Methane from Landfills and Ways to Reduce GHGs from Waste Management

Methane HACK : Strategies for Reducing Growth in Atmospheric Methane

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Overview

- What's in UK Landfills
- What do we know about methane generation?
- What do we know about methane emissions?
- How to reduce methane emissions from landfills
- Reducing GHGs from waste / resource management

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What's in Landfills?

- UK
  - 1945-2010
    - Estimated 6 billion tonnes waste landfilled
    - Estimated 3 billion tonnes not biodegradable (still there)
  - What does the waste currently landfilled look like?
    - Municipal — reasonably well characterised
    - Commercial — not much of a clue
    - Industrial — not much of a clue
  - What does the municipal waste landfilled look like pre 1990?
    - Not much of a clue

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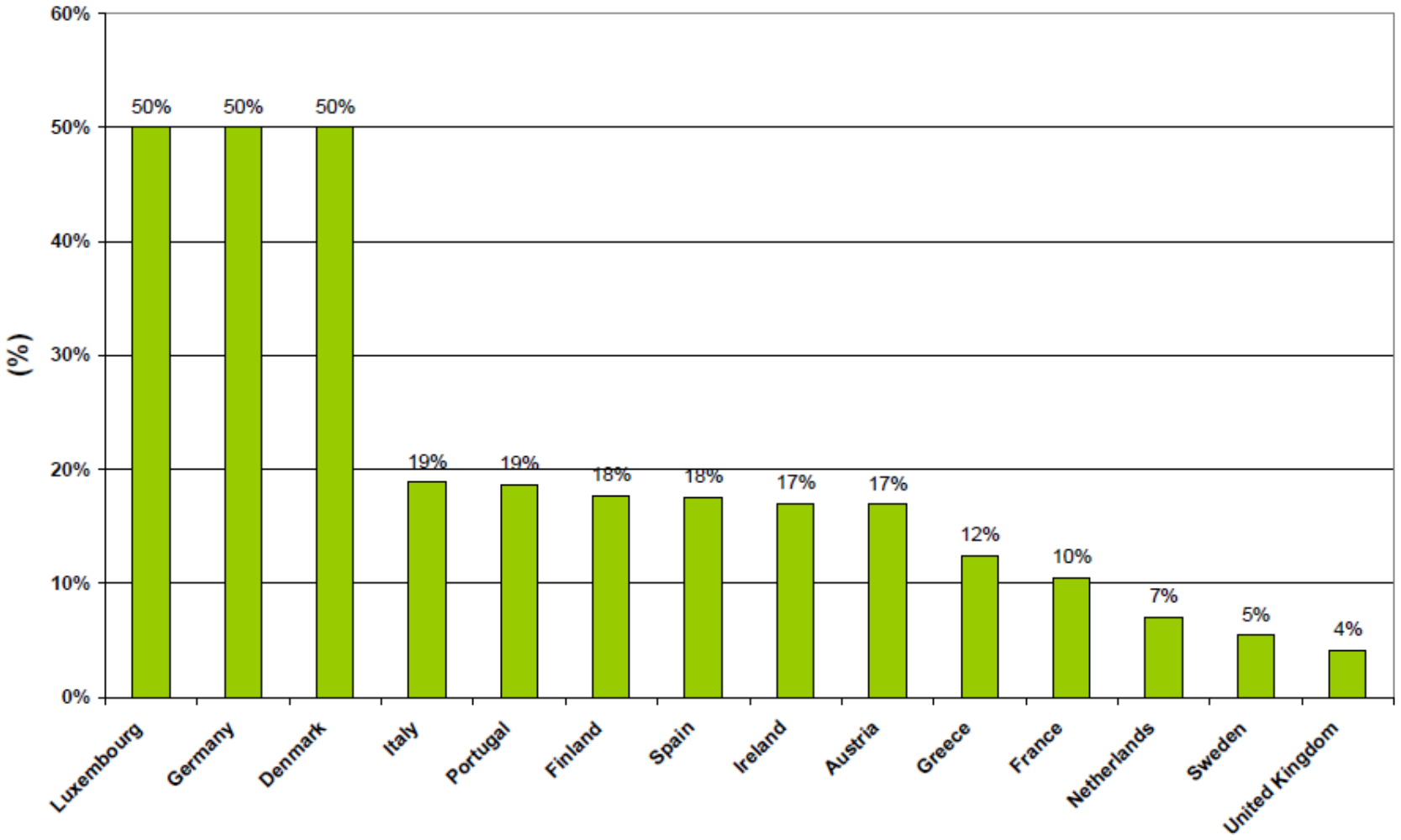
Methane Generation

