governments' perspective, assessment and appraisal not only make these entities accountable to ensure responsible use of public finance but also are an important exercise for identifying best practices for knowledge dissemination and reproduction elsewhere. NDRC in collaboration with other state departments assessed and appraised the pilot projects in two batches with results published in 2014 and 2015. The 25 entities that failed the assessment stopped enjoying relevant governmental CE benefits and were prohibited from applying for CE grants for two years (NDRC *et al.*, 2014, 2015a, 2015b).

3.2 Circular economy–oriented upgrading of industrial parks

Upgrading and transforming industrial parks in accordance with CE principles became the focus during the 12th FYP (2011–2015) period and continued into the 13th FYP (2016–2020) period. The 12th FYP sets the target to upgrade 50% of the national-level industrial parks and 30% of the provincial-level industrial parks to CE parks by 2015 (also identified as focus areas in State Council, 2013, ch 3 *s* 11 and ch 7 *s* 1; NDRC, 2015, Part III). These industrial parks include economic and technological development zones, high and new technology development zones, export processing zones and various specialised parks. The 13th FYP sets higher targets of 75% for national-level industrial parks and 50% for provincial-level industrial parks by the end of 2020 (NDRC *et al.*, 2017, Part I).

CE-oriented upgrading of industrial parks aims to optimise spatial layout, adjust industrial structure, extend industries included to close the loop and achieve circular movement of materials and conservation oriented development (State Council, 2013, ch 3 *s* 11). The central government offers direct support to 100 state and provincial-level well-established industrial parks with potential for CE-oriented upgrading. They shall take measures to improve resource productivity, land productivity and rates of 3Rs to minimise pollution (State Council, 2013, ch 7 *s* 1). (Re)designing the infrastructure and set up of parks can minimise both waste generation and virgin material consumption through sharing common infrastructure and services and trading industrial by-products such as heat, energy, wastewater and solid waste. A special fund was set up by the central government to support such transformations in key CE demonstration projects (State Council, 2013, ch VIII *s* 1), as discussed in the next section.

3.3 Circular economy 10–100-1000 demonstration initiatives

The State Council launched the "CE 10–100-1000 demonstration initiatives" in 2013 to foster best practices through CE demonstration projects in ten focus areas, 100 CE demonstration

cities (counties) and 1,000 CE demonstration enterprises or industrial parks (State Council, 2013, ch VII). The ten focus areas include (State Council, 2013, ch VII *s* 1):

(1) comprehensive resource utilisation;
(2) CE-oriented upgrading of industrial parks;
(3) system building for recycling and recovery of renewable resources;
(4) urban mining;
(5) industrialization of remanufacturing;
(6) recycling and safe disposal of kitchen waste;
(7) co-development of production and waste disposal processes;
(8) circular agriculture;
(9) circular service sector; and
(10) industrialization of recycling and recovery technologies.

The 100 demonstration cities (counties) have to fully implement CE production and green consumption. They should lead the nation in building a society with circular use of resources and increased resource productivity compared to the national average (State Council, 2013, ch VII *s* 2). To bid for "100 CE demonstration cities (counties)", local city (county) governments have to formulate their CE implementation plans for expert panels' review and selection. The 1,000 leading enterprises and industrial parks are selected as demonstration cases for their high productivity of resources and land, low energy, resource and consumption per unit of GDP, high rate of comprehensive utilisation of solid waste and high reuse rate of industrial water. The performance indicators of the 1,000 enterprises shall be at least equal to those top performers both domestically and internationally (State Council, 2013, ch VII *s* 3).

The CE 10–100-1000 demonstration initiatives aim to expand CE to cover industry, agriculture and service. Both central and local governments offer fiscal support. The subsidies from the central government are primarily used for non-profit infrastructure building, provision of public service platforms, key projects, capacity building and demonstration and promotion of industrialised CE technologies (State Council, 2013, ch VII).

