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Municipal Solid Waste and Air Quality Management - Scope of Waste to Energy Conversion (WHO)

1. Background

The aggregation of human settlements due to urbanization, together with unsustainable consumption and production patterns of the society, has led to generation of large amount of municipal solid waste (MSW), that the collection, transfer and disposal of waste has become a daunting task for the local government units. The increasing generation of MSW and improper management methods have contributed to several social and environmental issues. In particular, air quality degradation due to open burning, unsanitary landfilling and open dumping is more prominent, and management of MSW is gaining importance on the local political agenda. Larger portion of resources of local authorities has to be spent for the management of MSW; yet the issues have not been resolved satisfactorily. This situation has led the local decision makers to consider Waste-to-Energy (WtE) conversion as the only option for management of MSW, even though WtE lies in the bottom segment of the waste management hierarchy. This is primarily due to the fact that the higher level options are related to more on behavioural/system changes while WtE option is more of a technological intervention, where the volume reduction of waste could be readily achieved through combustion in most cases. Although a range of different WtE technologies at commercialized level is available in developed countries, adoption to Sri Lanka seems to be impeded by the presence of wide range of barriers and other hindering factors as none of the projects initiated so far failed to operationalize [1]. If such aspects are not taken into consideration, WtE projects risk failing at the cost of the local community and the environment [2].

Similar experiences could be observed in many developed countries, where the waste management process was initially defined largely in engineering terms - a technical problem with a technical solution. Gradually, however, it was learnt that (i) the combustion process itself leads to generation of air pollutants thus needing sophisticated control techniques, and (ii) no technology could on its own solve the problems related to economic and social sustainability of waste management activities and that the governance aspects of the necessary actions need to be duly considered [3]. It is understood that proper selection of WtE technological options within overall MSW management programme could resolve the present socio-environmental issues in the sector,

while contributing to other local development agendas such as energy security and global commitments such as nationally determined contributions (NDCs) in relation to the global efforts in combatting climate change. In fact, the emerging sustainable development models, such as the concept of circular economy, highlight the importance of sustainable waste management (SWM) where the WtE projects are implemented only with proper consideration of the principle of waste management hierarchy, such that the decisions taken do not affect implementation of higher level actions namely prevention/reduce, reuse and recycling. Use of such approach in introducing WtE conversion systems will have a synergistic effect on societal needs such as economic development, urban air quality management, energy security and mitigation of climate change [4].

This article analyses critically the option of WtE in the solid waste management sector in Sri Lanka, while giving due consideration for drivers and global contexts, with the objective of obtaining better understanding on the role and scope of WtE conversion in mitigating adverse impacts of disposal of MSW, while contributing to other development agendas.

2. Drivers For Sustainable Waste Management

2.1 Local Drivers

Identification of local drivers for SWM within the broader context presented above and establishment of linkages of such multiple drivers with national agendas will provide a sound platform for the development of specific policy elements and strategies relevant to the waste sector. These drivers are usually related to aspects such as social, environmental, financial/economic and policy/institutional, in line with the three sustainability domains [5], [6]. Accordingly, following could be identified as specific drivers for SWM in Sri Lanka:

- Social health and well-being
  Failure to manage MSW properly has resulted adverse effects on human health and welfare, which poses a major challenge for local governments. Provision for a more sanitary and environment-friendly method of waste management is fundamental to improved quality of life of the communities.

- Local environment protection
  SWM helps to mitigate adverse impacts on natural resources, such as air, water and soil. Further, it helps to reduce the ecological footprint by limiting overall impact of resource use.

- Economic efficiency
  Implementation of SWM programmes, which call for a move away from disposal towards the more sustainable options of reduction, reuse, recycling and energy recovery offer opportunity to improve economic efficiency by converting waste to resource, thus reducing not only cost of the disposal but also replacing non-renewable raw materials or products including fuels.

- Market innovations
  In line with the economic efficiency highlighted above, the development of SWM systems has to be ensued through technological advancements and process improvements; thus acts as an engine of growth and market innovation. This can offer opportunities in developing local solutions to the needs of raw materials and energy for industrial development.

- Energy security
  Heavy dependency on imported fossil fuels and limited commercialized renewable energy (RE) options are among the key factors influencing the energy security of the country. Basically, availability, sufficiency, affordability and sustainability of energy supply are interlinked facets of energy security. As one of the options of SWM, the WtE conversions could diversify the energy resources and enhance the indigenous energy resource base.

- Knowledge society
  The development of SWM programmes represent extraction of an indigenous resource to resolve local issues (e.g. waste, energy) involving utilization of local expertise for design, manufacture, operate and manage. Scientific research activities could lead to development and localization of technology that drives the establishment of new and innovative waste management practices. There is a tremendous opportunity for knowledge development, sharing and application; thus allowing all stakeholders to acquire the knowledge, skills, attitudes and values necessary to shape a sustainable future.