- Methane is formed from the degradable organic carbon in the landfilled waste
- Most models and IPCC default are first order (exponential) decay models
  - How much of the organic carbon degrades from which material?
    - Total waste estimates
    - Waste specific approaches

Degradable Organic Carbon in MSW



Source: EEA (2011) Annual European Union Greenhouse Gas Inventory 1990-2009 and Inventory Report 2011, Technical Report No.2/2011.

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Methane Generation

- Are the biochemical characteristics the key determining factor?
  - Lignin, cellulose, hemi-cellulose, fats, proteins….
- Or, in landfills, is the extent to which the carbon degrades more facility specific? (….which is more important?)
  - Wet and dry spaces, better and worse conditions for degradation
- What is the decay rate? Approaches vary:
  - Different materials
  - Different biochemical constituents

Decay Rates

Model	Half life, Slowest (years)	Half life, Moderate (years)	Half life, Fastest (years)	Country
IPCC	12-23	7	4	MSW Europe
TNO		7		HHW NL
Gas-Sim	15	9	6	HHW UK
Landgem		14 (non-arid)		MSW USA
Afvalzorg	23	7	3	HHW NL
E-PRTR (France)		10		HHW France
E-PRTR (Finland)	23	14	3.5	HHW Finland
Vogt et al (1997)		17		MSW California

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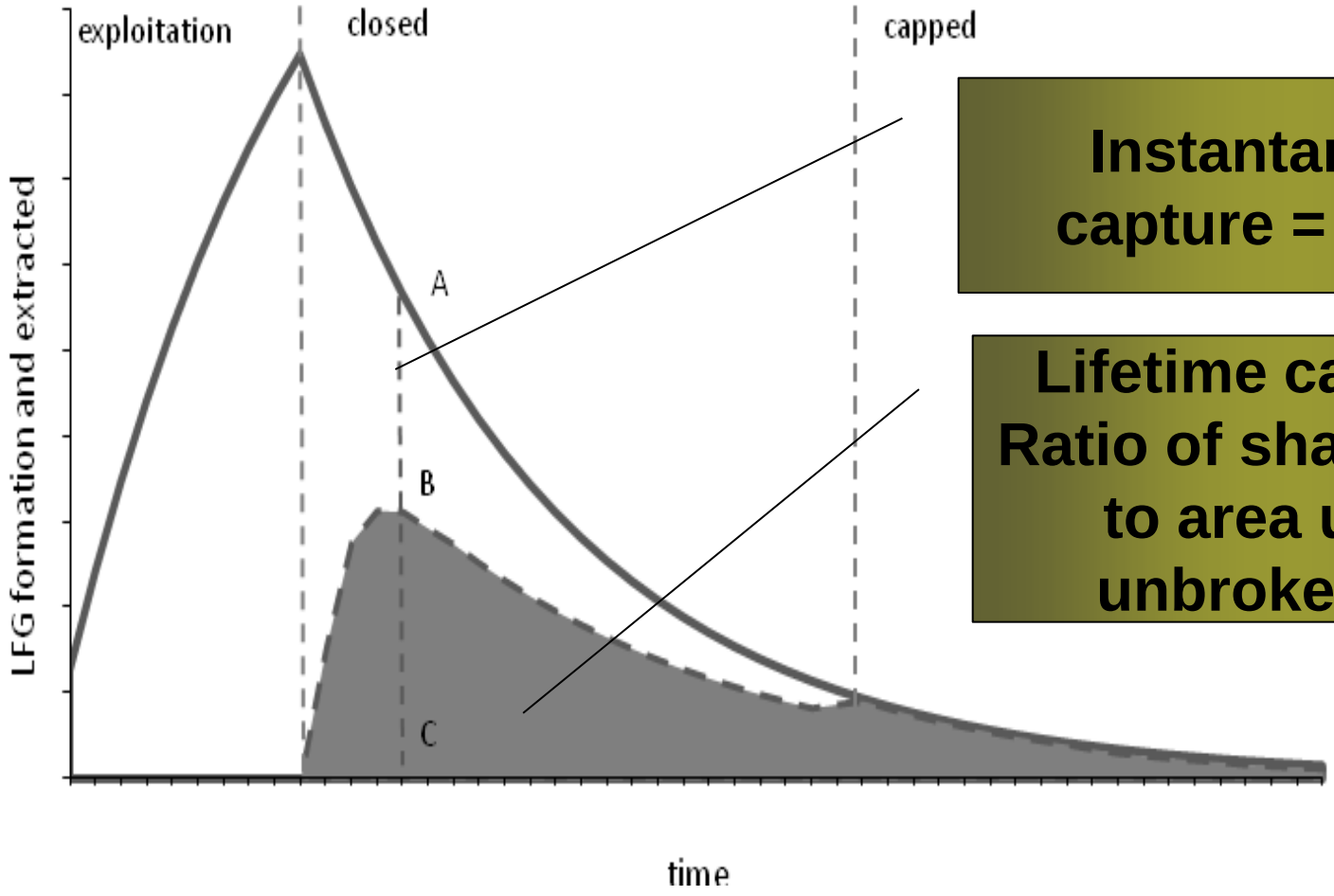
Methane Generation (cont.)