3.4 Disseminating best practices from circular economy pilot projects

The central government has invested heavily to pilot CE schemes – ¥13.6bn has been used from the CE development fund to support key CE projects – at different levels of enterprises and industrial parks and cities to explore and accumulate successful experiences and best practices for further replication across China (NDRC, 2011; NDRC and Ministry of Finance, 2016a). The NDRC and Ministry of Finance (2016) identified the following best practices for national replication:

- promulgating provincial CE regulations, such as in the provinces of Gansu, Jiangsu, Guangdong, Shaanxi and Shanxi, including the establishment of a designated CE fund in the Gansu and Qinghai provinces;
- attracting investment in identified sectors to fill the gap and close the loop of CE;
- establishing a data-sharing platform for timely access to information on waste generation and utilisation;
- using third-party professional service for waste collection, recycling, reuse and disposal;

- using full-service operators for collection, transport, treatment and disposal of kitchen waste, such as in the city of Suzhou; and
- using internet platform and mobile applications to improve online and off-line waste collection for recycling (NDRC and Ministry of Finance, 2016b).

One successful case is the Suzhou Hi-tech New Industrial Development Zone, also known as the Suzhou New District (SND) (Xu, 2015). It was one of the 13 industrial parks launched by NDRC in the first batch of CE pilot programme in 2005 (Mathews *et al.*, 2018). Using urban mining of copper as an example, SND closed the loop for the printed circuit board (PCB) industrial chain. Copper is traditionally mined as a virgin resource and China relies on imports from Brazil or Australia for production of PCB. In SND, firms recover copper from waste etching solution, waste copper foil and sludge and use recovered copper for new PCBs. A "circular loop" was thus formed by "mining" copper from waste. This not only reduced consumption of virgin resources but also tackled the problem of waste disposal (Wen and Meng, 2015). In closing the loop, the SND Administration played a crucial role at the initial stage. It was able to overcome the main barrier of linking the supply chains of firms to reconceptualise wastes as resources. China's top-down approach and local government's active involvement in the management of industrial parks offered an efficient solution to the linkage problem. The dual role of the SND administration as both local government and park manager allows it to go beyond a facilitator. When SND Administration identified recycling and recovery of metal resources, including gold and copper, as a gap in the park's PCB supply chain, it formed a joint venture with Dowa Metal (Japan) through its investment arm, SND Economic Development Group Corporation, in 2003. A technologically advanced metal-recycling business was thus established by SND that not only plugged the gap in the PCB value chain but also provided e-waste collection and recycling beyond SND to other parts of the city and region (Mathews *et al.*, 2018). In SND, both online platforms and offline CE promotion office in the Park provide location-based resource trading services, technology services and exchange of information. The park administration's active involvement and support has been found to be indispensable to sustain CE initiatives by enterprises (Yang, 2007; Wu, 2007).

4. Undue delay in the implementation of extended producer responsibility

Traditionally, producers are responsible for the quality and safety of their products. EPR additionally requires producers to adopt eco-design, clean production and be responsible for the collection, recycling or disposal of their products at the end of their life (the precise responsibility depends on the form of EPR). Clean production improves energy and resource efficiency and reduces pollution discharge and waste generation. Eco-design requires systematic incorporation of environmental consideration of both production process and final products. For instance, eco-design of electric and electronic products involves proactively addressing the environmental impacts of the product throughout its entire life-cycle.

CEPL covers the EPR scheme and requires manufacturers of products and packaging materials covered by the "Catalogue of Articles subject to Compulsory Recycling" to bear the primary responsibilities of recycling, reuse and disposal of used products and packages (article 15(1)). Where producers have entrusted retailers or other bodies to collect for recycling the used products and packages, or have entrusted waste disposal enterprises to reuse or dispose of the used products and packages, the entrusted bodies shall perform their duties to collect, recycle, reuse and dispose of used products and packages under relevant laws, regulations and the contracts signed with the producers (Article 15[2]). Under CEPL,

consumers have the responsibility to deliver used products and packages subject to compulsory recycling to the relevant parties for recycling (Article 15[3]). Unfortunately, as the "Catalogue of Articles subject to Compulsory Recycling" was never promulgated, EPR remained a mechanism on paper only until 2016.

