How Green is Mechanical Biological Treatment?

Dr Adam Read *and* ***Dr Andrew Godley*** *consider the potential role of mechanical biological and heat treatment (MBT/MHT) in sustainable waste management systems and compare the technologies' "green credentials" with waste to energy systems. Solid recovered fuel markets for energy generation are also explored.*

Societies have always produced waste but hand on heart, do we really believe that "zero waste" is possible? If so, then let's stop this discussion now by concluding that many developed economies have wasted a significant amount of money on new waste treatment facilities and associated collection infrastructure that will have nothing to treat in the near future.

So, if we take the view that society will always produce waste materials, then we need to consider how to effectively use them for the benefit of society and the environment, and to turn waste management into resource management.

Releasing waste's value

Waste is a resource: perhaps it is in the wrong form or location, but it is a resource and as such should not be discarded. This is why so much global effort goes towards developing processing technologies to release the resource and economic value of residual wastes. We recycle glass, plastics, metals and paper; we make compost from garden waste and we are encouraged by the EU, and in particular the UK government, to make energy from the anaerobic digestion of food waste. But, despite all this effort, a considerable amount of residual waste remains.

What do we do with the residual waste? We either burn it, hopefully to recover energy in a Waste to Energy (WtE) facility; bury it in a landfill site, but this is not a popular option given EU regulations; or utilise a mechanical biological treatment (MBT) or mechanical heat treatment (MHT) facility to pull out suitable materials (recyclables) for subsequent processing while decomposing/digesting the organic fraction.

There are complex models – such as the Environment Agency's WRATE model for estimating and comparing the environmental impact of different waste treatment facilities.

However, there is also an underlying perception that may override such scientific evaluation when a local authority/municipality is selecting its treatment solution. This perception, which we loosely term "green credentials" in this article, is prevalent around the world. It is evident in media statements and strategy documents that favour one technology over another because they have a smaller carbon footprint, or are better for the environment, even when the full scientific analysis might suggest otherwise.

With the current unpopularity of landfill sites across the EU, and legislation to divert biodegradable materials away from landfill to limit greenhouse gas (GHG) emissions, the emphasis is clearly on the development of thermal treatment and MBT solutions.

These options are rapidly being developed by many local authorities/municipalities across Europe to manage their residual municipal waste. With the stigma that surrounds thermal treatment in the UK in particular, many municipalities have looked to MBT and MHT solutions as possessing greater "green credentials". It can be seen from Table 1 that MBT facilities (along with MHT operations) are being developed in similar numbers to WtE plants across the UK.

Residual waste treatment facilities	Energy from Waste	MBT + MHT
Operational plants	23	18
In construction or planned	40	43
MBT plants producing RDF/ SRF		At least 31

Table 1 - Development of MBT/MHT and WtE plants across the UK

MBT vs WtE

In a simple comparison between WtE and MBT, how well do the green credentials of MBT stack up? Waste to energy plants have some obvious good features: the volume of waste is substantially reduced; energy is recovered from the heat energy released during combustion; and much of the ash can be recovered and recycled as metals and aggregates. It is also relatively cheap, small and simple and – most importantly – it works.

MBT facilities with SRF output can match WtE facilities' performance

So why is it not universally applied as a residual waste treatment technology? Simply, it has suffered from bad press as a source of toxic pollutants, stemming from poorly designed and operated facilities in the 1950s and 1960s. Airborne pollutants are quite rightly a cause for concern, but the level of pollutants from modern plants is well within EU requirements and there is little evidence out there linking WtE with poor health. But the stigma of the 1950s and 1960s remains.

MBT on the other hand is often considered as a green alternative that produces a range of valuable products such as recyclables and fuel. MBT is also widely considered as being more "acceptable" and less likely to generate public opposition than a WtE plant – and, as such, is classed as a safer bet when it comes to land-use planning and community consultation.

MBT's family of treatment systems

MBT is a "family of treatment systems" that uses a combination of mechanical and biological processes to separate and transform the residual waste into several outputs. Some of these are then recovered or recycled, but others are still destined for disposal in a landfill site, although the volume of this material will have been significantly reduced. So, this raises the question of how green is MBT? Generally, an MBT facility is bigger, more complex, and more costly to build and operate than an equivalent WtE plant treating the same amount of waste. Yet many MBT facilities do a similar job to a WtE plant – most are designed to produce a solid fuel that then has to go to another plant for energy generation (recovery).