- How much carbon (and ammonia) degrades aerobically (producing only carbon dioxide)?
  - In transport
  - On landfill surface
- What happens over the very long-term?
  - Ingress of air?
  - More degradation of carbon?
  - A lower proportion of methane in relation to carbon dioxide in the resulting landfill gas?

Methane Emissions from Landfill

- Landfill emissions result from uncaptured and un-oxidised methane
- Gas capture rates are key (if 100%, then no problem)
- Many high gas capture figures in the literature
  - Tend to be post-operational phase (when capture is easier)
  - Tend to be based on flux-box methods (known to underestimate emissions)
  - NEED TO DISTINGUISH 'INSTANTANEOUS CAPTURE' FROM 'LIFETIME CAPTURE'

Methane Capture Rates



Instantaneous capture = BC/AC

Lifetime capture = Ratio of shaded area to area under unbroken line

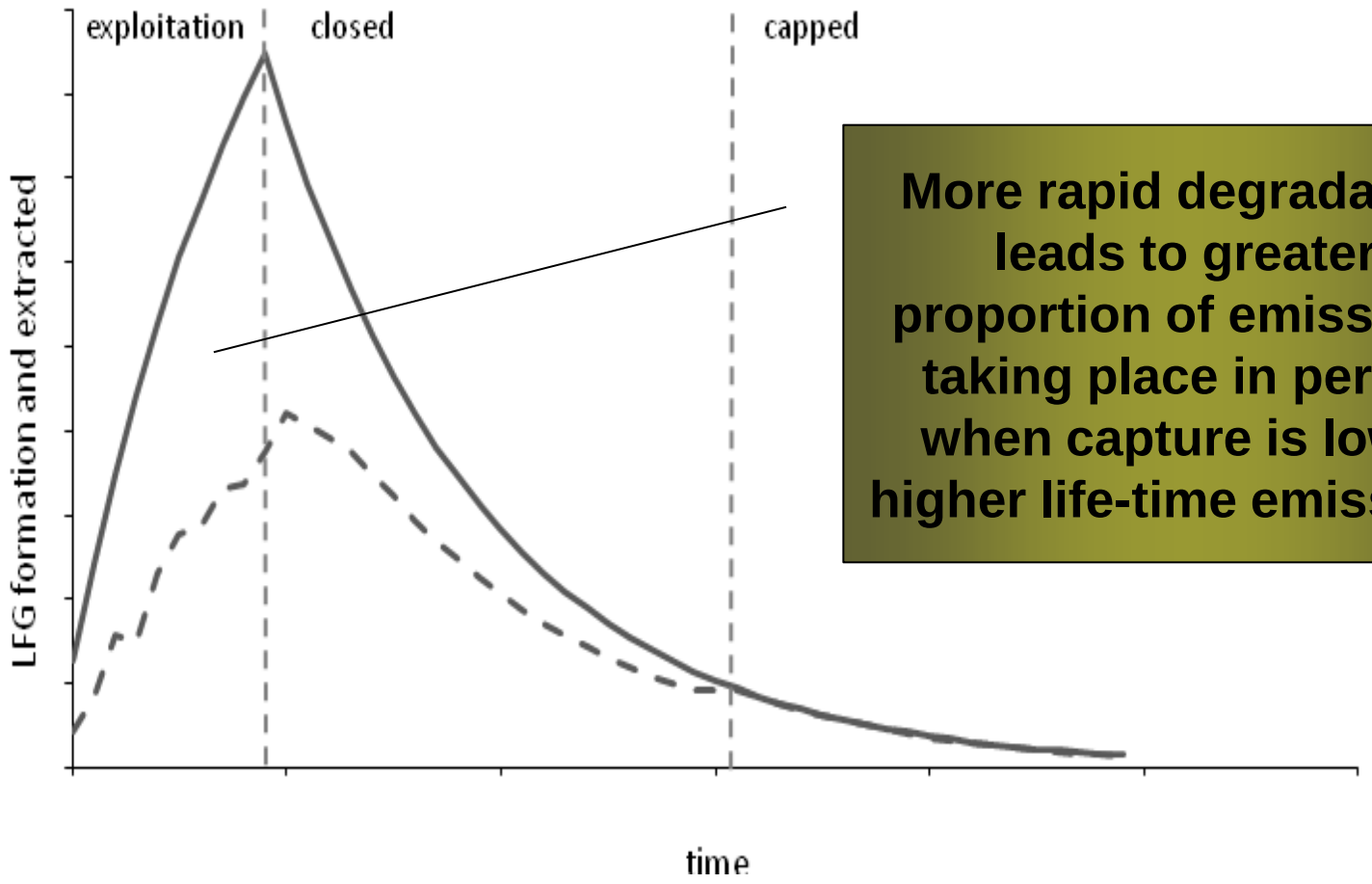
Source: Eunomia (2011) Inventory Improvement Project – UK Landfill Methane Emissions Model, Final Report to Defra and DECC, January 2011

