Challenges for Sustainable Development of Waste to Energy in Developing Countries

Article *in* Waste Management & Research · March 2020

DOI: 10.1177/0734242X20903564

CITATIONS
24

READS
1,042

3 authors:

Mi Yan
Zhejiang University of Technology
141 PUBLICATIONS **2,397** CITATIONS
SEE PROFILE

Agamuthu Periathamby
Jeffrey Sachs Center on Sustainable Development Sunway University
254 PUBLICATIONS **5,913** CITATIONS
SEE PROFILE

Joko Waluyo
Universitas Sebelas Maret
32 PUBLICATIONS **118** CITATIONS
SEE PROFILE

WM&R

Waste Management & Research
2020, Vol. 38(3) 229–231

DOI: 10.1177/0734242X20903564
journals.sagepub.com/home/wmr
SAGE

Challenges for Sustainable Development of Waste to Energy in Developing Countries

The global average generation rate of municipal solid waste (MSW) estimated by the World Bank Group was 0.74 kilograms per capita per day in 2016, and that around 2.01 billion tons of MSW were totally produced. It is projected that the global production of MSW will increase by 1.5% annually and it will reach 3.0 billion tons in 2030. Developing countries produced an average of 0.54 kg of waste per capita per day and that rate is projected to increase by around 1.1% per year, and it will reach 0.63 kg of waste per capita per day in 2030 (Kaza et al., 2018). Steady increase in MSW generation is driven by population growth, increasing Gross Domestic Product (GDP) (with associated consumption of consumer products), and urbanization. Countries with higher GDP generally generate a higher amount of waste (Agamuthu et al., 2020).

Globally, about 37% of MSW is disposed of in landfills (8% sanitary landfill, 4% controlled landfill and 25% unspecified) and 33% of waste is still openly dumped. About 19% of materials were recovered by recycling and composting and another 11% was combusted in modern incinerators (Kaza et al., 2018). Waste disposal practices vary by income level. Over two-thirds of MSW are deposited in open dumps in developing countries. Such dumping practices threaten an extremely negative impact on public health and the environment. Developing countries can start by decreasing the volume of waste requiring disposal on land by implementing measures to reduce waste generation at the source, sorting and separately collecting wastes to enhance recycling, and converting waste to clean energy (WtE).

Developing countries must stay focused on the risks and life-cycle costs of landfills and seek methods for sustainable waste management to replace current practices. Waste incineration with steam turbines and effective air pollution control systems is a technology for converting waste into clean energy, but experience shows that WtE plants are more often than not a poor economic choice for most developing countries, at least due to the high capital and operating costs (typically beyond the ability of local and national governments to finance). We probably want to avoid establishing unreasonable expectations for waste management planners in developing countries by suggesting they can go from open dumping to modern WtE in one giant step.

WtE development can extend the life of landfills and reduce the dedication of land needed for land disposal. The typical range of net electric generation is around 500 to 600 kWh per ton (of waste used as fuel) in developed economies and 300 to 400 kWh per ton in developing economies, as the quality and calorific value of MSW are different in different places. The calorific value of MSW in developing economies is low due to the high content of food waste, high moisture content and lack of MSW sorting systems.

Considering the present experience of waste management and waste-to-energy development in the world (WMW, 2019), several key challenges must be overcome to achieve sustainable development of WtE in developing countries.

(1) **Regulation and technical standards.** Regulations and technical standards should be established to guide and support the design and operation. Within the regulations, the business of WtE should be codified to support the opportunity for WtE development. The comprehensive system of regulations should cover MSW well storage at the source of generation, collection, transportation, investment, tax reduction, electricity grid connection, monitoring, and so on. The setting of technical guidelines and emission standards should consider the most advanced technologies in the world and the domestic situation of developing countries. The EU 2010/75/EC was established 20 years ago, but it still is one of the strictest standards for waste incineration in the world, and it is not easy for advocates of incinerators in developing countries to meet this standard. Some WtE equipment/system suppliers may claim the realization of cleaner emissions than the EU 2010/75/EC standard, but usually it means significantly higher operation cost is needed to attain the higher levels of emission controls, or only some pollutants emissions, such as particulates, are lower than the standard. So, it is reasonable to set initial WtE emission standards in developing countries at practical levels, then plan to gradually transition standards to more stringent levels as operating experience is gained over time.

