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Biogas Insight

FOOD WASTE RECYCLING

Anaerobic Digestion – unlocking the value in your organic waste

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Executive Summary



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A New Era For Waste Management

Waste management is entering a period of significant change. Linear systems that rely on burning or burying waste are increasingly being challenged by approaches that recognise waste as a resource, recovering its energy and valuable materials. It has been propelled to the top of the global agenda on climate change by COP31 making *Zero Waste and Methane Reduction* a priority of its Action Agenda.

Human activity generates ~105 billion tonnes of organic waste every year, arising from agriculture, food and drink manufacturing, households and hospitality, and sanitation. When poorly managed, these waste streams generate methane, a greenhouse gas (GHG) responsible for around 30% of the global warming experienced to date.[1]

A total of 159 countries and the European Commission have signed the Global Methane Pledge, committing to reduce global methane emissions from human activity by 30% against 2020 levels by 2030.[2]

[1] www.iea.org/reports/global-methane-tracker-2022/methane-and-climate-change
[2] www.globalmethanepledge.org

Treating the readily available 105 billion tonnes of organic waste produced annually by human activity delivers:

25%

Of current annual global gas demand (IEA)

11%

Of annual global greenhouse gas emissions

50%

Of the Global Methane Pledge

Continued>

Executive Summary

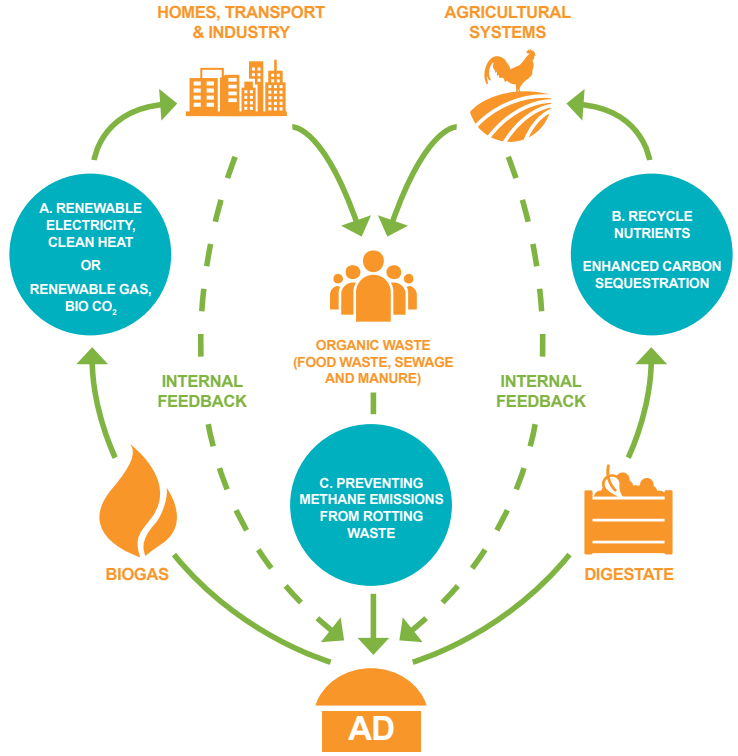
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Anaerobic digestion (AD) offers a significant opportunity to contribute to this goal. Treating the global organic waste resource through appropriate AD systems could deliver methane emission reductions equivalent to around 50% of the Pledge's target.

Post-farm-gate food waste – generated by households, hospitality and retail – accounts for only around 1% of this organic waste by mass, ~1.05 billion tonnes annually. Yet its relatively high energy content means that recycling this material through AD alone could deliver methane reductions equivalent to around 15% of the Pledge's target.

This Biogas Insight examines the scale of the post-farm-gate food waste challenge and the contribution AD can make to reducing methane emissions, recovering renewable energy and returning valuable nutrients to agriculture.

Charlotte Morton OBE, Chief Executive, **World Biogas Association**



Anaerobic digestion (AD) is a waste-recycling process that breaks down biodegradable organic waste under oxygen-free conditions.

Introduction

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Treating **unavoidable food waste** through **AD** is a practical, scalable way to rapidly cut methane emissions, an opportunity to deliver **~15% of the Global Methane Pledge** and with it energy, food and climate security through the production of:

Biogas/Biomethane. Biogas can be used to produce renewable electricity or upgraded to produce biomethane, suitable for domestic heat or transport fuel.

Bio-CO_2. A stream of gas suitable for industrial use or storage, reversing greenhouse gas (GHG) emissions.

Biofertiliser (digestate). An organic fertiliser which recovers nutrients found in all food waste and returns them to land, again reversing GHG emissions from the production of mineral fertiliser.

Anaerobic digestion delivers climate stability by turning a GHG emitter into a raft of renewable products to replace their fossil equivalents and creates millions of skilled jobs in the process.

