RESONANCE
ASSET MANAGEMENT

Anaerobic Digestion as a Sustainable Waste Solution
Global Context Research

Executive Summary

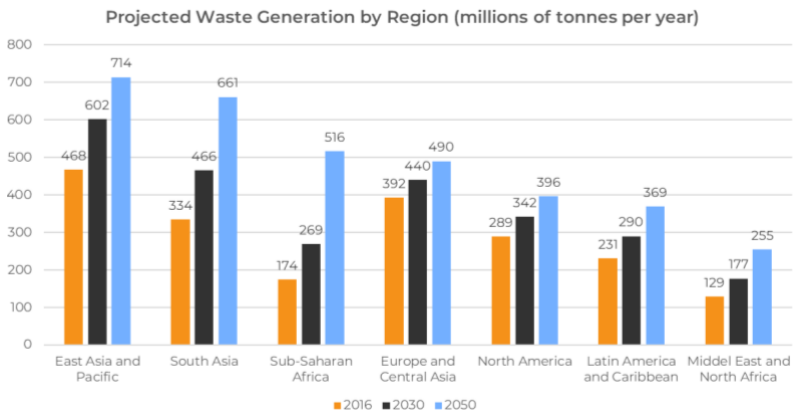
- Waste generation is continuously on the rise around the world with no indication of slowing down, driven by economic expansion and population growth.
- Improper disposal of this waste leads to negative externalities from emissions to environmental contamination.
- A significant portion of this waste is organic waste, from which valuable resources can be extracted like biomethane and fertiliser.
- Anaerobic digestion stands out as an infrastructure solution to close the loop of wasteful linear consumption – allowing the extraction of value from otherwise waste material.

Increasing Organic Waste - A Mounting Global Challenge

Waste generation is continuously on the rise around the world with no indication of slowing down, driven by economic expansion and population growth.

In 2020, it was estimated that the world produced 2.24 billion tons of solid waste[1]. Looking ahead, it is projected that global waste will increase to 3.4 billion tons by 2050[2].

Waste covers a wide range of discarded materials, ranging from municipal, industrial, to agricultural. While the composition of waste varies between countries due to different consumption habits, all regions produce approximately 50+% of their waste in organic form on average[3].



Organic waste refers to any waste material that is biodegradable, which can be broken down by micro-organisms over time into methane, carbon dioxide, water, and other substances over time. Examples of organic waste include food waste, green waste, and animal waste etc., coming from household, agricultural and industrial sources.

The products of unmanaged decomposition make the increasing volume of organic waste around the world a mounting challenge because they can cause significant health, environmental, and economic damage.

> China alone currently produces over 400 million tonnes of waste per year, with over half of it being organic waste[4].

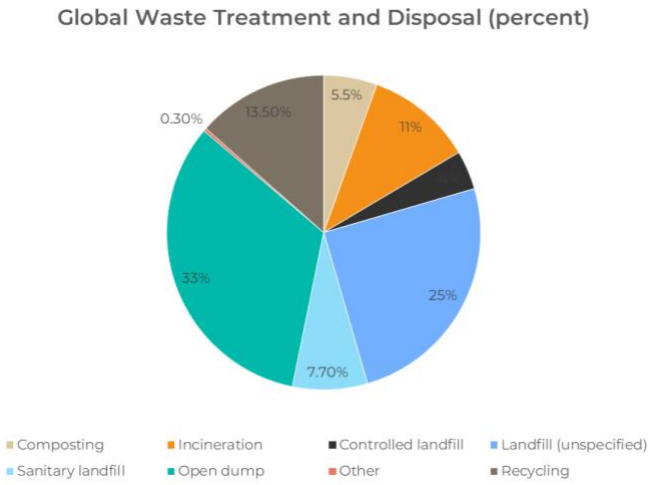
[1] Solid Waste Management, The World Bank, 23 September 2019
[2] What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050, the World Bank, 20 September 2018
[3] What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050, the World Bank, 20 September 2018
[4] A circular composting solution to food waste in China, WIPO GREEN, 24 January 2023

Improper Waste Management - An Environmental Risk

Globally, open dumping has still been the most common waste disposal method, accounting for 33% of waste. Lower-income countries, which lack infrastructure and financial support for waste management transition, particularly rely on open dumping. Upper-middle-income countries, transitioning from open dumping to landfills, have the highest percentage of waste disposed of in landfills at 54%. On a global scale, 37% of waste is disposed of in landfills[5].

