THE HONG KONG INSTITUTION OF ENGINEERS
ENVIRONMENTAL DIVISION CUM
THE HONGKONG INSTITUTION OF ENGINEERS
YOUNG MEMBERS COMMITTEE,
HONG KONG WASTE MANAGEMENT ASSOCIATION AND
INSTITUTION OF MECHANICAL ENGINEERS (HONG KONG BRANCH)
SEMINAR ON WASTE-TO-ENERGY FOR MUNICIPLE SOLID WASTE TREATMENT

The evening seminar was given by Ir Elvis W.K. Au, Assistant Director (Nature Conservation & Infrastructure Planning) of Environmental Protection Department of Hong Kong SAR Government (EPD) on 24 March 2014, presenting the latest development and operational experience of various modern waste-to-energy (WtE) municipal solid waste (MSW) treatment technologies. The following is a summary of Ir Au's presentation.

International and Regional Trends on Thermal and Organic Waste Treatment

Ir Elvis Au delivered presentation on waste-to-energy

No advanced economies in the world rely solely on landfills alone to handle their waste problems as it is not sustainable. Alongside waste reduction and recycling initiatives, WtE facilities adopting advanced thermal treatment technologies have become an indispensable part of the overall waste management strategy of any modern international city.

Thermal Waste Treatment Technology

For the past century, moving-grate incineration technology was the mainstream thermal treatment technology in dealing with MSW. In recent years, alternative thermal treatment technologies such as gasification, plasma gasification and pyrolysis, have emerged into the market. EPD have constantly kept abreast of the latest developments on the various waste treatment technologies by making reference to overseas' studies and paying visits to the newly developed facilities.

Up to present, there are about 2,000 incinerators, majority of which adopting grate-based incineration, developed for MSW treatment. About 500 plants are in Europe, 75 plants in USA, more than 1,200 plants in Japan and about 150 plants in China and South Korea. The overall treatment capacity is more than 100 million tonnes per year (t/yr).

Other thermal treatment technologies such as gasification, plasma gasification and pyrolysis have had certain limitations due to their complexity, difficult to handling variations in the waste stream (which requires waste pre-treatment) and lower net energy recovery (electricity and heat energy) once in-plant parasitic consumption is

accounted for. These factors tend to make these other thermal treatment technology less viable. At present around 25 pyrolysis installations, 100 gasification installations and 15 plasma installations are in operation worldwide with an treatment capacity of less than 1 million t/yr, about 2.5 million t/yr and around 0.3 million t/yr respectively. All these installations are very small in scale and are mainly used to treat specially separated streams of MSW rather than mixed unprocessed MSW, and there is very limited information on their operation performance. The total treatment capacity of the plants adopting other thermal treatment technologies is less than 3 % in comparing with the total treatment capacity of the plants adopting incineration. However, the industry continues to evolve and larger facilities that treat a portion of waste stream are being proposed, developed and commissioned but their reliability and performance are yet to be demonstrated.

Organic Waste Treatment Technologies

Organic waste such as food waste is high in moisture content and the combustion of which is low in terms of energy efficiency. Apart from setting a target of diverting the bio-degradable municipal waste from landfills by 65 % by 2016 (for some countries by 2020) through directives, European Union (EU) encourages its member states to separately collect bio-degradable waste with a view to composting and digestion of bio-degradable waste, which is in line with the global trend of treating organic waste by biological process and putting the biogas generated to beneficial uses. Across the world, there are more than 240 anaerobic digestion plants processing 7.75 million t/yr of organic waste. Europe is especially advanced in organic waste treatment, owing to the EU directives on management of bio-degradable waste, the drive of tackling climate changes and expanding renewable energy and the aggressive waste charging scheme imposed in EU member states in the late 1990s and early 2000. All these have created the financial drive which has encouraged the private investments to invest into organic waste treatment facilities.

Examples of WtE facilities

While Hong Kong is contemplating to build its first 3,000 tonnes per day (t/day) capacity incinerator, Singapore has had incinerator up to 10,000 t/day capacity in operation. In an EPD technical review conducted in 2009, it was concluded that the mainstream technology for MSW treatment was moving grate incineration. Over the past years to date, the conclusion remains sound.

