U.S.-China Collaboration on the Circular Economy
Background and Potential Topics

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SUMMARY

Circular economy (CE) is a regenerative growth model defined by renewable materials with minimum waste. The policy concept has notable traction in Europe, Japan, and China, but has caught on less in the United States. CE aims to improve economic prosperity, environmental quality, and social equity, all while saving resources and energy and creating local jobs. It has multiple co-benefits including mitigating climate change, lowering pollution, and reducing deforestation, among other AFOLU-related areas. The clear linkages between CE and climate change mitigation have been substantially explored in academic research and in policy practices. China has taken CE as a key approach in their climate change mitigation strategies. CE is estimated to have contributed 25% of China's carbon emissions reductions in 2016-2020 through material substitution, process optimization, fuel substitution, energy efficiency enhancement, and product design and remanufacturing. CE also has coupled effects with methane mitigation, such as through biogas recovery from livestock manure, landfills, and wastewater. Emerging collaborative opportunities include regenerative agriculture and circular carbon economy (CCE). In terms of future CE collaboration, the U.S. and China could explore areas including (CEE), regenerative agriculture, plastic pollution, recycling and utilization of retired wind turbines and solar panels, as well as waste sorting.

BACKGROUND

While "circular economy" tends to refer to the concept of reducing human impacts on ecosystems through more efficient use of materials, there is no commonly-accepted definition of circular economy (CE) among scholars and practitioners. It is widely recognized that the concept originated from the Spaceship Earth Theory of the ecological economist Kenneth Boulding (Boulding, 1966), in which the author argued that resources on Earth were finite and therefore placed hard constraints on economic activity. The concept was further developed in the field of industrial ecology, which studies the stages of production of goods and services with respect to natural resources and environmental impacts. Generally speaking, CE refers to a regenerative growth model underpinned by a transition away from the traditional linear model based on a "take-make-consume-throw away" pattern to the use of renewable resources and materials at every point in the chain by closing the cycles of the material flows. It aims to create an economy and society with minimal waste. In practice, CE is often associated with the "R frameworks," including the 3R Principle of "reduce, reuse, and recycle" — reflected for example in China's 2008 Circular Economy Promotion Law, and the 4R principle adopted by the EU,[1] which introduced "recover" as a fourth "R." However, many discussions around CE focus merely on one of the "Rs" — the process of recycling, which is not fully considered as circular. For example, various actions can be taken at every step of a building's life cycle, including design, construction, operation, modification, and construction waste utilization and treatment, as part of CE, where recycling is one step of the process.

Moreover, the scope of CE has grown beyond simply applying the R principles to individual production or consumption activities towards a system perspective. It requires a fundamental, as opposed to incremental, shift of the current economic system, including: (1) the micro-systems which consider the circularity of products and individual entities; (2) the meso-systems which highlight regional-level circularity such as the eco-industrial parks; and (3) the macro-systems which focus on the national/global industrial composition and structures of the entire economy (Jackson et al., 2014; Kirchherr et al., 2017).

POLICY DEFINITIONS OF CE

As a policy concept, CE has had notable traction in Europe, Japan, and China, but has had minimal focus at either federal or non-federal levels in the United States. In China, CE has been frequently invoked in policy documents and policy goals. However, China's definition of CE is not clearly stated in existing policies. Nevertheless, according to several official sources, CE is based on the highly efficient utilization and recycling of resources in economic activities, including design, production, circulation, consumption, and waste treatment, with the core principle of "reduce, reuse, and waste-to-resource." The basic characteristics are low resource consumption, low emissions, and high efficiency. CE requires organizing economic activities around the feedback loop of "resources-product-waste-regenerative resources," instead of the linear model of "resource-product-waste." It requires a fundamental transformation away from the traditional extensive growth model of excessive input, excessive resource consumption, excessive emissions, and low efficiency. The micro-level (individual enterprise), meso-level (industrial park), and macro-level (whole society) systems are all considered in China's CE.