However, both open dumping and landfilling pose serious environmental problems:

- **Emission of greenhouse gas** - When organic waste accumulates and decomposes in either open sites or in landfills, it emits methane, which during its breakdown is more than 28 times as potent as carbon dioxide at trapping heat in the atmosphere[6].
- **Contamination of water and soil** - leachate is an offensive, dark liquid that is produced by organic waste decomposition in unenclosed landfill sites. When filtering into water bodies, it contaminates surface water and underground aquifers. Accumulation of waste on land or underground also pollutes the soil, leading to land degradation.



- **Loss of biodiversity -** Pollution of water and land caused by organic waste negatively affects ecosystems, causing the loss of species.
- **Spread of bad odours and infectious diseases** – The decomposition of organic waste produces unpleasant smells that can attract insects and animals like rats, leading to the spread of germs and infectious diseases in the vicinity.

Although a range of measures have been introduced to mitigate the negative environmental impacts of landfilling, including leachate and landfill gas collection and treatment, it is still a less desired waste treatment method due to the land constraints and loss of value. Incineration is often presented as a better quick-fix solution to waste challenge than landfilling because it reduces the rapidly increasing waste volume while at the same time generating energy, and it can be practised in land-constrained countries. However, incineration still might not be the answer to waste problems due to:

- **Air pollution –** Without high-quality filtration incineration of waste can release harmful air pollutants such as particulate matter, carbon monoxide, nitrogen oxides, and cancer-causing dioxins, which pose a threat to the nearby population.
- **Emissions of greenhouse gas -** Waste incineration involves greenhouse gas emissions. It is reported that the carbon dioxide emissions from a waste incineration plant are approximately the same as those from a natural gas-fired power plant, and some estimates suggest that emissions are comparable to those from coal-fired power generation[7][8].
- **Energy inefficiency** - Organic waste, a major part of municipal waste, usually has a high moisture content. For example, food waste contains an average of 70% water[9]. As a result, burning this waste consumes a significant amount of energy. This results in a low or even non-existent net energy gain, making incineration a less efficient method to achieve sustainability objectives.
- **Nutrient loss -** Nutrients contained in organic waste are lost if it is incinerated, resulting in a loss of value.

Global emissions from solid waste are expected to rise to 2.6 billion tonnes of CO2-equivalent annually by 2050 if there are no advancements in waste management[10]. Striving to meet ambitious climate targets and achieve sustainability, countries around the world need a different approach to address the increasing waste issue.

[5] What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050, the World Bank, 20 September 2018
[6] Importance of Methane, United States Environmental Protection Agency, 1 November 2023
[7] Air emissions from MSW combustion facilities, USEPA, 2016
[8] Trash incineration and climate change: debunking EPA misinformation, Earth Justice Network
[9] Food Waste Properties, Selvam, Ammaiyappan & Ilamathi, Petchi & Udayakumar, Muthulingam & Murugesan, Kumarasamy & Banu, Rajesh & Khanna, Yukesh & Wong, Jonathan, January 2021
[10] Food Waste Properties, Selvam, Ammaiyappan & Ilamathi, Petchi & Udayakumar, Muthulingam & Murugesan, Kumarasamy & Banu, Rajesh & Khanna, Yukesh & Wong, Jonathan, January 2021

