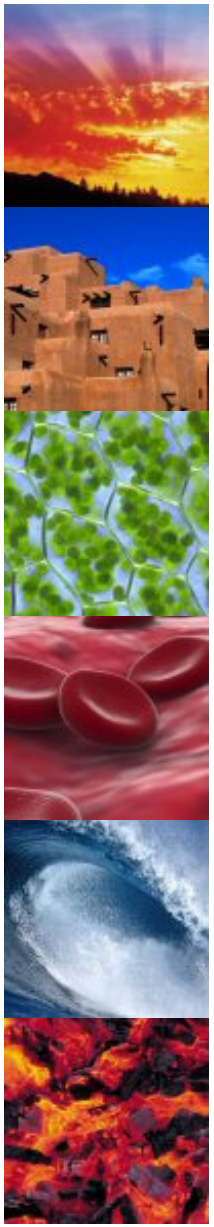


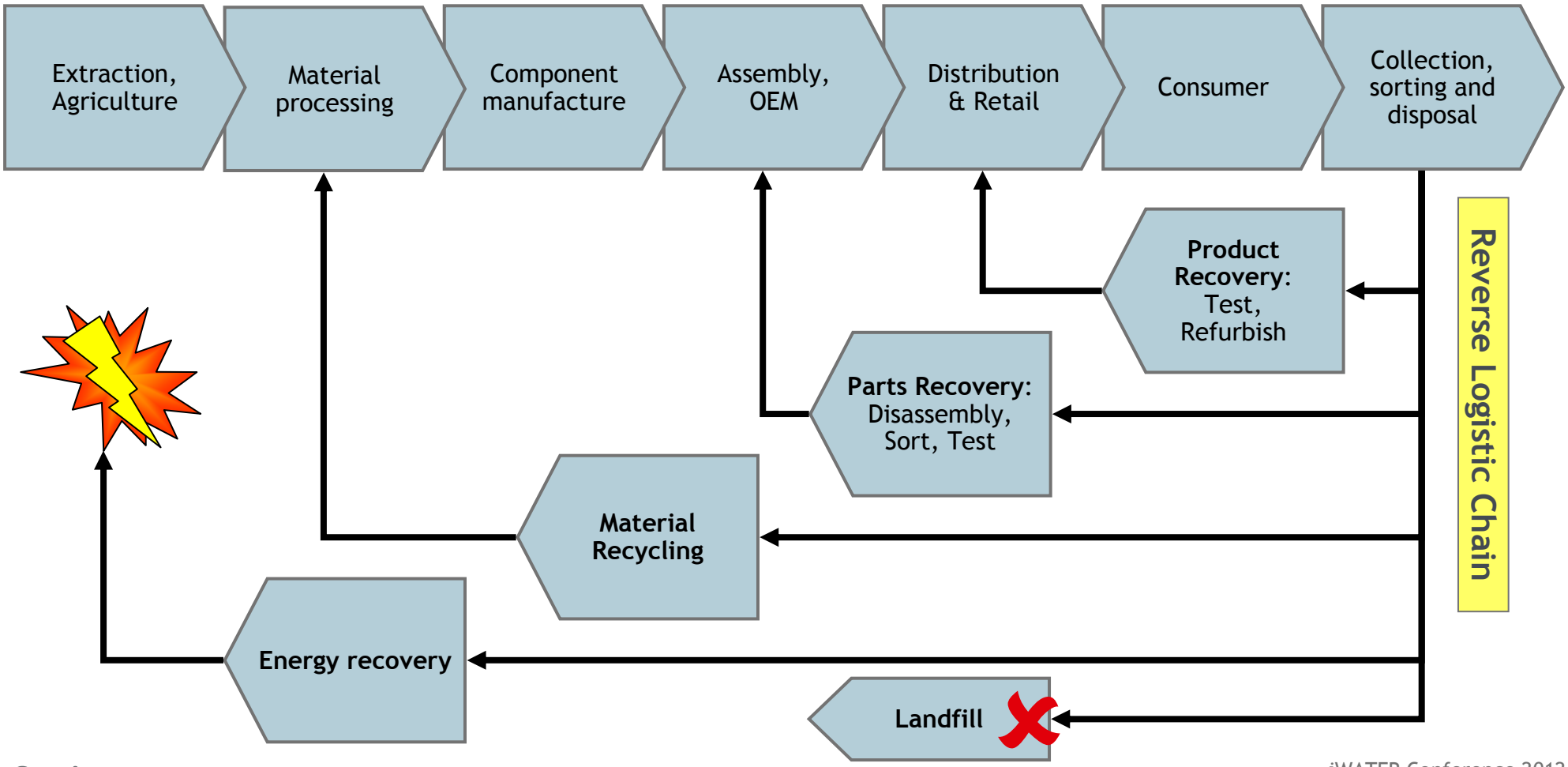
Energy Recovery from Waste

iWATER Conference 2012
13 November 2012 Cambridge
