Sustainability of feedstocks for biomass cofiring

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Introduction

- Why co-fire?
  - Revenue/profit
  - Legislation & compliance
  - Environmental impact
    - Greenhouse gas reductions
    - Emission reductions
    - Renewable fuel supply
    - Sustainable fuel supply

Co-firing in the UK

- Co-firing of biomass with coal represented 20% of UK renewable electricity in 2008-9 – second largest technology category[1]
- Co-firing of biomass with coal was 11% of total renewables capacity in 2009[1]
- OFGEM collecting sustainability information since April 2009

1 OFGEM, Renewables Obligation annual report, 2008-9, Feb 2010)

Feedstocks in the UK

- Incomplete picture, but what is being cofired?
  - Wood (pellets)
  - Some energy crop (miscanthus)
  - Imported agricultural residues (Palm Kernel Expellant & olive cake)
- To what extent are these
  - Reducing greenhouse gases?
  - Renewable and Sustainable?

Greenhouse gas reductions

- Different methodologies which can give very different results
- Baseline comparator is very important
- European renewable electricity directive sets out a calculation methodology which could become standard

Renewable feedstocks

- Resource or stock (energy) reserve is renewed at a greater rate than that at which it is depleted

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Sustainability

- OED – avoiding depletion of natural resources
- Environmental sustainability - rates of consumption/depletion compared to stock reserves or rates of pollution/deposition compared to acceptable environmental limits

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Sustainbility 2

World Commission on Environment and Development (Bruntland, 1987):

- *Sustainable development meets the needs of the present generation without compromising the ability of future generations to meet their needs*
- 3 pillars/dimensions of sustainability with tension between these:
  - *Environmental (conservation)*
  - *Economic (growth)*
  - *Social (equity)*

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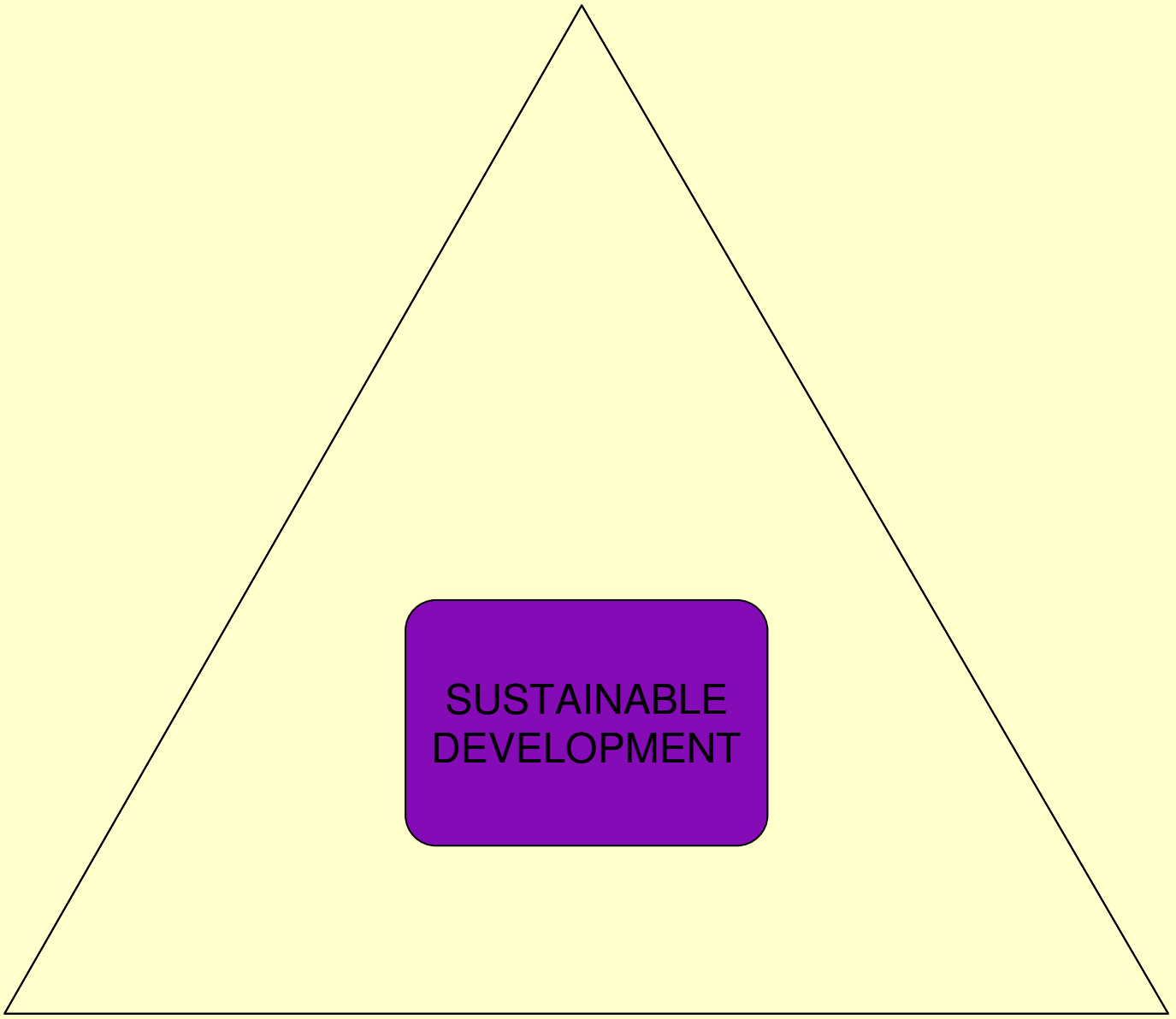

