Ricardo
Energy & Environment

Biological Treatment

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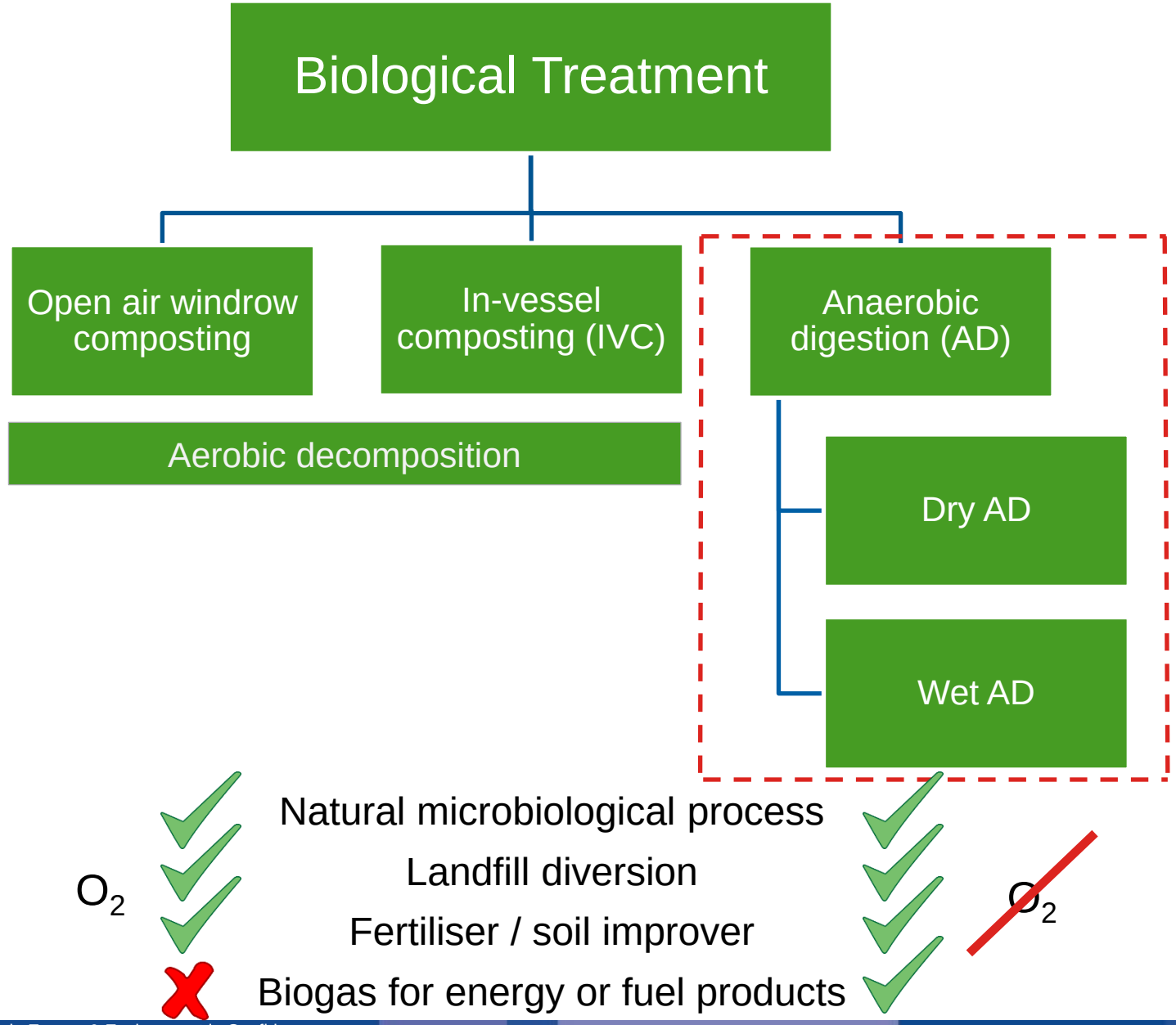
Biological Treatment – Feedstock

- Readily biodegradable
  - Garden and parks waste
  - Household food waste from households
  - Commercial food waste, including packaged
    - Past shelf life food
    - Hospitality and catering waste
  - Industrial waste
    - Food and drink manufacturing waste (e.g. brewery, dairy, bakery waste)
  - Agricultural wastes
    - Crop residues (energy crops)
    - Animal slurry, rendering waste
  - Sewage sludge
- Different pre-treatment requirements
- Different gas yields
- Source separated or screened residual organics

Biological Treatment



Biological Treatment – Aerobic Composting

- **Open Air Windrow Composting (OAWC)**

Simple, proven, understood

Low Capex / Opex, low risk

Compost for use as soil improver

Food waste / animal by-products

Bioaerosols, potential odour

Favours rural location

Net energy user

Significant land take

- **In-Vessel Composting (IVC)**
  - Initial ('sanitisation') stage in enclosed vessel
  - Subsequent open air windrow composting

Similar OAWC – higher Capex / Opex

Co-treat food waste / animal by-products

Faster processing

Better emission control (biofilter)

Similar OAWC – higher energy use

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REJECTED

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Biological Treatment: Anaerobic Digestion (AD)

