



Sustainable Resource Management and Energy from Organic Wastes

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What is waste?

Agricultural

- Poultry and livestock manure, and residual materials in liquid or solid form generated from the production and marketing of poultry, livestock or fur-bearing animals; also includes grain, vegetable, and fruit harvest residue (US EPA)
- Agricultural waste is waste produced as a result of various agricultural operations. It includes manure and other wastes from farms, poultry houses and slaughterhouses; harvest waste; fertilizer run-off from fields; pesticides that enter into water, air or soils; and salt and silt drained from fields. (OECD)

General

- An object the holder discards, intends to discard or is required to discard (EU)
- Anything you own, or your business produces, and you wish to get rid of. (Defra)
- ***An item for which the owner no longer has any use and which can be discarded by its current owner without any perceived loss. (i.e. the item has no current value)***

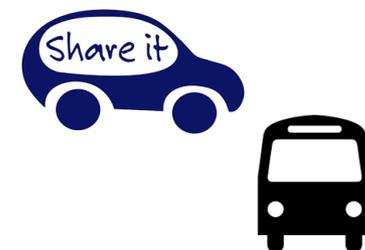
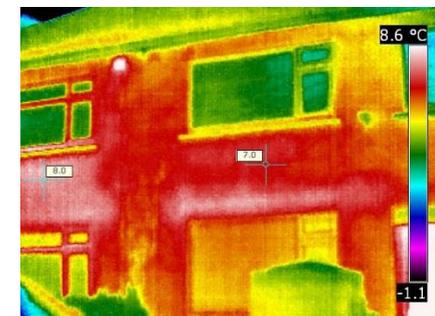
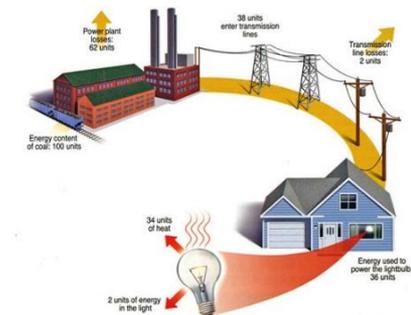


Less obvious waste

- Inefficiency in energy production and use

power and fuel

- Waste of natural resources
 - Water
 - Minerals
 - materials



Is waste biomass waste or is it just resource diversion?

- Some examples
 - Sugar beet pulp
 - Potatoes
 - Vegetable trimmings
 - Brewers and distillers grains



All of these had value as animal feeds and have been diverted to biogas production – not waste but marketable commodities – subsidies distort markets

Field residues – wastes?

- Cereal straws -



- Vegetative stalks



Other 'waste' biomass sources

- Forest industry
 - solids
 - process liquors
- Marine
 - seaweeds
 - fish and shell fish

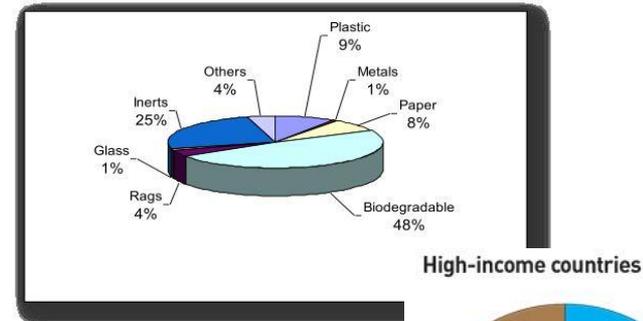


Urban wastes

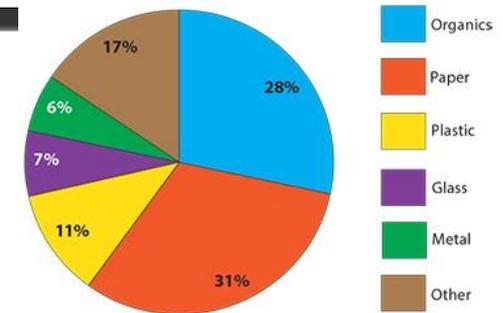


- Commercial and industrial

- Domestic and municipal



- Wastewater



Waste biomass classification

DRY

Recovery options

Combustion

Pyrolysis

Gasification

Advanced thermal

WET

Recovery options

Fermentation

Anaerobic digestion

So what really is 'waste' biomass?