Through proper resource management, we can extract every ounce of value from these wastes, feed this back into the systems from which they came, contributing to energy, food and climate security.



The problem

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Global Post-farm Gate Food Waste

Each year, the world produces an estimated **1.05 billion** tonnes of post-farm gate food wastes[3]:

"Recycling food waste through AD delivers 15% of the Global Methane Pledge"



Household: 631 Mt (60%)



Food service: 290 Mt (28%)

Retail: 131 Mt (12%)



Projected Urban Waste Growth

Under a business-as-usual scenario, The World Bank forecasts global municipal solid waste (MSW) will rise to 3.86 billion tonnes by 2050 - an increase of approximately 50%.[4]

Food waste is the largest single component of Global MSW, accounting for 38% the total. if food waste maintains its 38% share of municipal waste, the food component would rise from approximately 973 million tonnes in 2022 to 1.47 billion tonnes in 2050. That would represent an increase of around 500 million tonnes.

[3] UNEP Food Waste Index Report 2021 www.unep.org/resources/publication/food-waste-index-report-2024 and WWF Driven to Waste: The Global Impact of Food Loss and Waste on Farms www.wwf.org.uk/food/waste/farms

[4] www.worldbank.org/en/publication/what-a-waste

The problem

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Emissions From Waste: Methane (CH_4)

Emissions over time

When food waste is sent to landfill, it can take years to break down and its impact accumulates as more waste is piled on top. Organic wastes thrown away as far back as 75 years ago continue to emit methane, exposing the impact that poor management of food waste continues to have on our climate both now and into the future.

Food waste needs to be diverted immediately to reduce emissions not just next year, but for years to come.

10,000 tonnes



Every 1 million tonnes of food waste sent to landfill...

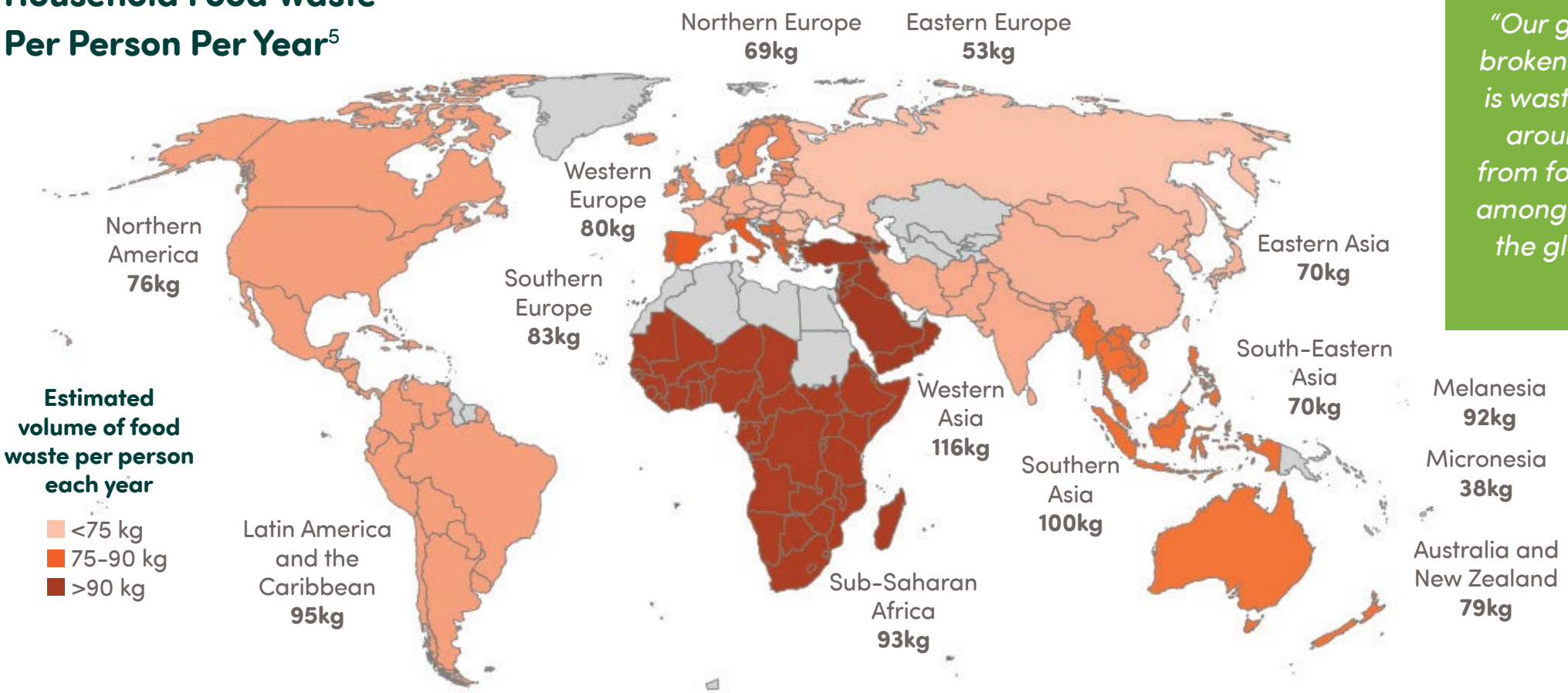
... releases 24,000 tonnes of methane...

