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History and state-of-the art of anaerobic digestion

AD:Science meets Industry
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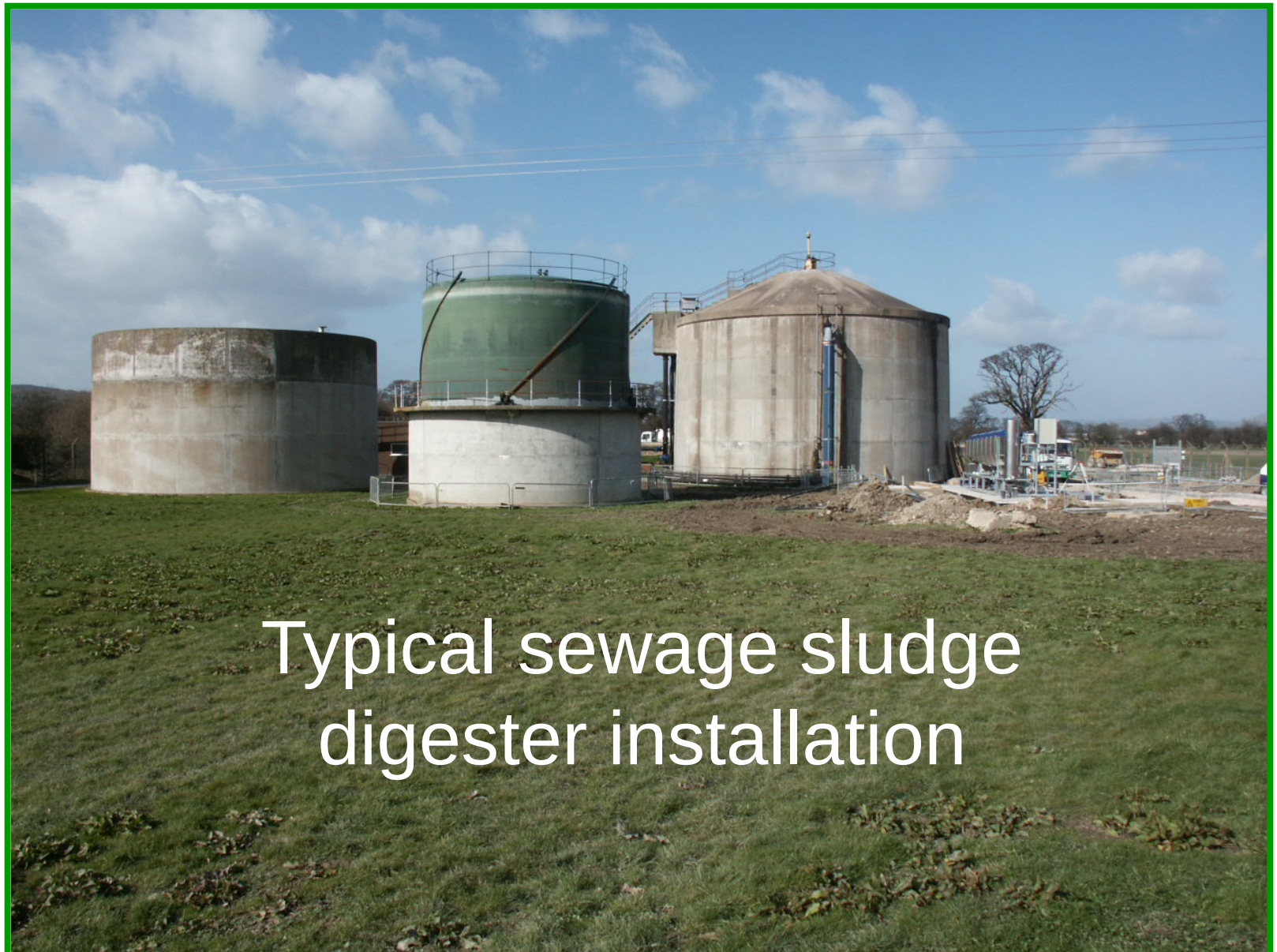
History