In 2016, the State Council implemented the EPR scheme by promulgating the "Plan on the Implementation of EPR Scheme" (Plan on EPR) (State Council, 2016a). It extends the producer's responsibility from the stage of production to the full life-cycle of the product. Major responsibilities include eco-design, use of recycled resources, reuse and recycling of waste and discarded products and information disclosure (State Council, 2016a, Part II). That is, producers shall at the stage of product design take into account not just the function and quality of their products but also the toxicity of the raw materials used for the making of the products, the pollution and waste generated during production and consumption, recyclability and recoverability of the products at the end of consumption and environmental impact of the final disposal. The Plan on EPR initially covers producers of four product categories:

(1) electrical and electronic products (EEP);

(2) vehicles;

(3) lead acid batteries; and

(4) paper-based drink packages, chosen as a result of their market scale, potential to cause environmental harm and the values in resource recovery (State Council, 2016a, Part III).

The plan sets clear targets for these producers: an average of 40% should be reused, recycled and recovered by 2020 and 50% by 2025 (State Council, 2016a, Part I *s* 3). Cities designated to carry out pilot exercises include: Beijing for reuse and recycling of e-waste, Shenzhen for reuse and recycling of batteries used in electrical vehicles and Shanghai for reuse and recycling of lead acid batteries (State Council, 2016a, Part III).

Out of the previously mentioned four product categories, China is most experienced with e-waste. Prior to the implementation of the EPR scheme, producers and importers of EEP had been "encouraged" to collect e-waste for recycling and were required to pay a fee to the special e-waste disposal fund to support and subsidise the recycling industry (Regulation on the Recycling and Disposal of Waste Electrical and Electronic Products, 2009, Articles 11 and 7, respectively). The Fund started operation on 1 July 2012 under the "Measures on the Collection and Management of Waste Electrical and Electronic Products Disposal Fund" (Ministry of Finance *et al.*, 2012). The fund supports qualified recycling enterprises for dismantling and disposing EEP (Ministry of Finance *et al.*, 2015). By 2015, China had become the largest generator of e-waste in the world, with estimations of discarding over 200 million major EEP each year amounting to over five million tons (Ministry of Industry and Information Technology *et al.*, 2015). There was thus urgency to address e-waste by more effective measures. The three-year pilot scheme was initiated under the "Work Plan on Pilot Exercise of EPR on Electrical and Electronic Products" (Work Plan on EEP EPR Pilots) (Ministry of Industry and Information Technology *et al.*, 2015). The scheme covers household electrical products (e.g. televisions, refrigerators, washing machines and air conditioners), computers and office electrical products (e.g. printers and photocopiers), communication and electronic products, lighting products and batteries (Ministry of Industry and Information Technology *et al.*, 2015, Part IV). Leading manufacturers of the relevant products were among the first participants of the pilot scheme, including Sichuan Changhong Electrical Co Ltd (television, refrigerator, air conditioner and mobile phone),

Zhuhai Gree Electrical Co Ltd (air conditioner, refrigerator, mobile phone, etc.), Hisense Corp Ltd (television, air conditioner, refrigerator, washing machine), Legend Co. Ltd (computer, notebook computer, mobile phone) and Huawei Co Ltd (mobile phone, tablet) (Ministry of Industry and Information Technology *et al.*, 2016). As producers, they are required to establish collection networks via their own sales or maintenance and repair channels or entrust a third party to collect the used products for recycling and recovery (Ministry of Industry and Information Technology *et al.*, 2015, Part III). With the implementation and expansion of a compulsory EPR scheme in China, it is hoped that such producers will be driven to design their products in such a way to facilitate best resource recovery at the end of use, which effectively cuts down waste generation and waste for final disposal.