www.cir-strategy.com/events/

Charles Lee

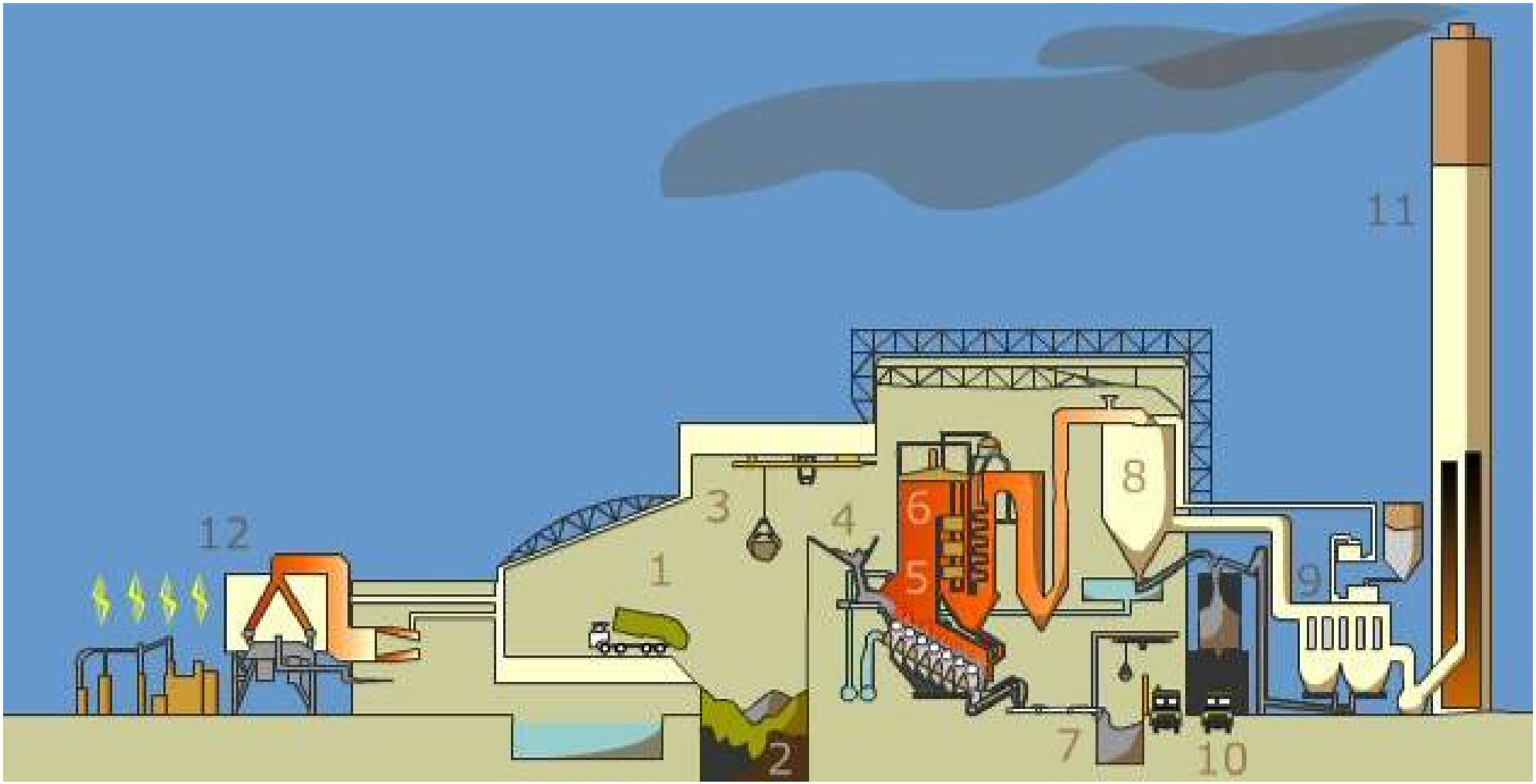
futureneering

Manufacturing supply chains are evolving from 'open loop' to 'closed loop'