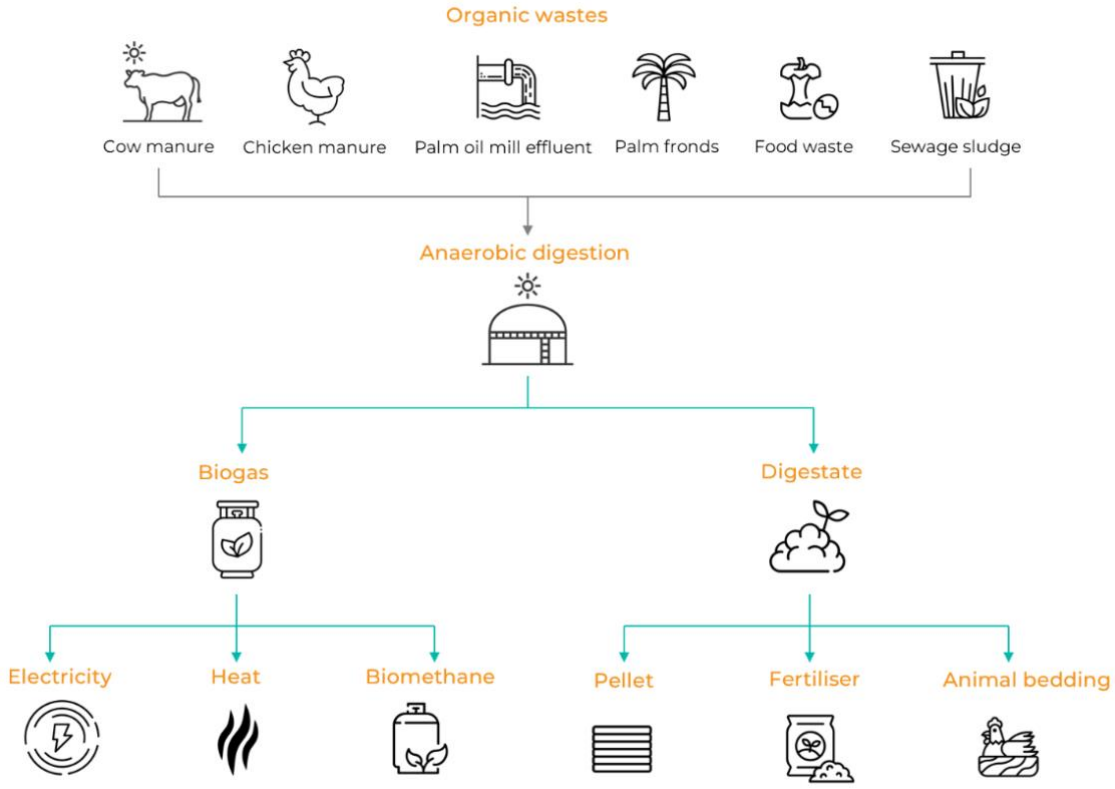
Anaerobic Digestion - A Solution to the Waste Challenge

Anaerobic digestion (AD) emerges as an effective solution that has proven to be capable of addressing the environmental impacts of organic waste and achieving decarbonization.

The AD process begins with putting organic waste into a sealed digester. By bringing large amounts of biodegradable waste into a closed and controlled environment, the AD process prevents the spread of germs and captures the carbon dioxide and methane, preventing emissions of greenhouse gases. Two valuable products are produced by the micro-organisms inside the digester: renewable energy in the form of biogas, and digestate which recovers the valuable nutrients necessary for plant growth.

The biogas can also be further upgraded to biomethane by removing inactive components, including CO_2, water, H2S, etc. Biomethane has identical chemical characteristics as natural gas and, therefore can be used as a drop-in replacement for fossil-based natural gas.

The digestate can be used as an organic fertiliser. The solid portion can also become bedding for the herd or become solid recovered fuel (SRF) for providing energy. There are other valuable resources to be extracted too as the below graphic shows.



Closing the Loop

As more and more organic waste is being produced and the environmental burden becomes heavier, anaerobic digestion stands out among various waste management strategies to combat the organic waste crisis.

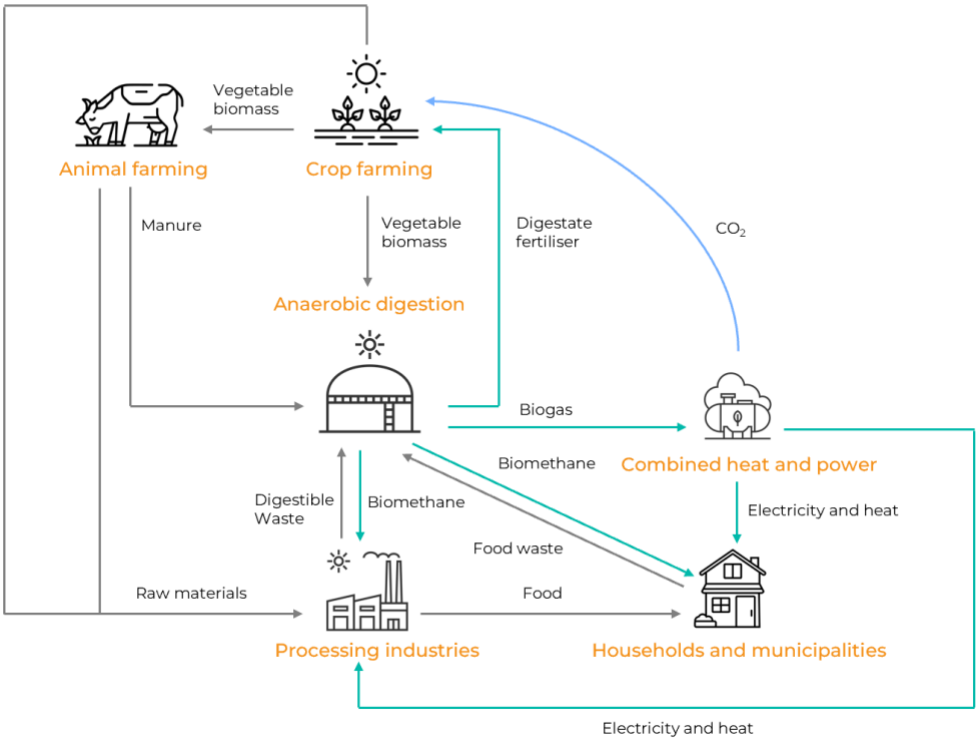
From Linear Economy to Circular Economy - Anaerobic Digestion as the Game Changer

