

Food Waste Digestion Systems

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Anaerobic Digestion in the Circular Economy

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What is food waste?

- There is no universally accepted definition of 'food waste' which is why it is difficult to obtain reliable data on how much is actually generated
- The EU parliament recently came up with a definition:

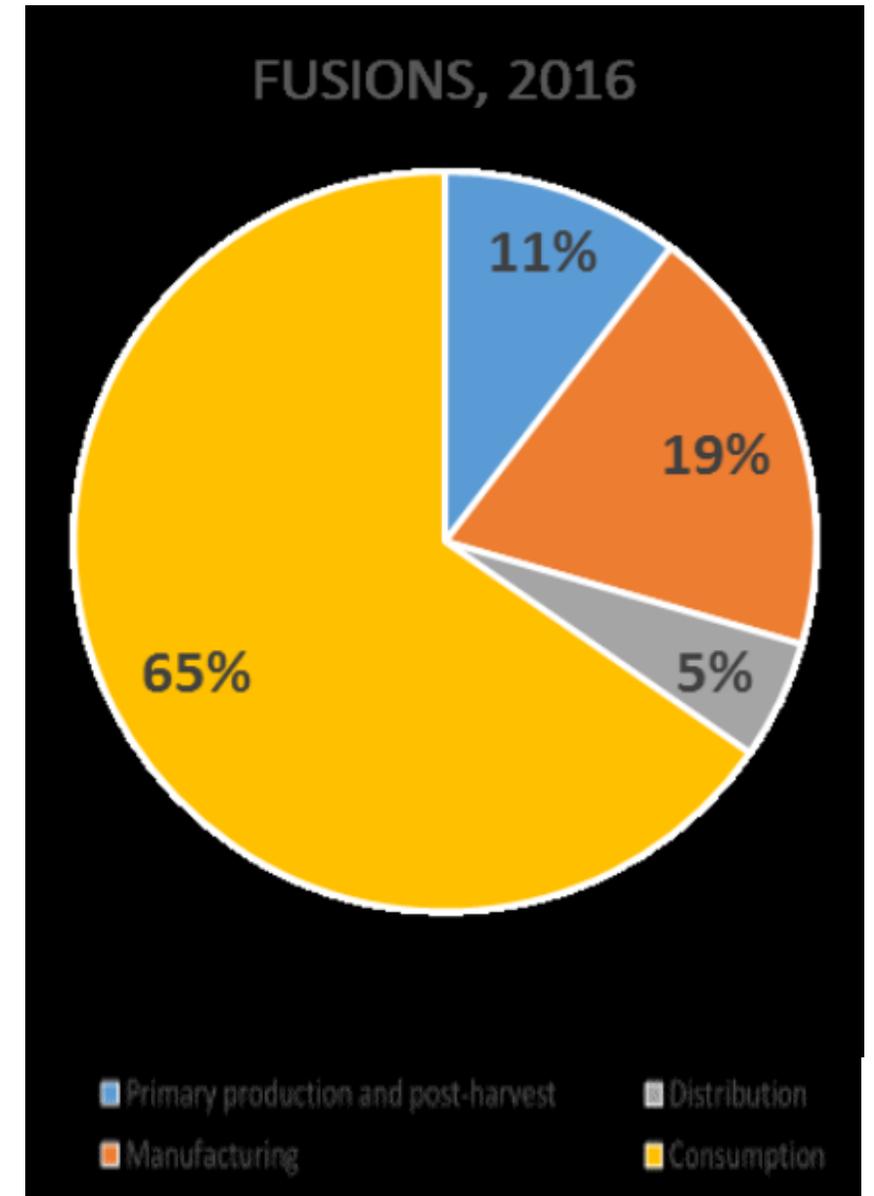
Food intended for human consumption, either in edible or inedible status, removed from the production or supply chain to be discarded, including at primary production, processing, manufacturing, transportation, storage, retail and consumer levels, with the exception of primary production losses'

- Adoption of the acronym FLW (Food Loss and Waste)

