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ENERGY GENERATION THROUGH WASTE MATERIALS IN GREEN BUILDING

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ABSTRACT

Wastes and residuals are undeniably part of human society. The accumulation of these materials and the "throw-away philosophy" result in many environmental and health issues and safety hazard problems, and prevent sustainable development in terms of resource recovery and recycling of waste materials. The carbon sources in the wastes can be converted to energy (electricity, heat, chill, fuels) and even materials using different technologies including collecting and converting current landfill gases, wet or dry anaerobic digestion to biogas, incineration, gasification and pyrolysis. Sweden has been one of the pioneers in waste

management and resource recovery with more than 30 years development. The MSW of 150,000,000 inhabitants (with a typical composition and amount similar to the Nordic European countries) can be converted to about 1,000-5,000 MW electricity, depending on the technology used. In every building there are tones of waste generated every week, so if we can change the waste to energy so that we can fulfill the energy requirement of building when the solar panels are not available then we can save a lot of our natural resources.

I.INTRODUCTION

The people in the world produce more than 2,000,000,000 tons per year municipal solid wastes (MSW), in addition to the wastes from agriculture, companies, forestry, etc. This waste is generally landfilled (Fig. 1). Emissions from landfills and accumulation of solid waste materials in developing countries are problems which grow in parallel with improvement of the welfare in these countries. At the same time and if correctly managed, waste can be a valuable reserve for production of material and energy. The accumulation of waste and the "throw-away-philosophy" results in several environmental problems, health issues and safety hazards and prevent sustainable development in terms of resource recovery and recycling of waste materials. The first problem comes from the perspective in which local governments have primary responsibility for solid waste materials, and carries out its activities from a primary concern with public health issues, and not 'environmental health'.

One of the objectives in this context was effective removal of waste from neighborhood residential areas, where the wastes disposed in sites outside the city boundaries. The limits to this approach became increasingly clear in industrialized countries during 1960s and 1970s as consumption patterns led to sizeable growth of waste flows, whose disposal went beyond the limits of social acceptability and the absorption capacity of local and global sinks. A perspective aimed at promoting greater sustainable development in the use of resources has influenced solid waste management practices, and is gradually becoming implemented through policy guidelines at national levels in a number of industrialized countries. Guidelines 2 and directives to reduce waste generation, and promote waste recovery are laid down according to the 'waste management hierarchy', in which waste prevention, reuse, recycling and energy recovery are designed to minimize the amount of waste left for final, safe disposal 1 .

Sweden's view on waste management is to take a holistic approach and acknowledge the complexity of the issues. It is not a problem to be fixed quickly, and policies, regulations and actions must be taken at all levels of society and be adapted to regional and local needs. By mixing economic incentives, such as garbage collection fees, with easy access to recycling stations and public awareness campaigns, Sweden has started this process more than 30 years ago and achieved very high recycling rates. Sweden banned landfilling of combustible waste in 2002 and organic waste in 2005 and nowadays, almost the entire household waste is recycled, reused or used as source of energy and materials (Fig. 2 2). Already in 2004, Swedes recycled 96% of all glass packaging, 95% of metal, 86% of corrugated cardboard and 80% of electronic waste. Waste that cannot be recycled is recovered through other means, often to local economic benefit, through biologically treatment to create compost, biogas and fertilizer or through thermal treatment to produce electricity and central heat.

Wastes and residuals are produced by industries, forestry, agriculture, municipalities, etc. in huge amounts. Although landfilling of organic wastes is banned in Europe, there are just a few countries have well