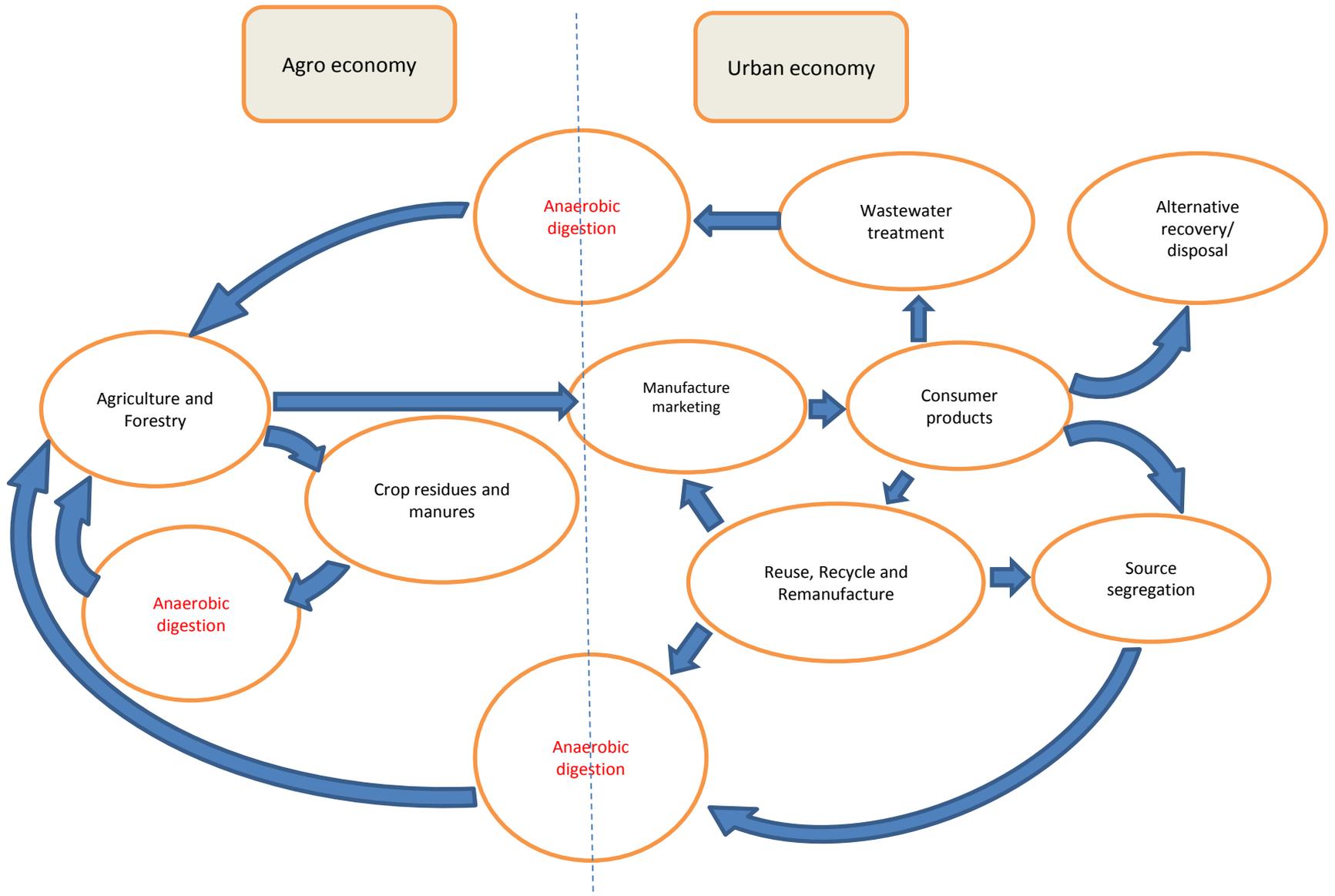
- Animal slurry and manures
- Inedible post harvest food residues
- Non recyclable municipal, commercial and industrial 'waste'
- I'm willing to add more to the list – but you need to justify it

???????