Post farm food waste

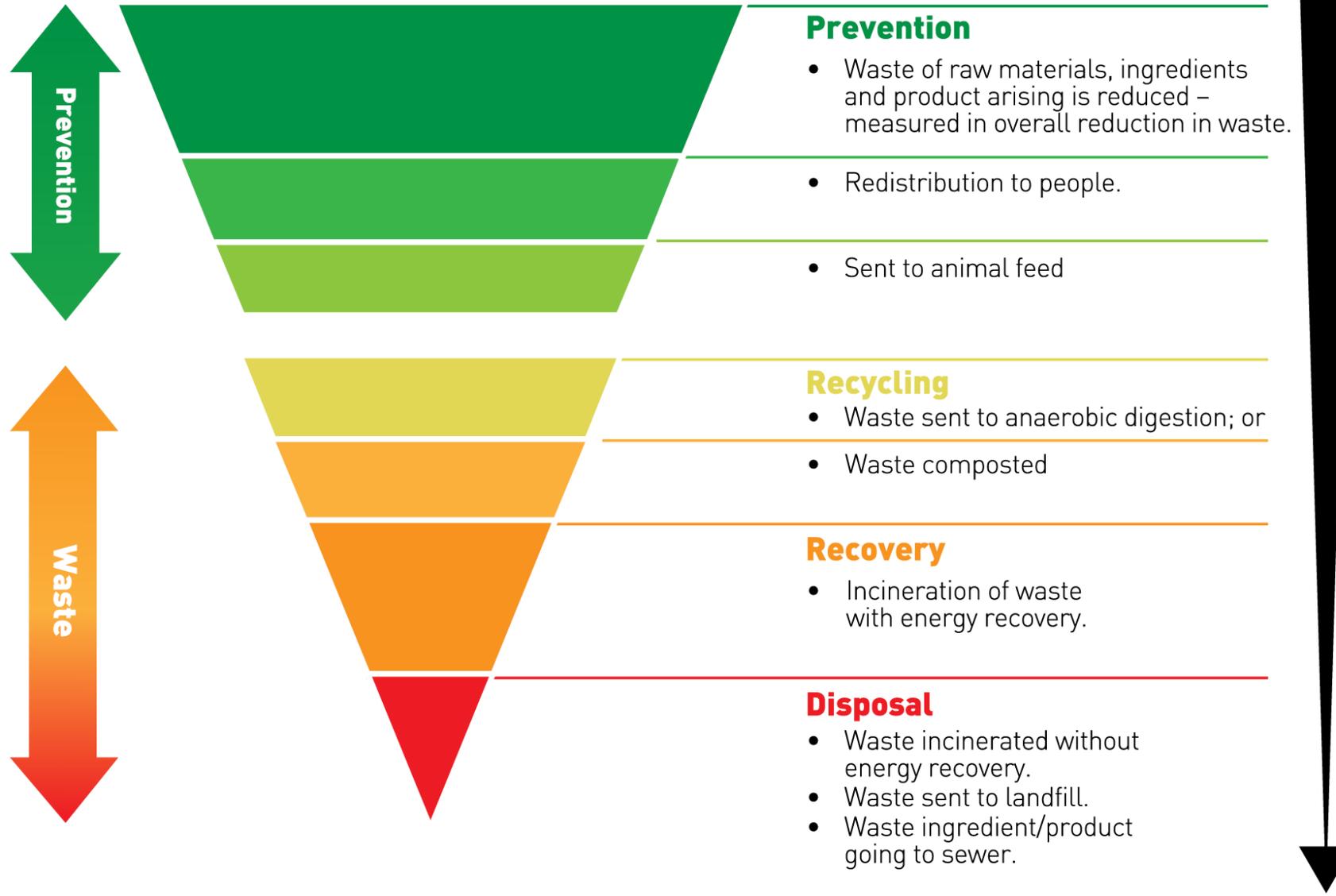
- This is the largest fraction of FLW, which represents around 90% of FLW and includes: waste from food production, by-products or co-products; food in the food supply chain that no longer has value through spoilage or sell-by date expiry; trimmings, peelings and scraps arising from the making of meals in food outlets and at home; uneaten leftovers; spoiled food as a result of over buying etc.
- Globally the FAO has estimated that one-third of food produced for human consumption is lost or wasted, equivalent to about 1.3 billion tonnes per year
- From the best interpretation of currently available data across Europe, food waste production is estimated at 173 kg person⁻¹ year⁻¹

