

Waste to Energy

DETAILS

SECTOR | Water, Waste

STAGE | Project Delivery, Operations and Maintenance, Renewal and Disposal

TECHNOLOGIES | Waste to Energy

SUMMARY

Organic waste products from sources such as food production and wastewater treatment, can be converted into energy through digestion, pyrolysis, and gasification processes. These processes turn the organic material into a gas (biogas, syngas, hydrogen) and a biosolid stream (biochar, biosolids). The gas stream can be used as an alternative to fossil fuels in a combined heat and power (CHP) plant as a renewable source of energy. While the biosolids stream can also be used as an alternative fuel source, it is typically more useful as a nutrient source and soil improver in land applications for the agriculture industry.

The digestion of sludge from wastewater has had a long history and originally the aim was to reduce the mass of the biosolids produced. The production of biogas from the process has also been long known, but this was commonly flared off and it was not until energy prices rose that interest was renewed in the energy potential from the biogas. In more recent years advances have been made in refining digestion operation, as well as in pre-treatment technologies, such as thermal hydrolysis, both of which have improved the biogas production and throughput. There has also been the addition of alternative organic feed stocks such as food waste which has dramatically increased the number of systems in operation.

Advanced thermal treatment processes, such as pyrolysis and gasification, are also not new concepts, but technological improvements in their operation as well as improved management of flue gases have made them more viable. These processes can use a wide variety of wastes as a feedstock, from municipal solid wastes, to food wastes and even biosolids from digestion processes, diverting this waste from landfill and generating valuable resources in the form of gas and biochar.

The gas produced from these processes has value as an alternative fuel for energy generation, but it also can be injected into the gas grid. There is a view that piped natural gas may cease to exist as a product at some stage in the future (due to the sustainability objectives and environmental impacts). As such, the industry is looking to incorporate renewable forms of gas (either via biogas or hydrogen) into their product and service offerings. The gas produced from these processes will require waste from food production and wastewater treatment and are attractive potential sources of gas.

The world is undergoing unprecedented changes in terms of population and economic growth, and it is predicted that the environmental tipping point will occur over the next 30 years. There are a finite number of resources in the world and yet single-use consumption (and a linear economy) is still a mainstream behaviour; only a small proportion of the products we consume are reused and recycled. With increasing population growth, the increasing mass of biosolids from wastewater treatment facilities is becoming a prominent concern globally,

especially in urban areas where it might have high levels of heavy metals, chemicals (e.g. PFAS and PFOS) as well as pharmaceuticals and micro-plastics, making its disposal particularly challenging. Waste to energy technologies are a key part of the shift from linear to circular economies and to help reduce pollution.

The achievement of a circular economy is a long-term ambition. It requires significant innovation in how projects are developed and managed, and involves complex, and potentially non-existent, supply chains. Behavioural change will be needed. Beyond energy, there are multiple valuable resources that can be generated from organic waste, such as nutrients, bioplastics, and proteins. There is potential for technologies that can automatically optimise and maximise the re-use of resources in waste.

VALUE CREATED

Improving efficiency and reducing costs:

- Waste to energy facilities are a considerable asset investment but they utilise waste products to produce energy which off-sets investment in large scale fossil fuel-based energy.
- Waste to energy facilities provide demand flexibility and increase the robustness of the energy grid.
- Biochar produced in advanced thermal treatment processes can be used as a soil improver, breaking down slowly to release nutrients and providing carbon storage.

Enhancing economic, social and environmental value:

- Diversion of waste from landfill, whether it is municipal solid waste or food waste, ensures that the resource is recovered and utilised for a positive return.
- Energy from waste addresses two of the three pillars of the circular economy, energy and food, and will play a key part in ensuring buy-in to sustainable development.
- Energy from waste reduces reliance on fossil fuels and reduces the associated greenhouse gases.

Reshaping infrastructure demand and creating new markets:

- Increased use of waste to energy generation plants will see small waste producers looking to send waste to centralised / larger plants or the development of small-scale decentralised waste to energy infrastructure.
- Alternative gas sources into the gas grid will change the upstream/downstream operation of the grid and make it more decentralised, similar to the energy grid. There will also be increasing demand for a “green” gas alternative to natural gas.

POLICY TOOLS AND LEVERS

Legislation and regulation: Legislation should set concepts and principles related to waste management, such as life-cycle thinking, as well as defining wastes and by-products and increasing resource recovery in production, circulation, and consumption. The cost of waste disposal is the main driver for waste producers, so policy and regulation should seek use cost incentives so that circular economy options are lower than the cost of standard disposal. Government can also put an obligation on electricity suppliers to source a percentage of energy from renewable sources and thereby encourage investment in renewable generation.

Transition of workforce capabilities: There will be a need to change mainstream behaviour from a linear consumption mindset to a circular one. Education and examples of beneficial re-use can be used with the goal of embedding innovation and sustainable development within public and industrial culture. Currently there is widescale workforce capability and knowledge in digestion, but there will be a requirement to increase the skills in the local workforce in regards to design, build, operate and maintain more advanced thermal treatment process.

Funding and financing: Government can incentivise the adoption of these technologies through renewable credits and guaranteed feed in prices for waste to energy operators to either the electricity or gas grids. Waste collection tariffs such as gate entry fees can provide a revenue stream to fund operations.

Effective institutions: Large waste producers will need to collaborate with small scale producers where small-scale waste to energy plants may not be feasible yet.