Comparatively, despite the relative lack of policy emphasis in the United States, the definition of CE in the U.S. is more specific: for example, the Save Our Seas 2.0 Act of 2020 defines CE as "an economy that uses a systems-focused approach and involves industrial processes and economic activities that (A) are restorative or regenerative by design; (B) enable resources used in such processes and activities to maintain their highest values for as long as possible; and (C) aim for the elimination of waste through the superior design of materials, products, and systems (including business models)."

AIMS AND CO-BENEFITS OF CE

The existing literature has identified four aims of CE, namely promoting environmental quality, economic prosperity, and social equity, without compromising future generations. Researchers have tended to locate the main aim as **economic prosperity**, such as creating new technologies and business opportunities, followed by **environmental quality** (Kirchherr et al., 2017). It is argued that CE would **save resources** and energy as well as **create local jobs**. Using resources for the longest possible time could cut certain countries' emissions by up to 70%, increase workforces by 4%, and greatly reduce waste (Stahel, 2016).

CE has multiple co-benefits with respect to many sustainable development challenges such as climate change, pollution, and AFOLU. For example, CE can contribute to reducing deforestation by significantly reducing timber resources for wood pulp in paper manufacturing, which accounts for 12% of the world's total timber consumption. Waste paper can replace wood pulp as raw material. The recycling of paper waste will significantly reduce timber consumption, as data shows that recycling 1 ton of paper saves 17 trees.[2] In China, through the implementation of CE, the amount of recycled paper waste increased from 44.7 million tons in 2012 to 64.9 million tons in 2021, and the recycling rate increased from 44.5% to 51.3% during the same period.[3]In comparison, 47 million tons of paper waste were recovered in the U.S. in 2021, accounting for 65.7% of total paper consumed.[4]

While the linkage between CE and environmental discourse is clear, the **social equity** dimension—how CE aims to strengthen and develop society, human well-being, and employment—was seldom discussed in the past, yet it has become a trending topic in the past two years (Greer et al., 2021; Kirchherr, 2021; Schröder, 2020). An increasing number of studies have emphasized the importance of incorporating just transition into CE (e.g., just circular economy and circular justice), especially with regard to employment impacts. The estimated CE-induced net job creation in the EU spans from 580,000 to 2 million jobs in the time frame of 2015-2030. In particular, employment in waste management is expected to increase because recycling is more labor-intensive compared to landfilling. However, employment may decrease in economies that rely on raw material production, processing, or apparel manufacturing due to reduced demand, and these economies tend to be at low- and middle-income levels (Repp et al., 2021).

As a global pioneer of promoting CE, the EU has initiated “a just inclusive transition to circular economy” (JUST2CE) project which explores the economic, societal, gender, and policy implications of the circular economy paradigm. It is bolstered by the idea that CE should not merely depend on the development of new technologies, but also the integration of democratic and participatory governance into the design and management of those technologies. However, in China, just transition has been relatively less discussed in the current CE policy agenda.

LINKAGES TO CLIMATE CHANGE MITIGATION

The synergy between CE and climate change mitigation has been substantially explored in research and policy discussions. Both enhancing resource efficiency (by slowing, closing, and narrowing material and energy loops) and promoting eco-innovations can contribute to carbon emissions reductions (Cantzler et al., 2020; Durán-Romero et al., 2020). Research shows that the industrial, energy, and transport sectors have the highest potential for carbon emissions reductions through the implementation of CE; mid-range potential can be found in the waste and building sectors; and limited reductions are expected in agriculture (Cantzler et al., 2020). China has taken CE as a key approach in its climate change mitigation strategies, with CE estimated to have contributed 25% of China’s carbon emissions reductions during the 13th Five-Year-Plan period (2016-2020). CE can reduce GHG emissions through five enabling pathways:[5]

