

Waste-to-Energy for Sri Lanka

Introduction

The waste-to-energy (WTE) or energy-from-waste (EfW) could offer a unique solution to some of the problems in Sri Lanka. To realize the benefit a different planning mindset is necessary. Waste is a perennial issue in any living eco-system and energy is a mandatory necessity for quality of life.

"The new clothing of the planet is garbage" – Marshall McLuhan

Even with the above expressive statement made some decades earlier, waste continues to haunt many cities and economies, and developing economies are really grappling with this issue seriously. This prompted us at DCPE to design the following diagram based on the statement above (Figure 1).

collection, disposal and treatment of waste in order to be socially accountable to their environment and community at large. Sri Lanka today has embarked on the *Pilisaru* program with the expressed intention of solving this issue in a time-bound manner. The program however, would follow the 3R concept and will resort less to WTE systems. Under prevailing conditions, this approach is perhaps the most pragmatic. However, we should not lose the opportunities available with WTE systems.

Energy recovery from waste has enormous potential in Asia, including Sri Lanka. According to Asian Development Bank (ADB) (EIA, 2006), "The average daily output of solid waste alone from Asia's largest cities today has been estimated to be 760,000 tonnes, and it is expected to increase to 1.8 million tonnes per

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day by 2025." From a WTE perspective, this is an important opportunity.

Although waste management is inefficient across many countries in this region, some useful energy is produced by waste, and it has been used for various kinds of activities for reducing energy demands in this region. There are varieties of on-site power generation systems in countries in this region in which different types of alternative fuels are used. Sri Lanka can learn from some of these regional case studies. (SOE, 2005)

An AIT study (AIT, 2007) estimated for few Asia-Pacific countries the waste availability and the growth scenario (Table 1).

These data only indicates the potential but could be vastly improved by a more systematic study.

Energy from Waste

The nature of waste is important in determining the most suitable pathway for energy extraction. It is important to realize that in developing economies, there is a distinct difference in waste stream compositions compared to developed economies. Lack of scientific understanding of

Figure 1



It is important to understand that waste industry and energy industry can be tied together. There is serious understanding today in the international waste sector that what they deal with day-to-day is energy and material streams. Still however, this understanding has been largely resides in developed economies.

The quantity of solid wastes being generated is increasing rapidly with growing economic activities and the production and use of consumer items. Inadequate waste disposal and management facilities in Sri Lanka present serious environmental health implications and will continue to do so if corrective actions are not taken immediately. Such actions include not only the establishment of regulatory mechanisms but also effective enforcement of these regulations (Jayawardena et al., 2004). Local authorities and government is under considerable pressure to streamline the

Table 1
Availability of Wastes in Some Countries

Type of Biomass	Sri Lanka		India		China		Philippines		Malaysia		Thailand	
	1997	2010	1997	2010	1997	2010	1997	2010	1997	2010	1997	2010
Agricultural residues	49.6	55.6	4714	6564	5068	5246	164	178	343	454	425	562
Animal wastes	6.3	6.5	336	374	1102	2095	2.9	4.9	-	-	13	13
Biomass from conservation	51.3	50.2	-	525	-	744	249	296	-	-	-	156
MSW	3.7	4.8	86	219	50	91	36.4	46.8	10	17.8	19	21.3
Waste water	0.2	0.4	6.5	15.1	102	102	-	-	-	-	7.8	8
Black liquor	-	0.2	-	-	157	287	0.4	0.02	-	-	8.8	9
Palm oil	-	-	-	-	-	-	-	-	67	90.5	1.3	1
Biomass from substitution	-	15.5	-	900	-	914	109	254	-	-	-	109
Total	111	133	5142	8597	6479	9479	561	779	420	562	475	880

MSW – Municipal Solid Waste.
Source (AIT, 2007)

had lead to many problems, and there are quite a few examples in the region (Grover and Hoggard, 2002). For wastes with high levels of organic matter and associated moisture contents, biological techniques become the preferred choice. These judgments could be made on the basis of waste analysis, and at times, it is important to consider even city-vs-rural differences in arriving at processing options. An example from Indonesia could be stated here. In Surabaya (Indonesia), a waste incinerator was built in 1991, and it doubled the MSW management budget for the city. Due to the climate and to the high moisture content of the MSW, the MSW must be dried in the sun for five days before incineration and even then auxiliary fuel was required in order to sustain combustion. After such bad experience, Indonesia has shifted to sustainable energy recovery by recovery of methane from the existing landfill and anaerobic digestion to generate electricity. There about 300 thermal process-based WTE systems in Asia-Pacific countries, handling about 50 million tonnes per year (Chilton, 2008). These are mainly centered in Japan, Taiwan, China and Singapore. The nature of the industry has to change with the WTE taking a broader definition with a wider technology base.

