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How does circular economy respond to greenhouse gas emissions reduction: An analysis of Chinese plastic recycling industries

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ABSTRACT

With the necessity of greenhouse gas (GHG) emissions reduction as a backdrop, the circular economy (CE) is increasingly being considered an effective response to this issue. Currently, China is facing a considerable challenge as it tries to respond to Paris Agreement targets; however, in many respects China is ahead of other nations as it relates to the implementation of such innovative strategies such as the circular economy policies. For over ten years, China has been investigating how the circular economy policies could be used to respond to GHG emission issue. In particular, the effects of such economic development pattern needs to be identified as well as the specific influence on GHG emissions reduction. This study presents an analysis of the Chinese plastic recycling industries (CPRI) through this lens. Plastics were specifically targeted, as such waste generation represents one of the highest fractions of global waste by mass, as well as the increasing public concerns of the environmental impacts of post-consumer plastics waste. Integrating the concepts of circular economy in this industry could be deemed an effective strategy, one which not only reduces post-consumer waste pollution, but also mitigates GHG emissions. This study analyzes the trajectories, features and driving forces of GHG emissions reduction achieved by the CPRI in the past ten years. The results show that the contribution of the CPRI to [specifically] CO_2 emissions reduction increased from 7.67 million tons (MT) in 2007 to 14.57 MT in 2016; the scale factor and structure factor had significant impacts on GHG emissions reduction changes. A scenario analysis is presented based on projected impacts of various relevant national strategies. Finally, the policy implications of the CPRI's further GHG reduction measures are proposed.

1. Introduction

1.1. Circular economy and GHG emissions reduction

The circular economy (CE) can be defined as an economic system by which products are designed as restorative and regenerative with the goal of utilizing products [as well as the components and materials] at the highest value at all times, distinguishing between the technical and biological aspects of the cycles [1]. Although there is no clear evidence of an originator of the CE concept, the accepted principles of the CE concept initially included the 3Rs (reduce, reuse, recycle) and then expanded to encompass the 6Rs (reuse, recycle, redesign, remanufacture, reduce, recover) [2,3]. In order to respond to intensive resource consumption and widespread environmental pollution, the CE concept has been applied globally, albeit with varying degrees of success. For instance, CE has been applied in the UK, Denmark, Switzerland, and Portugal for waste management. In Germany, CE has been introduced into environmental policy with the intent of addressing issues associated with raw material and natural resource use for sustained economic growth. In Asia, CE-related initiatives aim to increase consumers' responsibility for material use and waste (e.g. Korea and Japan). In North America, corporations have applied the notion of CE to enhance reduce, reuse, and recycle programs, and to conduct product-level life cycle studies [4].

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In China, the concept of CE is used as a mechanism for profitable product development, new technology development, upgrading equipment, and improving industry management. China's knowledge of CE originated from European Union countries like Germany, the United States of America (USA) as well as Japan, incorporating such learned experiences explicitly into industrial policy linked to improved resource efficiency and reduction goals, and the establishment of eco-industrial park pilot projects. However, due to a socio-political context different from most other nations, China's socioeconomic environment provides an unique and ideal canvas for the new, expanded CE policies' implementation. In recent years, China's CE strategies have developed rapidly, attributable to national political support. For instance, the latest legislative support for CE was amended in 2009 [5].

Against the backdrop of necessary global GHG emissions reduction, CE is considered as a powerful strategic response [6–8]. As the largest global GHG emitter, China faces a considerable challenge in responding to its agreed target of 40–45% GHG emissions reduction per unit gross domestic production (GDP) by 2020 as compared to 2005 levels [9]. In the past ten years, China has implemented CE policies at various scales: the micro level, i.e. individual processes or companies; the meso level, i.e industrial clusters or eco-industrial parks; and macro level, ie. ranging from cities to national economies [10]. It is the effects of such economic development patterns on GHG emissions reduction that was discussed.

For example, despite their indisputable benefits and ubiquitous presence in all corners of society, plastics [and thereby post-consumer plastic wastes] have been found to have significant economic and environmental drawbacks linked to environmental pollution in terms of single-use [11]. Chinese plastic production represents around 25% of global plastic projection, with a total production of 75.61 MT. Meantime, as of 2015, the total mass of Chinese recycling plastic waste accounted for over 50% ratio in the global recycling plastic waste – or 22 MT [12]. Simultaneously, public concerns about pollution caused by post-consumer plastic waste have risen considerably.