- Possibly ancient civilizations used AD to heat hot water
- First known digester was on a leper colony in Bombay (circa 1859)
- Exeter used street lights working on biogas from sewage treatment in 1895
- It was used extensively during world war 2 as a supplementary energy source
- It probably went ‘warm’ somewhere around this time or slightly later
- Its main purpose in early sewage treatment plant was to stabilize biosolids
- Rural small scale digestion in China goes back to the 1920’s but huge expansion in the 1970/80s

Scientific history

- Buswell et al around 1936 showed first real interest in anaerobic digestion
- Late 1960's : McCarty, Speece and others began to understand the science behind digestion
- The first methanogens were isolated in 1966
- The 1970's showed interest in new processes and substrates (examples and appologies)
  - Chenowyth on Solid substrates
  - Jewel on Algae
  - Lettinga on domestic wastewaters
  - RCUK funded research facility (Hawkes, Wheatley, Stuckey and others)

1970's - great ideas but most plants still looked like this:



Typical sewage sludge digester installation

Late 1970's onwards

- Development of high rate anaerobic systems for intermediate strength process waste waters:
- Fiber, food, meat, milk, brewing, pharmaceuticals, and chemical processing
- Used mainly as a pretreatment before discharge to sewer
  - Anaerobic contact process
  - Anaerobic filters
  - Upflow anaerobic sludge blanket
  - Fluidised and flocculent beds

1980's

- Interest in new 'solid substrates'
- Advent of new digestion concepts to meet the needs of new substrate types
- New markets and opportunities for biogas utilisation
- Interest in co-digestion of manures and food processing waste

