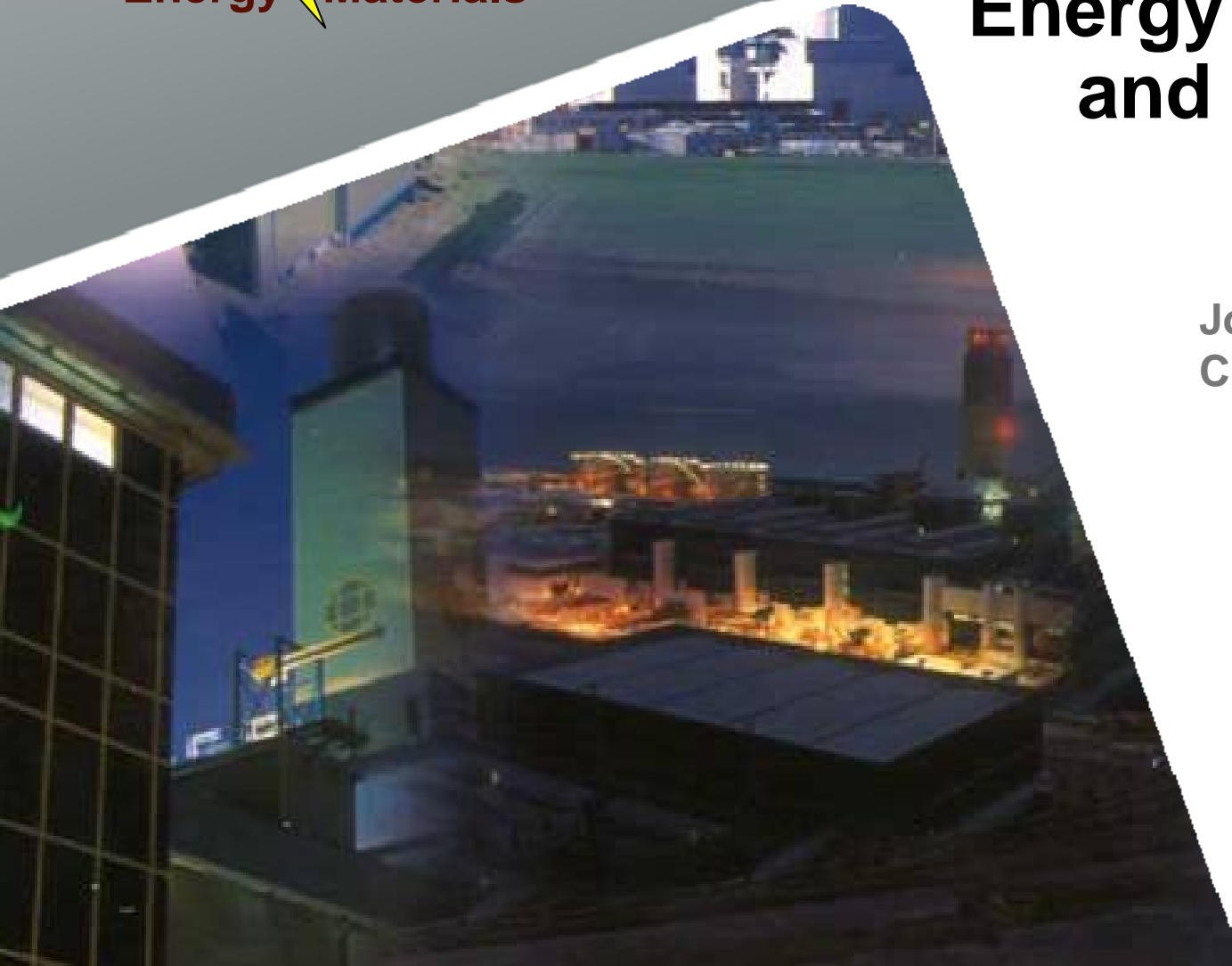




Energy  Materials

# Energy from Waste and Biomass

John Oakey  
Cranfield University

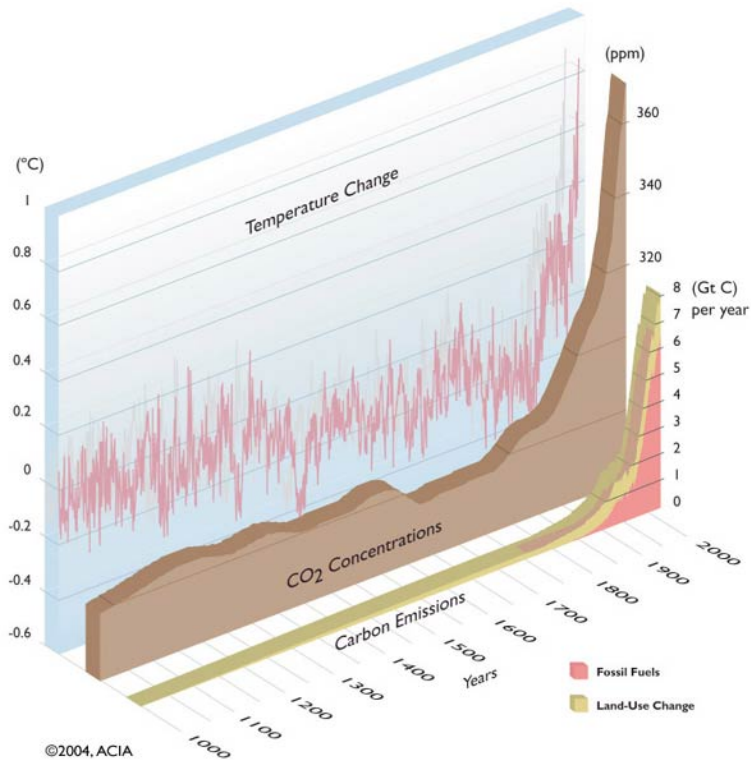


# Summary

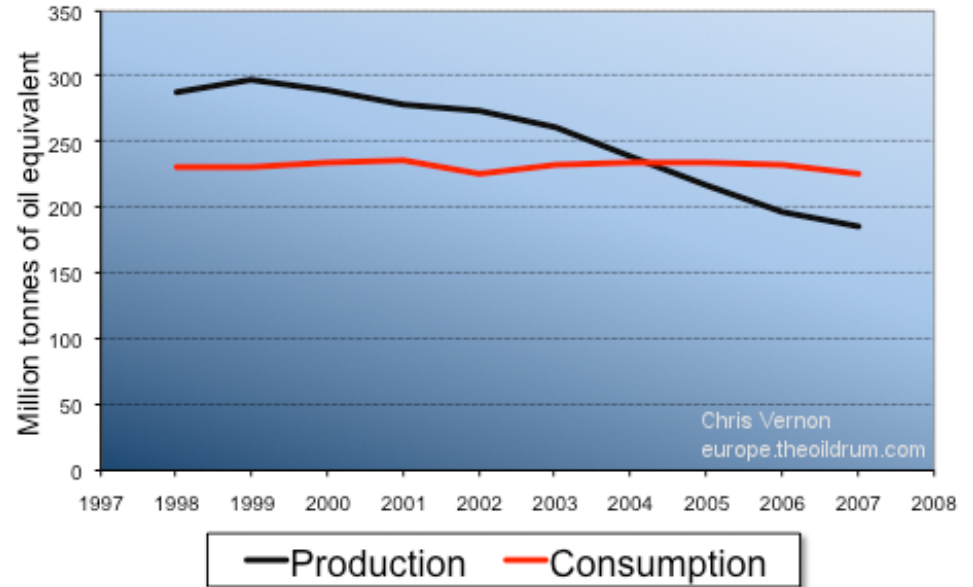
- UK Context
- The Opportunity
- Technology Options
- UK Market
- R&D Challenges
- Conclusions