An MBT facility would be expected to recover metals, both ferrous and non-ferrous, as well as glass for use as an aggregate. An MBT plant may also recover plastics and possibly paper, which would clearly not be recovered from a thermal treatment facility. However, due to contamination, the recyclables are not of the same quality as those that have from an MRF. Over time, as more and more MBT plants come on line, securing markets for these recyclables could become almost impossible, as re-processors favour kerbside collected materials on quality grounds. One of MBT's green credentials is thus undermined.

Yet – given that these are fixed-carbon resources being recovered, including the fossil carbon in the plastics – MBT systems producing plastics and paper might be entitled to some green "points", above and beyond a comparable WtE system.

Composting and anaerobic digestion

What about the biological processes? MBT facilities often include composting of the biodegradable fraction, producing a compost-like output (CLO). But these cannot be used with the same freedom as composts made from source-segregated wastes such as separately collected garden green waste, as they are considered to present a higher environmental risk due to possible contamination from other components in the residual waste.

But composting occurs at low temperatures so there is no energy recovery. It is also incomplete as not all the organic matter is degraded and it actually consumes energy to provide the aeration necessary to complete the process. In addition, composting produces exhaust fumes that may contain pathogenic bacteria and fungi, as well as unpleasant odours and pollutants such as ammonia and volatile organic compounds.

Finally, the CLO produced is considered risky as a material for application to the soil as it may pose environmental risks to the soil and groundwater from diffuse pollution. These potential MBT emissions are not always acknowledged by MBT supporters and, considered in this light, MBT systems may not be as green as claimed or widely perceived.

Many MBTs, however, are now including an anaerobic digester instead of, or in combination with, a composting phase. These AD systems will produce energy from the biogas which typically offsets much, but not all, of the energy required to operate the MBT. However, AD systems also often produce liquid effluents that can be difficult to dispose of.

So MBT systems with AD based solutions may have some green issues to resolve before they can truly claim any environmental high ground – even if life cycle analysis models come to a different conclusion.

Solid fuel from MBT

Many MBT processes are designed to produce a solid fuel from the residual waste, referred to as RDF or SRF. The distinction between RDF and SRF is a grey area but, in general, an SRF preparation is more complex than for an RDF. Both consist mainly of the separated combustible materials present in the residual waste, i.e. the plastics, paper, textiles, wood and carpets.

Aerial view of the MBT plant at the Waterbeach waste management park. The plant was built as part of a major PFI Contract for Donarbon

MBT facilities producing SRF or RDF are often simpler in design as there is less need to recover recyclables. Those that produce an RDF simply screen the larger combustible fraction from the rest of the waste; while those producing SRF do a similar separation step but often include a biodrying stage.

Yields of RDF and SRF may be up to 60% of the input material. After accounting for materials recycled such as metals and glass, as well as process losses such as through microbial decomposition and evaporation of moisture, this means that very little residue is typically left over for landfilling – a quantity comparable to that from large-scale WtE facilities.

MBT facilities with a SRF output are therefore very attractive to municipalities, as they can match WtE facilities' performance while being easier to procure because there are no chimneys or air pollution as the energy production can happen off site.

Environmental impacts of SRF/RDF

Yet we should remember that the SRF must still be burnt for this solution to realise its potential in terms of waste diversion and efficiency. MBT systems can only claim to be green if the SRF/RDF is burned – which could seem a paradox.

SRFs and RDFs might be used as fuel in traditional WtE plants – although this is a lengthy and expensive route to choose when you could tip direct at the WtE facility without the need for any expensive pre-treatment and fuel production – or possibly be co-fired in conventional combustion-based power plants, such as those powered by coal. It may also be used as fuel in gasification and pyrolysis plants that require a more homogenous and controlled feedstock.