Mass burn incineration is an alternative to landfill and recycling for municipal waste

Waste incinerator Credit: Material Recycling World



Credit: VOICE – Flash animation and explanation www.st-ig.co.uk/incinerator_tour.html

Incineration faces public opposition

Kings Lynn anti-incinerator campaigners. Credit: EDP24

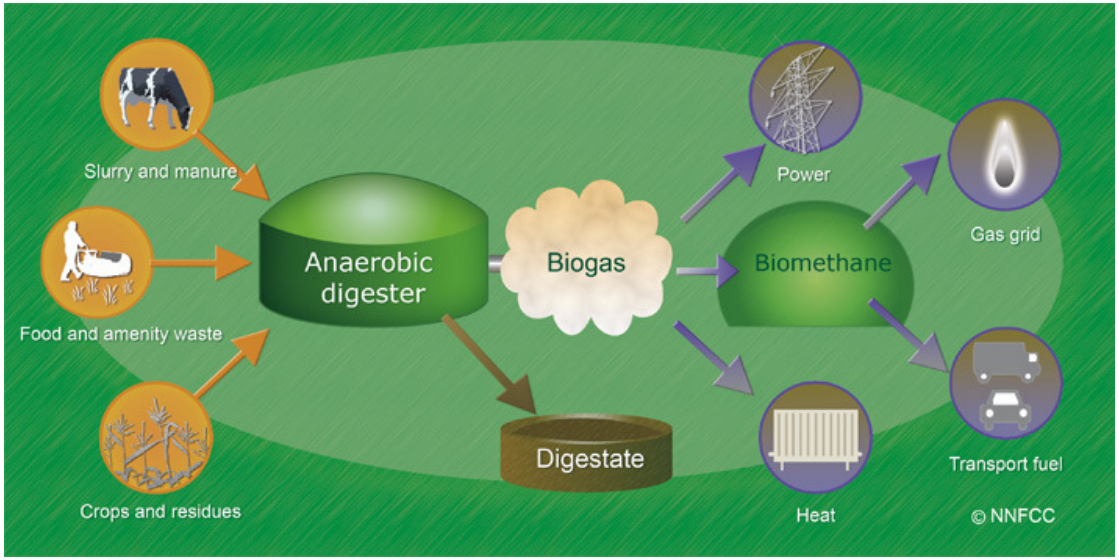
- Emissions and fly ash are a health concern
- Plants can be difficult to control. Breaches occur
- Said to 'suppress recycling'
- *'Waste is a resource so why would we want to burn it? Plastics are one of the key ingredients for generating the burn in an incinerator and plastic comes from oil which is a finite resource.'*
- Visual amenity and traffic issues are raised
- The debate tends to move to political outrage rather than rational assessment of the risks and benefits

MBT covers a range of hybrid processes that combine mechanical and biological processes to prepare, separate and convert mixed waste to useful products

Processes	Products
• Shredders, ball mills • Screens (static or vibrating) • Trommels, separators • Magnets, eddy current motors • Hand picking • Air classifying, NIR spectroscopy • Aerobic composting (open window, in-hall, tunnel, vessel) • Anaerobic digestion • Driers, pelletisers • Combustion, generation	• Ferrous metals • Non-ferrous metals • Glass * • Paper • Plastics * • Biogas • Compost, soil improver • Solid fuel (pellets) • Bio-stabilised output to landfill • Heat and electricity ** better separated by householders*

Upper: Inside the sorting hall of Cambridgeshire's Waterbeach Mechanical Biological Treatment facility. Credit: Cambridgeshire County Council
Lower: Inside the aerobic composting hall of the Waterbeach Mechanical Biological Treatment facility. Credit: Amey Cespa

Biogas is produced by anaerobic microbial digestion



Biogas composition	
Methane CH_4	50–75%
Carbon dioxide CO_2	25–50%
Nitrogen N_2	0–10%
Hydrogen H_2	0–1%
Hydrogen sulphide H_2S	0–3%
Oxygen O_2	~ 0%
Water vapour	saturated
Ammonia, carbon monoxide CO, silanes, non-methane organic compounds (NMOCs)	low