... these emissions are equivalent to releasing nearly 2 million tonnes of carbon dioxide – equal to the annual emissions of 950,000 cars.

The problem

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Household Food Waste Per Person Per Year[5]



"Our global food system is broken: one third of all food is wasted, yet many people around the world suffer from food insecurity. Food is among the largest drivers of the global climate crisis.."

C40 Cities

[5] www.unep.org/resources/publication/food-waste-index-report-2024

The problem

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Global Food Systems: Emissions from Waste

An estimated 8–10% of global greenhouse gas emissions are associated with food waste, at an estimated cost of US$1 trillion.[6]

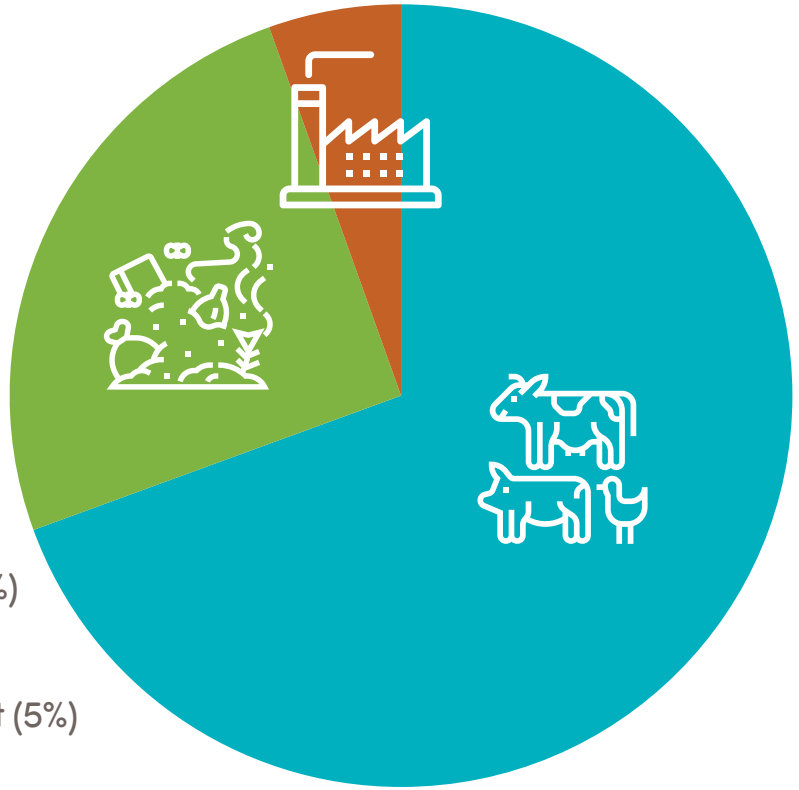
Though waste management accounts for 10% of GHG emissions within the global food chain, i**t is responsible for 58 Mt CH_4 each year – that's a quarter of all methane emissions** throughout the food supply chain.

Over a 20-year period, methane (CH_4) is up to **80-82 times more potent** than carbon dioxide (CO_2) as a greenhouse gas[7]

"A staggering one-third of all food produced globally is lost or wasted"

UNEP

Global Methane Emissions from Food Systems



[6] https://unfccc.int/news/food-loss-and-waste-account-for-8-10-of-annual-global-greenhouse-gas-emissions-cost-usd-1-trillion