# UK Context



## UK Indigenous Energy Production and Consumption

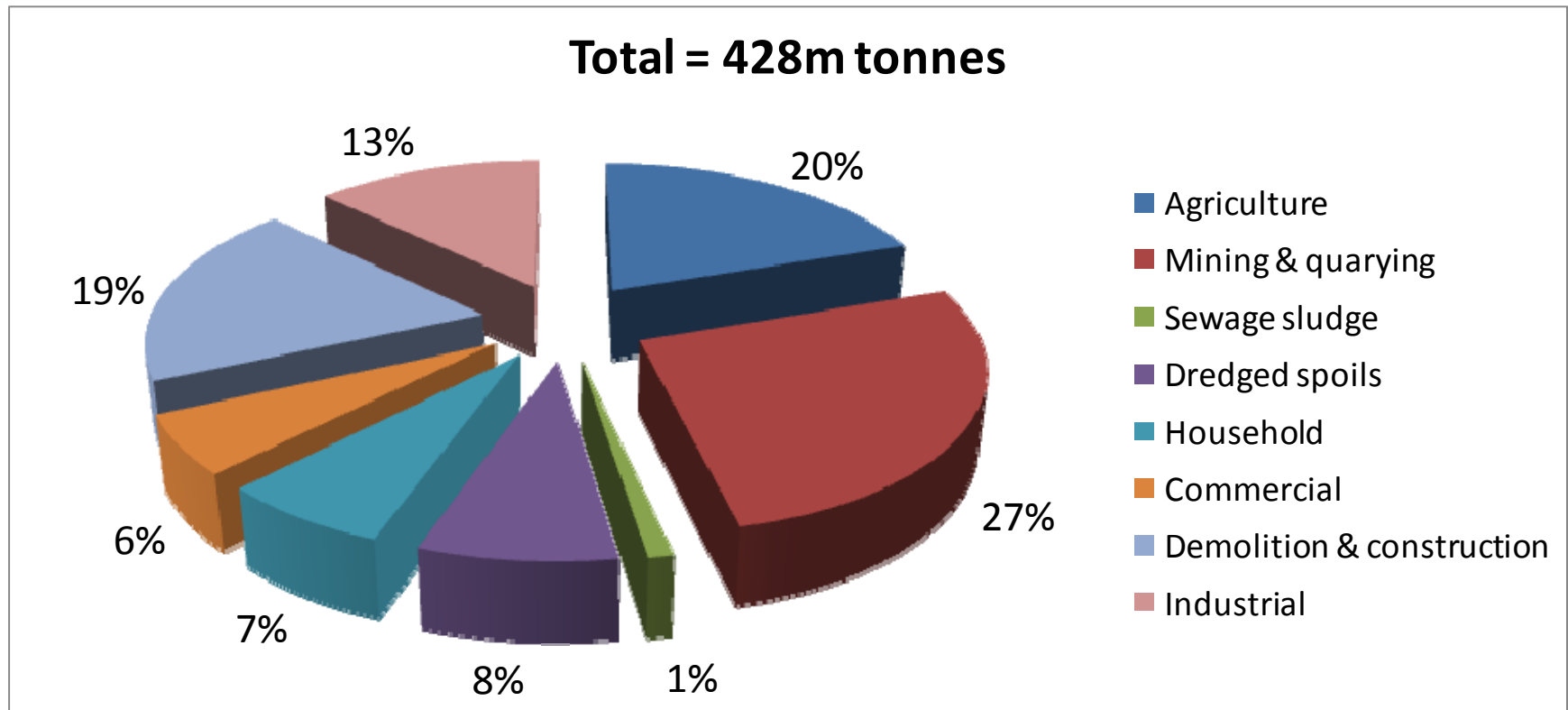


- “...we now face two immense challenges as a country – energy security and climate change...”
- we will soon be net importers of oil [and] ...gas at a time when global demand and prices are increasing