- By far the largest proportion of food waste is from household consumption.
- It can be categorised as unavoidable or avoidable
- Unavoidable consists of residues and by-products from food preparation, such as inedible peels or seeds.
- Avoidable consists either of unused food, often due to excess purchasing and/or passing of a 'best before' date; or left-overs from meals.
- 'Partly avoidable' is "food and drink that some people eat and others do not (e.g. bread crusts), or that can be eaten when a food is prepared in one way but not in another (e.g. potato skins)"



Food and drink material hierarchy

Most preferable option



Least preferable option

Food waste and anaerobic digestion

- Where there is unavoidable and inedible food waste then anaerobic digestion is the first preference within this hierarchy
- It is probable, however, that percentage of the avoidable fraction will also, for one reason or another, find its way into the waste stream and require treatment and disposal



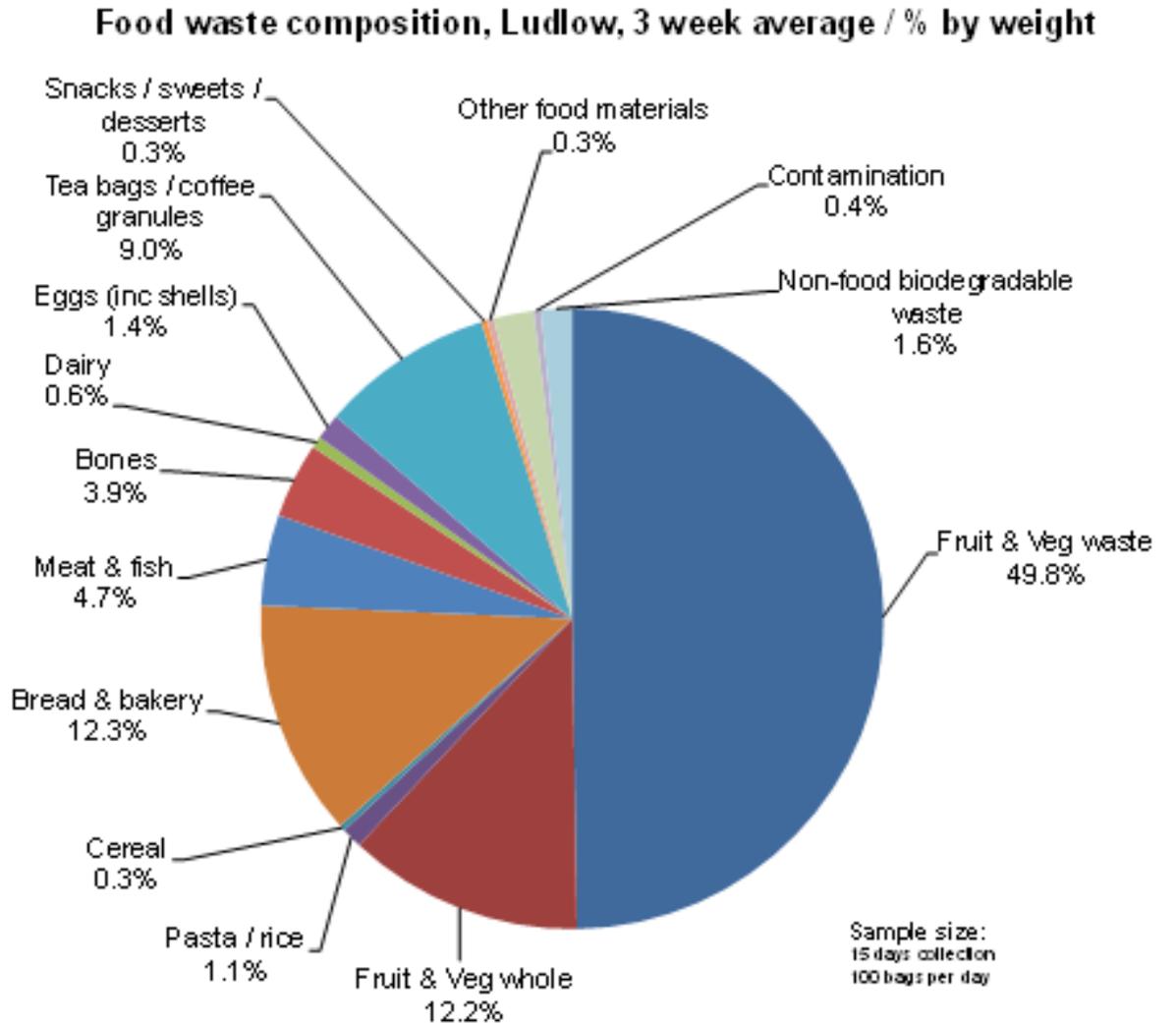
Collection schemes

- AD is a 2-product process and for beneficial use of the digestate, the most important consideration is the collection system
 - what it accepts, and what type of container is used for collection