[7] IPCC Sixth Assessment Report, 2023 www.ipcc.ch/report/ar6/wg1/#SPM

The solution

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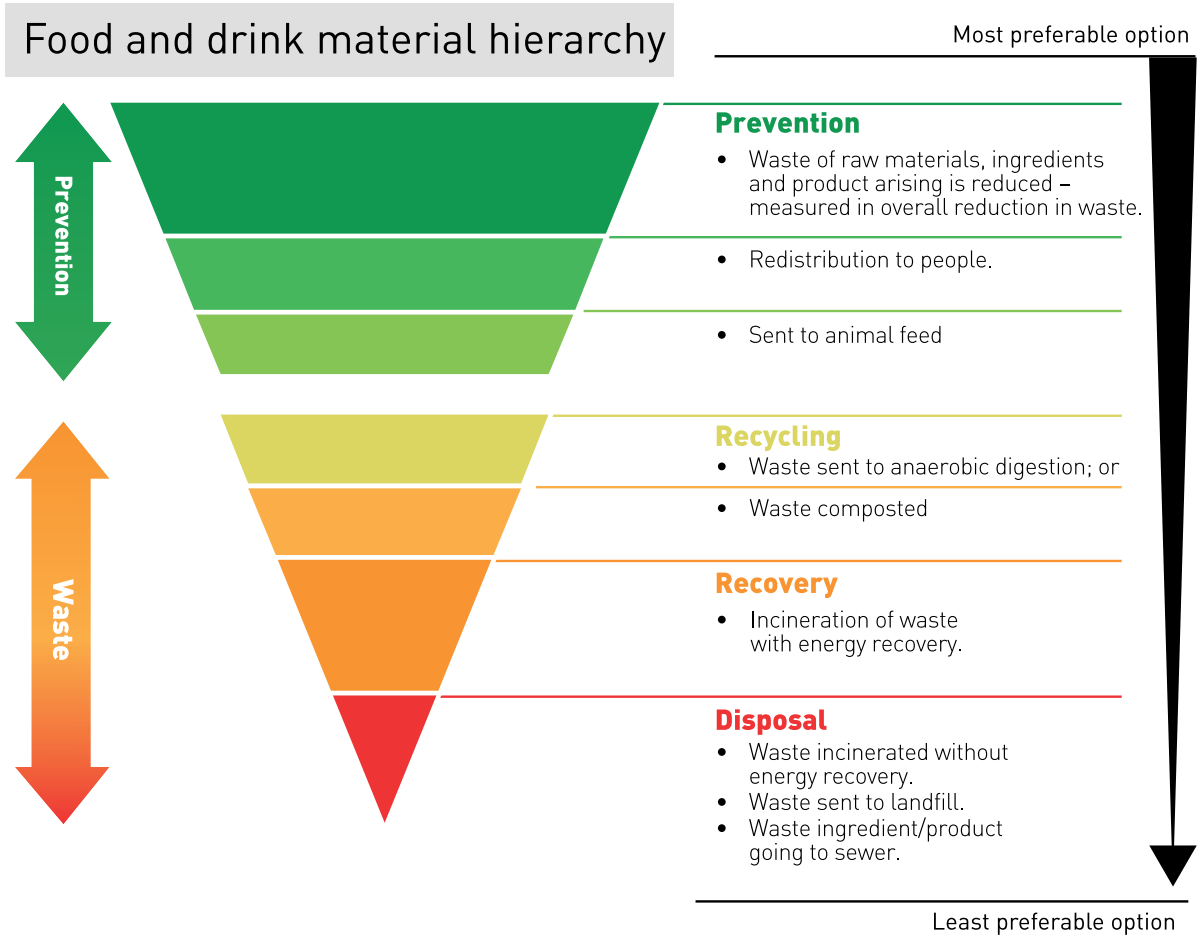
Waste Management

Food waste can be managed in a number of ways – the waste hierarchy orders these options from best to worst available.

Prevention is always most preferable, including the redistribution of food to people and animals, where possible.[8]

The remaining food is classed as 'waste' which can be:

- Recycled via **anaerobic digestion (AD) [most preferable]** or compost
- Recovery via incineration (also known as Energy from Waste, EfW)
- Disposal via landfill



[8] https://globalbiogasframework.org/pillar-2/

The solution

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Food Waste Management: Options Available

Unsustainable

Linear economy promoting the single use of resources

Sustainable

Circular economy promoting the recycling of resources



Landfill

- Responsible for nearly 12% of global methane emissions, air and water pollution
- Landfill tax makes current and future use an expensive option, in support of organics diversion
- Landfill gas capture and utilisation must be treated as a durable, funded pillar of national methane strategies, to address current emissions.



Incineration

"Don't invest in solid waste incineration" recommends C40 Cities **https://bit.ly/2OwlC81**,

"It is expensive, inefficient, requires strict environmental regulation, emits GHGs, and locks cities into producing high volumes of waste to 'feed' the incinerator."



Compost

- Converts food waste into a valuable fertiliser
- Minimises methane emissions as waste decomposes
- **However, it does not extract the green energy which is left inside.**



Anaerobic digestion (AD)

- **Converts food waste into renewable energy, preventing methane emissions**
- Recovers valuable fertiliser in the form of digestate
- Captures biogenic CO_2, suitable for industrial use or permanent storage, reversing emissions
- Produces other valuable bioresources.

The solution

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Wasted Value

1.05 billion tonnes of post-farm gate food waste produced each year recycled through AD would recover...

1,159 TWh of biogas



This could...

- Heat **96 million** homes,
- Power **374 million homes** or,
- Fuel **12% of the worlds trucks and buses**

(Both heat and power based on average annual UK household consumption.)[9]

Carbon savings: 236 Mt CO_2e

6 million tonnes of nitrogen



This could...

