Resources, Conservation and Recycling 87 (2014) 1–7

Contents lists available at ScienceDirect

Resources, Conservation and Recycling

journal homepage: www.elsevier.com/locate/resconrec

Challenges and political solutions for steel recycling in China

Jost Wübbeke [a,*], Timo Heroth [b,1]

[a] Mercator Institute for China Studies, Klosterstraße 64, 10179 Berlin, Germany
[b] Institute of Chinese Studies, Free University of Berlin, Ehrenbergstraße 26-28, 14195 Berlin, Germany

ARTICLE INFO

Article history:
Received 12 November 2013
Received in revised form 11 March 2014
Accepted 12 March 2014
Available online 3 April 2014

Keywords:
Steelmaking
Steel scrap
Recycling
China
Circular economy

ABSTRACT

The circular economy is an essential component of China's sustainable development. To promote the recycling of end-of-life products, the government has adopted various policies. Steel scrap is an important resource for steelmaking. Yet, the Chinese iron and steel industry uses less scrap to produce new steel compared to other large steelmaking countries. This article examines the reasons, why steel recycling is still relatively weak in China and what measures the government takes to improve the situation. We found that limited availability of scrap, high scrap prices, inadequate steelmaking capacities, industry fragmentation and unclear responsibilities for manufacturers are the main obstacles for steel recycling in China. The government is trying to improve steel recycling through tax incentives, import facilitation, support for supply, industry reorganization, and recycling parks, but with modest results.

1. Introduction

The "3R" (reduce, reuse, recycle) are in the center of recent efforts to put the Chinese economy on a sustainable footing (Yong, 2007; Geng et al., 2012). With the circular economy, a cyclical thinking has replaced an open-ended conception of the value-added chain. The closed-loop perspective pays attention to the integrated and efficient use of energy, water, soil, and other materials at all stages, from production, to distribution, to consumption. It allows reducing the consumption of virgin materials and energy. Through various legal measures, first and foremost the Circular Economy Promotion Law enacted in 2009, the central government promotes the implementation of the "3R" principles into the Chinese economy.

The iron and steel industry (ISI) is one of China's pillar industries, generating immense tax revenues, providing broad employment, and feeding the immense economic build-up. China contributes about 46% to the global production of 1547 million tons of crude steel, is a steel consumer of almost similar size, and exports 7.6% of its domestic steel production (World Steel Association, 2013). Concerning the ambitions of the low-carbon and circular economy, recycling is of utmost importance and bears high potential for the ISI. Metals were seldom discarded in history, due to their rareness and high value. Treating metals as waste is a phenomenon and consequence of their vast availability in the industrialized economy (Ayres, 1997). Because steel maintains its functionality without any loss and dissipative use is small, the alloy is suited for extensive recycling.

However, there are many challenges to the circular economy in China (Geng and Doberstein, 2008). The aim of this article is to give an overview of the current status of steel scrap recycling in China from a national perspective, identify barriers to tapping its full potential and analyze current national government policies. Though China can expect many benefits and already has achieved a certain level of steel recycling, it is still lacking behind many other steelmaking countries such as the United States, Japan, Germany and Turkey in terms of scrap utilization. A flourishing steel recycling industry emerged, but several problems remain: limited availability of scrap, high scrap prices and inadequate steelmaking capacities; lack of coordination between collection, distribution, processing and utilization of recyclables; problems to deal with informal and small-scale waste collection and processing; and unclear responsibilities for original equipment manufacturers (OEMs). These factors impede a more efficient development of the Chinese recycling industry. The government is trying to improve steel recycling through tax incentives, industry consolidation, and pilot projects, but with modest results.

The study is based on an examination of relevant data and documents of steel industry publications and government documents in China. We will set out with a short presentation of the virtue of necessity that motivates the Chinese economy to promote recycling. Second, we shortly outline the structure of the

* Corresponding author. Tel.: +49 30 34409932; mobile: +49 176 23943604.
E-mail addresses: jost.wuebbeke@merics.de, j.wuebbeke@gmail.com (J. Wübbeke), theroth@zedat.fu-berlin.de (T. Heroth).
[1] Tel.: +49 30 33859969; mobile: +49 151 65168898.

http://dx.doi.org/10.1016/j.resconrec.2014.03.004
0921-3449/

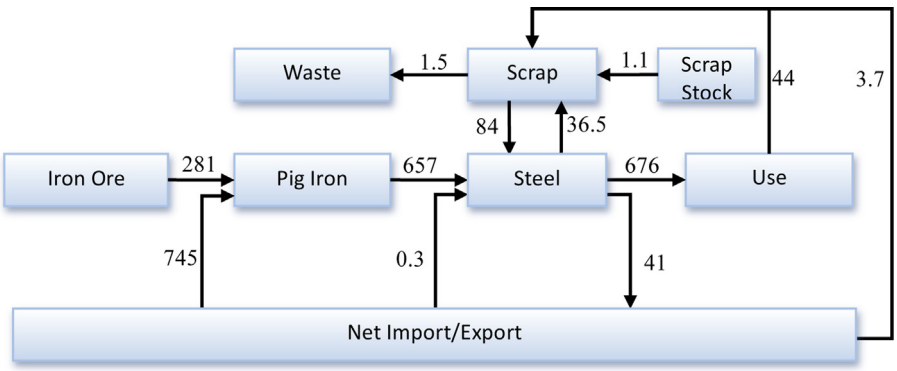

Fig. 1. Overview of iron and steel flow in China in 2012. All numbers are in million tons. Stocks and losses are not considered, except for scrap. Scrap data is from CAMU. *Sources*: Bureau of International Recycling (2013a), Liu (2013) and World Steel Association (2013).

