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Energy Recovery from Municipal and Industrial Wastes: How much Green?

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Waste feedstock, including and industrial wastes can be transformed into various forms of fuels that can be used to supply energy. The waste-to-energy technologies can be used to produce biogas (methane and carbon dioxide), syngas (hydrogen and carbon monoxide), liquid biofuels (ethanol and biodiesel), or pure hydrogen; and later, these fuels can then be converted into electricity. This transformation can be facilitated by various physical, thermal and biological methods. These processes have been driven by many technical drivers, such as the need for improved pollution and emissions controls for combustion, advanced non-incineration conversion methods, and hydrogen production enabling other clean technologies, such as fuel cells. Likewise, the strategic drivers, such as reduction in land filling, reduced dependence on fossil fuels, decreased greenhouse gas emissions and pollution and eligibility for carbon credits and tax incentives has been fueling the energy production from wastes. Despite the technical and strategic drivers, the energy recovery from waste often runs into dry owing to various technological bottlenecks, such as lack of versatility (each system is specific for each type of waste); waste-gas clean-up and conversion efficiency (consuming more energy than producing it). In addition, there are strategic challenges, such as regulatory hurdles, high capital costs and opposition from environmental and citizen groups (social backlash).

In the existing world of mounting energy prices, population growth, and concerns regarding greenhouse-gas emissions, the need for alternative energy and alternatives to landfills and livestock waste lagoons has to increase. Further, bioethanol producers have begun to face the irk of their "environmentally friendly" products relying too heavily on fossil fuels for their production, and they are now using biogas from landfills or feedlots to power their refineries - biogas power for biofuels.

Among different thermal methods of waste management pyrolysis, gasification and combustion are the technologies commonly used for simultaneous waste management and energy recovery. Though these methods have been successfully used even in pilot scale, still they have certain environmental concerns. Similar to any other process used in waste management pyrolysis also has a few shortcomings which need to be considered for efficient/sustainable energy recovery using this technology. Firstly, the products (liquid/gaseous) of the process are complex. Secondly, it may use the wastes which are actually recyclable. Likewise, the process may utilize the organic part of the waste which otherwise could be used for other highly sustainable process such as composting. Further, requirement of high temperature could be another disadvantage of pyrolysis process. For example, a plasma pyrolysis vitrification process may require a temperature between 5000-14,000°C. Therefore, if the energy required to run the process is obtained from a sustainable source then only it may be considered as a green technology for energy recovery. Likewise, gasification of waste for energy recovery has also some issues regarding its sustainability. Firstly, the process may not have very high carbon sequestration efficiency as carbon dioxide may be released. Similarly, during the process toxic substances such as heavy metals and halogens could be released into the environment [1]. Combustion is another method for energy recovery by the utilization of waste. Presently, United States alone has nearly 86 plants for energy recovery by the combustion of municipal solid waste. However, combustion of waste materials for energy recovery has also certain serious concerns. Firstly, in terms of pollutant content, the gaseous emission of waste combustion process is almost similar to energy recovery by fossil fuel combustion. Likewise, the process needs proper management of the ash (fly ash or bottom ash) generated during the process. Additionally, possible release of heavy metals and polyaromatic hydrocarbons during energy recovery by combustion of waste material is another issue [2].

As already mentioned, waste materials could also be subjected to biological processes for energy recovery. Among different bio-based techniques anaerobic digestion is comparatively simple, common and old process. However, it has a range of disadvantages/technical constraints which need to be assessed and resolved to make this technology one of the most efficient technology for energy recovery. Firstly, similar to any other process for the production of gaseous fuel it has a risk of fire and explosion. Likewise, the cost associated with collection, transportation as well as processing of the waste materials may be prohibitory for economic feasibility of the process. Further, harmful emission due to transportation of the waste materials and operation of the process could be considerable with respect to the environmental benefit of the process. Moreover, the efficiency of the process is directly dependent on the organic content of the waste feedstock and the waste with less organic material is not suitable for the process. Hence, waste separation may be required to improve the energy conversion efficiency of the system. Additionally, presence and propagation of pathogen in the putrescible substrate is another serious concern of anaerobic digestion process. Further, according to a report from US-EPA the process of energy recovery by anaerobic digestion of waste is not an economically feasible process until it is integrated to another source of revenue [3].

Besides anaerobic digestion and thermal methods, landfill gas recovery is another successful method of energy recovery from waste materials. Landfill gas is mainly composed of methane (and CO_2) which could be considered as the most dangerous greenhouse gas as it is nearly 20 times potent than CO_2. Methane emission from landfill sites is a serious problem as landfills are one of the three major sources (16% of total methane emission) of methane emission in United States [4]. Therefore, considering the problem of global warming, utilization

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of landfill gas as a source of renewable energy is recognized to have an additional benefit of greenhouse gas reduction. However, often the techniques used to recover the landfill gas can capture only a small fraction of methane produced in a landfill and the release of methane during landfill gas recovery process could have serious environmental consequences [5]. Moreover, due to high capital cost involved, landfill gas recovery may not be economically feasible for smaller landfill sites.

Thus, apart from the concerns associated with techno-economic feasibility energy recovery from wastes, they have certain environmental issues which need to be seriously dealt with prior to its long term application. In retrospective, energy recovery from municipal and industrial wastes can be often energy intensive and thus, theoretically would turn out to be a non-environmental option. However, taking into consideration the value-added effects of the energy recovery, such as simultaneous treatment and detoxification, the energy recovery is globally a green approach.

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