Methane Emissions from Landfill

- Gas capture rates are key (if 100%, then no problem)

- Capture likely to vary by phase of operation
  - If different materials have different decay rates, then the lifetime capture will vary by material
- Measurement method used may also be expected to give different results

Methane Capture Rates



More rapid degradation leads to greater proportion of emissions taking place in period when capture is low – higher life-time emissions

Source: Eunomia (2011) Inventory Improvement Project – UK Landfill Methane Emissions Model, Final Report to Defra and DECC, January 2011

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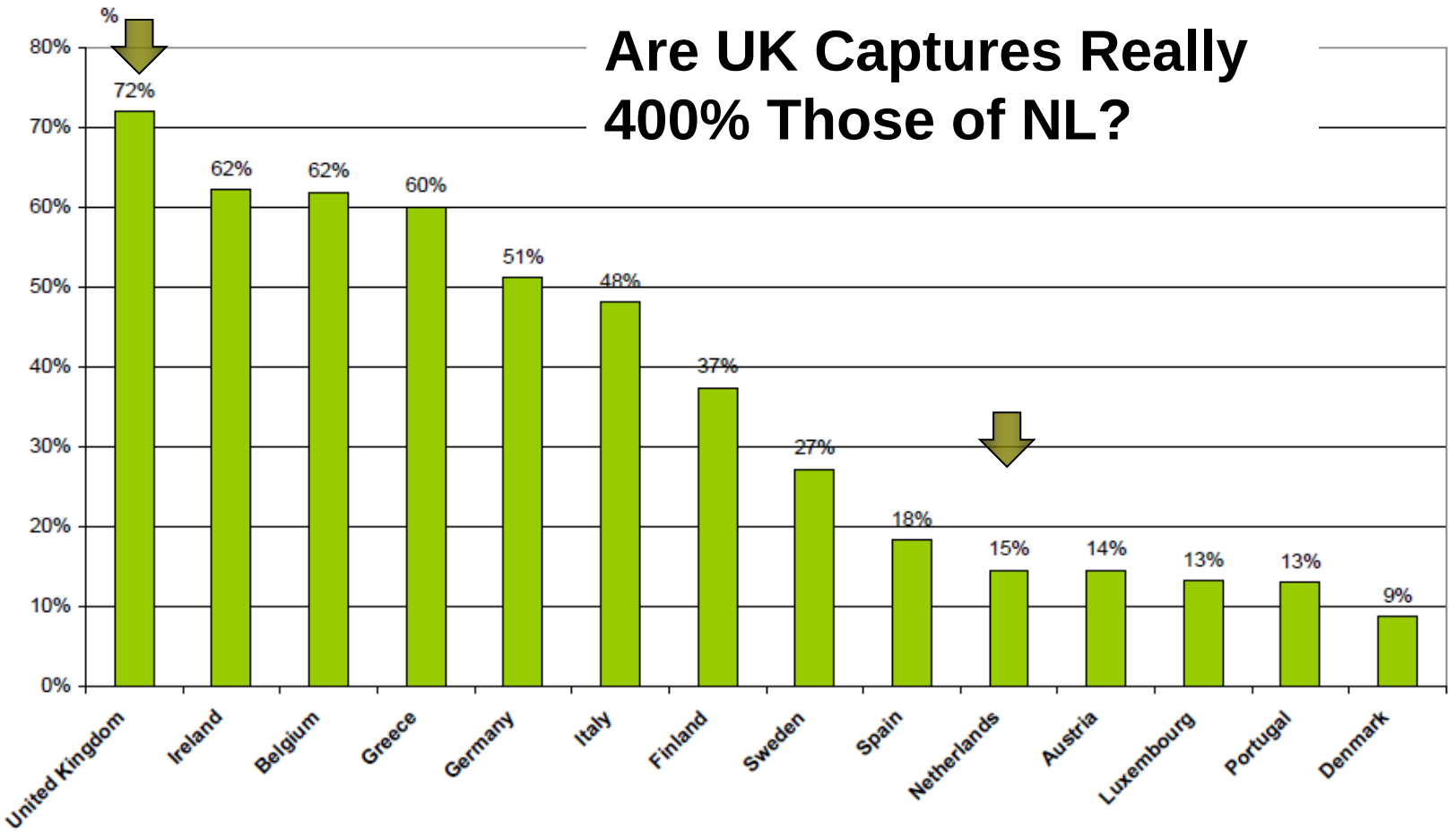
Methane Emissions from Landfill