- [more importantly] ...is the impact that our sources and use of energy are having on our planet.

(BERR, 2006)

- Energy security
- Cost efficient waste disposal
- Climate change

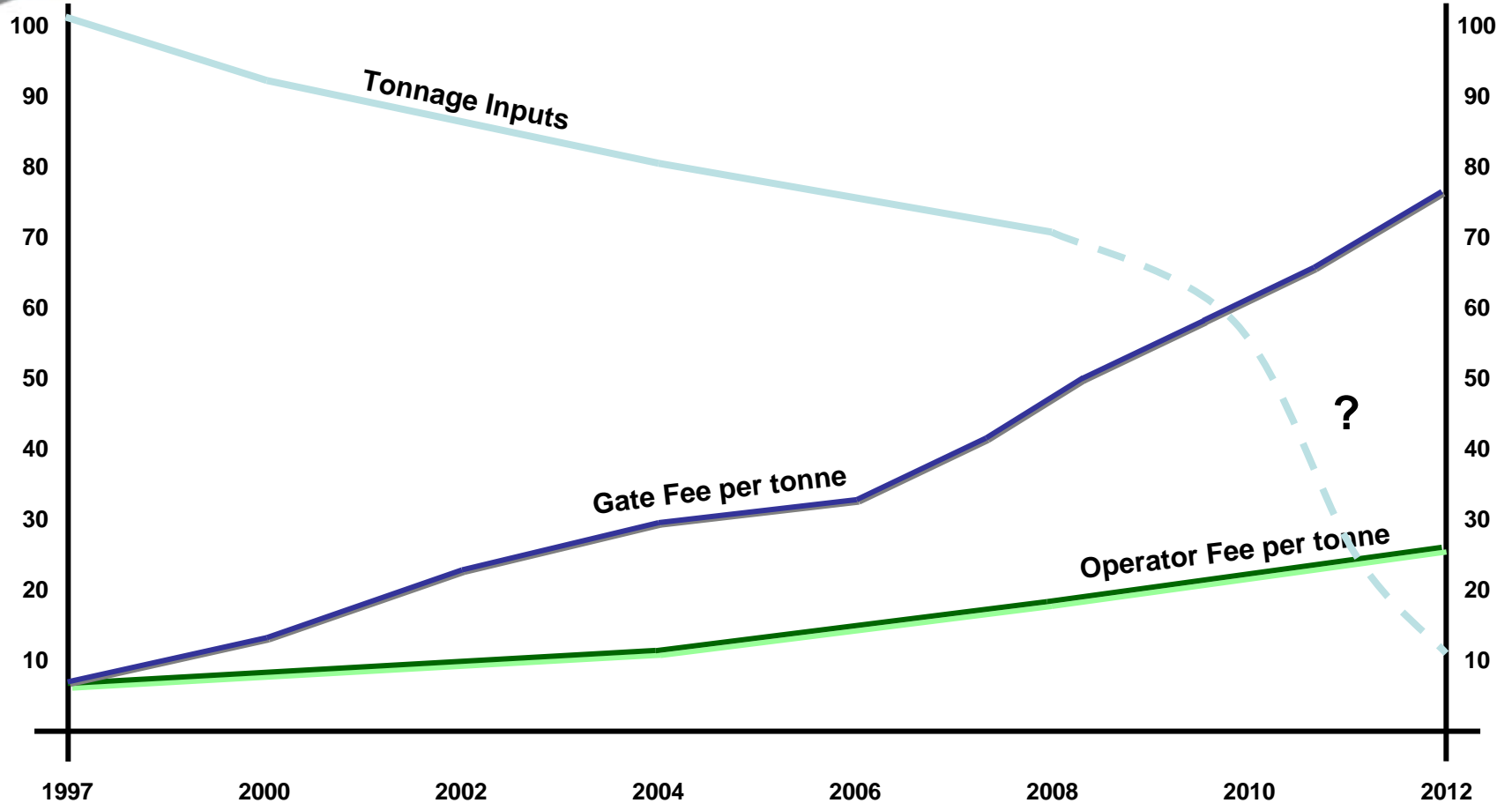
# Waste – a key loss of resource & cost to the UK