Like WtE facilities, SRF/RDF production relies on input material with a minimum calorific value

While these types of facility are commonly cited as being the way forward for the UK and further afield, they are not readily being developed due to the reluctance of municipalities to procure newer technologies with little track record of operation, and this is the same world-wide. As a mixture of fossil and biomass carbon, residual waste-derived SRF is not a totally renewable energy source. It needs to be transported to the site of its use and is often a material of low bulk density. In many respects, at face value it is little different to transporting untreated MSW directly to a WtE facility.

So what are the green credentials of producing an SRF, in view of the costly processing at an MBT facility that is required? SRF can substitute other more traditional fuels in industrial processes – for example, replacing natural gas as a fuel in industrial boilers. This may be a smaller local-scale fuel solution than is possible for more conventional energy from waste plants.

The market for SRF

The characteristics of the SRF may be modified though the MBT processing to produce specific qualities relevant for some applications. For example, SRF has found widespread use as a fuel in cement kilns where the required calorific value (typically >15 MJ/kg) is greater than the calorific value in residual MSW but can be achieved through many MBT processes. Like WtE facilities accepting residual waste direct, cement kilns will be paid to take this material (a gate fee), which is lower than the fees the local authorities would pay to have the material landfilled – so everyone wins. In the UK, the production of SRF for use in industrial facilities benefits all parties: the municipality saves on landfill costs and meets landfill diversion targets, and the industrial user gets paid for using a substitute fuel instead of the fuel they would normally pay for.

It has also been widely suggested that, over time as more SRF comes onto the market and its quality is proven to be consistent, SRF will actually command a price at these industrial facilities. But this is certainly not yet the case in the UK, where a limited market for SRF has raised concerns about municipalities having to landfill it.

The downside to this use of SRF is that in times of economic recession, such as now, industry's fuel demands may fall. Dealing with a waste-derived product in a fluctuating market is risky as the waste supply tap cannot be switched off. Hence, there are risks to the development of SRF as an MBT product stream – and, with MBT in the UK in its infancy and most MBTs being commissioned with SRF production, difficult times may lie ahead. Perhaps more worrying is the situation that might arise if SRF is stockpiled with nowhere to go. Landfilling SRF would result in additional expensive disposal costs and would undermine the local authorities' ability to meet its landfill diversion targets.

So this material (SRF), which is expensive to produce, could also be expensive to dispose of if the end market is not fully developed. Without the markets, the green credentials of MBT facilities producing SRF are shot down! A critical issue for municipalities to consider when selecting their residual waste treatment solutions is the markets for all the products.

It is important to realise that SRF production and use as a fuel is not that different to WtE incineration, as they both rely on fuels with a minimum calorific value to be self combusting. Both SRF and residual wastes rely on plastics to maintain the calorific value. Plastics derived from fossil fuel may in the future be seen as too valuable a form of fixed carbon to burn. It may be increasingly removed from the residual waste stream and encouraged to be recovered as it is. In this scenario, WtE plants burning residual waste may suffer as the calorific value of the input waste may drop below design limits. An MBT facility designed to produce a high calorific value SRF for a specific end user may also suffer in this scenario as maintaining the high calorific value of the SRF may be difficult.

An MBT design, however, that has in-built flexibility to produce a wide range of products and can increase or decrease the yield of these products may be likely to survive such a scenario. While this would almost certainly increase the complexity and cost of the MBT design, this flexibility and robustness may be worth it.

MBT: not such a green alternative

So what does all this mean? An MBT system is a complex combination plant utilising aspects of MRFs, composting, AD and WtE. The key feature about MBT is that it offers a degree of flexibility that may enable it to be better in terms of future proofing than pure WtE solutions, which cannot change feedstock quality or increase or decrease yields.

In a changing world where priorities are shifting in terms of energy demand, resource availability and product specifications, a flexible solution will always be favoured but the flexibility comes with an increase in complexity and cost. Some municipalities will accept this and pay the premium that comes from choosing an MBT system. Others will not and, in a recession-hit world, these decisions will be more scrutinised than ever before.

But, in terms of the "green credentials" of MBT, the simple truth is: MBT is not such a green alternative to WtE as it is often promoted as being. The net transformation of waste by an MBT producing SRF is very similar to that in a WtE plant, but through a more complex process with its own environmental emissions to consider. Not what you expected to hear we presume, but an important reality for decision-makers around the word to accept.

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