(2) **Business model.** Based on the regulation and emission standards for WtE plants, a suitable business model is essential to attract investors. Different business models are in place in different countries and cities, including build-operate-transfer (BOT), public-private partnership (PPP) and full state-owned, with tipping fees and electricity subsidies. The business models depend on the country or city's financial budget and the degree to which the city is willing and able to subsidize a WtE plant to ensure long-term viability. The investment cost-benefit relationship should be calculated based on local costs of materiel and labor, and a reasonable rate of return. In China, the average investment for a plant of 100 tons per day capacity increased from around 4.3 million USD in 2010s to approximately 8.6 million USD at present (2020). Most of the cost increase is due

to the increasing requirements of emission standards, better construction as de-industrialization (outstanding architectural construction design) and labour costs; i.e. the cost to install a basic WtE plant has not increased significantly over the past 10 years. Usually, the payback period for WtE investment is roughly 10 to 15 years for WtE construction with an estimated design life of 25 to 30 years. The biggest challenge is the cost-benefit balance for small scale plants, as a capacity of less than 300 tons per day will not receive reasonable benefits in China. It means that it is not easy to get any economic benefits from WtE in a small city with a population of 300,000 or less. So it is encouraged that some small cities share a WtE plant with reasonable capacity.

(3) **Technical localization and development.** The main technologies for MSW incineration are moving grate and fluidized bed, and many companies supply such proven technology in the international market. As we know, the fuel characteristic of MSW varies from different cities as a consequence of different customs and economic levels. So, the incineration technology best suited for developing countries must fully consider the local conditions, including the characteristics of waste, skills of local labour force in order to properly maintain and operate a plant, and the diligence of owners and managers in upgrading the plant when new technology emerges. This is defined as technical localization. During localization or development of domestic technology, the involvement of local academic institutions and design companies is important. After the localization and development of domestic technology, the technology costs will be significantly reduced. So, during the development of WtE technology, it is necessary to promote the development of domestic capabilities.

(4) **Not in My Back Yard (NIMBY).** Proposals to construct WtE facilities in or near residential neighborhoods more often than not result in protracted protests by concerned citizens who are usually not fully informed about MSW management in general or WtE technology in particular. Those who embrace the NIMBY attitude are concerned about a range of potential negative impacts, including local and regional pollution, increased traffic, odors, decline in housing values, and stress. So, efforts for addressing NIMBY focus not only on how to improve the technology and reduce emissions, but must also include a robust and long-term public information program.

(5) **Fly ash treatment.** The management and treatment of fly ash is the biggest challenge facing efforts to develop a sustainable network of WtE plants in China. Flue gas from combustion and leachate from the tipping hall of waste storage before incineration are well managed by a series of technologies. Bottom ash collected from the incinerator can always be used as construction material after metal recovery. However, fly ash which is rich in organic (dioxin, etc.) and inorganic pollutants (heavy metals, etc.) is a hazardous material for the environment. At present, there are few effective and reliable sustainable disposal technologies available for fly ash in China. These include landfills with solidification and co-disposal in cement kilns with salt prewashing. Each method has specific shortcomings, for instance, land requirements and leaching for landfill, difficult treatment of wastewater with high content of salt for cement co-disposal. Therefore, WtE planners should closely monitor research on emerging technologies for fly ash processing and disposal.

(6) **Labour training.** The operation of a modern WtE plant is highly automatic; even artificial intelligence has started to be applied. So, labour training for the operation and maintenance is very important before construction and after routine operations begin. It is often best to form a collaborative training team comprising of both domestic and international experts with the requisite experience, e.g. involving professionals from universities, institutes, design companies and equipment manufacturers.

WtE technology has improved greatly over the past decades and will surely continue to evolve. All factors of WtE development will vary in time, such as waste composition, costs and revenue sources, technologies, so the regulations/emission standards, business model and management should be updated to lead and fit the evolving conditions. For example, history shows that the heating value of MSW will gradually increase over time with economic development, so planners should expect to retrofit or even replace any WtE plant under their charge. Increasing temperature and pressure of steam fed into electricity-generating turbines is an effective method for enhancing the efficiency of electricity production and the associated profits. And research will surely lead to new technologies for air pollution control, so WtE emission standards will gradually become more stringent, leading to the need to upgrade or replace older technology and plants.

China has the fastest-growing WtE market in the world. It is reported that over 430 WtE plants are under operation as of the end of 2019, with a total incineration capacity of 450,000 t/d, which is more than 70% of China's MSW generation. Similarly, EU members will be permitted to dispose of no more than 10% of their municipal waste to landfills.

References

Agamuthu P, Hamid FS and Bhatti MS (2020) Sustainable waste management challenges in developing countries. Hershey, PA: IGI Global Publications.

Kaza S, Yao L, Bhada-Tata, et al. (2018) What a waste 2.0: a global snapshot of solid waste management to 2050. Washington, D.C.: World Bank Group.

Waste Management World (WMW) (2019) November-December 2019 edition. Vienna: International Solid Waste Association (ISWA).

Mi Yan
Institute of Energy and Power Engineering, Zhejiang University of Technology, People's Republic of China
Email: yanmi1985@zjut.edu.cn

Joko Waluyo
Department of Chemical Engineering, Sebelas Maret University (UNS), Indonesia
Email: jokowaluyo@staff.uns.ac.id

Agamuthu P
Jeffrey Sachs Center on Sustainable Development, Sunway University, Malaysia
Email: profagamuthu@gmail.com