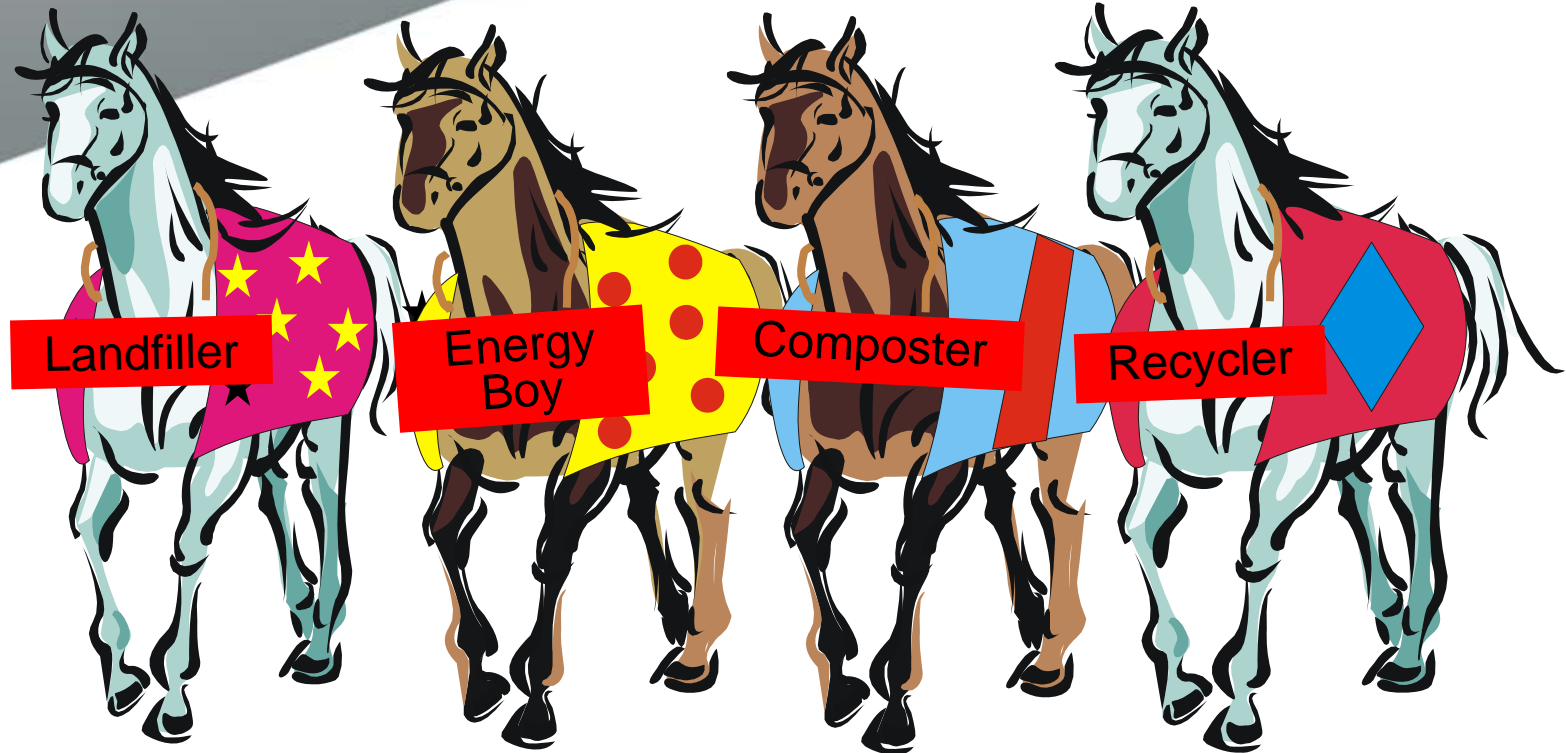
# Timing the Landfill Transition 2007

Tonnes to Landfill  
(millions)

