Chapter 13
Circular Economy in Energizing Smart Cities

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ABSTRACT

Principles of the circular economy are adopted in many fields to achieve sustainable ecosystems and to mitigate greenhouse gasses. Industry 4.0 technologies can significantly assist in applying circular economy principles to save energy and mitigate greenhouse gases to an extent. This chapter focuses on opportunities and challenges of adopting circular economy principles in the energy sector specifically in managing futuristic smart cities. Six major areas of energy conservation processes in smart cities are analyzed for this purpose. Given the interdisciplinary nature of the problem, an effective link is established between different areas such as circular economy, smart cities, Industry 4.0, and energy sector. Major energy conservation strategies such as demand-side management, waste to energy production, and recycling of apparatus are taken up. A novel, Industry 4.0-based information system for monitoring various energy-related processes in a smart city and a conceptual dashboard to visualize key indicators are proposed.

INTRODUCTION

The tenets of "circular economy" point to "circularity" feature in any ecosystem to reduce (or eliminate) waste and continuous use of resources. Many countries are now working towards using circular economy principles, processes and business models. There are several examples that have been presented by various authors over the years on the benefits of adopting the concepts of circular economy. Precious commodities such as water, energy etc., are taken up for efficient resource conservation. Manufacturing sectors like automobiles, batteries, construction and metal fabrication etc., have been also taken up to improve process efficiency. One of the good examples is producing energy from the waste. Municipal Solid Waste (MSW) Management is a widely discussed topic, related to energy, society, and environment, and thus has a lot of hygiene and economic implications (Singh, K, Kelly S and KS Sastry, Musti,

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2009). Thanks to the advances in technology; over the years, Waste-to-Energy (W2E) technologies have evolved to become more affordable and efficient. Besides the energy production, waste can be utilized to manufacture different products that can be used for long time. Hence, MSW is considered as a resource. Similarly, battery recycling is an excellent example for circular economy business model. Bloomberg estimates that globally Lithium-Ion battery sales for electrical vehicles and other storage purposes will reach 5 million tons by 2025 (Pagliaro, M, and Meneguzzo, F, (2019). Managing and disposing such large volumes of harmful waste is always a challenge. Technologies for recycle used batteries and other electronic equipment that have reached their end-of-life do exist and are continuously improving. Construction technologies specifically for roads and buildings are also changing and using waste and other materials along with conventional construction materials. Plastic blending with concrete for building construction and with tar for paving the roads are proven efficient, long lasting and environmental friendly; as the plastic, itself is not easily biodegradable and harmful to the environment. Lean manufacturing principles are actively being used to reduce the use of materials and resources such as water and energy. It is estimated that commercial opportunities in the implementation of circular economy may reach USD 4.5 trillion by the year 2030. This may also lead to 40% of S&P500 companies to go out of businesses in about 10 years' time, according to SAP (Coloumbus, 2016).

Electrical power is an essential commodity everywhere and expensive. Typically, the fossil fuels such as coal and gas are used in large quantities in energy production. The process of coal based energy production using fossil fuels is not only results in high volumes of greenhouse gas carbon dioxide and fly ash; and thus polluting the environment. Oil and gas are relatively cleaner forms of fuels, however are very expensive; and most countries have to import them from international markets. Renewable energy sources are now becoming the norm across the globe due to increased awareness of both economic and environmental impacts of using fossil fuels. Use of renewable energies, though is increasing; there are several challenges exist as on date. In any case, energy production is cost intensive, with or without the use of fossil fuels. The question is how well the energy sector can imbibe the core tenets of circular economy to reduce overall expenses and energy use. For applying circular economy principles, many parameters in the contemporary energy systems need to be monitored and measured. Some of such opportunities and challenges include - continuous monitoring of energy usage patterns of the customers, controlling (reducing) the energy usage during peak load conditions (just as the principle of postponing the usage), encouraging use of alternate forms of energies (such as solar water heaters, just as the principle of substitution) and many more.

While the opportunities in Recycling, Reducing and Reusing (3R) the infrastructure and resources are well understood and many industries across the globe are taking necessary actions to realize the benefits. However, it is important to understand the contemporary technological advances. With the advent of the fourth industrial revolution (aka industry 4.0), application of circular economy principles has also changed drastically. Internet of Things (IoT) and big data help significantly in data acquisition, information processing and apparatus control. Forbes estimates that around 10 billion Industrial Internet of Things (IIoT) devices will be online and they are likely to contribute a market value of USD 3.7 billion (Coloumbus, 2016). Similarly, it is estimated that market value for big data based analytics may exceed USD 200 billion (Press, 2017). However, such niche technologies do need relatively modern, smart infrastructure and economies. Smart cities are an excellent example, where such smart infrastructure can be seen in use right from the planning and developmental stages. The operating environment in smart cities with industry 4.0 will move common public forward into digital space, as a majority of the activities will be automated (BeSmartCity, 2019). At the same time, smart cities do need very high