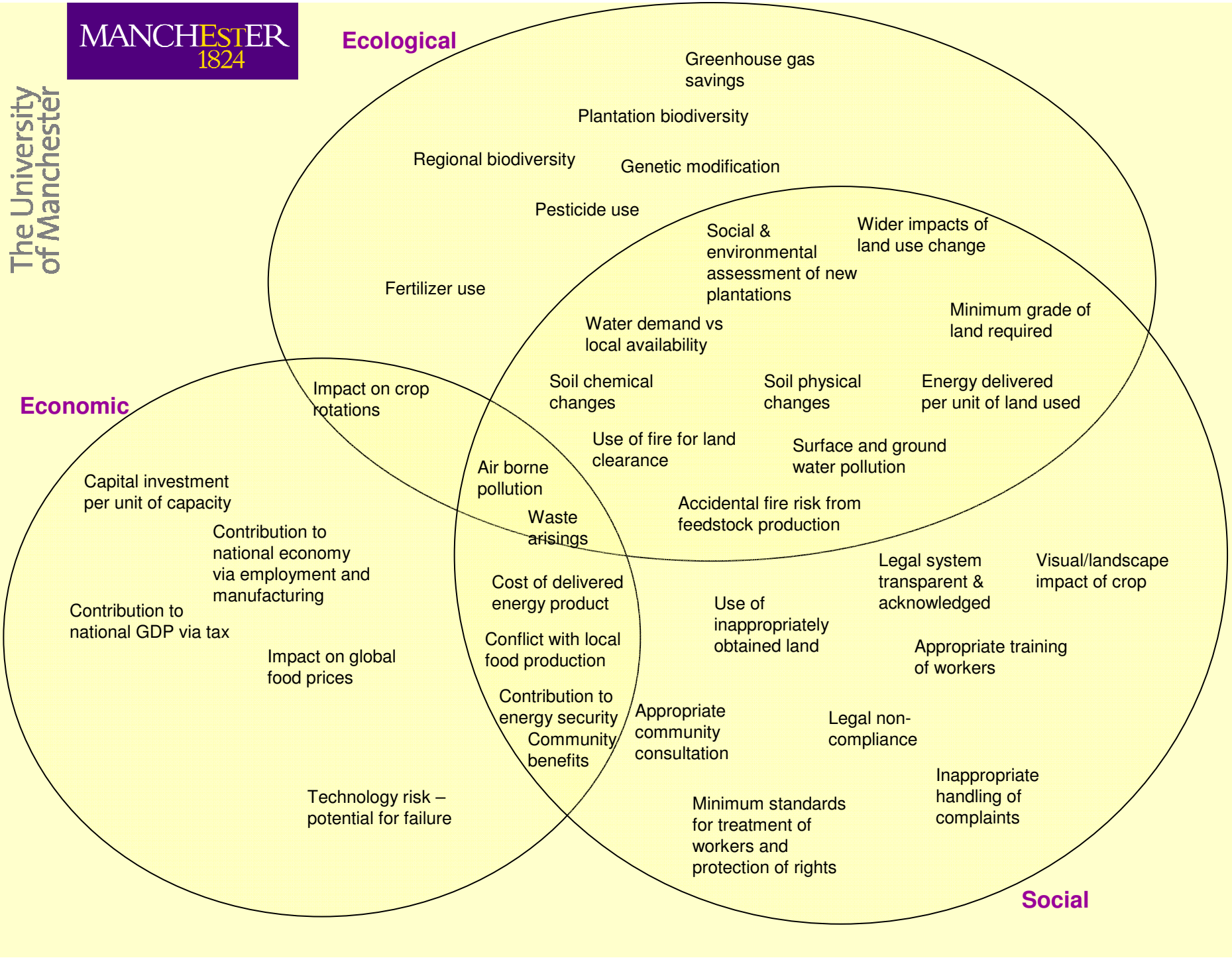
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Ecological
Greenhouse gas savings
Plantation biodiversity
Regional biodiversity
Genetic modification
Pesticide use
Fertilizer use
Social & environmental assessment of new plantations
Wider impacts of land use change
Minimum grade of land required
Water demand vs local availability
Soil chemical changes
Soil physical changes
Energy delivered per unit of land used
Use of fire for land clearance
Surface and ground water pollution
Accidental fire risk from feedstock production
Economic
Impact on crop rotations
Air borne pollution
Waste arisings
Capital investment per unit of capacity
Contribution to national economy via employment and manufacturing
Contribution to national GDP via tax
Impact on global food prices
Cost of delivered energy product
Conflict with local food production
Contribution to energy security
Community benefits
Technology risk – potential for failure
Legal system transparent & acknowledged
Visual/landscape impact of crop
Use of inappropriately obtained land
Appropriate training of workers
Appropriate community consultation
Legal non-compliance
Inappropriate handling of complaints
Minimum standards for treatment of workers and protection of rights
Social