£ Gate  
Fee



# Options for Waste – the runners



Landfiller

Energy  
Boy

Composter

Recycler

## Form

Long term

- Handicaps
- Planning Consents
- Taxes
- Better odds elsewhere

**Early  
Faller**

- Traded Permits
- Renewable targets
- Import dependency on rivals
- Rising logistics costs
- High value prizes
- Improving technology

**Expensive  
Thoroughbred  
Regular Winner**

- Low value prizes
- Staying power
- Plenty of local runners
- Cheap setup
- Soils directive
- Low distribution costs

**Stayer**

- EU targets
- Energy trends
- High value prizes
- Traded Permits
- Producer reuse

**Good Value  
All Rounder**

# The Opportunity

**To offset 34 million tonnes of carbon from fossil fuel sources by implementing advanced energy from waste/biomass technologies.**

# Technology Options - examples

## Sheffield Distributed Energy Scheme

Source: Veolia



ENERGOS

Isle of Wight Gasification Waste to Energy Plant

Bedfordia Biogen Plant, Milton Ernest

Source: BIOGEN



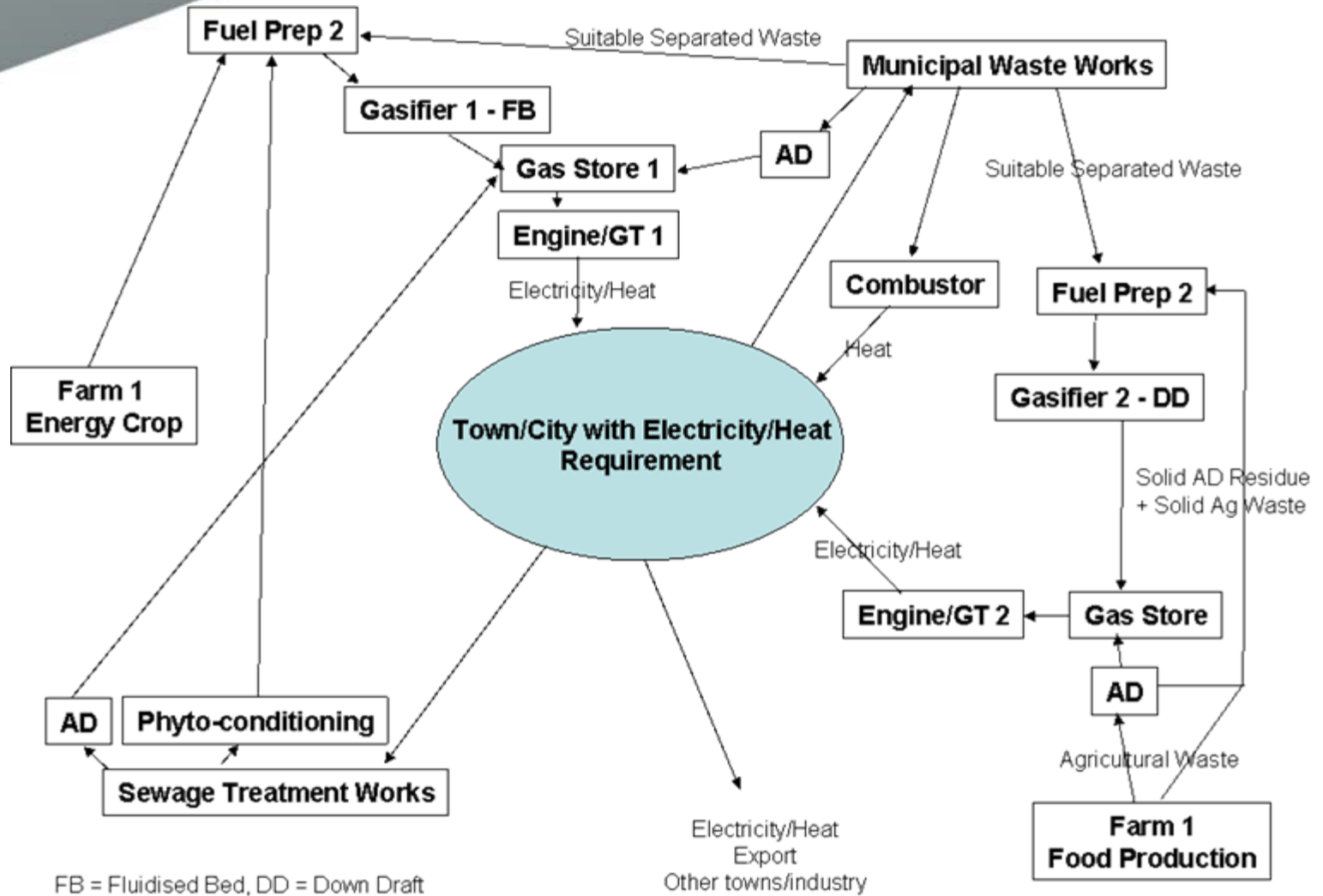
Source: Severn Trent Water



Typical Sewage Works Digestion Plants



# Why hasn't EfW developed? What is needed?



# Energy From Waste Potential Market

*Based on the latest available waste arisings data from DEFRA the following table demonstrates the potential EfW market for different technologies in the UK.*