- Grow **227 million tonnes** of wheat
- Produce **5% of globally applied nitrogen**

Carbon savings: 34 Mt CO_2e

177 million tonnes of bio-CO_2



This could...

- Provide **approximately 79%** of all CO_2 used globally
- Boost renewable fuel production, increase greenhouse crop yields, be sent for geological storage, or used in other industrial processes

Carbon removals: 177 Mt CO_2e

[9] www.gov.uk/government/statistics/national-energy-efficiency-data-framework-need-report-summary-of-analysis-2026/national-energy-efficiency-data-framework-need-report-summary-of-analysis-2026-accessible-webpage

The business case

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The Greenhouse Gas Savings

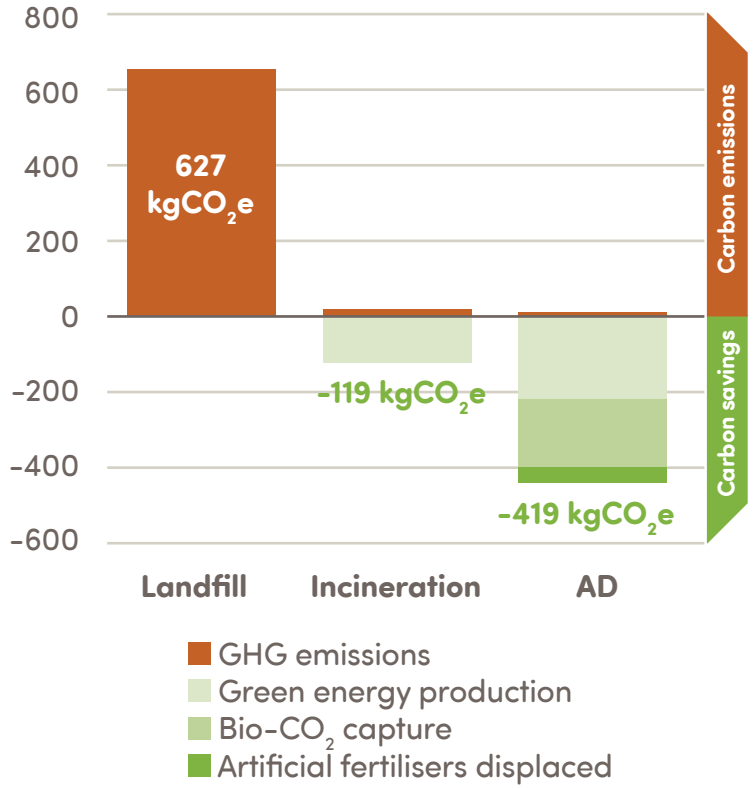
By processing food waste through AD, countries around the globe can contribute to energy and food security, while mitigating methane and carbon emissions through three significant pathways[10]:

- Avoided direct GHG emissions from preventing food waste from being sent to landfill
- Abated GHG emissions from green energy production
- Abated GHG emissions from using organic fertiliser in place of energy-intensive artificial fertiliser

AD is the only technology that can produce renewable energy, fertiliser and bio-CO_2.

Decarbonising waste:

One tonne of food waste emits/saves...



[10] Based on UK emissions data. www.wrap.ngo/resources/report/uk-food-waste-food-surplus-key-facts

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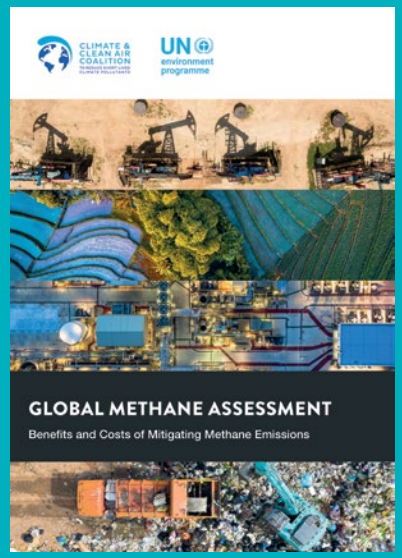
The Cost Savings

The AD industry stands at the heart of the circular economy. For the economic, environmental and social benefits it delivers, the guardians of the Paris Agreement call AD reactors a 'win win win win win' technology and say its capacity to reduce methane emissions is the fastest and most economic way to keep global warming below 2˚C.

While the direct cost savings vary vastly around the world, by making use of organic wastes countries can address waste and sanitation concerns while producing renewable electricity, heat, transport fuel, cooking gas, nutrient-rich biofertilisers, biogenic CO_2 and other bio-based products, reducing reliance on costly imports or multiple infrastructure.