Adopting CE strategies within the CPRI could be a win-win strategy – reducing plastic waste while mitigating GHG emissions. Diverting plastic waste in order to offset the use of virgin materials in plastic production positively contributes to GHG emissions reduction [13,14]. However, due to the complexity of the supply-chains associated with plastic waste, the study of the relationship between plastic waste and GHG emissions at a national scale is limited. Eva et al. [15] conducted a quantitative analysis on the GHG emissions linked to post-consumer plastic waste recovery in Spain from the perspective of material and energy. They considered the factors like the plastic waste quality, the recycled plastic applications and the markets of recovered plastic products. However, no other scholarly research was found (at the time of writing) regarding the impact on GHG emissions trends linked to plastic waste recovery from a national perspective. Therefore, the experience and contribution of the CPRI provides some novel insight to this perspective and starts to fill the knowledge gap by analyzing trajectories, and better understanding the features and driving forces of GHG emissions reduction within the CPRI in the past ten years. In addition, a scenario analysis projecting out 15 years is presented for various relevant national strategies. Finally, the policy implications for the CPRI - as a result of the drive for further GHG emissions reduction- are proposed.

1.2. CPRI development

Plastics are used extensively around the world, bringing consumers conveniences in their daily lives in the form of packaging, vehicles, electronic device, and appliance – amongst other products. Its versatility, and its lightweight but durable structure has lent to a growth in global plastic production from 1.5 Mt in 1950 to 299 MT in 2013 [16]. In addition, it is estimated that global plastic production will increase another 300% by 2050 – based on current projections [17,18]. For example, the Chinese plastic industry has witnessed rapid growth even in the last 8 years (see Fig. 1) [12], now representing 25% of global plastic products. European Union Countries, North America, Middle East and Africa, as well as Latin America account for 22.9%, 20%, 7.3%, and 4.8% respectively. However, plastic waste generation has also increased sharply each year as well. Against the backdrop of concerns around continuing upward trends for GHG emissions, reutilization and recovery of plastic waste is deemed as a [potential] key response to such both issues. The reasoning is that plastic products originate from fossil fuels – a carbon intensive resource. Therefore, reutilization and recovery of plastic waste mean reducing fossil fuel inputs leading to a reduction in the associated GHG emissions – at the same time post-consumer plastic waste pollution is being reduced.

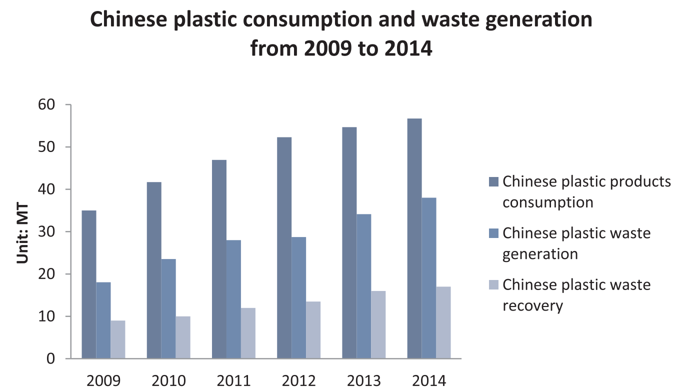

Fig. 1. The Chinese plastic products consumption and waste generation.

Under such circumstance, plastic waste recycling industries have developed quickly in recent years. Westernized countries planned and implemented recycling supply-chains much earlier than in other global regions. For instance, Germany amended the “plastics waste package items” from 1991, which regulated the obligation of collection, conduction and recycled reutilization among producers and retailers in the life cycle span. Starting in the 1960, Japan began amending a series of policies and regulations to with the intention of improving the management of solid waste.

Since its inception about 10 years ago, the CPRI has developed rapidly under the auspices of national supportive policies. For instance, in order to encourage CPRI development, the Chinese government approved 49 national-level circular economy parks; two thirds established specific CPRI zones to facilitate CPRI development. To date, over 10 thousand enterprises have emerged, participating in the CPRI sector around the nation. Spatially, they are mainly located in the economic developed provinces such as Guangdong, Zhejiang and Fujian Provinces. The amount of recovered plastic waste products increased from 9 MT in 2009 to 17 MT in 2014. The corresponding ratio of plastic waste recycling was improved from 25.70% in 2009 to 30% in 2014. In addition, the shares ratio in mixing new plastic and recycled plastic was around 3.35:1 in 2014 [12]. Products made from recycled plastic waste are mainly for packaging products, household appliance, electronic devices and vehicle plastic (see Fig. 2). Until the recent ban suggested otherwise, it was believed that domestic recycling plastic waste alone could not meet the demand for the CPRI – plastic waste was imported from abroad every year (see Fig. 3) [12]. Importing plastic waste has been seen to play a significant role in supplementing resource deficiency of China, balancing trade as well as increasing job opportunities. China imports most recently were recorded as 8 MT annually. The five provinces importing the most plastic wastes were Guangdong (38.53%), Fujian (12.82%), Zhejiang (11.44%), Shandong (8.81%), and Jiangsu (7.66%) respectively, accounting for 79.27% of total importing mass.

Although the CPRI emerged much later than the recycling industries in western countries, Fig. 3 shows that it has maintained a fast growth in the past few years. As noted, the total amount of Chinese recycling