Anaerobic Digestion Technology Today and Tomorrow

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Biogas Workshop October 2004

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Waste Technology Group Ltd

History

The Company was established in late 1993 when Duffill, Watts & King Ltd, a New Zealand-based consulting engineering firm, purchased Waste Technology Group from AgResearch.

At this point, the Waste Technology Group had a track record of over 10 years experience in biogas technology, waste treatment research and technology transfer to end users of a wide range of new environmental technology products.

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Through the offices of Duffill Watts Group of Companies, Waste Technology Group Ltd can provide local support and project management in many locations throughout New Zealand and South East Asia

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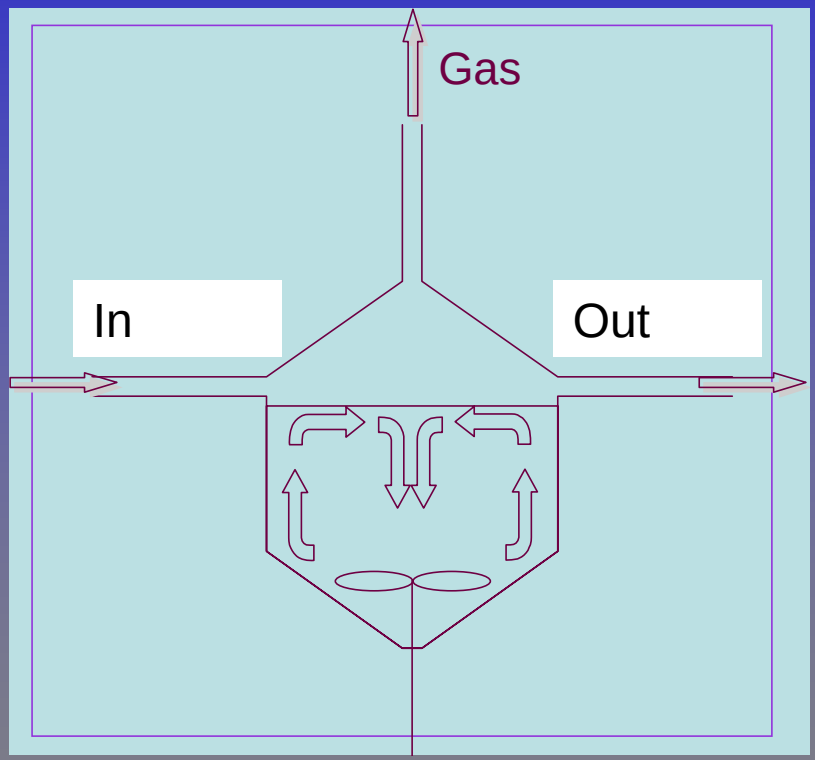
Methane Recovery



Anaerobic digester for solid waste (constructed 1990)

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Pilot scale reactors. 200 l **U**pflow **A**naerobic **S**ludge **B**lanket **(UASB)** reactors used for research on advanced methane recovery systems

