State of Science Report: Energy and Resource Recovery from Sludge

There is a general consensus among sanitary engineering professionals that municipal wastewater sludge is not "waste," but a potential source of valuable resources and alternative energy. Interest in extracting products from sludge, while not recent, is rising because of increases in energy costs, the threat of decline in phosphate rock production, and impacts of global warming, to cite a few factors. Resource recovery from sludge is gaining global importance and has become a key aspect in almost all sludge management master plans.

For each 4.5mgd wastewater treatment facility with anaerobic digestion, the biogas produced can generate 100 kW of electricity.

Many technologies are currently able to recover energy and/or resources from sludge. The technologies can be divided into two main categories, namely established and emerging technologies. The established technologies are full-scale commercial applications, as well as those that can potentially be commercialized. International cases studies of such technologies are provided in the report. The emerging technologies have only been demonstrated in pilot projects or on a bench (laboratory) scale.

Energy recovery technologies can be classified into sludge-to-biogas processes, sludge-to-syngas processes, sludge-to-oil processes, and sludge-to-liquid processes. The technologies available for resource recovery include those to recover phosphorus, building materials, nitrogen, volatile acids, etc., and this report documents technical, capital cost, operating and maintenance (O&M) costs information to the extent possible. The report also discusses new research areas, such as upgrading biosolids pellets produced from sludge as renewable source of inoculum for bio-hydrogen gas production, and the recovery of bio-pesticides from sludge.

Triple Bottom Line (TBL) Assessments Show Costs and Benefits

Technologies are increasingly subjected to an assessment of social, economic, and environmental performance. The report provides an initial "triple bottom line" (TBL) assessment on the technologies.

The report concludes that, with the large number of technologies available, it is technically feasible to recover energy and building materials from sludge. It is well established that a resource like phosphorus (P) can be recovered with efficiency of 60-70%, and possibly higher. Although full-scale P recovery is a technically feasible option, operating practices are in early stages because most of the technologies are still in development.

To be attractive, technologies for energy and resource recovery must be affordable and cost-effective, but this is currently not always the case. Some projects have failed because of the high capital and O&M costs of the technologies. Examples of such projects are certain phosphorus recovery and building material production processes.

The social acceptance of a technology depends on the inputs and the outputs. Chemical

BENEFITS

- Discusses international practice for energy and resource recovery from sludge.
- Explains the influence of market and regulatory drivers on sludge end-products.
- Demonstrates the feasibility of energy and resource recovery from sludge.
- Assesses the social, economic, and environmental performance (triple bottom line or TBL) of current alternative technologies.

RELATED PRODUCTS

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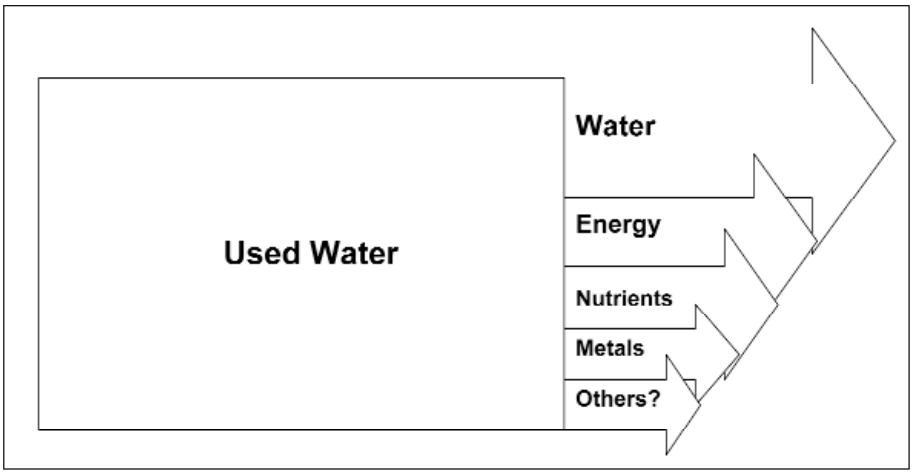

What's the value? What can we mine?

use may be required in certain processes, but it may not always be the best option in terms of health protection and life cycle impacts (energy use and emissions during production and transportation). For example, most current technologies for P recovery are based on extraction with sulfuric acid, a highly corrosive and potentially harmful chemical. In addition, technologies with high potential for pollutant emissions, either upstream or onsite, will have less public acceptance. Technologies involving several process units are generally viewed as less desirable complex processes, which require material and energy for production, greater land consumption, and higher capital and O&M costs.

Suitable Options for Energy Recovery

A TBL assessment showed that, in terms of energy recovery, overall sludge-to-biogas processes are the most suitable options. For phosphorus recovery, it appeared that the technologies using less harmful chemicals like lime are the more acceptable options. Thermal solidification for brick production appeared as a better option compared to slag and artificial lightweight aggregates production.

The report's cursory TBL assessment could not evaluate all technologies in depth, and should therefore be used as general guide rather than as a definitive review. Indeed, many key information requirements are missing for some of the technologies, leading to incomplete or subjective assessment. The limits of the assessment are discussed in the report.

Concerns, Costs, and Government Requirements Drive the Market

The report identifies and discusses four market drivers:

- sustainability and environmental concerns, such as the threat of soil pollution, global warming, and resource depletion
- rising energy costs and the need of more electricity and heat to operate the plants
- requirements for high quality of resources for industrial applications, such as calcium phosphate for the phosphate industry
- regulation as factor stimulating the development of new technologies

A review of the international situation of energy and resource recovery from sludge showed that Sweden and Japan are probably the most advanced countries in the area. Many other countries, including the Netherlands, United States, United Kingdom, Germany, New Zealand, China, and Malaysia, have also been implementing energy and resource recovery from sludge for many years.

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