Clean Energy Utilization of Waste and Biomass to Cope with Climate Change and Environmental Risks
i-CIPEC Workshop: Green Energy from Alternative Fuel and Air Pollution/GHGs Reduction

Recent Climate Change Issues and GHG Emission Reduction Potential from Biomass Resources

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Abstract: This paper examines the current technologies and mitigation potentials relating to waste-to-energy. Biomass sources include forest, agricultural, and livestock residues, short-rotation forest plantations, dedicated energy crops, the organic component of municipal solid waste (MSW), and other organic waste streams. Part of these are already used as feedstocks which, through a variety of chemical and physical processes, produce energy carriers in the form of solid fuels (chips, pellets, briquettes, logs), liquid biofuels (methanol, ethanol, butanol, biodiesel), and gaseous fuels (synthesis gas, biogas, hydrogen). Policies are discussed that can support the production of energy services from these carriers for use in thermal, electric, transport, construction, and biorefinery applications, that can take place in a centralized or decentralized fashion.

Introduction: Wastes arising from end-use consumption create around 5% of total greenhouse gases (around 1.35 Gt CO2-eq / year) (Bogner *et al.,* 2007)). These are mainly in the form of methane from landfills, methane and nitrous oxides from wastewater, and carbon dioxide from incineration of the plastic and synthetic textile components of municipal solid waste (MSW). The CO_2 arising from the biomass component can be assumed to be recycled.

Methane emissions from landfill sites in OECD countries have largely been stabilised but those from non-OECD countries are increasing due to more landfills and poor management. Reduction by alternative and improved waste management practices and development of landfill gas recovery technologies (possibly under the clean development mechanism - CDM) could reduce these emissions. Commercial recovery and use of landfill gas as a source of renewable energy has been undertaken since 1972 and now avoids GHG emissions of over 100 Mt $CO_{2\text{-eq}}$/yr.

Thermal waste-to-energy processes may become more viable as energy prices increase. Landfills can produce methane for decades. Therefore incineration, composting and other strategies that reduce landfilled waste volumes are complementary mitigation measures to landfill gas recovery in the short- to medium-terms. Incineration and industrial co-combustion of wastes-to-energy can provide fossil fuel offsets and renewable energy benefits. Currently there are over 600 incineration plants operating worldwide and more than 130 Mt of waste per year are incinerated. Such thermal processes with advanced emission controls are proven technology, but they tend to be more costly than controlled landfilling linked with landfill gas recovery.

Technologies: Electricity generation based on renewable MSW in 2010 was 17.3 TWh, up 13.5% since 2009. Around 46.3% of the total was generated by CHP plants and the remainder by electricity-only plants. Heat produced through the combustion of renewable MSW accounted for only about 3% of the total heat generated from all solid biomass in 2010.

In developing countries, biogas produced in large digesters is generally used for power generation. In China, by the end of 2009, nearly 2,000 large and medium-scale biogas digesters had been installed at industrial enterprises. A further 22,570 digesters had been installed at livestock and poultry farms, and 630 in municipal waste and sludge treatment facilities. By the end of 2010, China's total biogas power generating capacity stood at 800 MW. India had 70 biogas plants based on urban and industrial wastes amounting to 91 MW of installed capacity as of 2010 (REN21, 2012).

In the United States in 2011, 576 operational landfill methane-capture projects produced useful heat (along with electricity) to meet the heat demand of almost 750,000 homes, for a total of 62 PJ. Biogas produced from anaerobic digestion of organic wastes is being used increasingly for heat production. In developed countries, it is used primarily as fuel for CHP plants, with relatively small amounts used in heat-only plants. Total heat consumption from biogas in Europe was 63 PJ in 2010. As of early 2012, about 186 biogas plants were operating in the U.S.A at commercial livestock farms, with 168 of these generating around 0.2 PJ/year of useful heat energy (excluding gas flaring). Biomethane (purified biogas) is produced in 11 European countries, and in nine of them it is injected into the natural gas network. Its use in CHP plants along with other applications is well established in these countries, led by Germany.

In developing countries, biogas produced from domestic scale digesters is used for cooking and to a smaller extent for water heating and lighting. China and India have the largest numbers of domestic digesters in the world, with 43 million and 4.4 million domestic biogas digesters, respectively, in 2011. Nepal and Vietnam also have them in significant numbers, while several other countries in Asia and Africa have initiated digester programmes.

Potentials: The total global economic mitigation potential for reducing landfill emissions in 2030 is estimated to be >1000 Mt $CO_{2\text{-eq}}$ (or 70% of estimated future emissions). Most of this potential is achievable at negative to low costs with around 20–30% of projected emissions for 2030 reduced at negative cost and 30–50% at costs <20 US$/t$CO_{2\text{-eq}}$ /yr. At higher carbon prices, more significant emission reductions are achievable, with most of the additional mitigation potential coming from thermal processes for waste-to-energy at costs below US$ 100/t$CO_{2\text{-eq}}$/yr.

CDM projects can assist developing countries with respect to both waste and wastewater management, but constraints on sustainable development include the local availability of capital as well as the selection of appropriate and truly sustainable technologies. Providing infrastructure for wastewater management in developing countries can give multiple benefits for GHG mitigation, as well as improved public health, conservation of water resources, and reduction of untreated discharges to surface water, groundwater, soils and coastal zones.

References

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