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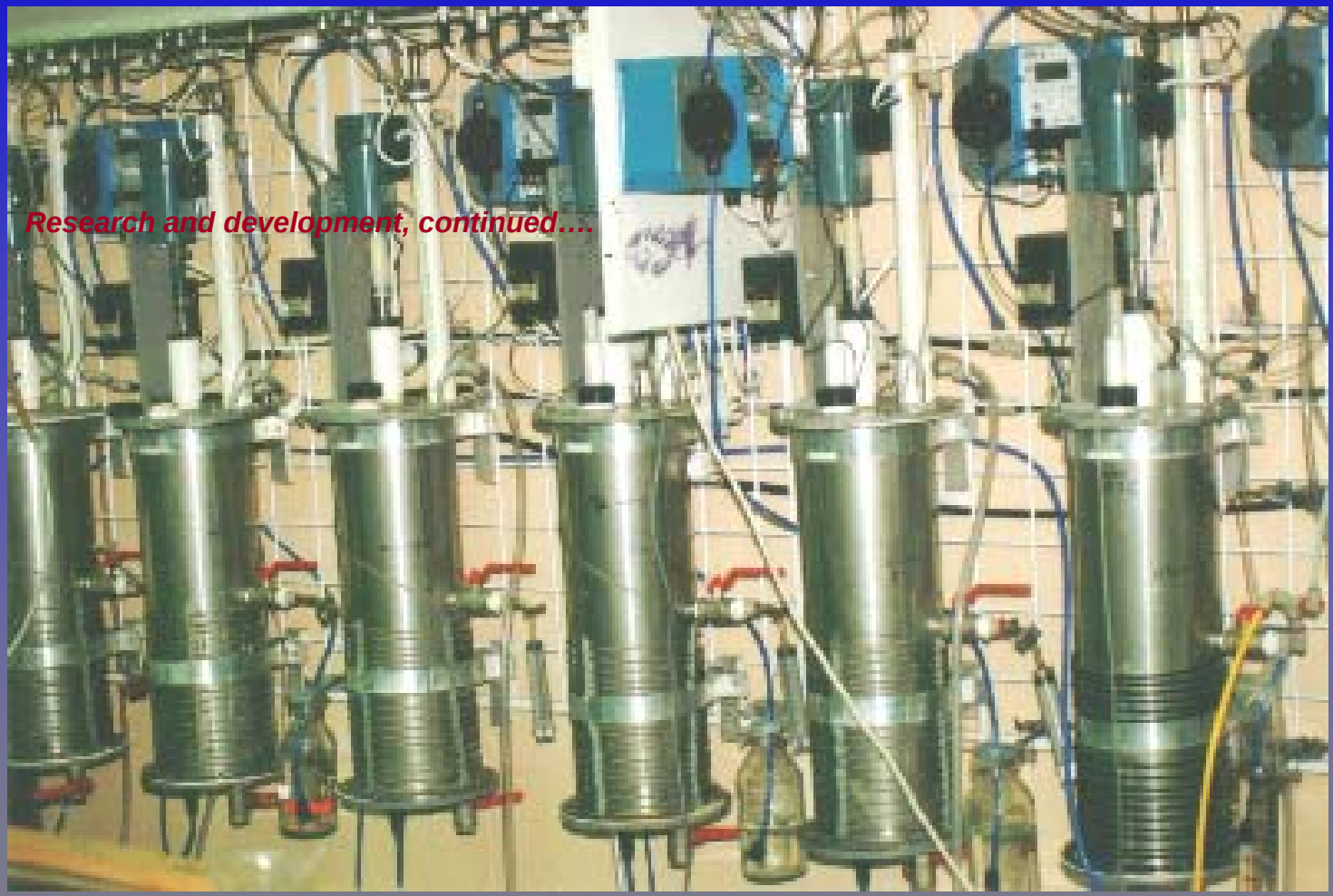
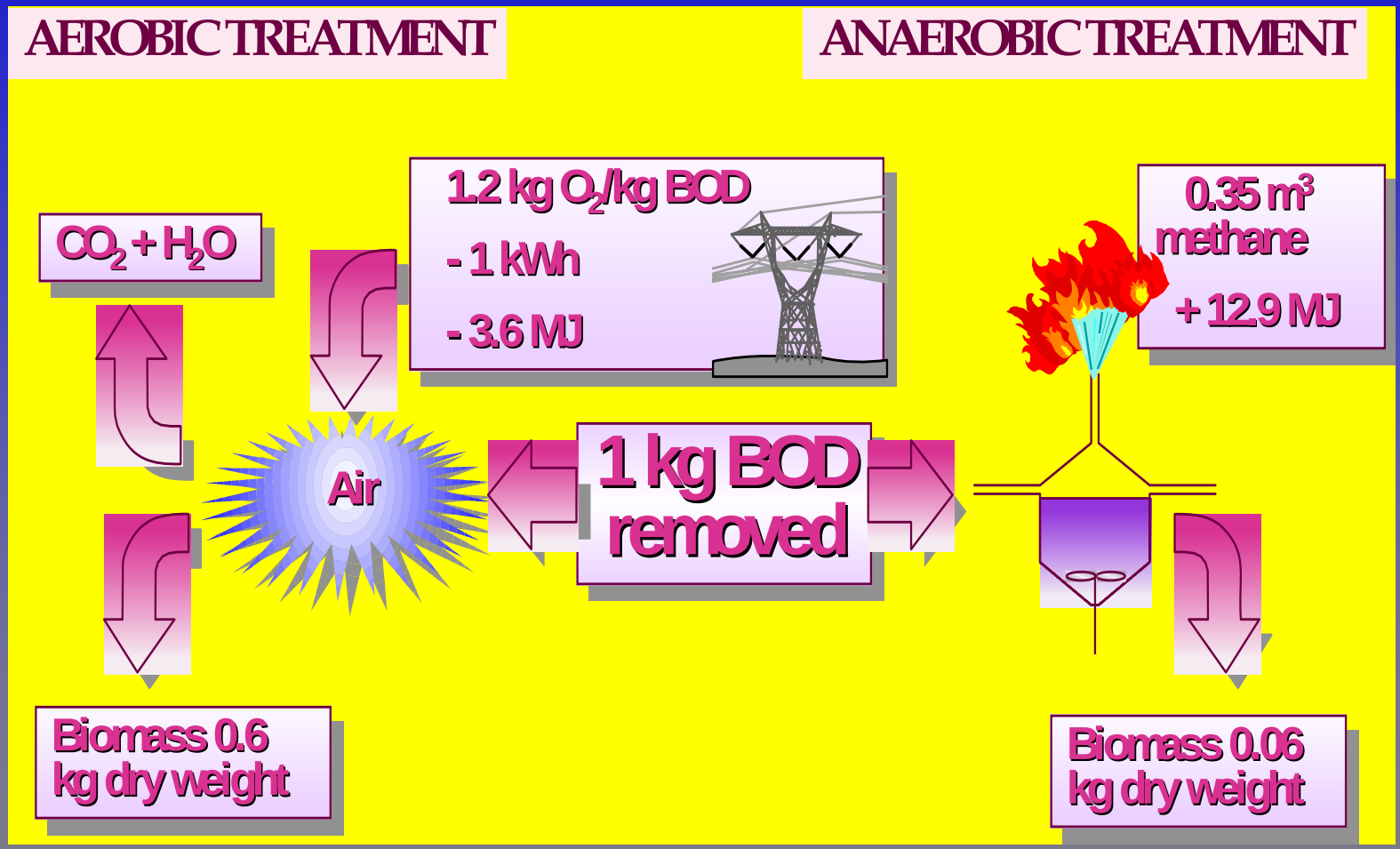