- FW-only collections that use small containers have a very low degree of contamination. This minimises pre- and post-processing requirements and the energy demand associated with these.
- It is clear that collection systems which minimise contamination make it possible for even a simple AD plant to produce a high quality output



Food waste characterisation

- Food waste can differ significantly in visual appearance
- Characterisation is most frequently done by compositional analysis- this involves sorting and itemising items by type
- Compositional analysis is a useful tool in identifying materials categorised as unavoidable or avoidable, and has allowed the United Nations to define a Sustainable Development Goal
- But



Chemical and biochemical analysis

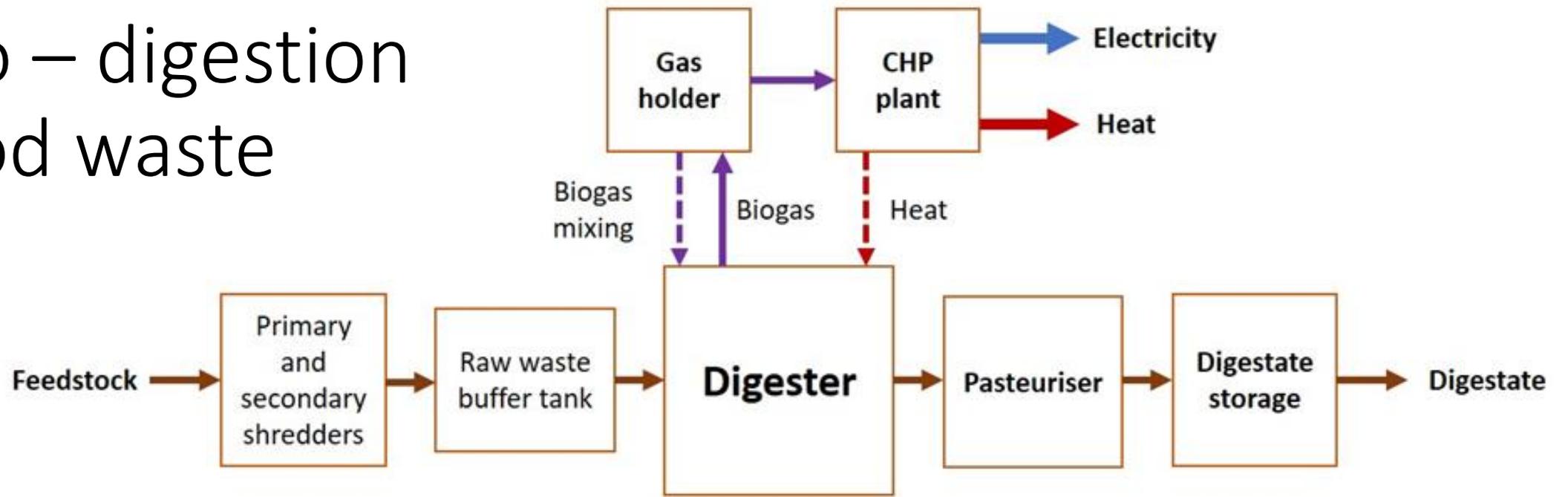
- High moisture content
- High % volatile solids
- High in readily degradable components
- Low in fibre and lignin
- High in nitrogen
- High in phosphorus
- High methane potential

Parameter	Unit	Typical value
TS	% fresh matter	24
VS	% fresh matter	22
TKN	g kg ⁻¹ fresh matter	7.4
CV	MJ kg ⁻¹ TS	22
Carbohydrates (starch and sugar)	g kg ⁻¹ VS	480
Lipids	g kg ⁻¹ VS	150
Crude proteins	g kg ⁻¹ VS	210
Hemi-cellulose	g kg ⁻¹ VS	70
Cellulose	g kg ⁻¹ VS	60
Lignin	g kg ⁻¹ VS	30
N	g kg ⁻¹ TS	31
P	g kg ⁻¹ TS	4
K	g kg ⁻¹ TS	13
C	% VS	55
H	% VS	6.9
O	% VS	35
N	% VS	3.3
S	% VS	0.3
BMP	m ³ CH ₄ kg ⁻¹ VS	450

