WASTE TO ENERGY

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Rising energy costs, increasing landfill prices and the environmental imperative to reduce atmospheric emissions of fossil CO_2 are all compelling medium and large energy users throughout Australia to consider decentralised onsite power generation options. In addition to the rollout of household and community-scale photovoltaic (PV) and wind, waste-to-energy technologies such as landfill gas and biogas-based powerplant are now well established in Australia. However, various other waste-to-energy technologies, operating elsewhere, have yet to take off.

This presentation provided an overview of waste-to-energy processes, including examples of currently operating commercial processes as well as recent research to highlight the interesting mix of processes and economics that make up the waste-to-energy landscape.

In considering opportunities for waste, it is important to recognise that conversion of waste to high-grade energy (such as electricity, heat and liquid fuel) is not a preferred waste management solution. Converting waste to energy should only be considered after other strategies (prevention, minimisation, reuse and recycling) have been adopted to the maximum possible extent.

From an energy technology perspective, wastes can be broadly separated into two types: wet and dry wastes. Wet wastes (e.g. food wastes, biosolids, manures) are most often treated using biological processes such as anaerobic digestion and fermentation, respectively yielding methane gas and ethanol as energy carriers. Dry wastes (non-recycles plastics, woody biomass, crop stubble etc.) are most often treated using thermal processes such as combustion, gasification and pyrolysis.

Because of the wide variety of waste types and their broad-ranging characteristics, it is important to ensure that the selected technology is actually fully compatible with the given waste stream. Many waste-to-energy projects have failed due to a poor feedstock–technology match, with one of the most frequently overlooked factors being solids-handling systems. Other factors to consider in thermal processes are variances in waste energy content and moisture content, the presence of any halides or sulphur (which could cause air emission problems), the behaviour of ash in the process (deposition and fouling), and material shape, size and flow properties.

Combustion systems, where waste is burned completely to ash, suffered from improper operation and poor regulation in the past, leading to air emission problems. Many suitable wastes are now co-combusted in cement kilns and pulverised coal boilers as an alternative solid fuel. Amager power station in Copenhagen is an example of biomass waste (pelletised straw and wood waste) being combusted at large scale (~100 MW) as a replacement for the coal that the power station was originally designed for. Smaller plants incorporating modern organic rankine cycle (ORC) technology for converting the combustion heat to electricity exist at the 1–5 MW scale throughout western Europe. At Fussach, Austria, a small ORC plant charges a fee to accept demolition wood waste, which is then converted to heat, electricity and refrigeration for export to adjacent facilities. Recycled metal and boiler ash are also sold. The Nipuna rice mill in Sri Lanka demonstrates the benefits of using agricultural wastes (rice husks) directly available at the site for the provision of heat and power to the mill and other processes.

Gasification systems involve the high temperature conversion of carbon-containing feedstocks (including wastes) in a limited oxygen environment to a fuel gas called ‘producer gas’, ‘wood gas’ or ‘syngas’, depending on the production context. The technology has existed in a variety of forms for at least 200 years; many still remember car-mounted ‘charcoal burners’ (gasifiers) substituting for petrol during the fuel rationing of World War II. Gasification plants are typically more sensitive to feedstock properties and changes than combustion plants, though they may have a lower capital cost. The town of Güssing, Austria, hosts a 2 MW fluidised bed gasification system that runs on chipped forestry waste, providing electricity, heat and synthetic natural gas to the local community. The gasification plant is part of a long-term regional renewable energy vision and has transformed the town of Güssing from a backwater to a thriving European alternative technology hub over the last ten years. Plasma gasification is often considered the ultimate waste-to-energy solution – particularly for contaminated and toxic organic materials. However, the technology (though technically successful) is extremely expensive.

Anaerobic digestion has been implemented at numerous wastewater treatment works in Australia as a means to reduce odour and sludge volumes while generating electricity. Many Australian landfill sites also generate electricity from digestion occurring within the landfill. However, the large energy yields possible from the digestion of wet food wastes have yet to be fully exploited.

Earth Systems has been investigating a new technology known as hydrothermal processing (conversion of wet wastes to oil and gas in hot pressurised water) as a means to convert contaminated legacy biosolids from wastewater treatment plant to a benign form. This and other forms of pyrolysis (conversion of organic matter to oil and gases via heating in the absence of free oxygen) have been the subject of much interest in recent years, with a variety of new technologies being developed. Pyrolysis enables a wide range of byproducts to be produced in addition to high grade energy; these include biochar, bio-oils, fuel gases, ash, nano-structured carbons and a variety of other industrial chemical precursors. Via a rotary kiln pyrolyser, the RWE Contherm plant in Germany converts municipal solid waste to energy-rich volatiles which are fed into an existing coal power station boiler, reducing the need for coal. Dynamotive (Canada) is exploring the production of drop-in replacement liquid fuels from woody materials including eucalyptus. Earth Systems has developed a transportable pyrolysis kiln for the conversion of stranded waste biomass in remote areas into biochar for soil improvement, reducing the emissions associated with alternative disposal methods such as open burns.

Although waste-to-energy technology uptake has been most widespread in Europe, economic conditions in Australia are now changing – landfill prices have risen significantly, as have retail electricity prices. The financial incentives for waste-to-energy processes are beginning to be recognised and it is likely that a variety of waste-to-energy projects will be implemented in Australia in the next five years.