Laboratory reactors used for digestion trials. The reactors shown have automated controls for gas collection, liquid mixing, pH and temperature.

Bioengineering principles



BOD = biochemical oxygen demand COD = chemical oxygen demand

Typically: 1 BOD = 0.6 – 0.8 COD

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Methane Recovery Opportunities

Typical Applications

- Municipal sewage
- Feedlot manure
- Dairy shed effluent
- Primary processing effluent
- Industrial sludges (flotation foams)

New Applications

- Post consumer waste
- Food residuals
- High fat waste
- High nitrogen waste
- Energy crops

International Carbon Trading
(Clean Development Mechanism - Kyoto Protocol)

- Greenhouse gas (GHG) emission abatement
- Methane 21 times more powerful than CO2
- Successful projects get annual emission reduction units issued that can be sold on international markets

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- 1st digester project launched in 1998 (The Philippines)
- 2nd digester project launched in 2001 (Thailand)
- 4 more projects in preparation

Developments in New Zealand - Projects to Reduce Emissions

- Framework established in Kyoto Protocol
- Participants rewarded with Emission Units
- Voluntary and take place in New Zealand
- Emission Units expected to be tradable
- Have direct benefit for environment
- Encourage innovative initiatives that reduce emissions

Potential projects

- Wind farms
- Biomass
- Biogas - Bioenergy
- Hydroelectric
- Geothermal
- Solar
- Coal mine gas
- Landfill gas
- Fuel efficiency
- Fuel switching
- Heat recovery
- Others

What's on offer ?