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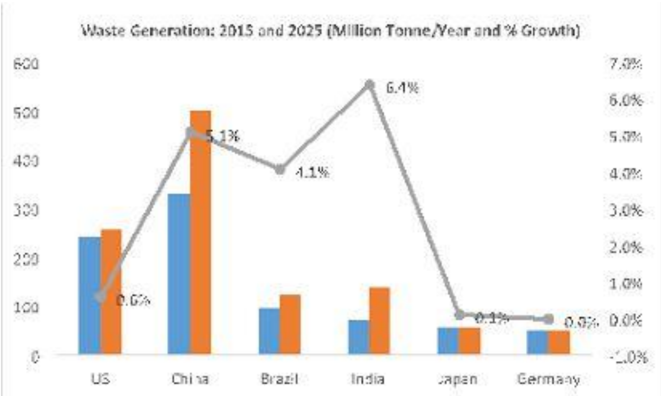
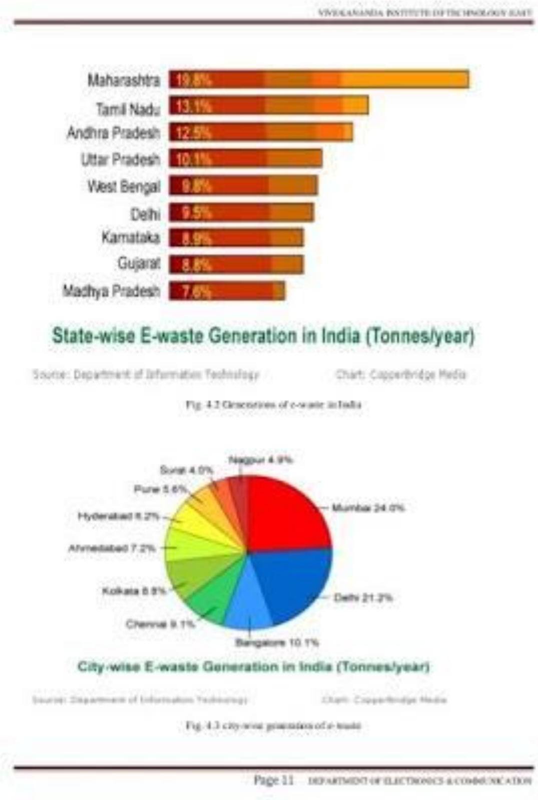
succeeded, while many eastern and western European countries are still struggling with high proportion of landfilling of their wastes (Fig. 3 3) was landfilled . However, a perspective aimed at promoting greater sustainable development and resource recovery has influenced solid waste management practices, and is gradually becoming implemented through policy guidelines at national levels in a number of industrialized and even developing countries. In Sweden, continuous development of knowledge and technology of treating wastes and residuals is a demand for using our resources. Otherwise, a sustainable society cannot be achieved. In addition, exporting this technology to other countries will improve the global environment.



What a Waste: A Global Review of Solid Waste Management, World Bank, 2012



II.WASTE TREATMENT AS A PUZZLE

There are several factors in converting wastes into energy and materials, which are usually not all considered (Fig. 4). It should be noticed that it is not possible to solve the waste problem and convert it to energy in "economical way" by just buying and installing some equipment. The vision of the city, environmental and health protection regulations for both people as well as those who work on the waste sites should be considered. The collecting system and separation of the hazardous wastes are very important factors. On the other hand, the energy or materials forms of the final products and their market and prices are also important in order to select a treatment method. Last but not least, education of the people is one of the most important factors in order to improve the collecting system and maintaining and improving treatment methods and technologies.

Fig. 4 –Different factors in converting wastes to energy

III.LANDFILL GAS AND BIOGAS

In addition to inorganic wastes, different types of small molecules and polymers are available in various waste materials. Natural materials such as starch, lipids, glycogen, elastin, collagen, keratin, chitin and lignocelluloses, as well as synthetic polymers such as polyesters, polyethylene and polypropylene, are among these polymers. These monomers and polymers can be degraded by enzymes or microorganisms, and converted to some products. The major products in degrading processes in nature are methane and carbon dioxide:Microorganims Organic wastes Oxygen Microorganisms CarbonDioxide Water □ □ □ □ □ □..

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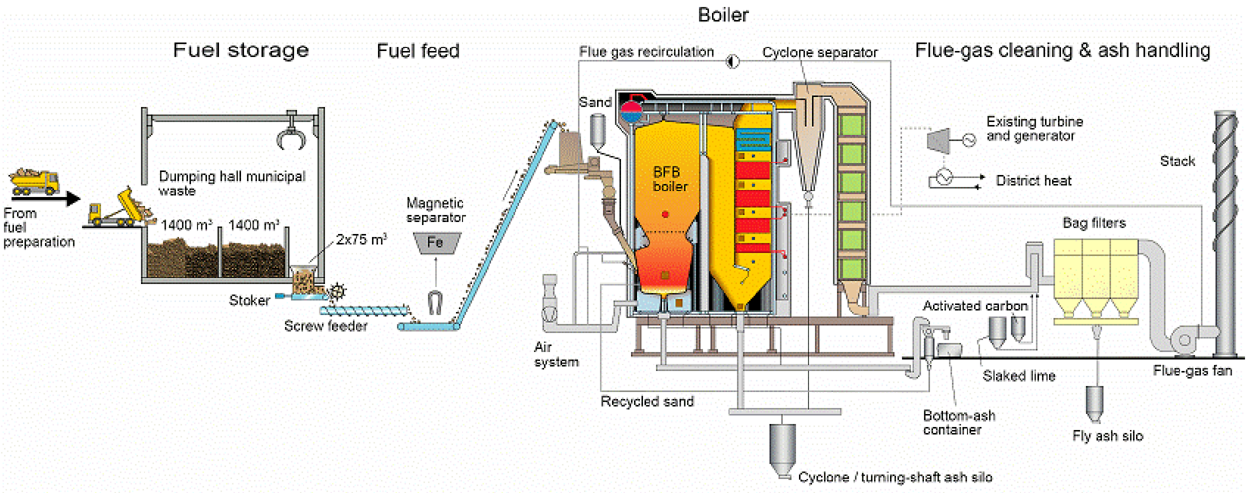
In a dumping area (open landfill), the oxygen can diffuse into the waste. The depth of the diffusion depends on how dense the waste is, but can be typically one meter. Therefore, from the surface of the landfills, CO_2 will be the dominant gas product, while the deeper part of the landfill goes through the anaerobic digestion, and CH_4 will be 40-70% of the gas developed. Methane is 21 times worse than CO_2 in terms of greenhouse effects, and its emission from the landfills is a serious threat to the global environment. Other gas present inlandfill gas are generally nitrogen (0-5%), H_2S (0-0.5%), water vapor (1-5%), dust (> 5μm), siloxane (0-50 mg/m^3), and sometimes oxygen.The methane present in landfill gas is a source of energy. A typical landfill of a city with 100,000 inhabitants produces 500 m 3 /hour landfill gas with 45% methane content. This amount of gas is equal to 2250 kW energy, which can be converted to 750-800 kW electricity.There are microturbines and gas engines that convert the landfill gas into electricity.