Contribution of biogas technology

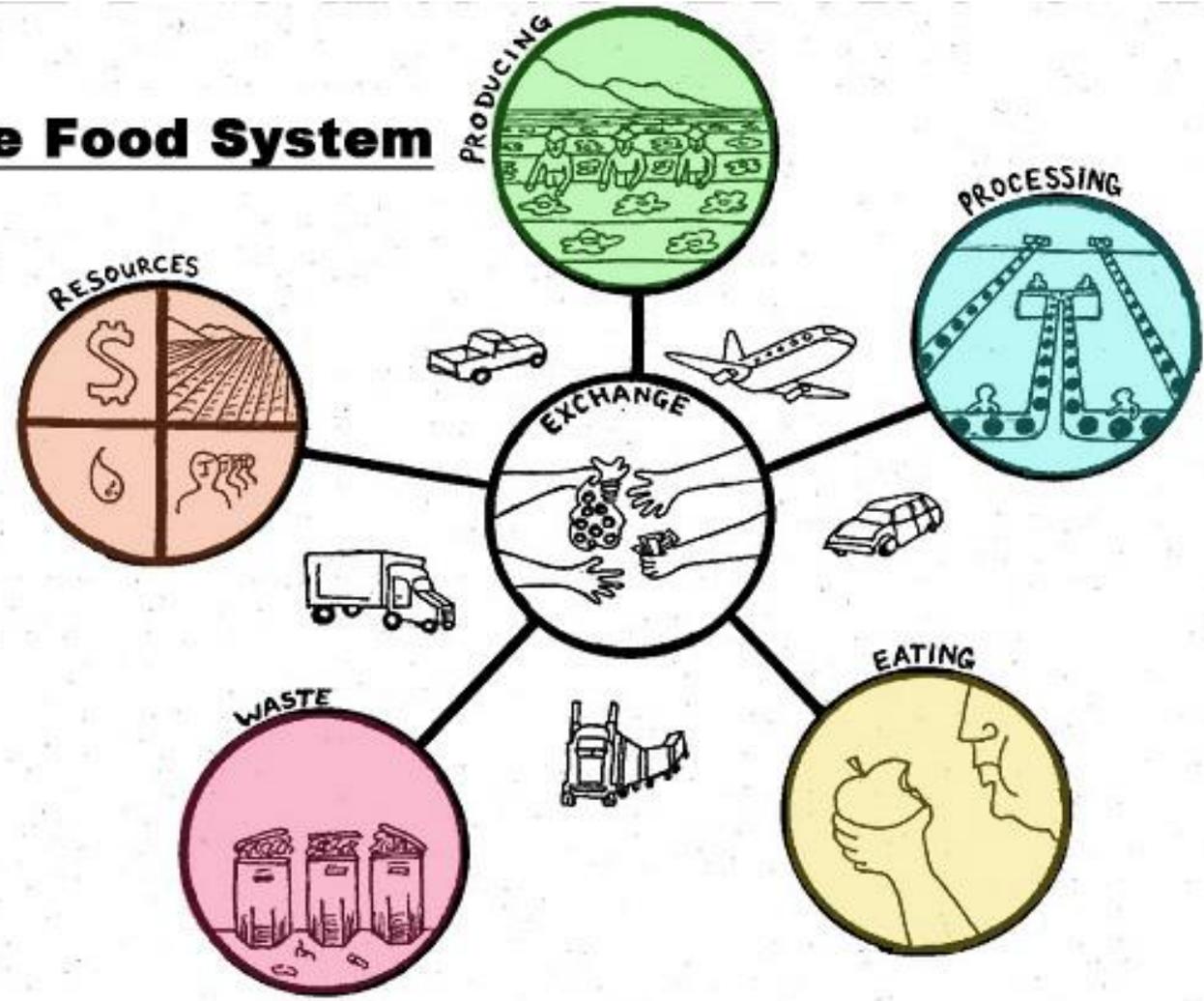


- Renewable energy
- Greenhouse gas emissions
- Waste management
- Environmental



Achieving the circular economy for organics is not that simple

The Food System



Renewable energy

Grid injection – biomethane from biogas is compatible with natural gas



CHP- potential has been demonstrated at all scales with a market stimulated by feed in tariffs



Vehicle fuel – can be coupled to CNG vehicle growth, about 25% worldwide



Heating and cooling – local application or for DCH or community projects



Reduction in GHG

- Savings in tonnes CO_2 per tonne ww processed)

- cattle slurry:

0.24 t fossil fuel displacement by using biogas as fuel

0.024 t prevention of fugitive emissions from tank storage

- Food waste:

0.74t CO_2 eq assuming half of the methane potential from landfill is prevented

0.17t from electricity generated (at 35% efficiency)