Upper: Biomass anaerobic digestion process outline Credit: NNFCC
Lower: AD Plant at Gask Farm, Turriff, Aberdeenshire operating on farm slurry, abattoir waste, fish waste and CAT3 material Credit: John Rennie & Sons / Renewable Energy Association
http://www.biogas.org.uk/plants/biogask-gask-farm

AD can consume a variety of feedstocks: commercial waste, farm waste and sewage

Feedstocks

Waste-fed

- Garden waste (dry AD only)
- Fish waste
- Manufacturing waste liquors & washings
- Out of specification fruit and vegetables

Farm-fed

- Cattle slurries & manures
- Poultry litter
- Pig slurries & manures
- Purpose grown crops (e.g. grass or maize silage)
- Whole crop silage
- Fodder beet

Sewage

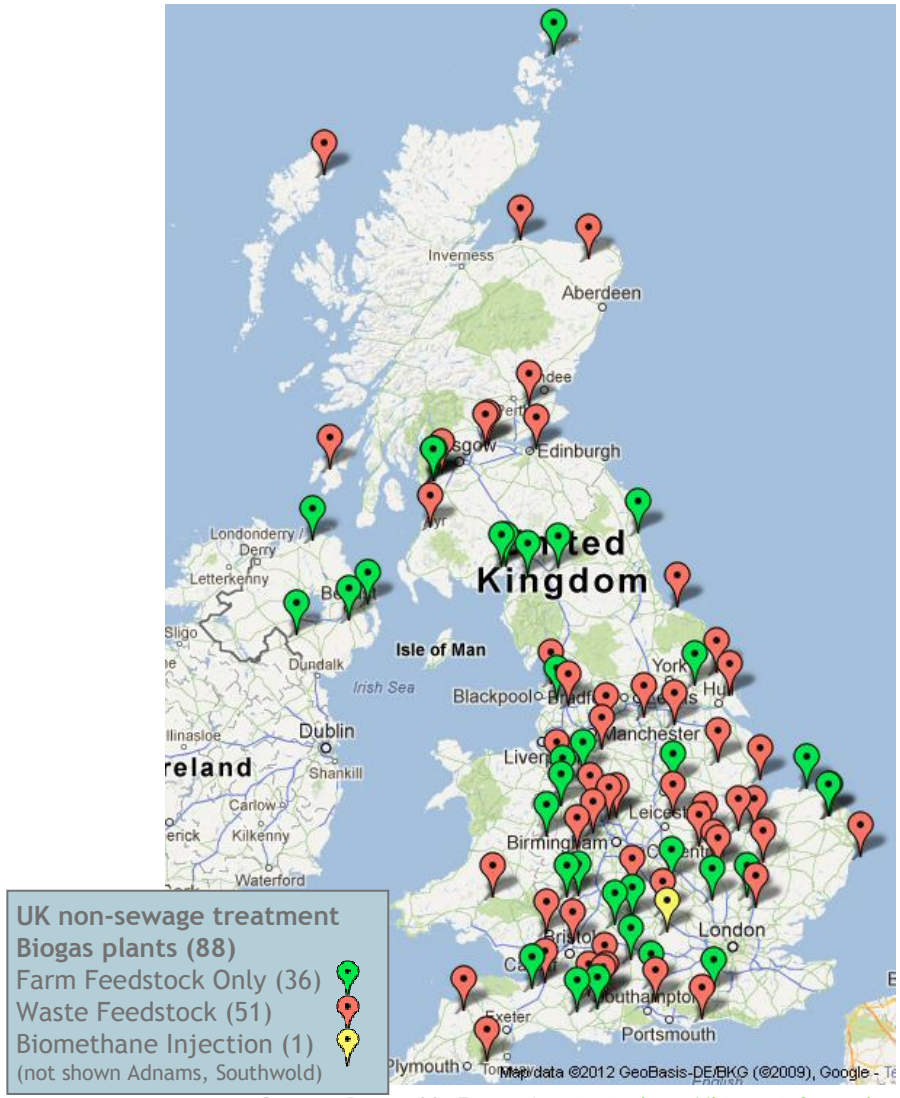
Processes

- Feedstock storage and preparation
- [Pasteurisation]
- Anaerobic Digestion
  - Hydrolysis
  - Acidogenesis
  - Acetogenesis
  - Methanogenesis
- [Pasteurisation]
- Storage of digestate
- Biogas purification for mains *or* combustion to heat & electricity