The **Global Methane Assessment** outlines the benefits of mitigating methane, a key ingredient in smog, which include preventing some 260,000 premature deaths and 775,000 asthma-related hospital visits annually, as well as 25 million tonnes in crop losses.[11]

[11] https://wedocs.unep.org/items/4d9774f8-1a9d-42d1-be2c-122408159b15



"Given the wide range of impacts from methane, the societal, economic, and environmental benefits of acting are numerous and far outweigh the costs."

Global Methane Assessment

The business case

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One 7.5 MW-Capacity Food Waste Plant Annually Delivers...

	Organic waste management	Biofertiliser also known as digestate	Renewable biogas ~60%	Renewable biogas ~40%
			Biomethane also known as Renewable Natural Gas (RNG)	**Bio-CO_2**
Uses:	Prevents methane emissions from waste Recycles valuable nutrients back into food production	Nitrogen, Phosphate and Potassium fertiliser Soil conditioner and carbon sequestration	Heat and cooking Transport	Food packaging and animal slaughter Drinks carbonation
Amount:	**55,000 tonnes** of organic waste recycled	**45,000 tonnes** of digestate	**60 GWh** energy	**9,200 tonnes** bio-CO_2
Carbon savings:	**33,920 tonnes CO_2e** from avoided methane emissions	**1,860 tonnes CO_2e** from displaced artificial fertiliser	**12,360 tonnes CO_2e** From displaced fossil natural gas	**9,200 tonnes CO_2e** Available for Carbon Capture Use and Storage (CCUS)

Total carbon savings: 57,340 tonnes CO_2e per year

Global action

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Global Action & Case Studies

- Global Action
- C40 Cities; San Francisco (case study)
- World Bank; Ningbo (case study)
- GMI
- Global Biofuels Alliance
- #MakingBiogasHappen



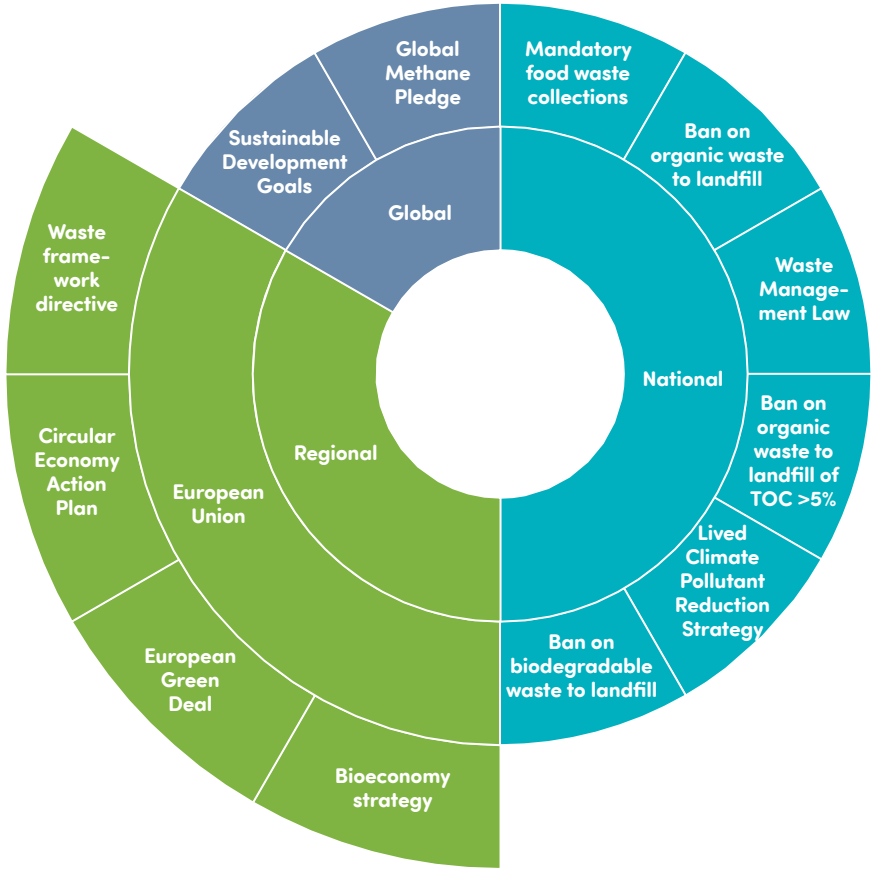
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Global Action

As governments wake up to the increasing need for urgency of climate action and realise the valuable resources contained within their food waste, policy and support has emerged.

The Global Methane Pledge, the Paris Agreement, and the Sustainable Development Goals are global initiatives designed to tackle root causes of climate change, and a suite of complementary policies have been enacted regionally and nationally to support increased recycling of food waste.

Efforts to **reduce food waste**, ensure **proper waste treatment**, and **encourage the use of AD co-products** are being enshrined in both legally-binding policy and voluntary initiatives. As a result, more food waste is being recycled than ever before in Europe, but globally, **overall recycling rates remain alarmingly low** at less than 2%.