- Emission Units or 'carbon credits'
- One Emission Unit = abatement of one tonne of CO_2-equivalent
- Current value: (12 – 15 $NZ/ t CO_2-equivalent)
- Market developed for units in Europe e.g. Dutch ERUPT program
- 2003: Four million Emission Units
  2004: Six million Emission Units on offer
- Kyoto coming into force

Opportunities in New Zealand

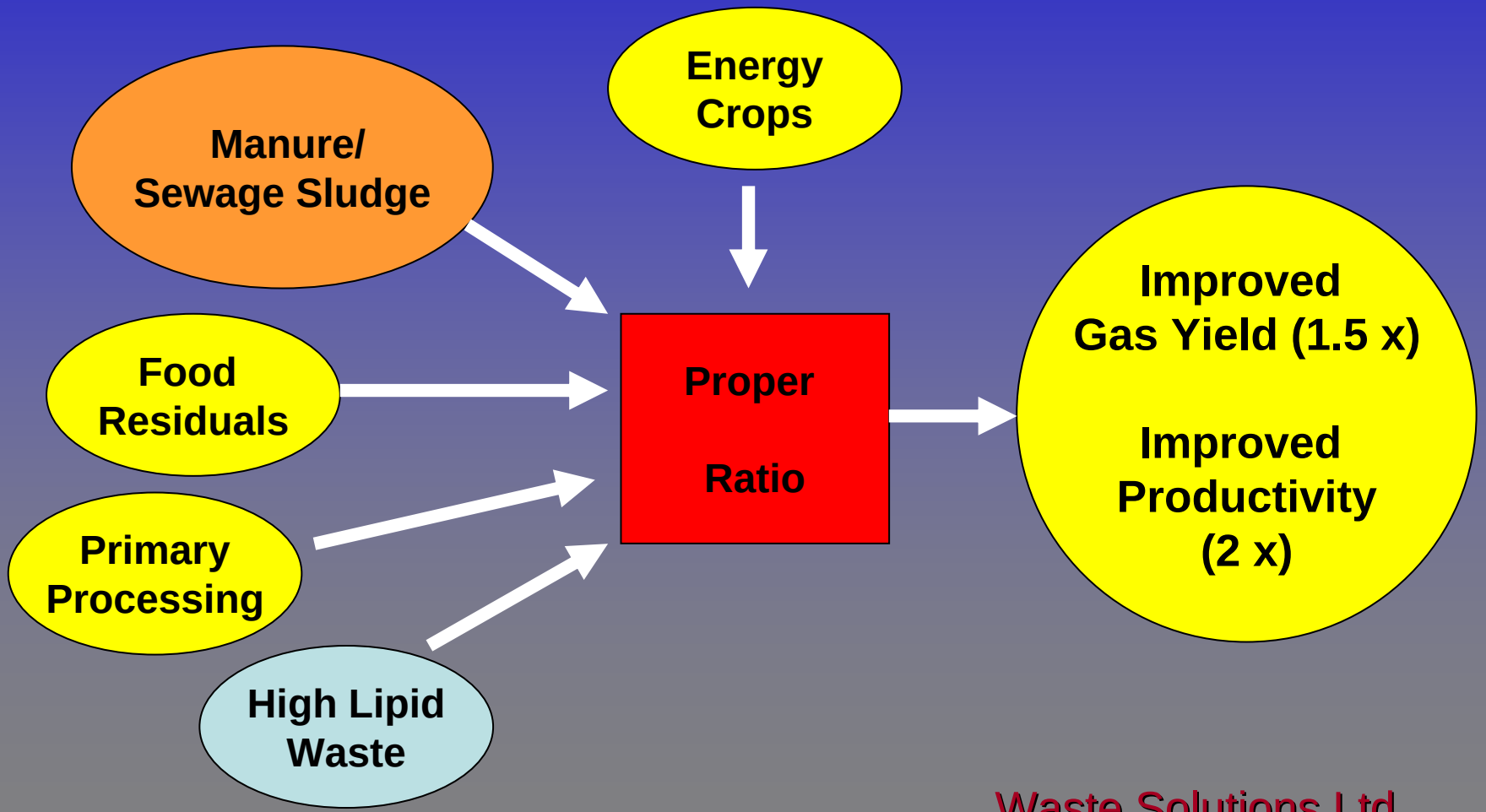
- **Pre-consumer waste (immediate)**
  - primary processing waste (dairy, meat, wool)
  - food industry waste (canning, restaurants, canteens)
  - putrescible waste (Institutional, Commercial, Industrial. ICI)
  - dairy shed effluent (manure)