1990's Process types

Wet

Dry

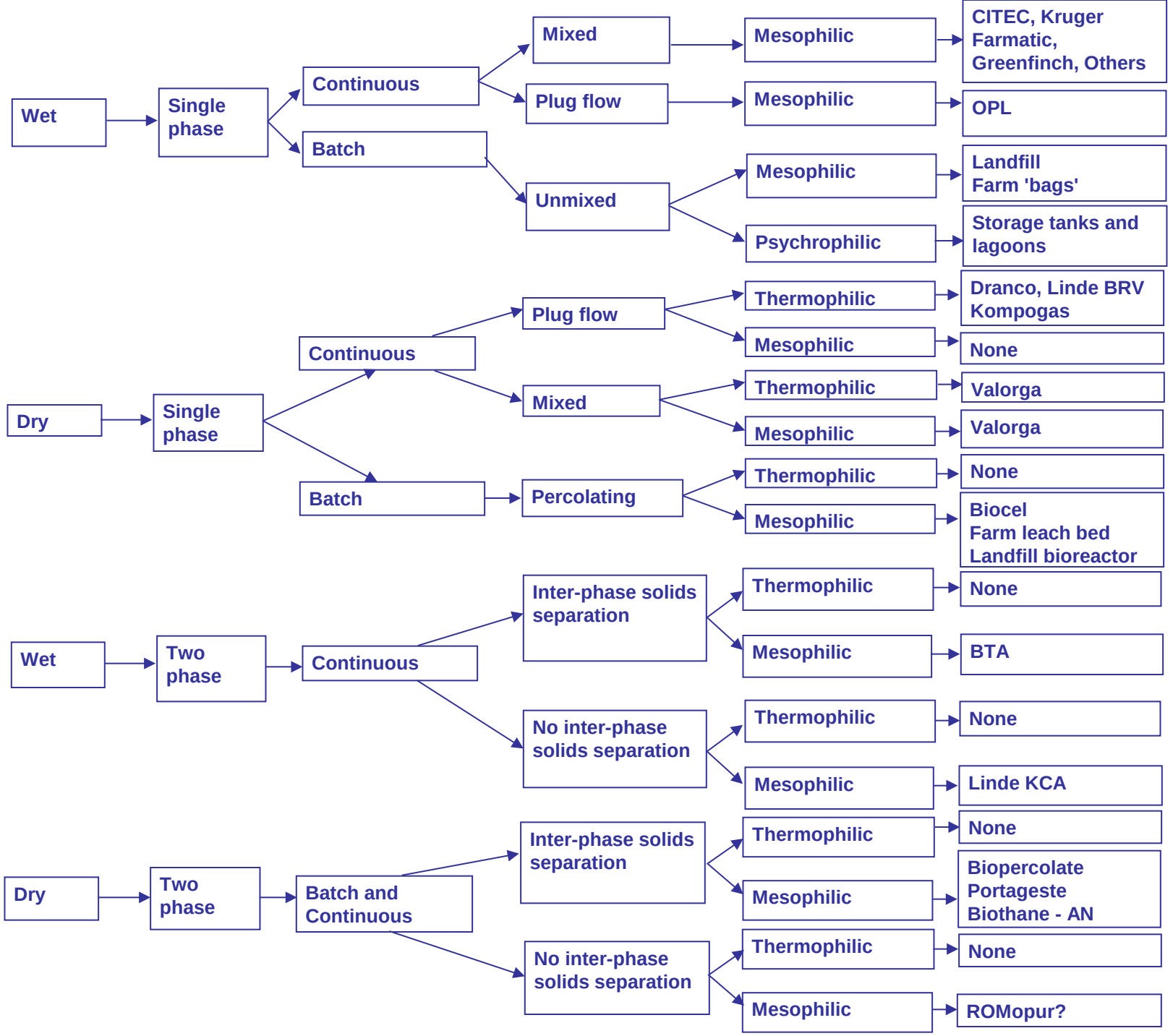
Mesophilic

Thermophilic

One stage

Multi-stage

Instant recognition!



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2000 onwards

- Renewable energy incentives
- Distortion of markets
- Food or fuel debate
- Lost sight of digestion as a 2 product process (biogas and digestate)
- Digestate no longer the primary product and a ‘disposal issue’ as even more substrates begin to be utilised
- Markets for biogas and biomethane influenced by subsidy policies

State-of-the-art

- Appear to be many ‘state of the art’ digesters
- Each may be suited to a particular substrate type
- and, some may be suited to none!
- The state of the art may still be more operator based rather than technology based
- The holy grail – reduction in hydraulic retention time?
  - or is it!

HRT

Food waste digestion Food waste VS = 200kg m^{-3} (1kg VS ~ 1kg COD)

- CSTR
- Max load for CSTR digester = 10kgVS m^3 d^{-1}
- HRT = 200/10 = 20 days
- For 1 tonne (m3) food waste requires 20m^3 of digester volume

- Retained Biomass
- Max load for high rate digester (eg UASB) = 10kg COD m^3 d^{-1}
- Dilute 1m3 food waste with 19m3 clean water (COD of 10,000mg l^{-1})
- Digester volume = 20m^3
- HRT = 1 day

Limitation in digestion is not the HRT it is the organic loading that can be converted per unit of digester volume

Improving the 'metabolic capacity' of digesters

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- Better control of existing systems, working closer to the tolerance limits :– state-of-the-art of the operator
- Improving the system biology – understanding the limiting factors that control rates of reaction
- Meeting the nutritional and environmental needs of the microbial community
- Matching reactor design to system biology requirements
- Bio-mimicry ?

State of the art - digestate

- Digestion is a 2 product process
- Need to pay more attention to the ‘second product’
- A state of the art digestate would be one that matched the fertilizer requirements of the land base to which it is applied
- There is a need to move towards ‘designer’ digestates either by feedstock blending or by nutrient sequestration (ammonia and phosphrous recovery)
- For digestion to be really state-of-the-art it has to be truly part of the circular economy

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Thank you for your attention

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AD NETWORK
Harnessing Anaerobic Digestion