A critical component in tackling waste issues is recycling. The linear economy pattern of "produce, consume, and throw away" should be changed. Under growing consumption, a linear economy will push us towards the constraint of material supply, economic difficulties, and environmental damage.

Instead, a circular economy aims to maintain products, components, and materials at their highest utility and value. The higher the recycling and re-usage of waste, the more it aligns with the principles of the circular economy. Anaerobic digestion and circular economy are closely interconnected.

By recycling valuable materials in organic waste into biogas and nutrient-rich bio-fertiliser, anaerobic digestion is regarded as a technique which can utilise the leftovers that would otherwise go to waste while closing the loop of a circular economy - avoiding unwanted waste. Since anaerobic digestion is seen as the hub for creating value from waste, the issue of disposing of waste is turned into the upcycling of low-value products as shown below.

Anaerobic Digestion as the Center Point in Circular Economy



Biogas from Anaerobic Digestion - A Sustainable Enabler to Energy Transition

Derived from organic waste, biogas does not contribute to the CO_2 in the atmosphere, as the CO_2 produced by biogas combustion is either offset by the CO_2 absorbed by biomass or by capturing the fugitive methane emission from open dumping or landfilling. Also, utilising this methane as a fuel significantly decreases its climate warming impact by converting it into relatively less potent CO_2.

Energy-intensive industrial processes, such as steel and cement manufacturing, have extremely high thermal requirements that can only be met by natural gas at present. Given that these sectors drive to decarbonise, upgraded biogas can be part of the solution to facilitate their energy transition. In this sense, biogas produced from anaerobic digestion can be viewed as low-carbon, green energy, which has significant implications in decarbonising energy supply.

Digestate from Anaerobic Digestion - Nutrients Recovery for Sustainable Agriculture

Through anaerobic digestion, valuable organic materials and essential nutrients such as nitrogen and phosphorus that are beneficial to plants and soil are collected in the digestate, which can be returned to the soil and used as organic fertiliser to reduce/replace chemical fertiliser. Therefore, encouraging sustainable agriculture practices and contributing to a circular economy.

Investing in the Circular Economy Through AD Projects

Anaerobic digestion is a multifunctional process that provides solutions for organic waste treatment and the energy transition, embodying the circular economy concept. Biogas from the AD process is a more sustainable alternative to fossil fuel, and the organic material and nutrients contained in the digestate are returned to the soil.

Resonance Asset Management specialises in financing anaerobic digestion projects, having financed six plants globally in the Industrial Water Infrastructure Fund. The team possesses the technical expertise to collaborate with operators and developers to service industrial clients with their waste management and renewable energy needs.

Benefits for Client Corporations:

A low-carbon solution for both energy and waste allows industrial clients to:

- Outsource expertise for constructing and operating assets.
- Achieve emissions targets with access to the latest low-carbon solutions and expertise.
- Reduce costs through waste disposal savings.
- Comply with current and upcoming regulations.
- Gain approval from end-consumers, thereby supporting brand reputation.

Benefits for Investors:

For Resonance's investors, sustainable solutions offer:

- Tangible and measurable impact by reducing emissions and limiting waste.
- A diversified portfolio of environmental investments.
- Predictable cash flows from long-term off-take contracts.
- Additional upside potential from various subsidies and tradable carbon offsets.

Get in Touch

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