- **Post-consumer waste (immediate)**
  - co-digestion of source segregated “biowaste”
  - bioreactor landfills and leach bed systems

- **Energy crops, liquid fuel (5-10 years away)**
  - perennial grasses (USA, Europe, Scandinavia)
  - annual crops (intercrops)

Co-Digestion Systems

Co-digestion : Waste + Industrial Feedstocks



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Key Process Components:

- Pretreatment (contaminant removal)
- Nutrient balancing (Ni, Fe, Co, Mo, N, P, K, S)
- Water / alkalinity re-use (effluent recycle, strong waste)
- Biomass recycle (high rate)
- Contacting/mixing (digester tank)
- Heating (digester tank)
- Biogas flare
- Fuel management (purification/compression)
- Biogas end use (heat, CHP, transport fuel, fuel cell)
- Fertiliser recovery
- Residue management

Anaerobic Digesters (2 x 5,500 m3)

Paramatta - Sydney

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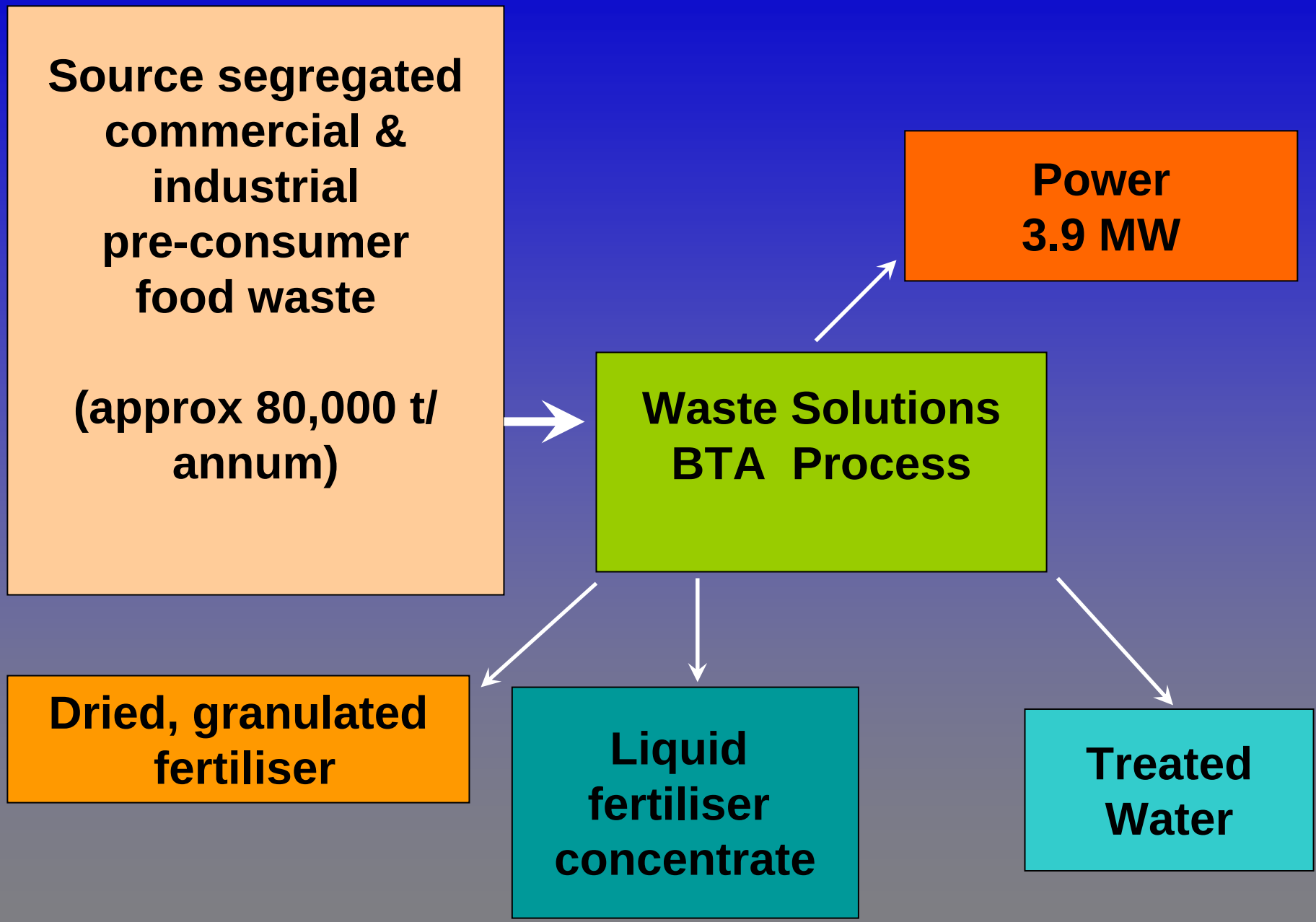

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Fertiliser Recovery Options

- **Magnesium Ammonium Phosphate**

  N:P:K 4.5 : 11 : 0.2 (% w/w dry)
- **Ammonium Phosphate Solutions**

  N:P:K 7.1: 8.1 : 0.1 (% w/w wet)
- **Ammonium Bicarbonate Solutions**

  N:P:K 1.5: 0.1 : 0.1 (% w/w wet)
- **Dried granulated organic fertiliser**

  N:P:K 5.5: 1.4 : 0.9 (% w/w dry)