5. Circular economy in wider society: from production to consumption

Successful implementation of CE requires active participation by all industrial sectors and civil society. Even though pilot schemes have worked well to initiate and promote CE in the early stage by concentrating on increasing resource efficiency within key industrial sectors and industrial parks, most government-led CE initiatives have ignored sustainable consumption and limited dissemination and awareness beyond direct participants (Liu and Bai, 2014; Zhu *et al.*, 2018). It is therefore now time to expand CE implementation beyond the boundaries of pilot schemes and industrial parks to the wider society covering production, distribution and consumption. Low awareness of and weak participation in CE development by industries and the community would inhibit CE development in China. In response to criticism that China's CE plans and strategies target industrial pollution but fail to change patterns of consumption (McDowall, 2017), the 13th FYP (2016–2020) has placed greater emphasis on the circular link between production and consumption, strengthening resource recovery and safe disposal of kitchen waste, construction waste and waste textiles and improving the linkage between household waste sorting and the resource recycling sector (13th FYP, ch 43 *s* 5; see also: State Council, 2016b; Ministry of Commerce *et al.*, 2015; NDRC *et al.*, 2017).

CE performance at city level varies significantly according to empirical studies conducted by researchers (Guo *et al.*, 2017; Wang *et al.*, 2018). Facilitating more widespread CE implementation at city and provincial levels will require more complex and extensive cooperative networks between enterprises and industrial parks from primary, secondary and tertiary sectors. It requires the redesign and rearrangement of a city's infrastructure and industrial layout according to local characteristics. CE at the city and wider-community level operates under the direct planning of local governments, who should develop CE production, improve and coordinate resource recycling among different industrial parks and different communities, invest in society-wide resource recycling and recovery systems and promote green lifestyles (including green consumption, transport, buildings and logistics) to foster a strong CE culture within society.

Urbanisation, population growth and overall improvement of living standards have boosted consumption of goods and services, the by-product of which is growth of municipal solid waste generation. One of the fundamental requirements is thus a change in attitude and behaviour across society. To effect such changes, CE development requires public participation and support. Consumers are the ultimate driver of CE development as their behaviours of consumption and waste disposal determines the level of the 3Rs. There has been low awareness of the concept, method and potential benefits of green consumption and household waste recycling among the general public until very recent years. Perhaps the most significant change of lifestyle in urban China in 2019 was the compulsory waste sorting requirements implemented in Shanghai.

The high-profile promulgation and implementation of the Regulation on Municipal Solid Waste Management (Shanghai Regulation) in 2019 caught public attention and raised awareness and interest in waste separation at the source. The local regulation aims to increase the rates of the 3Rs and safe disposal of municipal solid waste by establishing a system of waste sorting from deposit to collection to transport and disposal covering the whole city (article 3). It requires waste generators, i.e. entities and individuals, to sort waste according to the four categories:

(1) recyclables including waste paper, waster plastic, waste glass products, waste metal and waste textile products;

(2) hazardous waste including waste battery, waste light tubes, waste medicine, waste paint and its container;

(3) wet waste including kitchen waste, flowers and plants; and

(4) dry waste including all other waste (Article 4) and deposit the sorted waste at designated collection points and during designated hours (Article 24).

Furthermore, the regulation will gradually establish a municipal solid waste treatment fee to reduce waste; entities and individuals are to pay for the waste they generate based on quantity and type in accordance with the polluter pays principle (Article 7). The compulsory waste sorting and fee scheme are measures that force individuals to reflect on their lifestyle and steadily curb consumption if they want pay lower fees.

The regulation further mandates separated collection and transport of different types of wastes for safe disposal (Chapter V). Local government bodies are required to strengthen the work on recycling and recovery of resources from waste by financial support, network building and utilisation of recycled wet waste in public greenery and agriculture (Chapter VI). Public participation in waste sorting provides an indispensable foundation for waste recycling and recovery. It is the duty of local governments to ensure an existing urban and rural infrastructure for the management of municipal solid waste from separate collection and transport to recycling, recovery and disposal to implement CE in the city.