Outputs

- Biogas
- Digestate
- Heat and electricity

- The UK has >233 AD plants
  - Grown from 214 since 30 Sept 2011
  - Sewage treatment AD plants: **146**
  - Waste Fed AD plants: **51**
  - Farm fed AD plants: **36**
  - Overall capacity to process > **5 million** tonnes of material pa
  - Total installed generating capacity >**170MW** electricity
  - Two plants inject biogas into the gas grid
- Germany has around 6,000 plants
- Smallholders in developing countries are using smaller less sophisticated plants for treatment of sewage, manure and plant waste to biogas and fertiliser or compost
- China built 6 million plants in 1970s



UK non-sewage treatment Biogas plants (88)
Farm Feedstock Only (36)
Waste Feedstock (51)
Biomethane Injection (1)
(not shown Adnams, Southwold)

Source: Renewable Energy Association http://biogas-info.co.uk

Risley 4 landfill site in Warrington, Cheshire Credit: Clarke Energy

12MW generator plant at Shanks' Calvert Landfill Site near Milton Keynes Credit: Clarke Energy

Landfill gas collection pipeline at Summerston Credit: ESRU Strathclyde University

Landfill gas engine and generator at Endersby, Leics. Credit: Martin Bond/Science Photo Library

Waste vegetable oil can be converted to biodiesel

- Vegetable oil can be converted to biodiesel fuel, or used for heating instead of gasoil
- The process most widely used is transesterification using methanol (CH_3OH) and sodium hydroxide (NaOH)
- Waste cooking oil is now a sought-after commodity
- Demand for fuel exceeds the global supply of vegetable oils (primarily produced as foodstuffs) and vastly exceeds the supply of waste vegetable oils

TT400A biodiesel processor Credit: Goat Industries
www.vegetableoildiesel.co.uk/TT400A.html

The EPR Ely Ltd 36MWe straw fired power station was the largest straw fired power station in the world when built in 2000

EPR Ely Ltd 36MWe straw fired power station Credit: Fichtner

Iceni Energy Snetterton 40MW Biomass Plant

Eco2 Ltd 40MW straw powered renewable energy plant near Brigg, Lincolnshire

Eco2 Ltd 40MW straw powered renewable energy plant near Mendlesham, Suffolk

Credit: Upper and lower left: James S Peck, PX Farms Ltd (www.pxfarms.com)

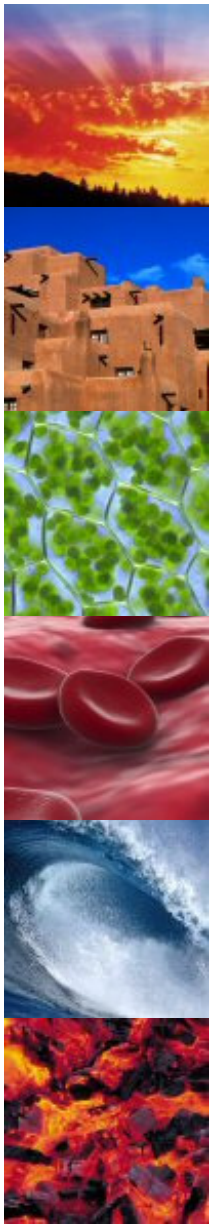
Credit: Lower right: BBC News 14 December 2011

HDG Navora 25kW log boiler installed near Cambridge Credit: Futureneering

Locally sourced log fuel is labour intensive to prepare and bulky to store Credit: Futureneering

Energy recovery from waste can be an attractive proposition, but opportunities are limited and can be challenging to exploit

- Free material is not free energy! Capex and opex are substantial. Free in the field is not free at the generating plant
- Energy recovery is a low value use of material (though better than landfill), but recycling is also difficult, costly and may only produce low value materials
- The decision is complex, and is economic and political as much as technical
- There is a limited amount of (cheap) material available
- Waste materials become valuable commodities as soon as a use is found for them
- Government policies and incentives can change the business case overnight
- Plants tend to be complex. It can be tricky to maintain optimum operation
- Simple pure feedstocks are easier to process, but the ability to process diverse feedstock protects against intermittent supply and cost fluctuations
- Distance adds to costs, favouring smaller local plants, limiting economies of scale
- Storage may be needed, if availability is seasonal or intermittent, and adds cost



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Futureneering is an advisory business assisting emerging technology ventures with strategy and commercialisation

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