- UK capture rate
  - Modelled generation (based on data discussed)
  - Based upon energy generated (methane content inferred)
  - Plus capacity for flaring (methane combustion estimated)
- Assumes
  - Generation estimate is accurate (it isn't)
  - Flaring estimate is accurate (it might not be)
- High gas capture over lifetime is difficult to justify
- Result: we don't have a really good handle on what is being emitted
- IPCC default – 20%
- Are EU landfills really operated so differently?

Methane Capture Rates



Are UK Captures Really 400% Those of NL?

*CH_4 recovery in% = CH_4recovery in Gg/ (CH_4 recovery in Gg + CH_4 emissions in Gg)*100*
Source: CRF 2011 Table 6A,C

Source: EEA (2011) Annual European Union Greenhouse Gas Inventory 1990-2009 and Inventory Report 2011, Technical Report No.2/2011.

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Reducing Emissions from Landfills

- Newer sites (waste already deposited)
  - Developing gas capture systems
- Old sites
  - (Gas capture)
  - Low calorific flares
  - Active cover layers (oxidation)
- Very old sites
  - 6 billion tonnes over a 65 year period in the UK
  - 3 billion non biodegradable
  - Landfill mining?

Waste Management - England

- *We will promote the use of life cycle thinking in all waste policy and waste management decisions and the reporting of waste management in carbon terms, as an alternative to weight-based measures.*

Reducing GHGs from Waste / Resource Management

- Prevent use of materials in the first place
  - Materials embody energy used to extract and manufacture them
  - Saving materials reduces energy use and other emissions
- Re-use
  - Extends life of products
  - Reduces materials use (and hence, emissions)
- Recycling
  - Substitution of primary materials by recycled ones
  - Differences in energy use / processes save energy (hence emissions)