Moving grate incineration technology is still being adopted by the majority of new WtE plants commissioned since 2009. It has adequate number of large scale incineration plants with proven track record and satisfactory performance. There are at least more than 120 incineration plants in operation with each treatment capacity of more than 1,000 t/day and among them, more than 30 incineration plants have treatment capacity of over 2,000 t/day. For examples, the Tuas South Incineration Plant in Singapore commenced in operation in 2000 has the treatment capacity of 3,000 t/day of mixed MSW, the last phase of AVI Amsterdam WtE Plant in Netherlands commenced operation in 2007 has the total treatment capacity of 4,400 t/day of mixed MSW and the Domestic Solid Waste Management Centre in Qatar commenced operation in 2011 has the treatment capacity of 2,300 t/day of mixed MSW.

Visit to Europe on Thermal Waste Treatment Facilities

During 3-7 March 2014, the government delegation, led by the Secretary for the Environment and the delegation from the Legislative Council (LegCo), led by the Chairperson of the LegCo Environmental Affairs Panel, visited the United Kingdom, the Netherlands, Denmark and Sweden. The delegates exchanged views with local officials and environmental experts on various waste management issues covering waste reduction and recycling, social mobilisation and waste infrastructure. The delegations also visited five WtE facilities in the countries and briefings on the technology and operation, WtE effectiveness and challenges in developing modern waste infrastructure were conducted. Some of the facilities visited by or presented to the delegates are as follows:

Denmark: Amager Bakke incinerator

The Amager Bakke facility is a direct replacement of the existing incinerators and locates only 2 kilometres from the palace of the Danish monarch. The innovative recreational uses of the roof top and the exterior of the facility include – a skiing slope, hiking trail, climbing wall and cafeteria near the top of the chimney. These recreational provisions fused into Amager Bakke and expand its function from an ordinary MSW treatment facility into a multi-purpose leisure activity compound. The Amager Bakke facility has a treatment capacity of 1,100 t/day. The new WtE facility has a dual purpose of Combined Heat and Power (CHP) production and recreational area for the Copenhageners. It is a shining example of innovative architectural design paired with sustainability and energy efficiency: the facility will supply low-carbon electricity to 550,000 citizens and heat to 140,000 households in the Copenhagen area.

Denmark: KARA/NOVEREN's waste-to-energy facility

KARA/NOVEREN's WtE facility at Roskilde near Copenhagen, Denmark, is designed by Dutch architect Erick van Egeraart. Its novel architectural design forms an axis with the cathedral of Roskilde (Roskilde Domkirke). It's backlight perforated aluminium façade transforms the incinerator into a gently glowing beacon when every spark of the light gradually glow into a burning flame that lights up the entire building, which symbolizes the plant's energy production. Another point worth noting is that the incinerator locates merely 2.5 kilometres from a United Nations Education, Scientific and Cultural Organization (UNESCO) heritage site and 500 metres from the nearest residential area. It has become an icon of Roskilde and is well accepted by the public. The architect also won a design award in 2008 for it seeks to embrace both the historic and industrial heritage of the site.

The Netherlands: AEB Waste Fired Power Plant

AEB Waste Fired Power Plant in Amsterdam is the largest WtE facility in Europe and, it achieves a thermal efficiency of 30%, and renowned as the most energy efficient WtE plant in the world. The plant was upgraded and developed in phases with the last phase commissioned a few years ago and the total treatment capacity is 4,400 t/day. There are 500,000 residents reside within five (5) kilometre radius of AEB, while the nearest residence is just 2 kilometres from the facility.

The U.K.: New Earth Solutions integrated waste treatment and energy recovery facility

The New Earth Solutions integrated waste treatment and energy recovery facility locates in Avonmouth, UK adopts the pyrolysis and gasification process to treat Refuse Derived Fuel (RDF) produced from the Mechanical Biological Treatment (MBT) Process for electricity and heat generation. The MBT employs various mechanical equipment such as magnets, screen and trommels, etc. to separate mixed MSW into different fractions according to their physical properties. Organic waste is separated for biological treatment, and the residues are processed further and converted to RDF. The pyrolysis stage involves heating the incoming RDF in the absence of oxygen, converting it into a synethic gases (syngas) and carbon rich char. The char is then gasified using high-temperature steam with the controlled addition of oxygen. This converts the char into syngas, with a remaining particulate ash to be safely disposed. The gas produced from both the pyrolysis and gasification processes is combined and fed through a thermal oxidizer operating at around 1,200 ℃ to generate heat and electricity. The MBT process requires a large footprint, about two-third of the site area is occupied by the waste pre-treatment process, whereas the remaining one-third is for the pyrolysis process itself. Since the facility has only been put into operation for a year, there is insufficient operation data to demonstrate the plant's performance.