Operating Temperature

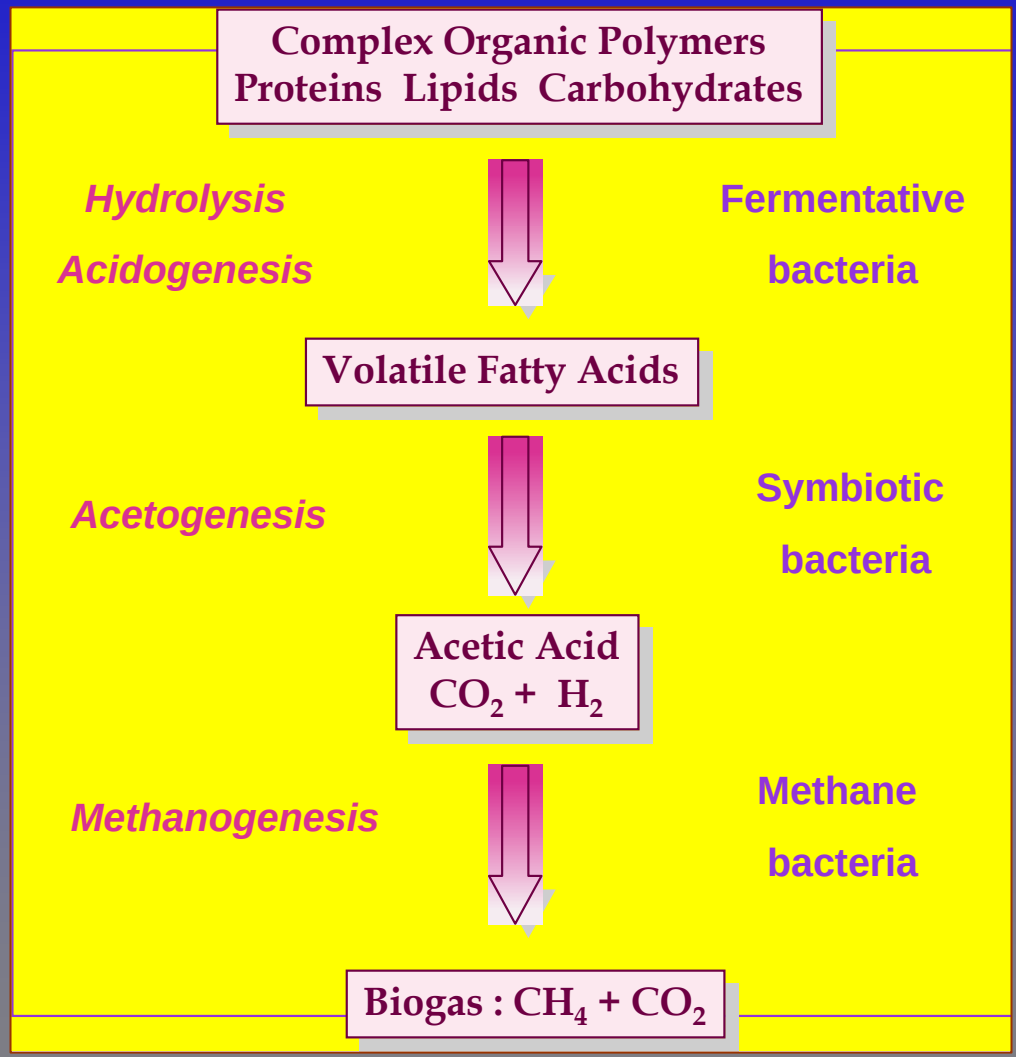
Mesophilic (30-42 C)

- Robust
- Lower rate
- Low effluent COD
- Suitable for dilute waste
- High toxicity tolerance
- Requires sanitation of digestion residue

Thermophilic (50-65 C)

- More sensitive
- 3-4 fold increased rate
- Higher effluent COD threshold
- Suitable for concentrated waste
- Low toxicity tolerance
- Residues are sanitized