	<b>Number Of New Plants Needed</b>	<b>Potential Annual Market</b>	<b>Total Capital Outlay</b>
<b><i>Biological Anaerobic Digestion</i></b>	<b>288</b>	<b>£400M</b>	<b>£1.44 Billion</b>
<b><i>Gasification/Pyrolysis &amp; Conventional Mass Burn Incineration "Technology Mix".</i></b>	<b>180</b>	<b>£1.57 Billion</b>	<b>£13.6 Billion</b>
<b><i>Total Biological &amp; Thermal Treatment</i></b>	<b>468</b>	<b>£1.97 Billion</b>	<b>£15.04 Billion</b>

# Technology Needs & Priorities for Innovation (Near market & 2020)

- Adaptability of plants for varying calorific value of inputs – including plant design software
- Easier test to demonstrate to *ofgem* the biomass content of waste used to claim for ROCs
- Carbon foot printing of different waste treatment options
- All technologies would improve from research on waste composition and the development of more rapid sampling tests, including chemical analysis and biodegradability testing.
- More innovative techniques and technologies to break down the artificial divide between MSW and C&I waste treatment, looking at integrated facilities
- Better technology transfer from Europe

**To deliver higher plant efficiencies, reduced emissions and cost effective plants, improved materials/protective coatings, maintenance & repair strategies and life assessment/modelling methods are needed for the following**

- Superheaters and other heat transfer equipment
- Condensing economisers
- Co-firing of waste/biomass-derived gases in existing plants
- Combustion engines & gas turbines

A key issue is reliability with variable waste-derived fuels

**Materials UK**  
Owned by the materials community

**Energy  Materials**

# Energy from Waste Technology Roadmap

2007

2013

2020

## Market Drivers

### Legislation and regulation:

- Directives and taxes to reduce in landfill
- Controlling content of landfill
- Controlling the incineration of waste & emissions
- Pollution prevention and control
- Renewable energy/low carbon targets and controls

Increased waste creation & increased calorific value of waste

Decreased availability of landfill

Increased costs of landfill and handling waste

Increasing environmental concerns

### Public perception:

- Desire for less waste & landfill vs. objections to incineration
- Potential backlash against recycling & separation of waste

Increased demand for 'green' energy from consumers

Increased industrial demand for secure, stable and low cost energy

Localisation: Waste & energy supply managed locally

Increased demand for electricity:  
• Population growth  
• Business demand

### Climate change:

- The need to produce energy with the lowest carbon impact
- Increased carbon & resource life-cycle management
- Increased use nuclear energy & other non-hydrocarbon based energy sources
- Implementation of alternative fuel sources & energy storage e.g. hydrogen economy, methane, liquid fuels e.g. syngas

Energy costs

Energy security: The need for national sources of energy

Cultural shift: Waste as a valuable resource  
Market for 'waste' & its associated products

Legislation & regulation based on:  
• Low carbon energy targets  
• Recovery & re-use of resources  
• Alternative fuel & energy sources

Localisation: Domestic scale EFW systems

## Target

...to offset 34 million tonnes of carbon from fossil fuel sources by implementing energy from waste technologies.

## Technology

### Key point:

Most relevant technologies exist and are in use in other parts of Europe but are **NOT** applied in the UK. There are incremental technology improvements to be made.

N.B. the technologies are shown in terms of the process cycle of EFW rather than as a time-line i.e. inputs, processing, outputs, energy generation/storage

Improved waste separation technologies vs. Technologies able to deal with mixed & variable inputs

Waste supply management & logistics  
• Waste sampling metrics & protocols  
• calorific value determination

EFW plants that can take variable calorific value inputs

Ability to optimise plant for variable inputs – type of waste and volumes

Improved plant efficiency:  
• Anaerobic processes  
• Mass Burn Processes  
• Heat to electricity

Integration of different EFW technologies e.g.  
• Anaerobic & gasification  
• Bio-processing & mass burn treatments

Increased reliability - increased plant life-time & reduction in down-time

Heat recovery & use  
Electricity generation

Efficient extraction and storage of refuse derived fuels – solids &/or gases - fuel cells, liquid cells etc.

Non-fuel residue/by-product recovery, clean-up & use, e.g. extraction of high-value products

EFW plants that can take mixed waste i.e. domestic, industrial, agricultural, sewerage

Small scale EFW systems for domestic use

Multi-fuel waste into current power stations

Improved resource life-cycle & carbon cycle knowledge

## R&D Priorities

Identify Best Practice implementation of EFW processes in other countries

Knowledge-based engineering to understand process efficiency optimisation for single & variable inputs

Waste sampling to determine content & calorific value including chemical analysis and biogradability testing

(Cheap) technology for demonstrating output residue quality and finding uses for these creation of value added products

Improved understanding of less desirable outputs e.g. flue gas residues in Mass Burn Treatment

Low temperature electricity generation and power generation vs. fuels production

Well defined UK SRF standard

Evaluation of the carbon balance of the different EFW processes & life cycles and consistent carbon footprinting.