Plasma Gasification Plant

The U.K.: Advanced Plasma Power Gasification Plant in Swindon

The advanced plasma gasification plant in Swindon is a pilot facility with a treatment capacity of 2 t/day. It is designed to test waste feedstocks, helping to maximise the efficiency of the fuel used in the full-scale energy from waste plant. The facility also enables investigating the transformation of wastes into syngas. Waste will first be sorted to produce RDF, then processed through a fluidized bed gasifier operating at 850 ℃, which produces ash and gases. This is then put through a plasma converter, which operates at 1500 ℃ in an oxygen-deprived furnace to crack and polish the syngas. The ash produced is vitrified and turned into slag, which can be used as construction materials. However, the application of slag is still very limited.

Limitations of Plasma Gasification and Gasification Technology

The adoption of Plasma Gasification technology in the treatment of MSW is very limited. There are only four (4) plasma gasification plants [one (1) in US and Canada each and two (2) in Japan] operating at a small scale for the treatment of industrial and hazardous waste, and even low-level radioactive wastes. The plant of the largest capacity is located in Utashinai, Japan, with a design capacity of 220 t/day. From the outset, this plant had encountered technical problems leading to major downtime during the first two years of operation. Moreover, the operator, AlterNRG, reported that the plant was closed in 2012 due to the lack of feedstock.

In UK, a plasma gasification plant of 1000 t/day is being built at Teeside and will be commissioned in 2014. However, this emerging treatment technology is still facing

challenging operation complexity and difficulty in treatment of mixed MSW. Operation data for a sufficient long period of time, however, has to be obtained before one can reliably evaluate the technical and financial performance of these new plants.

As for the gasification technology, it has been adopted in industrial application for many years. However, there is lack of proven experience in handling MSW of large scale (i.e. more than 1,000 t/day). In addition, gasification technology is not suitable for dealing with of mixed municipal solid waste of variable sizes and quality. It is often necessary to chop the mixed MSW into small particles beforehand. The technology review also found that some of the major suppliers of gasification technology have recently withdrawn from the international market.

Some plants in Japan adopt the gasification technology for the combustion of synthesis gas to melt fly ash at 1350 ℃, a much higher temperature than 850 ℃ adopted in moving grate incineration furnace. The technology review in 2009 showed that the operating cost of melting the ash is very high and therefore not widely used internationally.

Gasification is not without controversy. A plant in Germany experienced syngas leakage and explosion in 1998. Another plant at Dargavel near Scotland was ordered to cease operation by the Scottish Environmental Protection Agency in 2012 for there were over 200 reported breaches of emission limits, including dioxin, .

Summary and Remarks

The seminar received well attendance

WtE facilities and landfills are indispensable elements of a holistic waste management strategy. The key message regarding the WtE facilities is that Hong Kong is going to have a large scale, first-of-its-kind facilities and reliable and robust technology should be the priority consideration. The proposed moving grate incineration technology remains the mainstream MSW treatment technology with substantial proven track record and performance. It has been employed by the majority of the large scale thermal waste treatment plants in the world with many projects underway, which indicates that it is still the mainstream technologies for the years to come. It is the only thermal technology that proved to be capable of treating mixed MSW reliably at a scale comparable to the 3,000 t/day capacity for Integrated Waste Management Facilities Phase 1. Innovative designs, such as turning the exterior part of the facilities into unique community sports facilities could also be integrated into the new plant to gain public acceptance.

The organisers thank Ir Au for the delivery of the informative and inspiring evening lecture.

- END -

The photographs were taken by Ir T.Y. Ip with permission to use.

WHT