0.057 t from savings over fertiliser produced using fossil fuels



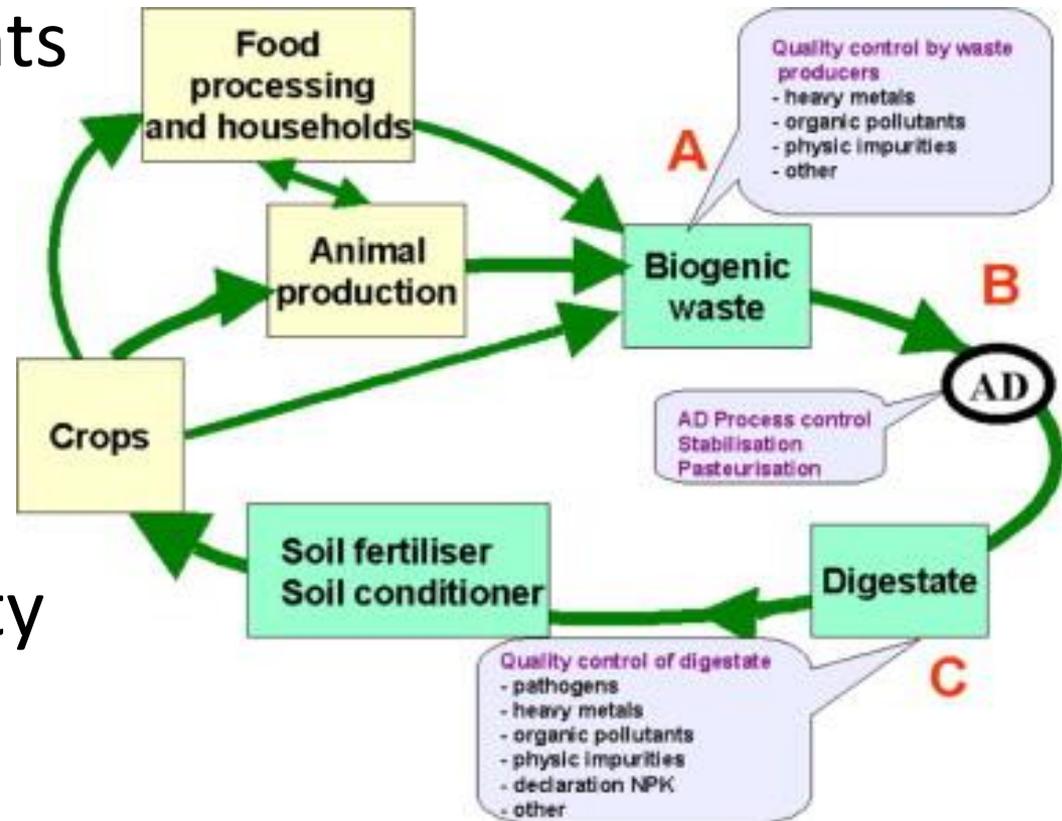
Waste management

- Landfill Directive
 - Municipal solid waste generation $400 \text{ kg person}^{-1} \text{ y}^{-1}$
 - 60% organic
 - Reduce biodegradable waste going to landfill to 35% of 1995 levels by 2014
 - Many of these wastes have a high moisture content, making anaerobic digestion a good choice for energy recovery (e.g. UK $50 \text{ kg person}^{-1} \text{ y}^{-1}$ food waste)



Environmental contribution

- Recycling of nutrients
- Returns organic matter to land
- Helps in resource recovery
- Improves biosecurity



J.B. Holm-Nielsen et al (2009) Bioresource Technology , 100, 5478–5484

Drivers

- Biogas can deliver many benefits, but not necessarily all of them simultaneously!
- Future direction will still depend on the drivers in place
 - Subsidies
 - Penalties
 - Regulations
- These drivers are not uniform and have not necessarily been put in place with sustainability as a major consideration



Future drivers

- Capital cost subsidy for schemes showing environmental benefit
- Consider marginal abatement costs for CO₂ in promoting manure digestion schemes
- Reward improved performance efficiency based on energy balance and sustainability criteria.
- Support of the infra-structure to capture wet biodegradable waste in urban environments

Some examples: Australia

Biogas potential

- Organic waste from domestic, industrial and agricultural industries has the potential to produce around 650 megawatts of electricity....that's enough to power almost one million Australian homes



Meat and dairy

- Pork industry
- Dairy industry
