

Executive Summary: Review of Current and Emerging Technologies for Enhancing Energy Recovery from Wastewater Treatment

This summary was produced to give the salient points from the in-depth reports by Ing. Marco Cremona, (Sustech Consulting, Malta) and Dr. Simon Judd, (Judd Water and Wastewater Consultants, UK) which contain sensitive data.

Introduction

This study examined opportunities to improve energy recovery from wastewater treatment processes in Malta, with particular focus on the management and treatment of sewage sludge. The review assessed existing facilities, evaluated emerging energy recovery technologies, and identified the most suitable options for integration within the existing wastewater treatment infrastructure while reducing greenhouse gas emissions and improving resource recovery.

Current Situation

At present, energy recovery from wastewater sludge is only undertaken at the Malta South Wastewater Treatment Plant (MS) through anaerobic digestion (AD) and combined heat and power (CHP) generation. No comparable sludge-to-energy facilities currently exist at the Malta North (MN) or Gozo plants.

The review found that anaerobic digestion remains a mature and widely adopted technology for wastewater sludge management worldwide. Analysis of operational data suggests that the current system at Malta South is recovering energy successfully, although there may be opportunities to improve overall efficiency through optimisation of plant operation and reduction of factors that inhibit methane production.

Key Findings

Anaerobic Digestion

Anaerobic digestion continues to represent the most established and commercially proven technology for recovering energy from wastewater sludge.

The process offers several advantages:

- Generation of renewable biogas for heat and electricity production.
- Reduction in sludge volumes requiring disposal.
- Compatibility with existing treatment infrastructure.
- Proven operational reliability and extensive international experience.

The study identified potential for improved performance at Malta South through optimisation of digestion conditions and by addressing the high salinity, which may reduce methane generation efficiency by introducing elevated sulphate concentrations.

Emerging Energy Recovery Technologies

The review assessed a range of technologies currently being implemented or investigated internationally.

Thermal Drying

Thermal drying significantly reduces sludge moisture content, improving handling, transport and suitability for downstream energy recovery technologies. It is generally considered an enabling technology rather than an energy recovery process in its own right and is often used before thermochemical treatment processes such as incineration or pyrolysis.

Incineration

Incineration is the most established thermochemical sludge treatment technology currently available.

Its principal benefits include:

- Significant reduction of sludge volume.
- Recovery of thermal energy.
- Long operational history and extensive commercial experience.
- Effective destruction of pathogens and contaminants.

However, the technology also presents challenges:

- High capital and operational costs.
- Requirement for extensive flue-gas treatment systems.
- Production of ash requiring further management.
- Greater emissions control requirements.

Pyrolysis

Pyrolysis was identified as one of the most promising emerging technologies.

Key advantages include:

- Production of biochar that can potentially be used for soil improvement and nutrient recovery.
- Lower operating temperatures than incineration.
- Reduced air emissions.
- Smaller footprint requirements.

- Potentially lower capital and operating costs.
- Reduced waste generation compared with incineration.

The technology is commercially available and increasingly implemented internationally, although it is less established than incineration and currently carries greater technology and supply-chain risk.

Hydrothermal Technologies

Hydrothermal carbonisation and related hydrothermal processes were also reviewed. These technologies offer the advantage of treating dewatered sludge without requiring extensive drying. However, the study found that commercial deployment remains limited, operational experience is relatively scarce, and additional liquid waste streams are generated that require further treatment. As a result, hydrothermal technologies were not considered the preferred option for immediate implementation.

Technology Selection Assessment

A comparative assessment was undertaken considering:

- Capital expenditure.
- Operating expenditure.
- Energy recovery potential.
- Environmental performance.
- Technology maturity.
- Operational risk.
- Footprint requirements.
- Resource recovery opportunities.

The assessment found that:

- Adding hydrothermal pretreatment ahead of anaerobic digestion provides limited overall benefit relative to its additional cost and space requirements.
- Retaining anaerobic digestion remains advantageous because it reduces sludge volumes and supports energy recovery.
- Pyrolysis generally compares favourably with incineration in terms of footprint, resource recovery potential, and likely capital and operating costs.
- Incineration remains the lower-risk option due to its maturity and wider commercial availability.

Site-Specific Considerations

Malta South

Malta South is the most suitable location for future energy recovery infrastructure because it already contains anaerobic digestion facilities and manages the largest sludge volumes.

The study concluded that future resource recovery technologies should be centred around this site, making use of existing assets where possible.

Malta North

The relatively small sludge quantities generated at Malta North make standalone energy recovery facilities economically challenging. Transporting sludge to a centralised treatment facility is likely to be more cost-effective than constructing dedicated infrastructure.

Gozo

Gozo presents unique opportunities because wastewater sludge is supplemented by high organic waste streams. This creates potential for anaerobic digestion and energy generation. Nevertheless, any residual sludge would still require further management or transport to a centralised treatment location.

Environmental Considerations

The review found growing evidence that advanced thermochemical technologies such as pyrolysis can provide environmental benefits through:

- Reduced greenhouse gas emissions.
- Recovery of nutrients and biochar.
- Reduced reliance on landfill disposal.
- Potential carbon sequestration benefits when biochar is applied to land.

However, published life-cycle assessments show that results can vary significantly depending on assumptions and local conditions. Consequently, technology selection should consider both environmental and economic factors.

Conclusions

The review concludes that anaerobic digestion remains the cornerstone technology for energy recovery from wastewater sludge due to its proven performance, reliability and compatibility with existing infrastructure. Opportunities exist to improve current performance through process optimisation and by reducing high salinity in the sewer network.

Among emerging technologies, pyrolysis appears to offer the most promising long-term option for Malta, providing opportunities for both energy and nutrient recovery while reducing waste disposal requirements and potentially lowering lifecycle environmental impacts. Although incineration remains the most mature thermochemical technology, pyrolysis offers a more resource-efficient approach and aligns more closely with circular economy principles.

For Malta North and Gozo, centralised resource recovery at Malta South is likely to be the most practical and cost-effective approach, with the possible exception of targeted anaerobic digestion opportunities in Gozo linked to high organic waste streams.