Improve understanding of resource flow in economy

Catalysis for conversion to liquid fuels and membrane separation techniques

Zero net - waste initiatives in all EFW plants

Pre treatment and co-digestion of wastes (including biomass and agricultural wastes)

Improved understanding of contaminant level possible for effective anaerobic digestion processes & underlying microbiology

Cost effective heat distribution and optimization of heat utilization

Corrosion & erosion resistant coatings for plant equipment

Plant design optimisation software

Scalability and modularity of installations

# Conclusions

- There is a strong national case for the increased development and deployment of sustainable energy from waste/biomass technologies
- The barriers to deployment are understood and are being addressed – but R&D challenges remain to meet the hopes of the stakeholders
- Continued R&D is required in a number of areas to deliver higher plant efficiencies, reduced emissions and cost effective plants including materials and manufacturing
- The UK market is estimated at nearly £2bn per annum, with the potential to offset 34mt Carbon emissions from fossil sources and delivering c. 15% of UK energy needs



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[www.cranfield.ac.uk/powergeneration](http://www.cranfield.ac.uk/powergeneration)

# Energy From Waste Potential Market

- Energy from waste market could grow to more than £2Bpa by 2025 with a capital investment over the next 15 years of £15B.
- Figures based on the assumption that 25% of food waste will go to Anaerobic Digestion and 33% of the rest of MSW and C & I waste will go for Thermal Treatment (66% Incineration and 33% Gasification/Pyrolysis).
- Conservative returns per tonne for AD, Incineration and Gasification/Pyrolysis of £70, £50 and £57 are assumed.



# Energy From Waste Drivers

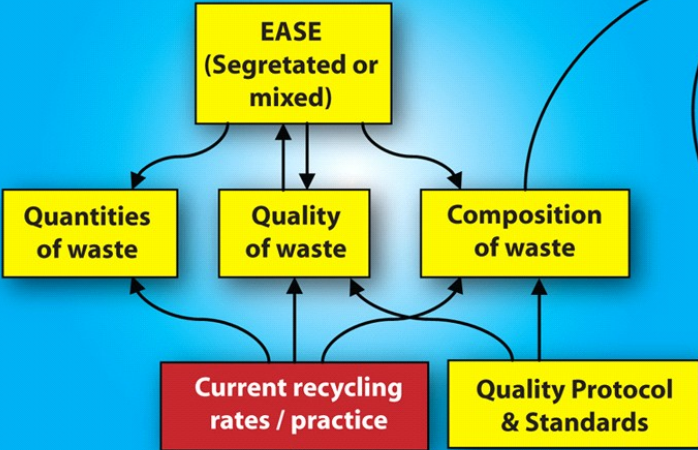
- Legislation/Policy
  - Landfill Directive,
  - Waste strategy review
  - Energy white paper
- Social / political/ economic
  - Fiscal incentive - Proposed double ROCs
  - Policy recognises energy-from-waste (EfW) as an integral part of the waste solution for UK

# Energy From Waste Barriers

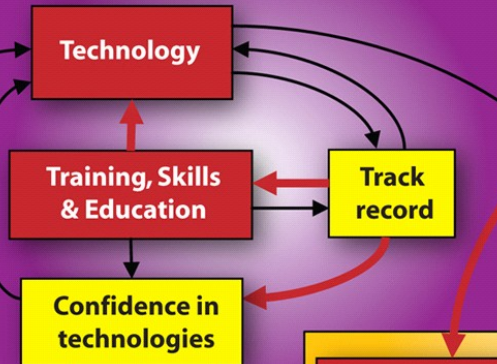
- Public perception of the health implications of mass burn incineration
- Green lobby view on the impact EfW will have on recycling rates
- Planning consent hurdles
- Lack of full scale gasification/pyrolysis and AD demonstration plants in UK
- Waste contracts – MSW vs. Industrial and Commercial i.e. long vs. short
- Public perception and acceptance of recycling schemes
- Skill shortage in waste technology
- Transportation of waste – vehicle movements