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SUPERGEN

Supergen bioenergy consortium

- Industrial-academic collaboration
- Whole systems perspective
- Theme 6 (systems analysis) aims to facilitate an informed answer to the question

"What is the best use of our limited biomass resource?"

by consistently and comprehensively assessing the relative economic, environmental and social impacts of bioenergy conversion to electricity, transport fuels and heat

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Wood pellets

Greenhouse gas issues for wood (pellets)

- Utilizing waste material has GHG benefits – but is it really a waste? And does large scale utilization result in a market shift?
- Forestry generally less GHG intensive than energy crop which is less than agricultural products, but allocation can be critical
- Pellet production is energy intensive and carries a GHG penalty; utilizing biomass (e.g. for drying) can help offset
- Importing material from overseas carries a GHG penalty, but shipping is one of the most carbon efficient methods of transport
- Fuel nitrogen may be converted to N_2O – especially chipboard/MDF
- Soil carbon changes may reduce GHG savings if residues are overharvested, but limited data
- Road haulage in non-specialized vehicles or multiple short transits can have substantial GHG penalties

Sustainability issues for wood (pellets)

- Long term soil fertility e.g. residue removal
- Mixed impacts of residue removal on biodiversity
- Soil nutrient balances
- Land-use change risks e.g. plantation forests
- Impacts of monocultures on biodiversity
- Groundwater depletion for high yield forests

Thornley et al, “Assessing the sustainability of bioelectricity supply chains”, BIOTEN conference, September 2010

Managing wood (pellet) impacts

- **Forestry certification schemes (widespread in northern hemisphere) vary but most tend to cover**
  - **Forest regeneration and succession**
  - **Conserving biological diversity**
  - **Protecting endangered species and high conservation value forests**
  - **Community relations & workers' rights**
  - **Tenure and land-rights**

Outstanding issues from forest certification schemes

- Lack of consideration of carbon pools in forest management
- Lack of understanding of impact of residue removal on soil carbon and fertility
- Wider biodiversity impacts
- Groundwater depletion and hydrology