Shanghai is therefore taking the lead nationally in incentivising behavioural changes through economic and regulatory measures and building infrastructure for increased recycling and recovery. The central government has planned for 46 cities to implement compulsory waste sorting and achieve 35% of recyclables and kitchen waste to be recycled and recovered by 2020 (Ministry of Housing and Urban Rural Development, 2017, Part 1; NDRC and Ministry of Housing and Urban Rural Development, 2017). It requires local governments' efforts, resources and governance capacity to build cities with circular flow of materials supported by the recycling and recovery service sector. The State Council identified ten focus areas for CE demonstration projects in 2013, which remain to be the focus of efforts in the coming years (State Council, 2013).

The resource recycling and recovery sector has remained under-developed, as the operation has so far not been profitable or financially viable. Given its importance in CE development, it is the responsibility of the government to provide strong and stable financial support to foster the growth of the recycling industry and the administrative coordination and service needed to boost recycling and recovery rates. The central government earmarked funding support for 100 sites of waste product recovery, sorting and assembling and to foster 100 enterprises that are well-organised and technologically advanced to engage in recycling and recovery of renewable resources (State Council, 2013, ch VII *s* 1), but more is needed from the local governments. The same is true for the recycling and safe disposal of kitchen waste generated by the catering industry, canteens of schools and institutions and

households. These wastes are either landfilled – cities in China face the challenge of mountains of kitchen waste – or end up in illegal recycling business in which environmental standards are not monitored and thus pose a serious risk to human health. There is therefore urgent need to invest in capacity for kitchen waste recycling systems and to establish a management system covering their life cycle from generation to collection, transport and disposal.

6. Conclusion

Within a 15-year period from 2005 to 2020, China has turned CE from a concept into state policy and a national development strategy focussing on the 3Rs with central government taking the lead. By providing substantial fiscal support, the State Council mobilised provincial and municipal governments to implement CE at enterprise, industrial park and city levels through pilots and in stages. There are both successful and unsuccessful CE pilot projects carried out under the overall supervision of NDRC, providing best practices and lessons learnt for wide dissemination. Local governments have played an important role in CE implementation by providing supra-firm management together with the capacity to invest and bring firms together to close resource loops. As the administrative authority, they facilitate inter-firm cooperation along the value chain, building collaborative relationships and capturing complementarities among enterprises.

The inclusion of CE in the FYPs indicates that CE will remain a key strategy for China's long-term sustainable development ambitions. With continuing support and facilitation from central to local governments, the next stage of CE implementation is to widen participation, for example, by extending the EPR scheme beyond the four designated categories of products and compulsory household waste sorting beyond the 46 designated cities. To build a society based on closed-loop materials flows, the central and local governments must support and invest in technology advancement and infrastructure building for the 3Rs. With China's CE 1.0 focussing on industrial sectors through pilot schemes at industrial parks, the next stage – China's CE 2.0 – should cover resource production, distribution and consumption across the whole of society, including all enterprises, institutions and individuals, to achieve resource conservation and environmental protection. Overall, this paper has demonstrated that China has embarked on its journey to CE, which will need central and local governments' sustained efforts to further engage and support active participation by both industry and consumers to continue the transition.

Notes

1. National People's Congress Standing Committee. Circular Economy Promotion Law of the People's Republic of China (promulgated by The Standing Committee of the National People's Congress, August 29, 2008), effective 1 January 2009.
2. The estimate could be at the lower end of the actual cost, as the study excluded many items such as the cost of groundwater pollution and the cost of soil contamination because of, *inter alia*, lack of relevant data.