IMPLEMENTATION

Ease of Implementation



Waste to energy technologies have already been implemented in numerous applications around the world. The key challenge with implementation is having a guaranteed upstream supply chain of waste sources as well as downstream energy and resource users. Bringing together the right stakeholders with the right technologies, to identify the investment opportunities will assist in paving the way for implementation.

Cost



Currently, capital costs for waste to energy technologies are relatively high compared to the cost of continued disposal of waste to landfill, though this is changing due to the increasingly favourable business case of energy generation in the form of energy efficiency, emissions reduction and generation of other valuable resources.

Country Readiness



Developed countries are well-placed to benefit from circular economy synergies as innovation and sustainable development are more mature. Though there are opportunities for developing countries to fast track their circular economy targets by producing renewable energy from their waste.

Technological Maturity



There are multiple technologies already utilised in large scale waste to energy operations. There is potential for incremental increase in energy conversion efficiency of these technologies and size to make it commercially feasible for smaller sites. Technologies involving waste to hydrogen production are also in the early commercial stages.

RISKS AND MITIGATIONS

Implementation risk

Risk: Exposure to the competitive and/or regulatory landscape. For example, it is challenging (and in many cases, impossible) to secure long-term contracts for the supply of high-calorific commercial and industrial waste for the purposes of digestion or gasification. This is a key market risk for waste-to-energy projects as waste producers and/or waste management companies will be driven to dispose of their waste at the site that offers the lowest possible disposal cost. This can lead to fluctuations in revenue due to the competition. This is a critical risk that has led certain projects to accept the waste for free to guarantee its availability.

Mitigation: Waste to energy will need guaranteed waste sources. Building these facilities close to waste producers or on waste producers' sites would assist in providing guaranteed waste for energy production and prevent underutilisation of infrastructure.

Environmental risk

Risk: These technologies are thermally decomposing waste products into gas which is then combusted to generate electrical energy. The quality of the gas produced and the method of combustion determines the amount and type of greenhouse gases emitted into the atmosphere.

Mitigation: Improvements are being made in combustion exhaust scrubbing to reduce pollution, but there have also been developments in carbon capture technologies, though most are not economical on a small scale.

Alternatively, greater implementation of pyrolysis processes would reduce greenhouse gases because they operate in the absence of oxygen, producing a gas with a higher quality and energy value compared to gasification or digestion.

Economic risks

Risk: The implementation of a circular economy project attracts a high price tag; not just in the capital and operational expenditure but in skilled staff to design, build, operate, market and sell the recovered products. As mentioned previously, technical and market risk can quickly erode profits if not managed appropriately.

Mitigation: One way to mitigate financial risk is to establish a joint venture with a credible and experienced partner (or partners). In a joint venture, all project stakeholders invest capital into a new entity which is then mandated to design, build, own and operate the project.

Risk: Individual proprietary technologies (and combinations of them) can present stark contrast even for the same energy production. This is because each technology will have different CAPEX and OPEX figures (e.g. some may use chemicals, some may not) but more importantly, each technology will produce different yields for the same waste product. Quoted figures from technology companies may overstate their yields which will have an impact on the business case if savings or revenue are being relied upon for a positive net present value. For this reason, a reasonable level of confidence in the business case inputs is critical during the feasibility stage.

Mitigation: This can be managed by direct engagement with technology companies and client references to gather quoted vs. actual data; where the level of confidence in the data is relatively low (say, in the case where a technology company has no commercial-scale installations) then this presents a technical risk (as identified above) and should be weighted accordingly during the decision making process.

EXAMPLES

Example	Implementation	Cost	Timeframe
Lithuania Co-generation plants	A waste-to-energy cogeneration power plant is being constructed in the Lithuanian capital of Vilnius, led by Vilnius kogeneracinė įėgainė, a subsidiary of state-owned energy company Lietuvos Energija. It will convert waste into heat and electricity. Once operational, the power plant will employ an average of 35 people to cogenerate heat and electricity from waste, with an efficiency coefficient of approximately 100% ¹ .	Total investment for the is EUR €141 million, with the EU's Cohesion Fund contributing €48 million through the "EU Structural Funds Investments" Operational Programme.	The power plant is expected to be completed by 2020.
Hazer Group	The hydrogen production plant will be built at the Western Australia Water Corporation's Woodman Point Wastewater Treatment Plant, using biogas produced during waste treatment. ²	Australian Renewable Energy Agency (ARENA) will provide \$9.41 million in funding to the project to construct the Hazer Process Commercial Demonstration Project.	Plans to have the plant operating by the end of 2020.
Xylowatt	Project in Tournai, Belgium to design, construct and validate a 1.8 MW gasifier technology with 6 different sources of bio-wastes with the end objective to upscale into a 12.6 GWh energy produced per gasifier per year, with 2,495 tons of CO2 emissions avoided ³ .	Total investment for the project is EUR €5.5 million, with the EU contributing €2.7 million through the LIFE Programme.	The project started in 2014 and a fully operational prototype by 2020.

CONTACT INFORMATION

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¹European Union. [Cogeneration in Vilnius: converting waste into electricity and useful heat](#). Accessed 21 May 2020

² Australian Manufacturing Forum. [Hazer Moves ahead with low emission hydrogen plant](#). Accessed 25 May 2020

³ European Union. [LIFE OxyUp - Biomass gasification for CO2 emissions reduction and valorization of bio-wastes in energy-intensive industrial processes](#). Accessed 21 May 2020