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Global Top Performers

Recycling rates measure a country's progress towards waste and resources targets. Data collected by the World Bank estimates that the food waste content of household bins sits at an average of 40%, but could be as high as 88% in some countries.

Separate food waste collections are the most efficient way to reach national recycling targets. The top five countries with the highest recycling rates have achieved it through a range of measures. All top performers have supportive policies driving food waste collections.[12,13]

Germany	Austria	South Korea	Wales	Switzerland
Recycling rate: 56.1%	Recycling rate: 53.8%	Recycling rate: 53.7%	Recycling rate: 52.2%	Recycling rate: 49.7%

Supporting policies

- Ban on biodegradable waste to landfill/ incineration
- Widespread separate food waste collections
- Mandatory municipal waste recycling targets
- Disposal charges

[12] https://datacatalog.worldbank.org/search/dataset/0039597/what-a-waste-global-database
[13] https://eunomia.eco/reports/recycling-who-really-leads-the-world-issue-2/

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C40 Cities

C40 Cities is a network of 96 world city leaders (Mayors) committed to fighting climate change and driving circular systems. The group represents 920+ million people and 23% of the global economy. They drive this work through a number of **High-Impact Accelerators**.

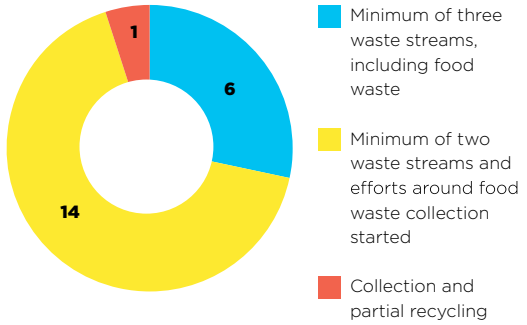
The C40 Towards Zero Waste Accelerator focuses on waste management, with the underlying principle that sustainable, prosperous and liveable cities of the future will ultimately need to be zero-waste. **68% of the global population is projected to live in mega-cities by 2050. (UN)**. Actions from signatories include the rollout of separate food waste collections, construction of infrastructure, grant funding for disadvantaged communities, and food waste reduction strategies.[14]

C40 CITIES

Signatories to the Zero Waste Accelerator:
Auckland, Boston, Copenhagen, London, Los Angeles, Melbourne, Milan, Montreal, New York City, Paris, Philadelphia, Portland, Rotterdam, San Francisco, Stockholm, Sydney, Tel Aviv – Yafo, Tokyo, Toronto, Vancouver, Washington DC.

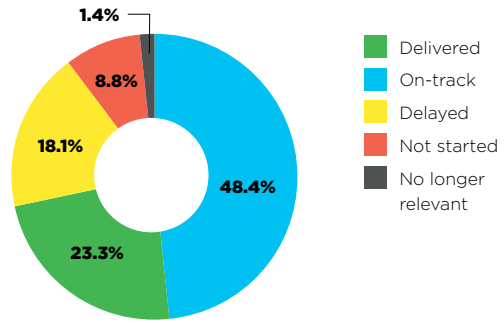
[14] www.c40.org/accelerators/zero-waste

Cities with segregate collection



All 21 signatories are actively moving towards segregate collection, with the majority having at least 2 waste streams or more, and 6 cities having fully rolled out collection for food waste.

240 actions reported by signatories



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C40 Cities: Milan

C40 CITIES

Milan is often hailed as the world-leader in city food waste recycling, having been the first to establish a successful recycling programme across the city in just two years.

Milan provides the largest food waste collection programme in any European city. It successfully provides weekly food waste collections to 1.3 million inhabitants, over 80% of whom live in high-rise apartments, which contributes to its 58.8% recycling rate in 2021.

Food waste is recycled at a local anaerobic digestion and composting plant to produce biogas, which can be injected into the grid or used to fuel waste collection vehicles, and compost, which is then sent to local farms and households.[15,16]

Snapshot of the city

- >1.3 million residents
- 130,000 tons recycled
- 11,200,000 m^3 biogas produced
- 58.8% separation rate
- 26,000 tons of compost



[15] https://zerowastecities.eu/wp-content/uploads/2021/11/Milan-Case-Study-1.pdf
[16] https://tinyurl.com/ypehn699

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World Bank: Ningbo, China

THE WORLD BANK
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Ningbo Municipal Solid Waste Minimization and Recycling Project

In 2013, the World Bank approved a loan of **US$80 million** to the People's Republic of China to improve municipal solid waste management in Ningbo City, to address the lack of transport, sorting and recycling infrastructure, policy development and public awareness programmes.

The City was able to construct an **AD facility** processing food waste and wastewater to serve **3 million people**, along with **six** waste transfer stations, a waste sorting facility, and deploy **357** waste collection vehicles.