References

Guo, B., Geng, Y., Ren, J., Zhu, L., Liu, Y. and Sterr, T. (2017), "Comparative assessment of circular economy development in China's four megacities: the case of Beijing, Chongqing, Shanghai and Urumqi", *Journal of Cleaner Production*, Vol. 162, pp. 234-246.

Johnson, T.M., Liu, F. and Newfarmer, R. (1997), "Clear water", *Blue Skies: China's Environment in the New Century*, World Bank, Washington, DC.

Liu, Y. and Bai, Y. (2014), "An exploration of firms' awareness and behavior of developing circular economy: an empirical research in China", *Resources, Conservation and Recycling*, Vol. 87, pp. 145-152.

McDowall, W. (2017), "Circular economy policies in China and Europe", *Journal of Industrial Ecology*, Vol. 21 No. 3, pp. 651-660.

Ma, K. (2004), "To implement the scientific outlook on development and vigorously promote circular economy development", *Speech delivered at the first National Working conference on Circular Economy*, 28 September 2004.

Mathews, J.A. and Tan, H. (2016), "Circular economy: lessons from China", *Nature*, Vol. 531 No. 7595, pp. 440-442.

Mathews, J.A., Tan, H. and Hu, M.C. (2018), "Moving to a circular economy in China: transforming industrial parks into eco-industrial parks", *California Management Review*, Vol. 60 No. 3, pp. 157-181.

Ministry of Commerce *et al.* (2015), "Medium and long-term plan on building resource recovery network (2015-20)".

Ministry of Finance and State Administration of Taxation (2011), "Circular on adjusting and improving the value-added tax policies for products and labour services that comprehensively utilize resources".

Ministry of Housing and Urban Rural Development (2017), "Notice on speeding up the work of waste sorting in designated cities".

Ministry of Industry and Information Technology, Ministry of Finance, Ministry of Commerce and Ministry of Science and Technology (2015), "Work plan on pilot exercise of EPR on electrical and electronic products (promulgated on 29 June 2015)".

NDRC (2011), "Model cases of CE pilot projects".

NDRC (2015), "2015 Plan on promotion of circular economy".

NDRC and Ministry of Finance (2016a), "Notice on publication of national CE pilots best practice".

NDRC and Ministry of Finance (2016b), "Guide on promotion of national CE pilots best practice.NDRC and ministry of housing and urban rural development (2017), implementation plan on sorting of municipal solid waste".

NDRC *et al.* (2005), "Notice on the work of CE pilots (1st batch)".

NDRC *et al.* (2013), "Notice on assessment and appraisal of national CE demonstration pilots".

NDRC *et al.* (2014), "List of national CE demonstration pilots passing the assessment (1st batch)".

NDRC *et al.* (2015a), "List of national CE demonstration pilots passing the assessment (2nd batch)".

NDRC *et al.* (2015b), "List of national CE demonstration pilots failing the assessment".

Pearce, D.W. and Turner, R.K. (1990), *Economics of Natural Resources and the Environment*, Pearson Education Limited, Essex.

Qi, J., *et al.* (2016), *Development of Circular Economy in China*, Springer, Singapore.

State Council (2005), "Several opinions of the state council on accelerating the development of the circular economy".

State Council (2013), "CE development strategy and short-term action plan".

State Council (2016a), "Plan on implementation of the EPR scheme".

State Council (2016b), "13th FYP on protection of eco-environment".

State Environmental Protection Administration and State Bureau of Statistics (2006), "Report on china's green GDP for 2004", *Environmental Protection*, Vol. 98, pp. 22-29.

Su, B., Heshmati, A., Geng, Y. and Yu, X. (2013), "A review of the circular economy in China: moving from rhetoric to implementation", *Journal of Cleaner Production*, Vol. 42, pp. 215-227.

Wang, N., Lee, J.C.K., Zhang, J., Chen, H. and Li, H. (2018), "Evaluation of urban circular economy development: an empirical research of 40 cities in China", *Journal of Cleaner Production*, Vol. 180, pp. 876-887.