Energy Generation Processes

Waste-to-energy (WTE) refers to any waste treatment that generates energy in the form of electricity or heat from a waste source. Most WTE processes produce electricity directly through combustion, or produce a combustible fuel commodity, such as methane, methanol, ethanol or synthetic fuels. WTE systems can have solid, liquid and gaseous fuels developed from waste streams. It is known that combustible renewables (biomass) and wastes provide 59% of the energy consumed by the residential sector in developing countries in the region (de Alwis, 2006). However, most of these energy schemes are not quite acceptable and lead to environmental problems.

Incineration

Incineration, the combustion of organic material such as waste, with energy recovery is the most common WTE implementation and the first type of process coming to any one's mind. This is the thermal pathway option. Modern incinerators reduce the volume of the original waste by 95-96%, depending upon composition and degree of recovery of materials such as metals from the ash for recycling. Pure combustion of waste with the sole intention of getting rid of the bulk volume does not constitute WTE concept. The

implementation of a modern incineration scheme is difficult and capital intensive, and there are no appropriate incinerators to suit developing economies. This is mainly due to the nature of the operation as well as the growing list of attributes considered mandatory in these systems due to environmental reasons.

Concerns regarding the operation of incinerators include fine particulate, heavy metals, trace dioxin and acid gas emissions. These issues have placed the WTE sector (thermal processing segment) as the most regulated waste-related industry in the developed economies. Facilities available to study such effects are absent except in two or three countries such as Singapore, Taiwan and Japan (Govt of Singapore 2006).

New technologies

There are a number of other new and emerging technologies that are cable of producing energy from waste and other fuels without direct combustion. These techniques can be catalogued into thermal and non-thermal technologies, but there are many variants within the same group as well. Considering the fact that the Sri Lankan solid waste is predominantly moist and organic in nature, non-thermal technologies are the most appropriate to us.

Waste preparatory technologies -Refuse derived fuels (RDF) – pelletisation. There are schemes developed to generate RDF's at lower costs and with higher energy efficiencies and to cover a variety of waste streams.

Refuse-derived fuel (RDF) is a fuel produced from MSW by shredding or treating steam pressure in an autoclave. RDF consists largely of organic components of municipal waste such as plastics, paper, wood waste, agriculture residues and biodegradable waste. RDF processing facilities are normally located near a source of MSW and, while an optional combustion facility is normally close to the processing facility, it may also be located at a remote location. The residual material can be sold in its processed form (depending on the process treatment) or it may be compressed into pellets, bricks or logs and used for other purposes either stand-alone or in a recycling process.

RDF's are used with thermal processing systems. RDF, once produced, can be used even in Coal-fired power stations. Hence an investment in a coal-based power station may not be totally wasted as there is an opportunity for biomass / RDF to find its way there!

Non-thermal technologies – Biological processing

Biological processing technologies include the following process schemes:

- Landfill systems and landfill bioreactors
- Anaerobic digestion (Biogas systems) with or without mechanical preprocessing (MBT)

These essentially produce biogas (gaseous fuel)

- Liquid biofuel production (saccharification and fermentation)
- Liquid biofuel production (transesterification)

These will produce bioethanol, biobutanol and biodiesel.

Landfill gas systems – Landfills with complete gas recovery and utilisation systems are limited. Several landfill systems are planned for Sri Lanka under the Pilisaruru program. A working system is currently present at Nuwara Eliya (at Moonplains) though gas utilisation is absent. More engineered and compact landfill scheme is known as landfill bioreactors. University of Peradeniya is experimenting in this area.

The term 'mechanical biological treatment' – MBT- relates to a group of solid waste treatment systems. These systems enable the recovery of materials contained within and the stabilisation of the biodegradable component of the material. Anaerobic digestion can be carried out through land-based landfill systems or specifically designed digesters.

Anaerobic digestion breaks down the biodegradable component of the waste to produce biogas and soil conditioner. The biogas can be used to generate electricity and heat. Some systems incorporate both anaerobic digestion and composting. This may either take the form of a full anaerobic digestion phase, followed by the maturation (composting) of the digestate. However, it is the digestion phase that result in an energy stream.

Usable Wastes for This System are:

- i. Municipal solid waste – organic biodegradable stream from source separated urban waste can be used as feedstock to a biogas unit.
- ii. Sewage sludge (In Sri Lanka, sewage treatment and more specifically the management of biosolids is in poor state. This however cannot be ignored forever and measures are being implemented).

iii. Certain industrial waste streams (i.e., from food industries)

Biogas systems for solid and slurries – both low and high rate systems are available.