A better quality of methane can be produced in digesters. There are two different technologies for this purpose: wet digestion (typical dry weight of 10-12%) and dry digestion with typical dry weight of 40-50%. The wet digestion is more popular and results in higher yield of methane gas. The maximum possible methane production from e.g. a ton of cellulose or starch give 415 m 3 methane, which contain about 4150 kWh energy or about 1500 kWhelectricity with the current technology. The new technologies such as fuel cells can lead tobetter conversion degree of about 50% of the energy content of the biogas. It should be noticed that the biodegradability of different wastes materials are not thesame and the amount of biogas production can be different. Therefore, in Borås, peopleseparate the wastes at home into biological (such as food and fruit wastes) and non-biological wastes (such as packages). The biological wastes are located into black bags and the second one into white bags. The black bags together with wastes from restaurants, slaughterhouse etc are directed into a 3000-m 3 digester with a capacity of producing 3,000,000 m 3 biogas perm year. This gas does not contain nitrogen and siloxane and therefore has a good quality to be upgraded to fuel. The upgraded biogas is sold to 50 buses that run in the city of Borås as well as all the garbage trucks, and the extra gas is sold to public for cars that run on bigoas (CNG). In addition, there is an old landfill in Borås that still produce biogas. This gas is used as energy source inside the waste station plant.

IV.WASTE INCINERATION IN POWER PLANTS

Incineration is another technology that is widely used in Sweden to produce electricity and heat. An important factor to decide if the waste should be incinerated or digested is the amount of water in the waste that affects its energy content. If the waste is too wet, the energy that should be added for incineration will be more that the energy that is produced by incineration. In this case, the waste has negative energy value. Therefore, the dry wastes are generally passed to incineration, while the wet wastes go to anaerobic digestion. There are currently 29 incinerators in Sweden that burn about 3.82 million tons wastes and produce 13.1 TWh energy. The incinerator in Borås (Fig. 5) takes about 300 tons/day wastes and burn it in two 40 MW incinerators and produce both electricity and heat. The wastes are incinerated and make a flue gas with more than 800 ºC temperature. The energy is used to produce high pressure steam, which pass through two turbines and produces electricity. The rest of the energy (from the low pressure steam) is used to heat up warm water that takes the energy to the city by pipelines for heating the houses and also warm water of the households.



V.RESEARCH ON NEW TECHNOLOGIES AND PRODUCTS

University of Borås 4 (UB) has a research profile named "Resource Recovery". In this profile, a total of about 40 researchers including 5 professors and 23 PhD students are working to develop new technologies for resource recovery. Different materials that are difficult to digest such as lignocelluloses, waste textiles, toxic citrus wastes, keratin-rich feathers, wool and hairs etc. are investigated to produce biogas, ethanol, fish feed or biological superabsorbents. Computer modelling of these macromolecules (e.g. cellulose and proteins) are carried out in order to study the effects of each process on these materials. Incineration is investigated to e.g. reduce the incinerator temperature, co-incinerate different materials and study the deposition of materials on the heat exchanger tubes inside the incinerators. In addition to incineration, gasification and pyrolysis are developed to produce syngas (CO and H 2) from waste materials, which are the raw materials for different petrochemical products and fuels, such as DME (dimethyl ether). The group is also working on recycling of polymers and plastic materials.This research at UB is partly carried out in collaboration with other Swedish universities, research institutes, and about 20 companies and municipalities. This research group is named Waste Refinery 5 , and invest about 1,5 million Euro each year on the research connected to wastes, and the results are used by the partner companies and also published in form of reports.

VI.ACKNOWLEDGEMENT

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