Wen, Z. and Meng, Z. (2015), "Quantitative assessment of industrial symbiosis for the promotion of circular economy: a case study of the printed circuit boards industry in China's Suzhou new district", *Journal of Cleaner Production*, Vol. 90, pp. 211-219.

World Bank and State Environmental Protection Administration (2007), *Cost of Pollution in China: Economic Estimates of Physical Damage*, The World Bank, Washington, DC.

Wu, Q. (2007), "Targeting zero emission by industry Suzhou new district to invest billions to close the loop", *Suzhou Daily*, 11 June 2007.

Xie, J., Pinter, L. and Wang, X. (2009), *Developing a Circular Economy in China: Highlights and Recommendations*, World Bank, Washington, DC..

Xu, Y. (2015), "CE development in Suzhou new district under ecological civilization", *Environmental Protection and Circular Economy*, Vol. 1, pp. 10-13.

Yang, J. (2007), "Suzhou new district: from waste information platform to attracting investment to close the loop", *Jiefang Daily*, 3 September 2007.

Zhu, J., Fan, C., Shi, H. and Shi, L. (2018), "Efforts for a circular economy in China: a comprehensive review of policies", *Journal of Industrial Ecology*, Vol. 23 No. 1, pp. 110-118.

Further reading

Ministry of Finance, MEP, NDRC, Ministry of Industry and Information Technology, Customs Administration, and State Tax Administration (2012), "Measures on the collection and management of waste electrical and electronic products disposal fund (promulgated on 21 May 2012; implemented on 1 July 2012)".

Ministry of Finance, MEP, NDRC and Ministry of Industry and Information Technology (2015), "Standards of subsidy by the waste electrical and electronic product disposal fund (issued on 26 November 2015; implemented on 1 January 2016)".

Ministry of Industry and Information Technology, Ministry of Finance, Ministry of Commerce and Minsitry of Science and Technology (2016), "Notice on the participants of the EEP EPR pilot scheme (1st batch) (promulgated on 4 February 2016)".

National People's Congress Standing Committee (2008), "Circular economy promotion law (adopted by the 11th NPC standing committee on 29 august 2008; implemented on 1 January 2009. The law was amended in 2018)".

NDRC, State Environmental Protection Administration, Ministry of Science and Technology, Ministry of Finance, Ministry of Commerce and national Bureau of Statistics (2005), "National action scheme for pilot programmes of circular economy".

NDRC, SEPA and National Statistics Bureau (2007a), "CE evaluation indicators system, revised in 2017".

NDRC, SEPA, Ministry of Science and Technology, Ministry of Finance, Ministry of Commerce and State Statistics Bureau (2007b), "Notice on the work of CE demonstration pilots (1st batch)".

NDRC, the People's Bank of China, the China Banking Regulatory Commission and the China Securities Regulatory Commission (2010), "Circular on the investment and financing policies and measures supporting CE development".

NDRC, Ministry of Science and Technology, Ministry of Industry and Information Technology, Ministry of Finance, Ministry of Land and Resources, Ministry of Environmental Protection, Ministry of Housing and Urban Rural Construction, Ministry of Water Resources, Ministry of Agriculture, Ministry of Commerce, State Assets Commission, State Taxation Administration,

State Statistics Bureau and State Forestry Bureau (2017), "Leading action on circular development".

National People's Congress (2006), "The eleventh five-year plan of the People's Republic of China for national economic and social development (2006-2010)".

National People's Congress (2011), "The twelfth five-year plan of the People's Republic of China for national economic and social development (2011-2015)".

National People's Congress (2016), "The thirteenth five-year plan of the People's Republic of China for national economic and social development (2016-2020)".

Shanghai Municipal People's Congress (2019), "Shanghai regulation on the management of municipal solid waste (adopted by the 15th municipal people's congress on 31 January 2019; implemented on 1 July 2019)".

Corresponding author
Yuhong Zhao can be contacted at: yuhong.zhao@cuhk.edu.hk