The project was a huge success, resulting in a significant increase in waste collection and a substantial rise in recycling rates.[17]

Value of loan: US$80 million

Recycling rate: 0 - 17.5%

Capacity: 130,000 tonnes a year

GHG savings: 46,000 tonnes/year

Number of households reached: 905,000

"This achievement is by far the most impressive in the relevant Bank portfolio for any city."

World Bank

[17] https://documents1.worldbank.org/curated/en/878751622737441606/pdf/China-CN-Ningbo-Municipal-Solid-Waste-Recyclin.pdf

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Global Methane Initiative

Launched in 2004, the Global Methane Initiative is an international public-private initiative that progresses short term methane abatement by attempting to overcome barriers to the recovery and use of methane in three sectors: Oil and gas, Biogas and Coal Mines.

One area of focus for GMI is in the municipal solid waste sector, and it has produced a tool to help users estimate emissions associated with waste management, from waste collection and transportation through to waste handling equipment.

By using the Solid Waste Emissions Estimation Tool (SWEET), decision-makers can evaluate and compare tailored waste management scenarios to assess emissions of methane, black carbon, and other pollutants from across the sector.[18]

"By using SWEET[19], the municipality of Naucalpan de Juárez, Mexico was able to assess a range of emission abatement scenarios and demonstrate the benefits of diverting organic wastes to AD.

The data from SWEET was used to demonstrate technical and economic feasibility to secure funding of ~$100 million USD."



[18] https://globalmethane.org
[19] www.ccacoalition.org/news/sweet-tool-sparks-change-cities-around-world-measuring-monitoring-and-mitigating-waste-emissions

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Global Biofuels Alliance

The Global Biofuels Alliance (GBA) is an international coalition launched in 2023 at the G20 Leaders' Summit in New Delhi to accelerate the global adoption and standardisation of sustainable biofuels.

It consists of 35 countries and 14 international organisations as members. WBA is a founding member.

The Global Biofuels Alliance (GBA) helps address the global food waste problem by driving a strategic shift toward second generation feedstock-based advanced biofuels (using foodwaste, agri residues) instead of first-generation feedstocks like corn and sugarcane, which directly compete with the human food supply and fuel global hunger.[20]



"With an unwavering commitment to green sustainability, the adoption of biofuels and biogas is an absolute necessity for an environmentally sustainable future."

Hon Shri Hardeep Singh Puri,
Minister of Petroleum and Natural Gas,
Republic of India

[20] https://biofuelsalliance.com/publications

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#MakingBiogasHappen

#MakingBiogasHappen — PROGRAMME —

#MakingBiogasHappen (#MBH) is the World Biogas Association's flagship initiative to accelerate the global growth of the biogas industry by fast-tracking the regulatory frameworks, technical standards and investment-ready project pipelines it needs. Its purpose is to cut years from the time normally required to establish the policies, regulations and standards needed to unlock the potential of the 105 billion tonnes of organic waste generated annually through human activity.

In 2025, MBH delivered the model Global Biogas Regulatory Framework (GBRF)[21] and the Anaerobic Digestion Certification Scheme International (ADCS International)[22], providing governments, businesses and plants with the frameworks and standards needed for safe, efficient AD operations. WBA is currently supporting national and sub-national governments in India, Brazil and Mexico to adapt and implement these frameworks.[23]

[21] https://globalbiogasframework.org/
[22] www.adcsinternational.org/
[23] www.worldbiogasassociation.org/mbh



"Our aim is simple: to help move the global biogas sector from fragmentation to industrialisation through harmonisation - helping governments adopt proven approaches instead of reinventing the wheel through recognised international frameworks and standards."

Charlotte Morton OBE, Chief Executive, World Biogas Association

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Conclusion

- Tackling global food waste through AD would reduce global methane emissions by 15%.
- Extending this along the food chain - capturing organic waste resources from farm to fork through to wastewater treatment - would deliver 50% of the Global Methane Pledge. The COP 31 Action Agenda on Waste provides an important opportunity to accelerate this transition.
- Treating the 105 billion tonnes of readily-available organic waste generated annually by human activity through AD could produce enough biomethane to meet 20–25% of current global natural gas demand, while recovering sufficient nutrients and minerals to replace 10–15% of current mineral fertiliser demand.
- Biogas is critical to the delivery of zero waste and methane reduction - central to delivering a low-carbon, circular economy and climate, energy and food security.



"Zero waste is the most powerful path opening the door to genuine transformation in every field, from production to consumption"

Turkish first lady Emine Erdogan, Honorary President of the Zero Waste Foundation

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Join a winning team and help put the world on track to keep global warming below 2°C, ideally 1.5°C.

Contact us to find out what value WBA can deliver for you and your organisation.

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