2.2 Global Drivers

- Sustainable Development Goals
  The local drivers for SWM stipulated above are, in fact, elaborated as global targets in the united nations (UN) Sustainable Development Goals (SDGs) of the 2030 Agenda for Sustainable Development, adopted by the 193 UN Member States in September 2015, which is a

universal call to action to end poverty, protect the planet and ensure that all people enjoy peace and prosperity [7]. Out of seventeen SDGs at least twelve SDGs and relevant targets have direct links to SWM [3].

- Global Waste Management Goals
  The Global Waste Management Outlook (GWMO), a collective effort of the United Nations Environment Programme (UNEP) and the International Waste Management Association (IWMA), sets forth Global Waste Management Goals and a Global Call to Action to achieve those goals [8]. It establishes the rationale and the tools for taking a holistic approach towards waste management and recognizing waste and resource management as a significant contributor to sustainable development and climate change mitigation.

- Climate Change Mitigation
  In addition to the direct local benefits, SWM represents an important component of global efforts in addressing climate change issue through mitigation of greenhouse gas (GHG) emissions. waste prevention, minimisation, reuse, recycling and conversion to energy represent a growing potential for reducing GHG emissions by conserving raw materials and fossil fuels. In fact, waste is one of the five sectors considered under the mitigation area in the Nationally Determined Contributions (NDCs) of Sri Lanka, which is submitted as the local commitment to address the global climate change issue.

In overall, above drivers represent a set of broader societal challenges and opportunities for contributing towards sustainable development. The drivers for SWM presented above act as a dynamic, interconnected system and could have either a synergistic or reduced impact.

3. National Perspectives Of Waste To Energy Projects

3.1 Background

The main window of opportunity for the development and implementation of WtE projects in Sri Lanka is provided through declaration of feed-in tariff (FiT) and standard power purchase agreement (SPPA) for grid connected new RE resources. This is based on the principle of technology-specific cost-reflective FiT, valid for a 20-year period. Under this scheme, several MSW based WtE projects were approved by Sri Lanka Sustainable Energy Authority (SLSEA), but none of them were materialized. This has led to further deterioration of the waste issues in the urban sector. Reasons for lack of progress could be attributed to the following factors [1]:

- Limited experience on WtE conversion technologies: Lack of capacity

to formulate sound request for proposals (RFPs) and evaluate project proposals by the relevant authorities.

- Inappropriate technologies: Most options proposed are new and emerging WtE technologies for which no proven operation records in a similar context can be made available.
- Lack of technical expertise: For design and develop projects (of the project proponents).
- Failure to quantify and characterize MSW: Detail characterization of waste materials has not been done, and technology selections failed to recognize the importance of composition of waste in some unit operations such as pre-processing, pre-treatment and emission control.
- Weak business and operation models: High investment and operating costs which cannot be recovered by existing waste fees and generated additional income from energy sales alone.

More recently, some notable changes to the waste sector have been introduced, creating conducive environment for the development and implementation of WtE projects, as briefed bellow [1]:

- Improved governance: Political leaderships; Improved institutional arrangements and coordination; Monitoring mechanism of implementation.
- Improved professionalism: Involvements of experts; Sound request for proposal (RFP); Establishment of a comprehensive list of performance criteria and indicators, particularly highlighting the requirements in pre-processing and emission controlling; Rigorous evaluation process and selection criteria.
- Better business model: Specific FiT for MSW based WtE projects in case-by-case basis; Incorporation of waste management cost (tipping fee) into FiT (for examples, for two technology options FiT of 36.20 LKR/kWh is given, equivalent to about 15,000 LKR/t of waste input).

3.2 National Perspectives of WtE Projects

Although there are several categories of WtE technologies, such as Direct combustion/ incineration, Co-processing with other fuels, Anaerobic digestion, Landfill gas collection, Gasification and Pyrolysis, selection of a suitable technology depends on several decisive aspect (both technical and non-technical) including (i) Overall level of waste management; (ii) Composition of waste; (iii) Calorific value of MSW for thermal processes, organic content; (iv) Suitable quantities of waste; (v) Efficient operation of waste facilities; (vi) Additional transportation time and distance for MSW to WtE plant; (vii) Marketing and/or final disposal of process residues; (viii) Legal framework & environmental requirements for WtE; (ix) Financing the management of MSW;

(x) Access to foreign currency; (xi) Access to energy end-users from WtE or residue derived fuel (RDF); and (xii) Incentives for low carbon energy generation. In each of the above aspects, the availability of relevant data too becomes a mandatory requirement for making the decision.

Based on the national perspectives in each of the above aspects, different technologies could be ranked into three categories as (A) Most suitable, (B) Needs more information and/or some improvements to local conditions, and (C) Not suitable, as presented in Table 1 (adopted from [1], [2]).