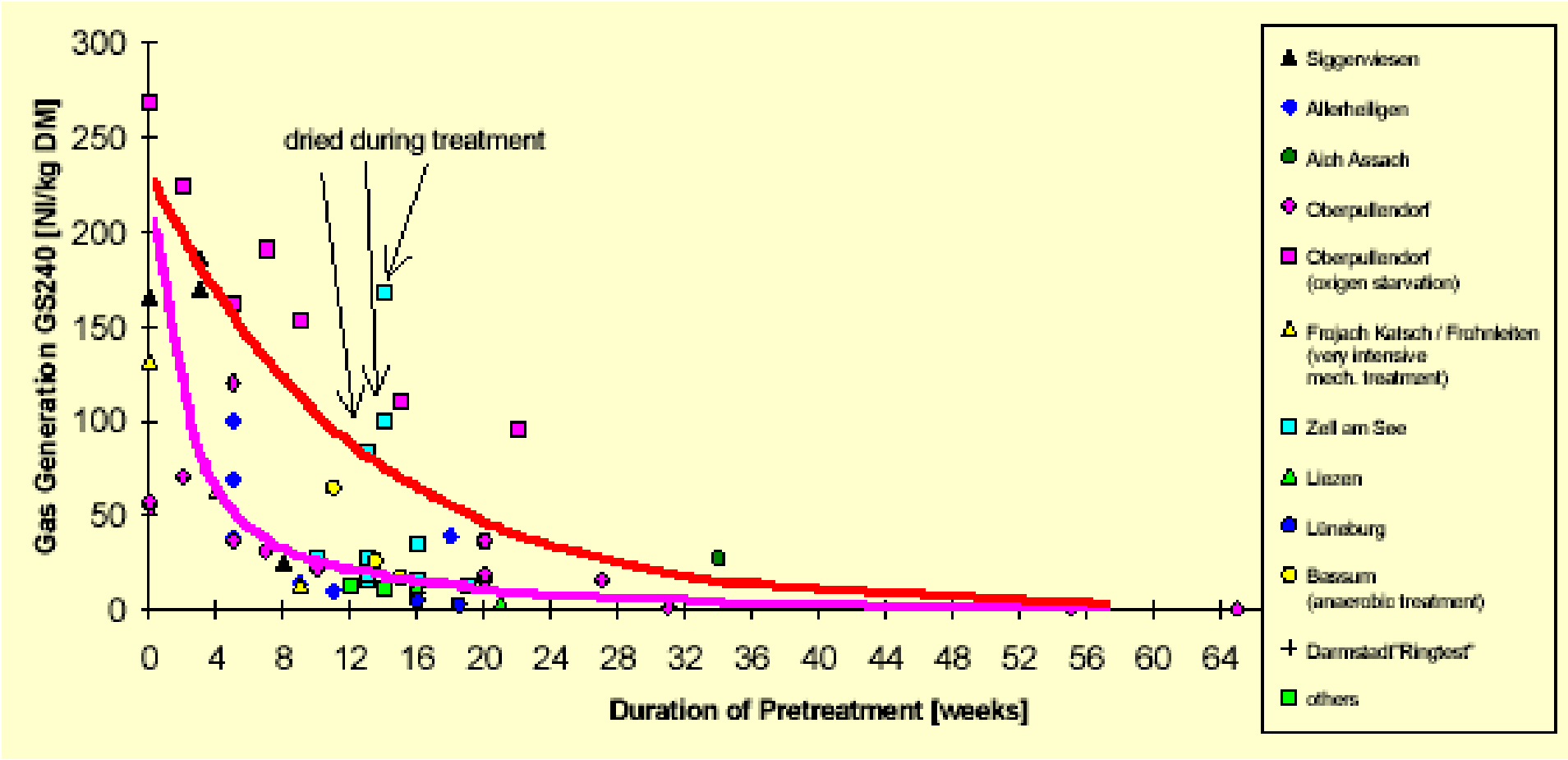
Waste Management - Scotland (Carbon metric)

	GHGs saved from recycling (tonnes CO_2 eq./tonne material)
Textiles	-13.77
Non-ferrous metal	-9.25
Ferrous metal	-1.70
WEEE	-1.36
Dense plastic	-1.17
Plastic film	-1.04
Wood	-0.43
Paper and card	-0.22
Glass	-0.20
Food waste	-0.16
Green waste	-0.04