So let's digest it 😊

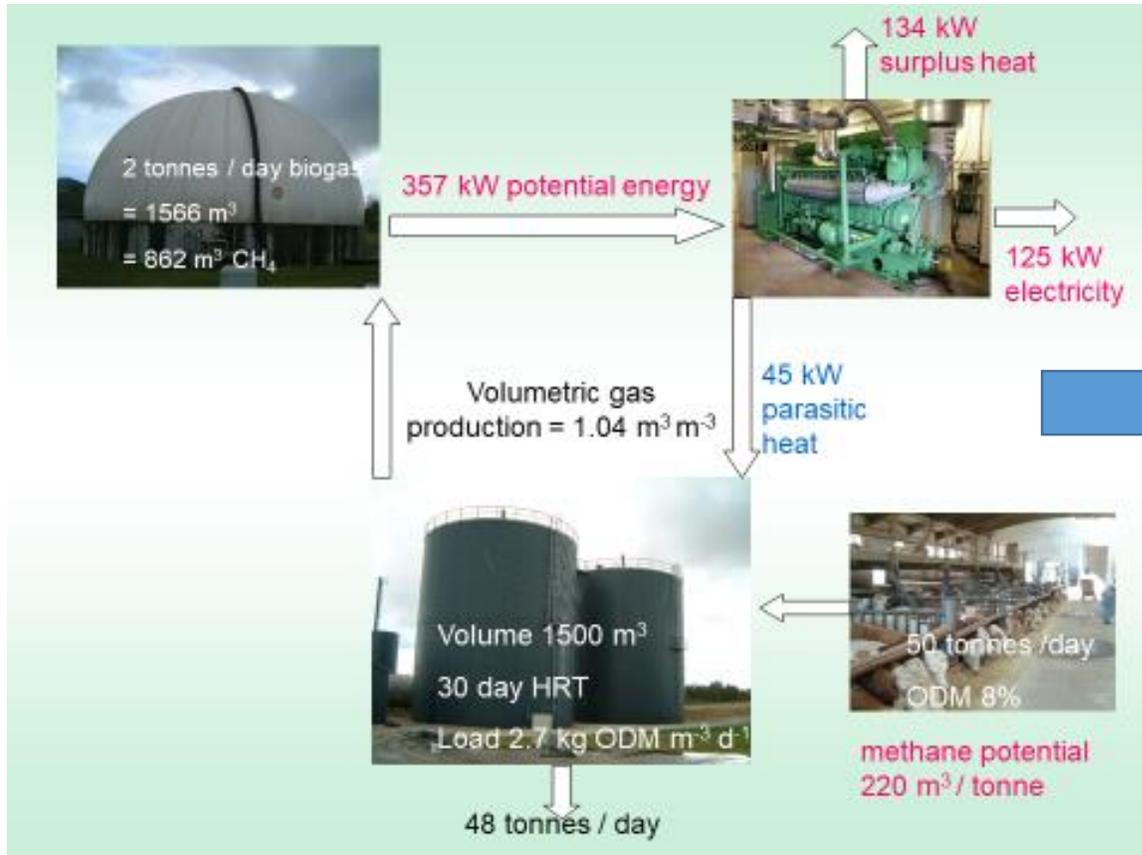


Mono – digestion of food waste



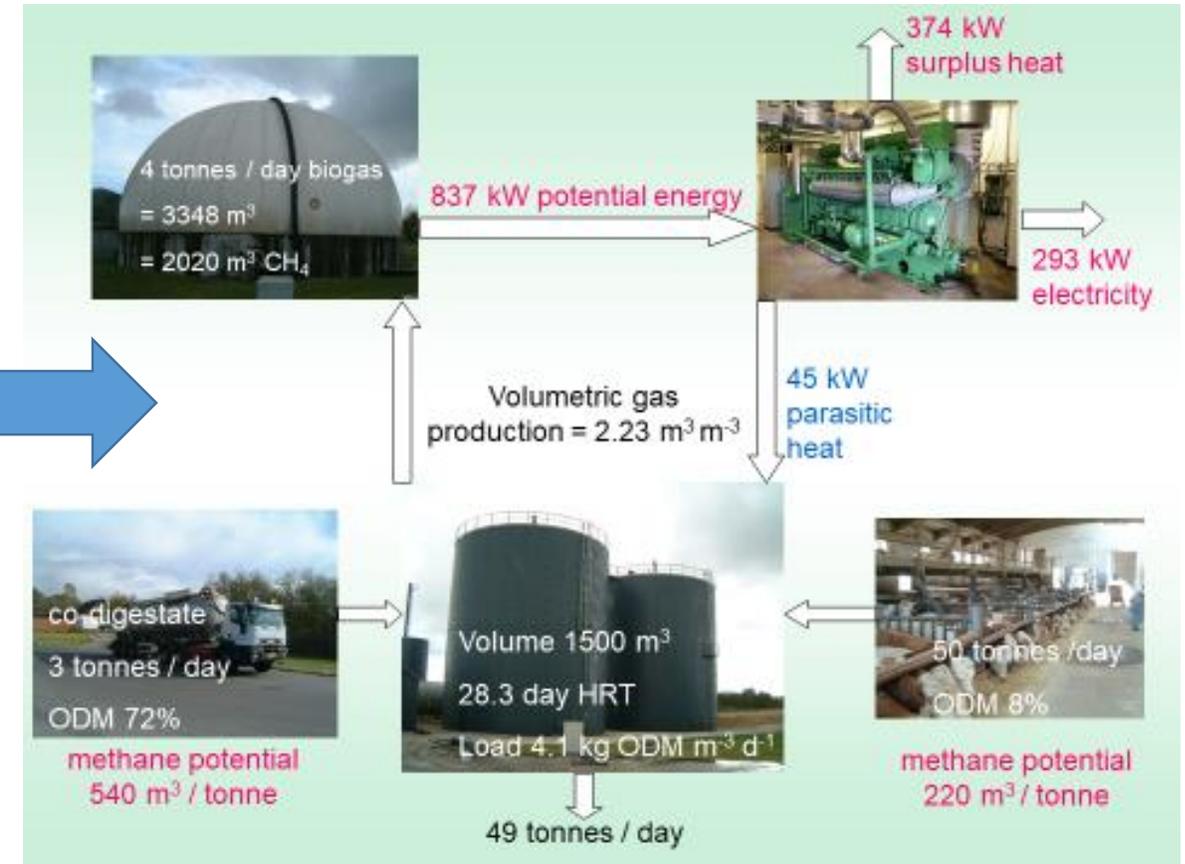
Parameter	kWh tonne ⁻¹ of input	% of CHP gross energy output
CHP net electrical output	216.5	30.6%
Parasitic electrical requirement of process plant	59.1	8.4%
Net energy output as electricity	157.4	22.3%
Recoverable heat output from CHP	374.5	53.0%
Parasitic heat requirement of plant	113.4	16.0%
Net energy output as heat	261.1	37.0%
CHP natural gas used	4.7	0.7%
Energy required for biofertiliser use	8.7	1.2%
Total potentially recoverable energy (heat and electricity)	405.1	57.3%

Co-digestion



Typical base substrates:

- Sewage sludge
- Animal slurry



Typical co-substrates:

- Food processing waste
- Source segregated household food waste or catering waste

Food waste digestion and the circular economy

- Source segregated food waste is generally regarded as being a safe material with respect to chemical and pharmaceutical materials, since it was intended for human consumption
- Pasteurisation and anaerobic digestion provide a double barrier to the transmission of disease, and it is accepted that if adequate precautions are taken high NPK content in the digestate can be beneficially returned to land