# Energy from Waste Systems Map

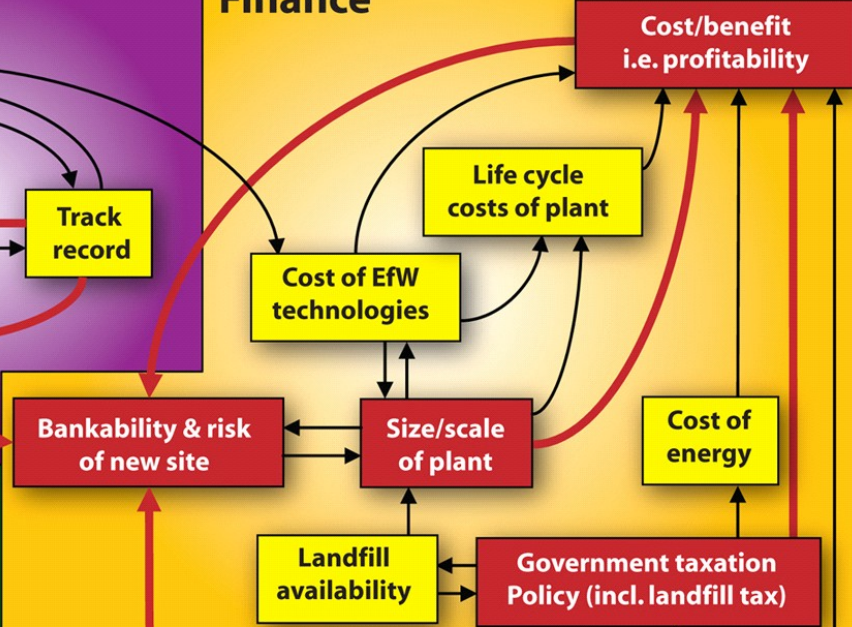
## Waste Inputs



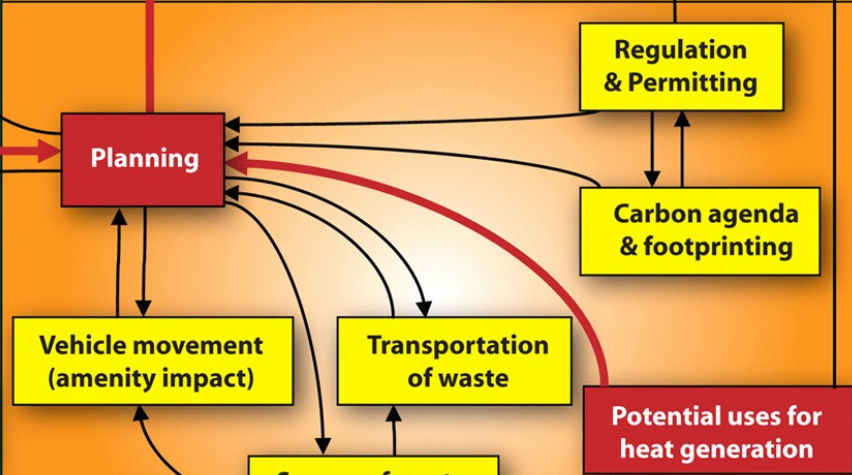
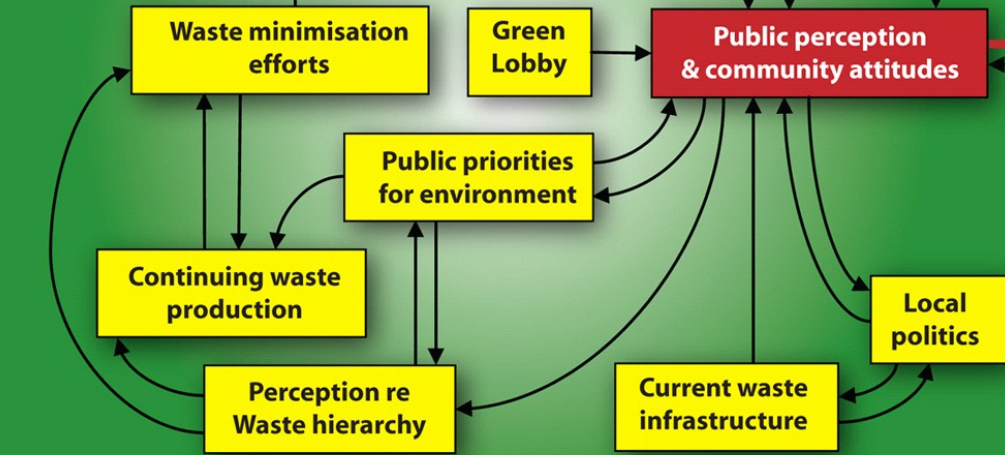
## Technology



## Finance



## Social



## Location & Outputs

# Key ROCs

## Recommendations from stakeholders



- Any guidance/standards must be clear, appropriate, achievable and not disproportionate (in time, effort and cost);
- Ofgem should work with stakeholders to establish acceptable and cost effective approaches to direct and indirect measurement. Evidence requirements must be reasonable and not overly onerous;
- An independent evaluation of the potential for existing and future direct and indirect measurement techniques would significantly benefit the community.
- An R&D programme for the development and evaluation of near-market, innovative advancements for direct and indirect measurement.
- If cost effective solutions to indirect measurement can be found and prove robust, then BERR/Ofgem should consider the evidence for extending indirect measurement beyond the 50% deeming level.
- Deeming 100% for AD, as long as no digestible fossil fuel derived substances are used, should act as an incentive for technology uptake.