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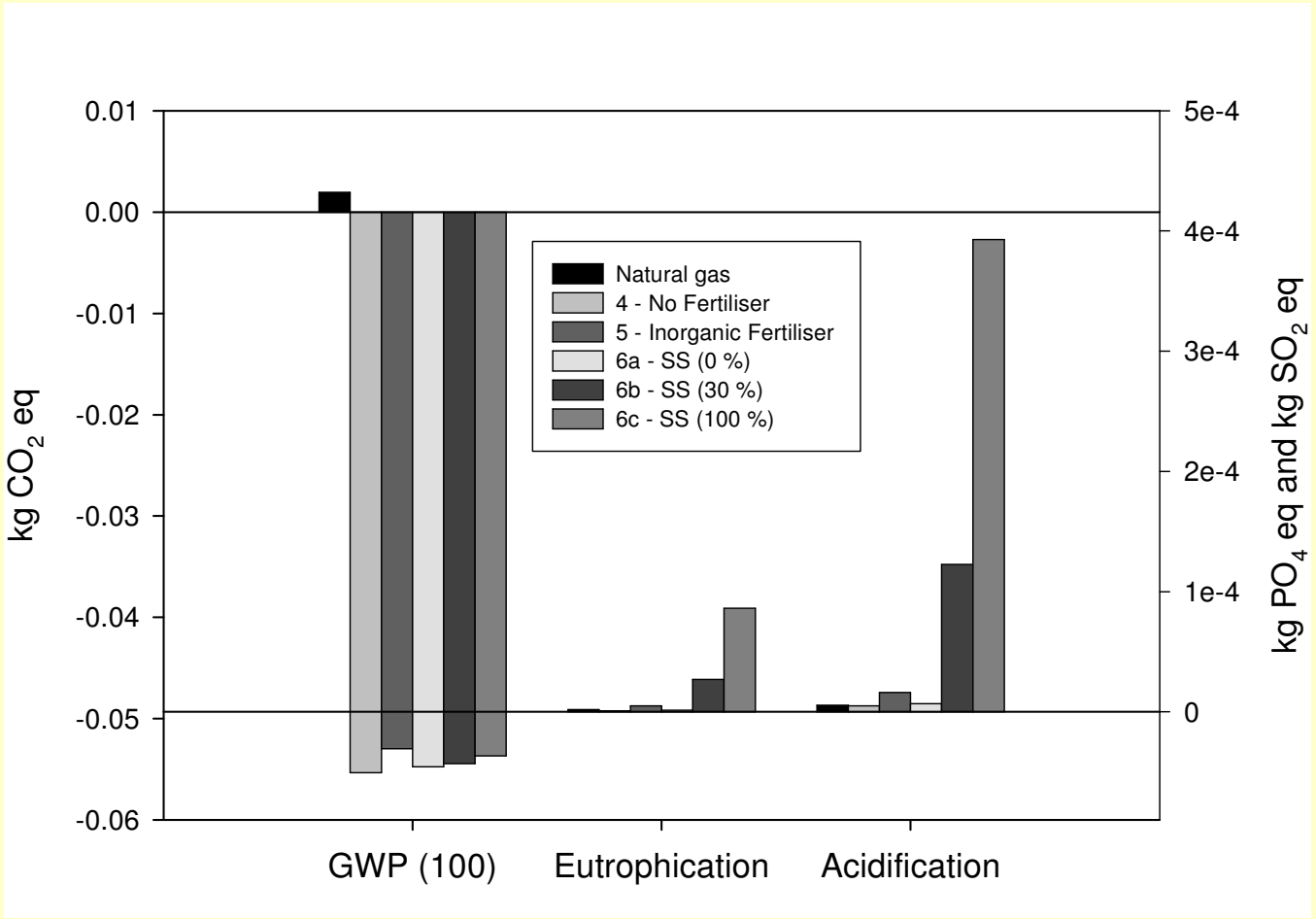
Miscanthus

Greenhouse gas issues fo miscanthus



Gilbert, Thornley & Riche, "The influence of organic and inorganic fertiliser application rates on UK biomass crop sustainability ", Biomass and Bioenergy, 2011

Greenhouse gas issues for miscanthus

- Inorganic fertilisers increase GWP by 2% compared to no fertiliser
- Sewage sludge application increases GWP by less than this
- Yield improvement of 0.2 t/ha sufficient to offset fertiliser application
- N_2O releases from soil are significant and variable

Gilbert, Thornley & Riche, "The influence of organic and inorganic fertiliser application rates on UK biomass crop sustainability ", Biomass and Bioenergy, 2011

Sustainability issues for miscanthus

- Requires more inputs than SRC but higher yielding
- Eutrophication & acidification potential is substantial (as with most agricultural operations)
- Land use and land use change may be significant – food/fuel, carbon balance
- Co-firing direct employment benefits limited and miscanthus results in less job creation than other energy crops (and arable farming)[1]

1 Thornley, Rogers & Huang, "Quantification of employment from biomass power plants", Renewable Energy 2008

Managing energy crop impacts

- Certification and monitoring a practical option, but need to focus on what will actually make a difference
- Greenhouse gas balance should focus on location, overview of agronomy and land-use change
- Visual impacts are important
- Impacts on biodiversity – importance depends on location
- Hydrology – consideration at outset?
- Socio-economic impacts difficult to quantify