Hub and PoD

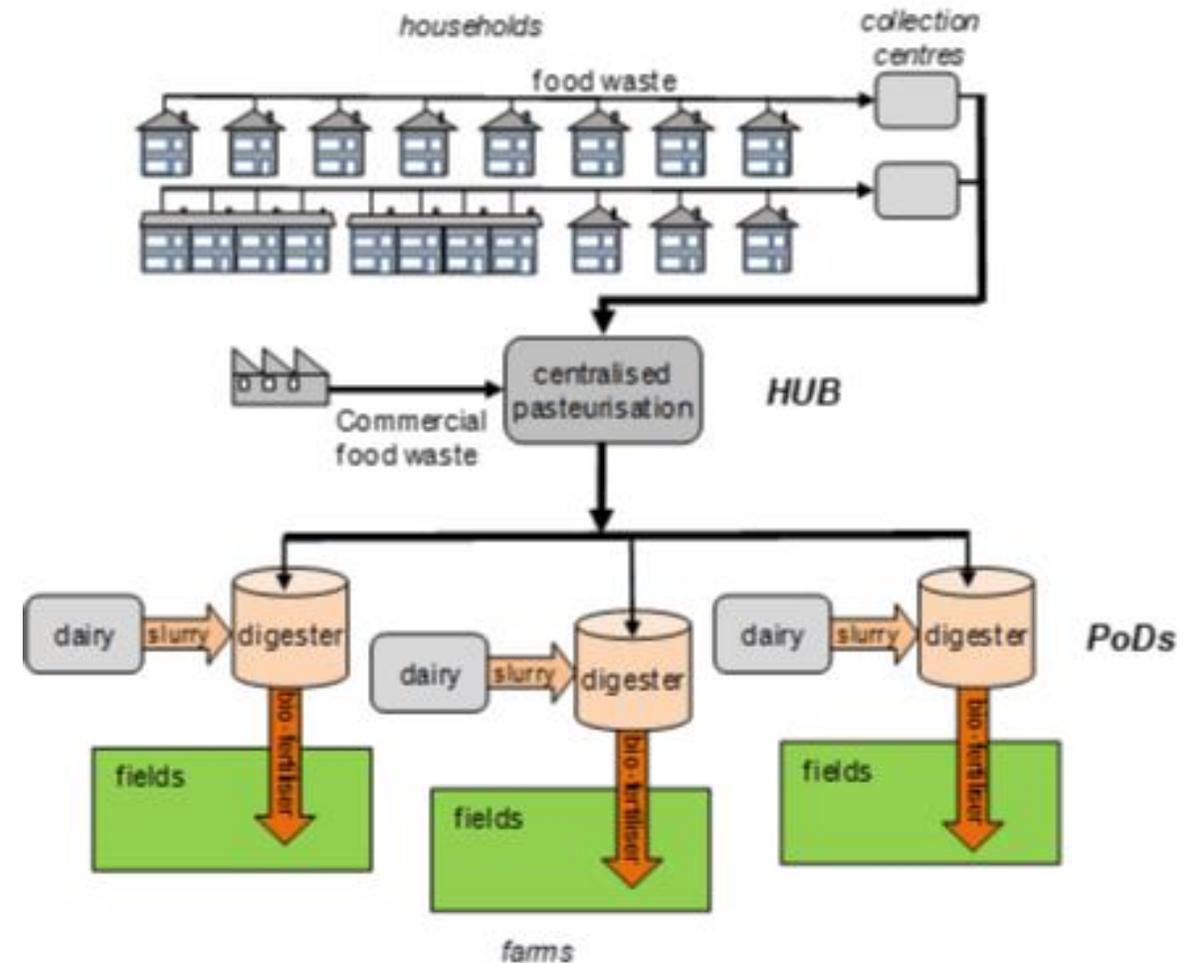
Benefits of HUB and PoD

Environmental

- Nutrients are returned to farm land
- Reduction in use of fossil fuels
- Reduction in GHG emissions from landfill and farms
- Decentralised power production (*AD framework*)

Economic

- Farm digestion becomes economical leading to increased take-up
- No requirement for centralised digestion results in lower capital costs to local government
- Income from energy sales to farms gives a boost to the rural economy
- Farm based digestion creates local employment opportunities in the rural community
- Waste management companies have greater flexibility and opportunities for recycling food waste back to agriculture at lower costs



Banks, C. J., Salter, A. M., Heaven, S., & Riley, K. (2011). [Energetic and environmental benefits of co-digestion of food waste and cattle slurry: a preliminary assessment](#). *Resources, Conservation and Recycling*, 56(1), 71-79.

Thank you

Thanks also to: Dr Yue Zhang, Prof Sonia Heaven and Prof Michael Chesshire