1. **Material substitution**. Solid waste such as fly ash (a coal combustion product) can substitute for limestone and other carbonate-based high-carbon-loading raw materials to reduce CO_2 emissions from calcination energy consumption and limestone decomposition. One ton of solid waste utilization can reduce 0.85 tons of CO_2 emissions.
2. **Process optimization.** Excessive energy and resource use can be effectively reduced by the reuse and recycling of waste steel, aluminum, plastic, and other renewable resources, as well as through shortened process flows. For example, waste steel can substitute natural iron ore for steel smelting. This approach can reduce 1.6 ton of CO_2 emissions per ton of steel produced.
3. **Fuel substitution.** Biomass waste-to-energy can substitute fossil fuels for electricity power generation, reducing 8.1 tons of CO_2 emissions per 10,000 kWh electricity generated.
4. **Energy efficiency enhancement**. Capturing and reusing waste heat and pressure, as well as sharing energy facilities within industrial parks, can significantly increase energy efficiency. In 2020, 375 Mtce of waste heat was captured and reused in China, resulting in 1 billion tons of CO_2 emissions reductions.
5. **Product design and remanufacturing.** CE principles can guide product design from the beginning, which determines 80% of its impact on the environment. Along with packaging design and business models following CE principles, waste and GHG emissions from a product’s lifespan can be reduced before it is manufactured. Moreover, energy/resource use and carbon emissions from manufacturing new products can be significantly reduced by technologies such as product remanufacturing, high-quality refurbishment, and product life extension. Compared to brand-new products, remanufactured products can reduce the use of raw materials by 70-80% and CO_2 emissions by more than 80%.

LINKAGES TO METHANE MITIGATION

The linkages between CE and methane emissions reduction have not been fully explored in the existing literature. Most of the CE literature related to methane mitigation focuses on bioenergy/bioeconomy, particularly in the waste and agriculture sectors. Biogas derived from organics in landfills, wastewater, and livestock manure is directly associated with the application of CE to minimize waste and improve utilization. One direct link is that the recovery of biogas can not only reduce methane emissions generated from these sources but also substitute fossil fuels to produce electrical power and heat. Waste-to-biogas-based circular economy requires an integration of waste management, biogas production and utilization, and policy support (Kapoor et al., 2020). The other way that CE can help with methane emissions reduction in landfills is to use technologies such as aerobic bioreactors or semi-aerobic bioreactors to prevent methane production.

In this regard, waste sorting practices adopted by firms, communities, and individuals are considered as an effective tool for methane mitigation. The separation of food and other organic waste can increase the yield of methane gas to increase the economic feasibility of the mitigation options (Davidsson et al., 2007). In China, community and individual-level waste sorting practices have gained high political attention from the central government. China has conducted policy experiments and pilot city programs on waste sorting practices in recent years and is instituting the “Zero-Waste Society” initiative across the country. A common business model is to separate organic/food waste from other municipal solid waste and process the waste in CE industrial parks across the country.

LINKAGES TO PLASTIC POLLUTION MITIGATION

Literature on plastic pollution mitigation is growing rapidly as global attention on plastic pollution increases, and CE features as the primary method to address this problem. CE principles can be applied to reduce impacts at every stage of the plastics value chain: product design, manufacturing, and service delivery, distribution and use, and end-of-life management (Fadeeva and Van Berkel, 2021). US policies have primarily focused on a narrow range of health impacts from plastic through policies such as the Microbead-free Waters Act (Syberg et al., 2021). China has implemented broader policies addressing more stages of the plastic life cycle, including a ban on the production and use of thin plastic bags, and a ban on the importation of plastic waste (Syberg et al., 2021). The 2023 negotiations to develop an international treaty on plastic pollution will provide an opportunity for collaboration and enhancement of ambition (Thompson, 2022).