Chinese steel recycling industry. Sections 3 and 4 will examine the present challenges to the industry and the measures of the central government.

2. The virtue of necessity

There are many reasons for recycling. To be sure, economies and enterprises do not opt for recycling materials without reason, but do so out of a "virtue of necessity" that responds to three structural factors: first, limited supply of raw materials or impending depletion of deposits; second, high material and energy costs; and third environmental pollution (Chandler, 1986). The Chinese promotion of the circular economy and steel recycling is a mixture of all three reasons (Su et al., 2013).

First, shortage of iron ore is an important concern. China is relatively abundant of crude iron ore, being fourth globally, but due to a low ore grade compared to for example Brazil and Australia, the actual iron reserves are much less. The Chinese mining industry massively exploits iron deposits, producing 15.1% of global iron with 9% of reserves. Nevertheless, China is unable to satisfy demand by domestic reserves alone and has to import large volumes of iron ore. China's iron ore imports accounted for 61.8% of global iron ore imports in 2011 (United States Geological Survey, 2013; World Steel Association, 2013). Reaching an apparent iron ore consumption of 1.03 billion tons in 2012, imports accounted for 745.4 million tons (China Daily, 2013; World Steel Association, 2013). Although the national mineral plan foresees to further increase the iron ore output, the material supply will not keep up with demand from steelmakers. Steel scrap recycling can lessen the pressure on the non-renewable iron reserves. As the international iron ore market is dominated so far by an oligopoly and iron ore prices have been rising and volatile, steel scrap can provide an alternative to primary material input. What is more, China's reserves of valuable coking coal, necessary for iron-making, are very limited. Fig. 1 shows the flow of iron, steel and steel scrap in China for the year 2012.

Second, the high costs and conservation of energy are further criteria. In the context of the government's efforts for energy efficiency and emission reduction, the ISI receives a lot of pressure from the government to make production environmentally friendlier. Public measures such as emission trading and liberalization of the energy sector make energy-intensive production more costly. The process of steelmaking is consuming a lot of primary energy, fresh water, limestone, and other materials and is a main industrial emitter of CO_2, SO_2, coal ash, and other pollutants. Iron and steel making are less energy-intensive than the production of aluminum and titanium (Norgate and Jahanshahi, 2011; Norgate et al., 2007), but because the ISI is the largest metals industry, it is the second largest manufacturing energy consumer and the largest carbon dioxide emitter. Steel consumes about 15% of the national energy, while it contributes only 3.14% to the GDP. It emits about 6.6% of national sulfur dioxide. Chinese steel producers are about 15–20% more energy-intensive than internationally advanced enterprises (Wang et al., 2007).

The use of scrap instead of primary iron can significantly reduce many of these adverse impacts. Steelmaking based on scrap can skip over iron smelting and the related processes of sintering, pelletizing, and coking, which are very resource-intensive and polluting. Coke combustion in the blast furnace is responsible for most of energy consumption, CO, CO_2, and SO_2 emissions, and slag during steelmaking (Zhang et al., 2012, 168). The usage of one ton of scrap saves more than 1100 kg iron ore, 630 kg coal, and 55 kg limestone. It consumes 40% less energy, emits 86% less waste air containing CO, CO_2, and SO_2, 76% less wastewater, and 72% less waste dust compared to steelmaking based on virgin iron (Bureau of International Recycling, 2013b; Yan, 2012; Wang, 2011).

Third, iron ore mining has immense impact on the local environment. As the valuable iron metal accounts only for a part of the iron ore, a lot of gangue is produced and deposited in spoil heaps. Chinese mines produce plenty of gangue due to the low ore grade. In addition, to reach the iron-rich layers, it is necessary to remove large volumes of overburden. The ratio between produced metal and waste is much lower than for most non-ferrous metals, but due to the size of iron mining, the environmental impacts are severe and the huge demand for coking contributes to the development of coal mining (Ayres, 1997). China is more and more concerned about the environmental externalities associated with mining.

3. The iron and steel industry and recycling

Due to the immense demand for steel by the growing economy and urbanizing society, China is, compared to advanced economies, a very steel-intensive economy in terms of the ratio between steel consumption and gross domestic product and in terms of per capita consumption. China is still below the peak intensity Japan reached during its process of industrialization. The per capita steel consumption in China was 477 kg in 2012, whereas Japan and the United States reached their peak consumption in the past at about 600–650 kg per capita (Lin et al., 2011; World Coal, 2012). Production is further on the rise as the infrastructure build-up in the Chinese economy is continuing. Total steel consumption and steel intensity ratio are estimated to reach the current level of advanced economies between 2015 and 2020 (Lin et al., 2011; Xu and Wang, 2007; Holloway et al., 2010).