Reducing GHGs from Waste / Resource Management

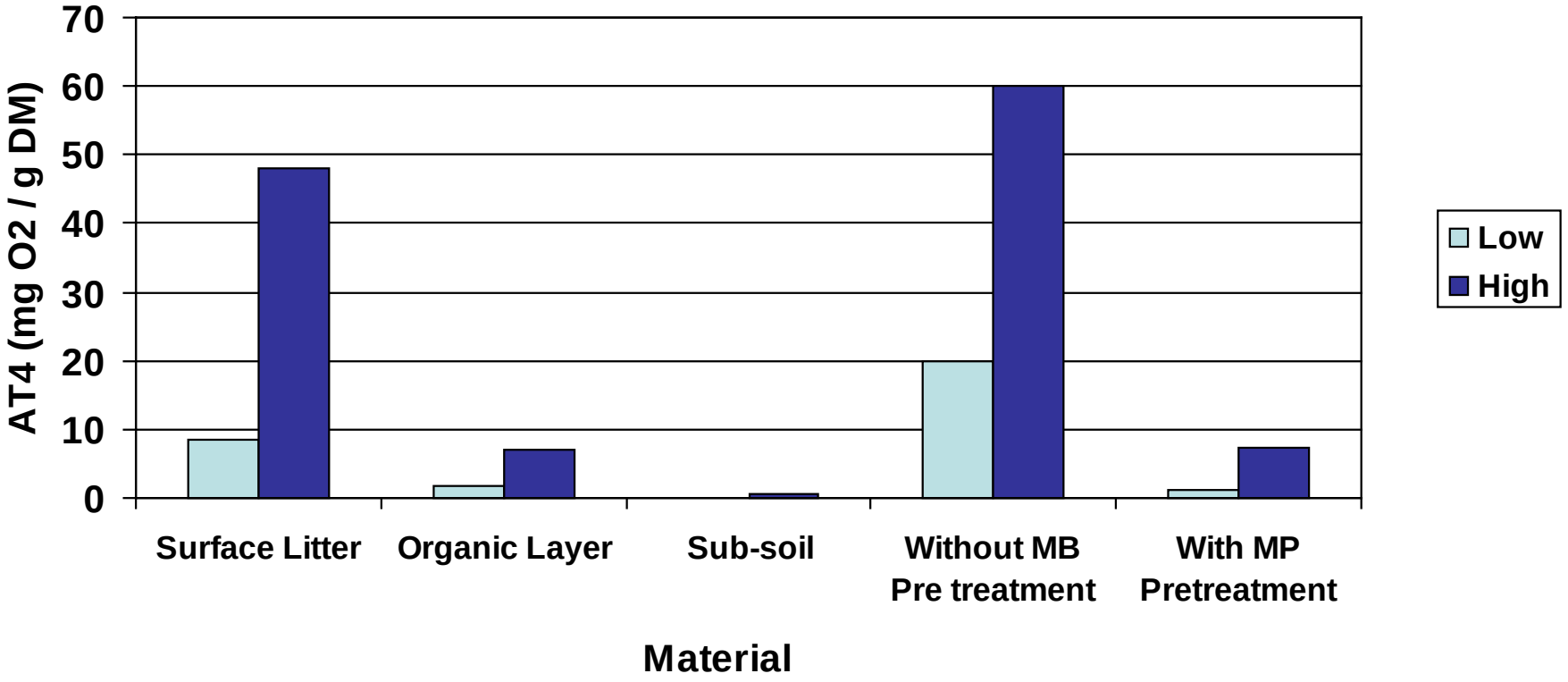
- Biological treatment
  - Composting / AD of source segregated waste
  - Minimal emission of uncaptured methane
  - Avoidance of synthetic fertilisers / soil improvers
- Residual waste management
  - Thermal treatment (but not suitable for wet wastes)
  - Biological pre-treatment to stabilise waste
    - Landfill in dedicated cells with active cover layers

Biological Pre-treatment



Source: Erwin Binner

Biological Pre-treatment



Source: K. Soyez and S. Plickert (2002) (Univ of Pottsdam)

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Closing Remarks

- Landfill has been our dominant management option…
- …But the list of unknowns is still long
- Capture rate information crucial
  - Studies of sites in different phases
  - Studies measuring not just what is collected …
  - … but designed to measure credibly what is not
- UK – 80% GHG reduction from waste
  - Follow the waste hierarchy
  - Achievement may be limited by content of plastics in thermally treated waste
  - High carbon content fuel converted at relatively low efficiencies, displacing lower C fossil fuel (e.g. gas)

References:

Eunomia (2008) *Development of Marginal Abatement Cost Curves for the Waste Sector*, Final Report to CCC, Defra and Environment Agency, December 2008

Eunomia (2011) *Inventory Improvement Project – UK Landfill Methane Emissions Model*, Final Report to Defra and DECC, January 2011

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