- Poultry industry
- Beef cattle feedlots
- Red meat processing industry

Livestock industries in Australia generate about 25 million tonnes of waste each year, with disposal costing around \$750 million annually.

Manure from livestock industries accounts for 22 Mt of carbon dioxide equivalents



Covered anaerobic lagoons are the preferred technology for agricultural industries.

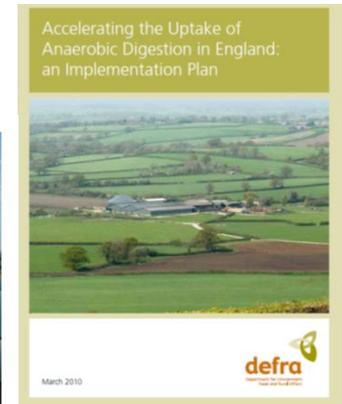
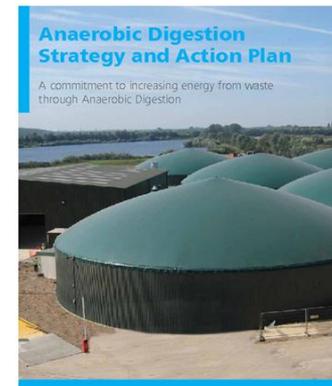
Korea

- Source segregated food waste since 2005
- Volume levy introduced in 2011 resulted in 12% reduction
- New concepts for treatment as high moisture content and high proportion of fermented food
- 30% non repayable grant for anaerobic digestion
- Preferred use of biogas is grid injection or vehicle fuel



UK

- Strong support for AD
- Subsidies based on energy output
ROC, FIT & RHI
- Encouraged agricultural reuse
- Discouraged energy crop digestion
- High gate fees for waste act as
further incentive
- Failed to encourage small scale
farm digestion
- Failed to provide an integrated
waste management infrastructure
to support new technology
- Failed to provide a platform for the
sustainable growth of the biogas
industry



Concluding remarks

- Biogas remains the only technology at market place which can take wet heterogeneous 'waste' biomass and produce energy, retain a proportion of the organic matter and potentially recycle farm nutrients
- It is currently an expensive technology
- Can we be more innovative in both the way we apply it and the drivers to permit its sustainable growth?



Thanks to the many who support our work

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