Anaerobic Microbiology



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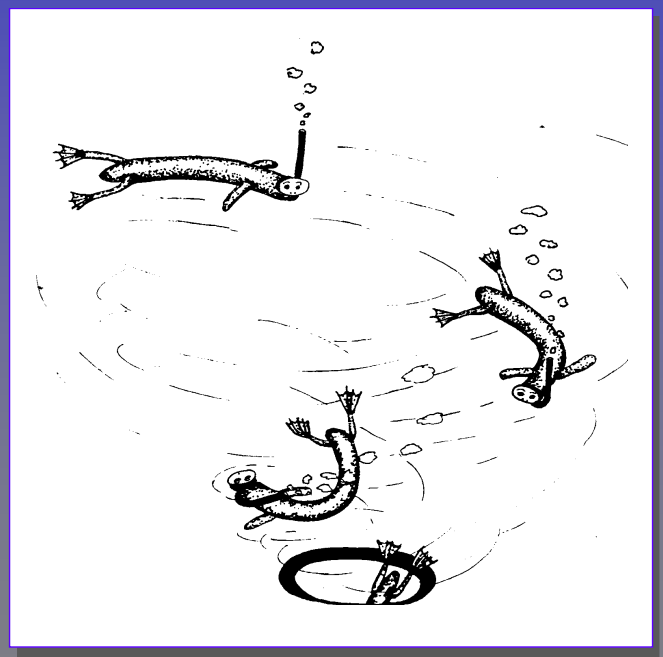
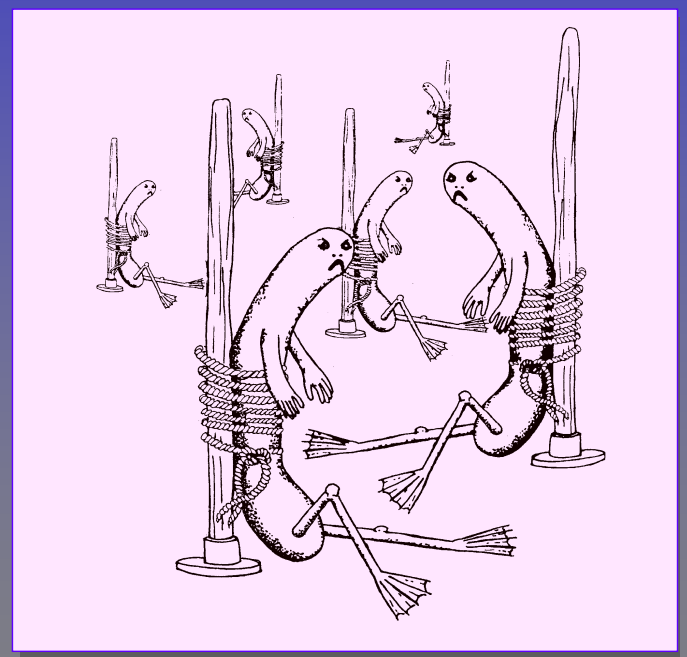
Low rate versus High Rate

(granular sludge, biofilms)

Free swimming



Immobilized bugs



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Low rate versus high rate
(Biochemical Alchemy)

- **Temperature**
- **Contact effectiveness - mixing (bugs <->COD)**
- **Biomass retention (immobilisation)**
- **Feedstock concentration (COD)**
- **Feedstock degradability (BOD/COD)**
- **Soluble feedstock versus slurry feedstock**
- **Inhibitory waste constituents**

- NH3/ NH4 (proteins, urine, faecal matter)	> 2500 ppm
- LCFA (soaps; fat content of the feedstock)	> 5000 ppm
- high sulfur/sulfate content (H2S , competition)	> 3000 ppm
- chlorinated solvents (CFC's and related cpds.)	> about 1 ppm

Key decision making (capacity)

Higher Cost	← →	Larger Space
Highly engineered compact	**Robust** space - intensive	**Simple** space - extensive
high rate (3-10 V/V/d)	low rate (1-3 V/V/d)	minimum rate (0.5 - 1 V/V/d)
Anaerobic contact **UASB** EGSB	**CSTR digester** **CIGAR** **Anaerobic Baffled Reactor**	BVF (ADI) **ww-lagoon**

V/V/d = volume biogas / volume digester / day

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Present Economic Drivers

- Low CAPEX ($/ MW - high rate, low cost)
- Proper system choice and technology
- Economy of scale
- “Control over the waste”
- Tipping fees (getting paid for service)
- Quantitative biogas end use
- Greenhouse gas abatement credits
- Production of saleable by-products

Future Drivers:

- Greenhouse gas emission abatement
  - 1 tonne CH_4 = 21 tonnes CO_2

- Electricity generation (rural, distributed)
  - gas motor gen sets
  - microturbines
  - solid oxide fuel cells
- Renewable fuels for transport
  - biogas purification
  - biogas compression
  - production of biomethanol from biogas

- Energy crops integrated into pastoral farming
- Recovery of value added fertiliser

Thank you

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