Low-rate systems:

Chinese digesters (China can claim up to 17 million such units)

Indian Digesters (India has also few million plants of varying types)

Drybatch systems (Sri Lankan)

Polytunnel systems (use of plastic bags with entry and exit)

Hi-rate systems - Two phase digesters – the process is separated into two segments during implementation.

Plug-flow systems (available from simple to complex such as KOMPOGAS system (de Alwis, 2002) (Figure 2).

If a proper collection mechanism is instituted beneficial returns could be realized as seen in USA. The switch between thermal to biological processing is made primarily on the basis of degree of moisture. RDF option makes use of the carbon in solid waste after a drying step. To make energy efficiency better, the source of energy used for producing RDF's have to come from waste heat.

A Way Forward in Making Use of WTE with Limited Financial Resources for Sri Lanka

As seen in the foregoing description, there are many opportunities, but sadly much less had been realised. Integrated planning is a way forward.

Waste-to-Energy concept offers great opportunities to energy planner as well as the environmental service provider. That is the opportunity to leverage on each others requirements and to use perhaps a common fund. This combined approach would mean significant cost savings to the national

the proximity principle. As such, when waste is used in electricity generation, the schemes of generation and distribution would have to be more decentralised. CEB will have to consider different strategies. The transmission and distribution losses will be much low with such schemes and perhaps greater reliability. Principally, environmental management will result in energy generation. These WTE operations may result in soil conditioners as a residue, an important by-product in its own right. Local agriculture too can benefit. The residue is a function of the technology employed. If biological pathway is used as the technology for the WTE scheme, a bio-residue would be the result. This is the process pathway of choice for Sri Lanka, which provides benefits as shown in Figure 2.

It is seen that innovative biological based waste-to-energy scheme if practiced in Sri Lanka could result in significant benefits and alleviate much pressures that are currently plaguing the economic planners of the country. As was raised in Figure 1 when would this reality be dawned in Sri Lanka?

economy. However, concepts and planning procedures may have to be changed and a different planning mindset needs to be in place.

To place the concepts, consider the allocation for environmental protection and the related component for solid waste management. Solid waste management is a

local government responsibility, yet it is a serious issue today for the central government as well. The existence of the *Pilisaru* program of the Central Environment Authority is an indicator for centre's interest in resolving this growing crisis. The government also allocates funding for electricity generation, a key requirement. Ceylon Electricity Board (CEB) is entrusted with this task of generation and distribution. If the waste to be managed properly, it is done in such a way that electricity is generated as an end result, and the funds required for two different systems could be reduced. This is Waste-to-Energy in practice. Waste-to-Energy also means decentralised energy generation as waste is not be hauled around for great distances for disposal practices. The simple economics as well as environmental principles dictate the adherence to

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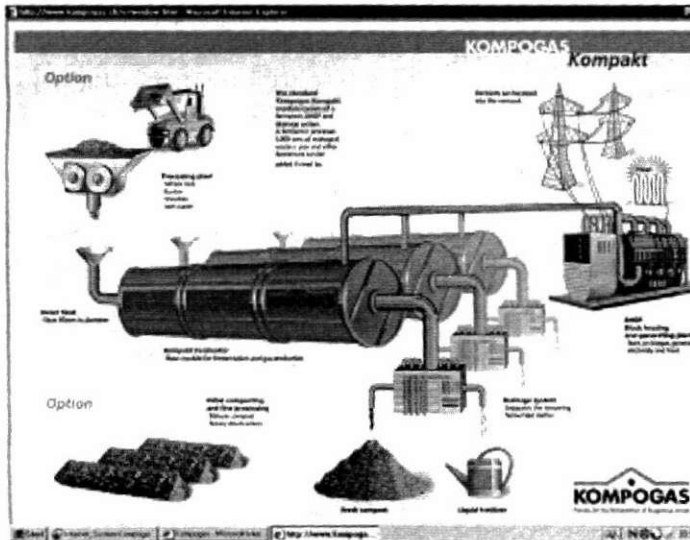
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Figure 2

KompoGas System serving urban waste management along with energy generation and compost production – Advanced biogas systems



There are other biological pathways – fermentation schemes which lead to liquid biofuels. Liquid biofuels such as bioethanol and biobutanol through fermentation pathways are examples. Waste streams could be fermented to realize liquid biofuels. Municipal solid wastes fermented to produce biofuels are still not commercially viable though the process path is known and tested. Certain industrial waste streams and agriculture sector wastes are however processed to produce liquid biofuels. There is significant scientific interest in this area as the potential is high.

Biofuel generation from waste cooking oils – with trans esterification – is commercially practiced. Collection of waste oils from kitchens and similar places is necessary to implement such a program.