Parameter	National Perspective	Suitability of Technology
1. Overall level of waste management	Systematic waste collection exists to some degree, but separation and recycling is not organized systematically.	(A) Landfill gas collection; (B) Incineration, Co-processing; (C) Anaerobic digestion, Pyrolysis & Gasification.
2. Composition of waste	Mixed MSW; Sometimes mixed with small fractions of mineral and hazardous waste.	(A) Incineration, Co-processing; Landfill gas collection; (B) Anaerobic digestion, Pyrolysis & Gasification.
3. Calorific value of MSW for thermal processes, organic content	The calorific value of MSW is < 7 MJ/kg. High biomass content with high average humidity/water content.	(A) Anaerobic digestion, Landfill gas collection; (B) Incineration, Co-processing; (C) Pyrolysis & Gasification
4. Additional transport time and distance for MSW to WtE plant	Transport time will increase < 1 hour, additional distance < 50 km.	(A) Incineration, Co-processing, Anaerobic digestion, Landfill gas collection; (B) Pyrolysis & Gasification.
5. Suitable waste quantities for WtE	> 150,000 metric tonnes of suitable waste fractions are available per year in some region.	(A) Incineration, Co-processing, Anaerobic digestion, Landfill gas collection; (B) Pyrolysis & Gasification.
	50,000 to 150,000 metric tonnes of suitable waste fractions are available per year in some region.	(A) Co-processing, Anaerobic digestion, Landfill gas collection; (B) Incineration, Pyrolysis & Gasification.
	10,000 to 50,000 metric tonnes of suitable waste fractions are available per year in some region.	(A) Co-processing, Anaerobic digestion, Landfill gas collection; (B) Pyrolysis & Gasification; (C) Incineration.
	<10,000 metric tonnes of suitable waste fractions per year are available per year in some region.	(B) Co-processing, Anaerobic digestion, Landfill gas collection, Pyrolysis & Gasification; (C) Incineration.

6. Efficient operation of waste facilities	Public actors have limited experience with WtE and recruitment of qualified national staff is difficult for public and private sector.	(A) Landfill gas collection; (B) Co-processing, Anaerobic digestion; (C) Incineration, Pyrolysis & Gasification.
7. Marketing and/ or final disposal of process residues	No market for process residues. Safe disposal may require large transport distances.	(A) Co-processing, Landfill gas collection; (B) Incineration, Pyrolysis & Gasification; (C) Anaerobic digestion.
8. Legal framework & environmental requirements for WtE	A national legal framework for WtE exists. Deficiencies on the level of enforcement, ordinances and by-laws are being addressed.	(A) Co-processing, Landfill gas collection; (B) Incineration, Anaerobic digestion, Pyrolysis & Gasification.
9. Financing the management of MSW	Collection and disposal costs of MSW are covered. Additional costs for WtE might be difficult to cover.	(A) Landfill gas collection; (B) Incineration, Co-processing; (C) Anaerobic digestion, Pyrolysis & Gasification.
10. Access to foreign currency	Key technology of the WtE plant must be imported. Delays are encountered in access to purchases in foreign currency.	(B) Co-processing, Anaerobic digestion, Landfill gas collection; (C) Incineration, Pyrolysis & Gasification.
11. Access to energy end-users of WtE	WtE or RDF facilities are located close to a large power transmission network. No heat demand in the area.	(A) Co-processing, Landfill gas collection; (B) Incineration, Anaerobic digestion, Pyrolysis & Gasification.
12. Incentives for low carbon energy generation	Economic incentives for low carbon energy generation is available through FiT.	(A) Incineration, Co-processing, Anaerobic digestion, Landfill gas collection; (B) Pyrolysis & Gasification.

Table 1 : National perspectives and suitability of WtE technologies

The above analysis demonstrates that, when considering the twelve parameters, none of the commercialized technologies qualifies as suitable unless some improvements to local conditions are done. This underlines the factors that contribute to none-implementation of WtE projects in Sri Lanka, and emphasises the need for careful consideration on the local context in several areas/aspects.

4. Conclusion

The steady increase of MSW generation in the urban sector, coupled with improper management and disposal methods, has led to increasing public concerns with regards to the resultant health and environmental impacts in Sri

Lanka. The inability to fully grasp the problems of waste generation and characterization has resulted in transforming solid waste management as one of the most compelling socio-environmental problem, particularly in the urban sector. The major projects being implemented for management of MSW are focused on WtE options due to the availability of FiT for electricity generation. However, the situational analysis highlights that, when considering all the key attributes of the MSW sector in the country, none on the WtE technologies at commercial status qualify as suitable. Therefore it could be concluded that the principle of waste management hierarchy should be considered when WtE projects are planned and implemented, such that the decisions taken do not prevent higher levels of prevention/reduce, reuse and recycling. That is, the WtE projects should be considered as an integral part of a SWM programme, than just a technical solution to the waste problem.

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