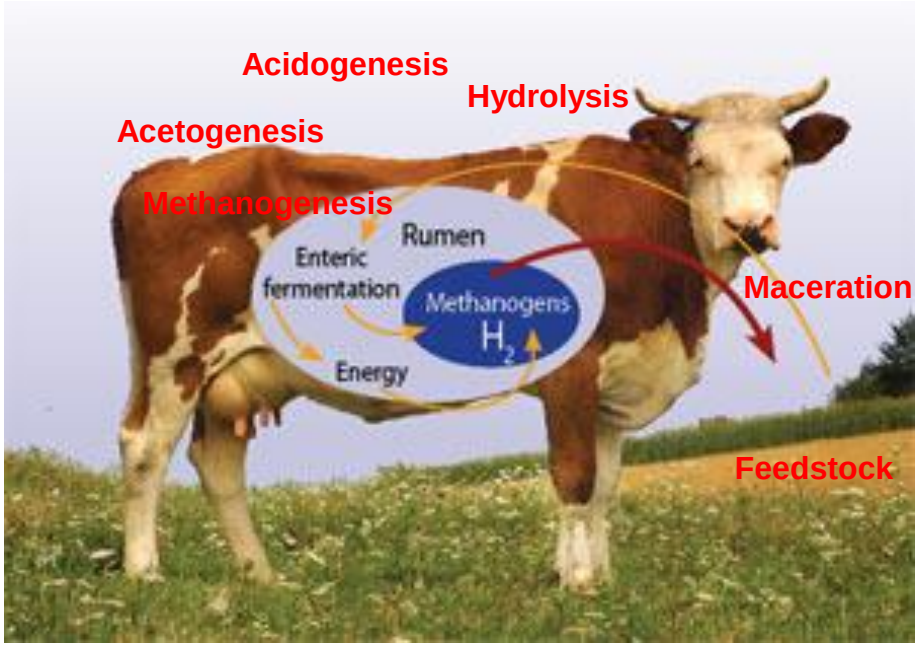
- Natural process
  - Micro-organisms digest organic matter in the absence of oxygen
  - Established 100 years in water sector – understood
- Generates biogas (c. 60% methane, 40% CO_2)
  - Renewable energy
  - Electricity & heat generation, fuels
  - Volume depends on biomethane potential of waste
- Controlled, accelerated process that occurs in landfill

Wet AD systems	Dry AD systems
<10% dry solids	Higher dry solid content 15-40%
Maceration and mixing required	Less mechanical treatment
Typically food waste, manure, slurry	Typically green waste, co-collected food and green waste, energy crops
Water addition or thickening for low solids	No water addition
Environmental constraints less onerous than dry AD	Environmental constraints more stringent, especially if combined with AOWC

Biological Treatment – AD Process

For example:
Mechanical size reduction
De-packaging
Enzyme hydrolysis
Nitrogen extraction
Autoclaving/thermal hydrolysis

Feedstock → Pre-treatment → Digestion process → Whole digestate → Liquid effluent
Whole digestate → Solid digestate
Pre-treatment → Rejects
Digestion process → Biogas (CHP engine) → Heat
Biogas (CHP engine) → Electricity
Biogas (CHP engine) → Cleaned & upgraded Bio-methane → Injection to grid
Cleaned & upgraded Bio-methane → Liquefaction
Cleaned & upgraded Bio-methane → Vehicle fuel



Meet fuel specification:
Remove CO_2 and contaminants (e.g. H_2O, H_2S, siloxanes)
Increase CH_4 (c. 95%)
Inject propane to increase CV and compress

Biological Treatment: Wet AD

- Most common AD variant – track record
- Water added to food waste to create slurry
- Tanks – process variants e.g.:
  - By temperature, by scale, by mixing method…
- Low solids 'whole' digestate or dewater (liquor / fibre fractions)

✓ Energy revenue

✓ Proven, understood

✓ Flexible, low footprint

✓ Potential urban setting

Single stage process	Multistage process
Single reactor	Two or more reactors to optimise process
Simple economical design	Better process control & built-in redundancy
Produces less biogas	More biogas (depends on retention time & feedstock)
Lower Capex	Higher Capex (balance against flexibility and gas yield)

✗ High digestate volume (85-100% input) – risk often overlooked

✗ Digestate storage capacity & effluent treatment

✗ No green waste – source separated collection

✗ Contamination – downtime (e.g. plastics and grit)

✗ Some energy required to heat tanks

Wet AD – Tekniska verken i Linköping (TVAB) Sweden

Opened 1996
Capacity 100,000 tonnes per annum
Feedstock 50:50 mix farm manures and organic waste
Biogas is upgraded to vehicle fuels
Operates 12 filling stations and 3 bus filling stations
Whole digestate to farmers (cost neutral)
Mesophilic

Biological Treatment: Dry AD (High Solids AD)

- Waste stream 15-40% total solids – up to 50%
- Physical characteristics requires different approach to handling, mixed and pre-treatment
  - Pre-treated (screened) to remove physical contaminants
  - Inputs handled using conveyor belts, screws, walking floors and powerful pumps
  - ‘Tunnels’ or vertical vessels (not tanks)
- Normally higher temperature (thermophilic) – faster microbial process for higher organic load
- The biogas and digestate dealt with as for wet AD systems


Source: FD Todd Ltd

Energy revenue

Tolerates higher contamination (lower technical risk)

Accepts green waste (co-mixed food) – suits less mature collection schemes

Proven (less common)

Composting back end – land take and emissions (although composting hall can be enclosed)

Favours rural location (if open air compost maturation)

Wet and Dry AD – Advantages and Disadvantages

Advantages

Wet AD Systems

Fully enclosed
Lower odour potential
Highly proven
Higher biogas yield
Smaller footprint

Source separated food
More complex system
Higher Opex
Maintenance (grit, plastic)
High digestate volume
Digestate post-treatment
Effluent lagoon (potential odour)

Renewable energy
Energy sales
Range of energy products
Fertiliser product

Feedstock security
Digestate landbank and restrictions
Odour from breakdown in process control or plant failures
Power infrastructure and network capacity

Dry AD Systems

Tolerate contamination
More flexible feedstock
Lower Opex
Less complex system
Less maintenance and critical equipment

Lower biogas yield
Composting back end
Higher odour potential
Fewer references
Urban sites less suitable

Disadvantages