IMPLICATIONS FOR US-CHINA COLLABORATION ON CE

CE has become a crucial pathway for mitigating climate change and promoting sustainable development in China. China has a long history of promoting waste-to-resource due to resource and energy shortages. The concept of CE emerged in the late 1990s and has become an important national strategy for resource conservation and sustainable development since 2002. China is the third country in the world to adopt national legislation on CE, following Germany and Japan. A comprehensive policy framework on CE was established, which also set mandatory targets for energy saving and efficiency (measured by energy intensity). In fact, the energy-saving requirements under the CE policy framework initiated and drove China’s actions on carbon emissions reduction prior to China’s climate policy agenda (Zhao and Qi, 2022). The Department of Resource Conservation and Environmental Protection of the National Development and Reform Commission (NDRC) supervises CE development in China. However, many other government authorities are also involved in the policy process.

China has achieved economic, social, and environmental benefits through CE. In 2020, CE-related industries yielded a total production value of 7,500 billion RMB (more than 1,000 billion USD) and provided numerous job opportunities. It is estimated that 2.6 billion tons of CO_2 emissions reductions were achieved by promoting CE in 2020.[6] For the 14th FYP period (2021-2025), China will be primarily focusing on building recycling systems for urban waste, CE applications for industrial parks, demonstration projects of industrial solid waste and building waste utilization, CE technologies and equipment innovation, remanufacturing industries, waste electrical and electronic equipment (WEEE) recycling and utilization, motor vehicle life cycle management, all-supply chain governance for plastic pollution, green packaging for delivery service, and EV batteries.

In contrast to China's top-down approach, US development of CE-related practices is more bottom-up, with the business sector as well as state and local governments often take the initiative. There are four potential areas of CE that the US and China can work on collaboratively in terms of policy-making, experience sharing, and academic exchange:

1. Circular carbon economy, with a focus on topics including carbon capture and sequestration, landfills, coal mine and oil/ gas methane emissions reduction, recovery and removal. The concept and framework are a recent development of CE and its application for carbon-intensive economies. The core idea is to take carbon emissions as a material that can be reduced, reused, recycled, and removed[7] within a closed loop system where carbon emissions are sequestered or chemically transformed into new products. Coal mines and the oil and gas sectors are the major methane emission resources for both the US and China. The CCE framework has the potential to catalyze waste gas reduction and recovery from these sectors. This framework has already been adopted by Saudi Arabia and has the potential to be applied in other countries, including China.
2. Regenerative agriculture for GHG emissions reduction, and in particular methane mitigation practices. Regenerative agriculture practices build up both organic soil carbon and nitrogen stocks while reducing nitrogen losses with proper management. Livestock management system under regenerative agriculture is also effective at reducing methane emissions from manure management, and more importantly from enteric fermentation by providing high-quality feed that is easier for the livestock to digest and decreases the need for antibiotics.
3. Recycling and utilization of retired wind turbines and solar panels. The US and China are the world's two largest national investors in wind and solar energy. China is the world's largest solar panel and wind turbine manufacturer. Waste equipment in the renewable energy sector will be increasingly important due to surging deployment.
4. Waste sorting. Collaboration can be explored in the subnational (metropolitan areas) or community-based waste sorting and recycling practices and governance, including reducing plastic pollution and deforestation.

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Endnotes

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7. Aramco

“Reduce: Energy efficiency and flaring minimization are top actions toward mitigating climate change, as is fossil fuel reduction through substitution with lower carbon energy sources like renewables, hydropower, nuclear and bioenergy.
Reuse: CO_2 has value and using innovative technologies to capture it means it can be reused as useful products, such as fuels, bioenergy, chemicals, building materials, food and beverages.
Recycle: CO_2 is chemically transformed into new products such as fertilizer or cement, or other forms of energy such as synthetic fuels.
Remove: Using technology to capture and store CO_2 is an important way to achieve large-scale reduction of emissions, while increasing photosynthesis by planting flora also contributes toward reduction.” Aramco
https://www.aramco.com/en/sustainability/climate-change/managing-our-footprint/circular-carbon-economy#

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