# Generation, Collection, and Recycling of Used and End-of-Life Mobile Phones

**Yong-Chul Jang**
*Chungnam National University, South Korea*

**Seunghun Lee**
*Chungnam National University, South Korea*

**Hwidong Kim**
*Gannon University, USA*

## INTRODUCTION

Across the globe, the use of mobile phones has exponentially increased from the first few users in the 1970s to 2.2 billion people in 2005. According a recent report by the International Telecommunications Union (ITU), the number of mobile phone subscriptions will reach almost 7 billion by the end of 2014 (ITU, 2014). This number is almost equivalent to the world's population. In other words, the average penetration rate of mobile phones in the world could be close to 100% by numerical data. More than half of the subscriptions (3.6 billion) are located in the Asia-Pacific region (ITU, 2014). After these mobile phones reach the end of their service life, they eventually become obsolete products because consumers continue to replace their mobile phones with newer models. Ever-increasing consumer demands, coupled with continual advances in the information and communication (ICT) industry's development of mobile phone technology have resulted in the generation of tremendous amounts of mobile phone waste. After purchasing new mobile phones, consumers may retain their used and end-of-life mobile phones rather than disposing them for many different reasons: reuse and sale, souvenir, data storage, or future use. In the United States, it is estimated that approximately 140 million units of mobile phone waste are generated each year (Reddy, 2012).

Used and end-of-life mobile phones typically consist of a number of components (e.g., plastics, glass, ferrous and non-ferrous metals, rare and trace metals, valuable materials, printed circuit boards) with various sizes and shapes. They may also contain toxic hazardous chemicals including cadmium, chromium, lead, nickel, and bromated flame retardants. Managing end-of-life mobile phones has become a subject of major concern for the solid waste community due to the magnitude of the waste stream and the toxic chemicals, and many developed countries are seeking environmentally sound methods to recycle and treat the waste. Collection and recycling methods for end-of-life mobile phones are important not only from the perspective of waste treatment but also from the purpose of recovering valuable materials such as copper, aluminum, gold, silver, cobalt, and lithium. Even though many countries have implemented successful recycling practices for municipal solid waste (MSW), the methods and infrastructure for collection, recycling and processing of used and end-of-life mobile phones are not yet well-established.

This chapter examines current generation, collection, recycling, and potential environmental impacts of used and end-of-life mobile phones. The authors reviewed the available literature of several of the most innovative and influential scholars to compile an overview of the latest research on current management of used and

DOI: 10.4018/978-1-4666-8239-9.ch022

end-of-life mobile phones. This chapter concludes with a discussion of future research directions for mobile phone waste along with recommendations for further reading.

## OVERVIEW

Due to consumer demand and rapidly increasing technologies, consumers continuously replace older mobile phones with new ones, resulting in the generation of substantial amounts of used and end-of-life mobile phones. Another factor that contributes the large amount of mobile phone waste that accumulates each year is the relatively short life spans of mobile phones, compared to other electrical and electronic equipment. In addition to inert materials, mobile phones consist of many valuable materials and toxic chemicals. Thus, environmentally sound management of mobile phone waste has become a topic of growing concern around the world.

Numerous researchers have examined the recycling potential and environmental impacts of mobile phone waste using the lifetime of mobile phones and generation rates of mobile phone waste. Although the definition of a mobile phone's life time may not be consistent among researchers, a commonly accepted practice is to estimate the lifetime using the active life (the period of time when phones are actively used by primary consumers), passive life (the period of time when phones are refurbished/reused by the next consumers), and storage time (UNEP, 2013). Researchers estimate the typical lifetime of a mobile phone to be in the range of 2 to 8 years. The estimated values highly vary because the lifetime of the phone is greatly affected by economic status and cultural and social behaviors. To calculate mobile phone waste generation rates, various data such as sales data, lifetime, penetration rates, and other relevant data are required depending on the methods employed by researchers. The details of the methods used for mobile phones waste generation rates are described in a later section of this chapter. Estimating and predicted mobile phone generation rates can be used for tracking materials and resource recovery and for assessing the potential environmental impacts upon disposal. Despite these efforts, it is still challenging to accurately estimate and predict the generation rates of mobile phone waste.

Considering that a large number of obsolete mobile phones are still disposed of in landfills, it is important to develop an institutional strategy to increase the recycling rates of obsolete mobile phones. To increase recycling rates, many countries have implemented a variety of collection programs and policies (Silverira & Chang, 2010): for example, the Extended Producer Responsibility (EPR) implemented worldwide; the deposit-refund policy, which enables consumers to redeem a deposit when they return their obsolete phones for recycling; and the EPR-plus policy, in which the government partially refunds recycling fees according to the manufacturers' and imports' cooperation with recycling programs. The Restriction of Hazardous Substance (RoHS) Directive in the European Union strictly regulates recycling and disposal of mobile phones that contain hazardous substances. In addition to the efforts of government and manufacturers, some small businesses buy used phones from customers (such as EcoATM, which is a phone recycling kiosk) (Figure 1(a)). Other collection programs, such as those found in schools and big suppliers of appliances, are racing to attract voluntary participation from customers (Figure 1(b)). Details of other phone collection methods/recycling programs are introduced in Section 5 of this chapter. In spite of these efforts, however, recycling rates of mobile phones are relatively low compared to those of other waste electronic and electrical equipment (WEEE) (Lim & Schoenung, 2010).