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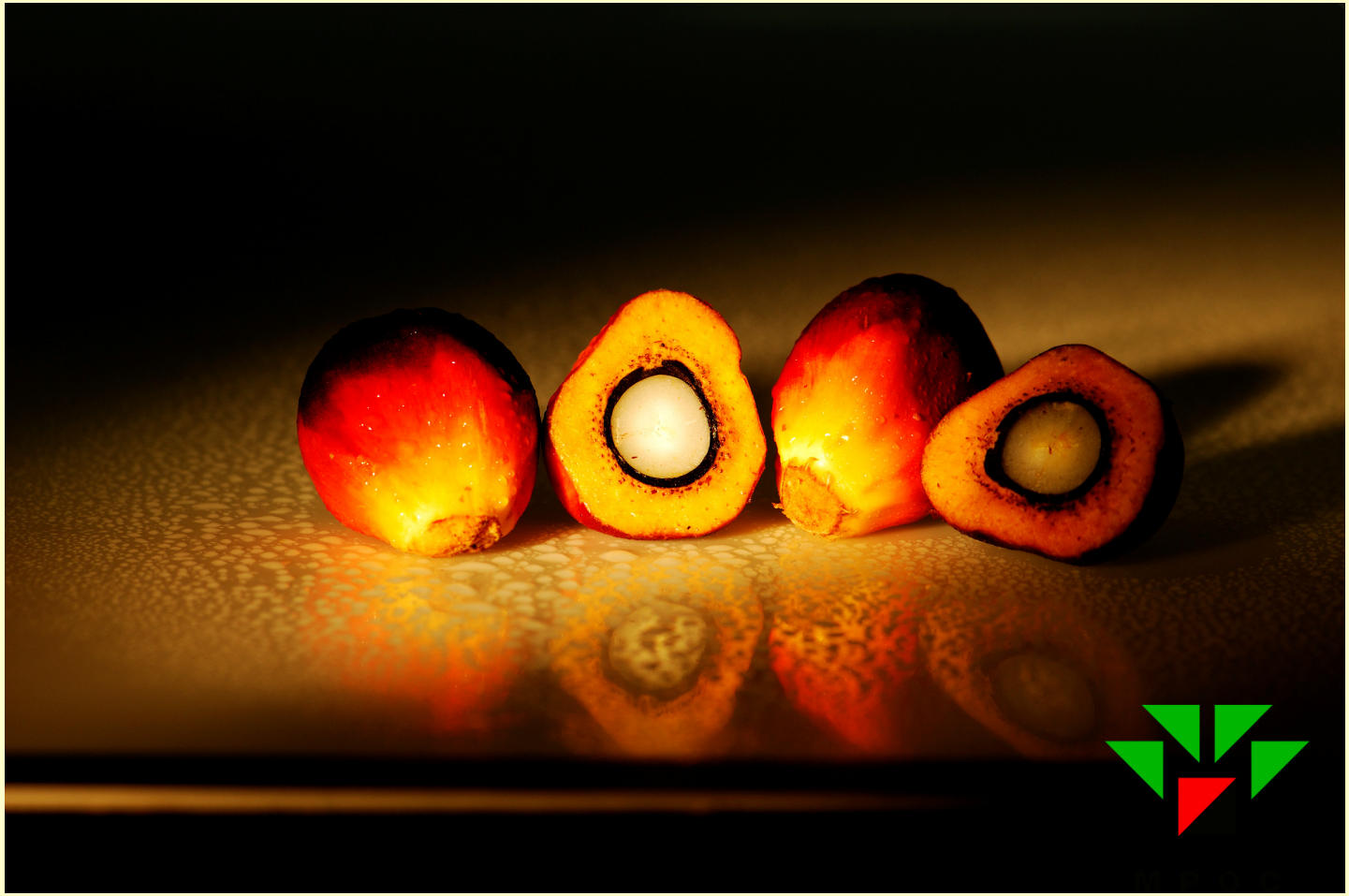
Palm kernel expellant (PKE)

PKE

Source: Malaysian Palm Oil Council

PKE



Source: Malaysian Palm Oil Council

Palm production

- Tropical cultivation (83% of production in Malaysia & Indonesia)
- Crude palm oil & palm kernel oil <10% of total biomass; PKE ~10% of palm oil production
- 30% of global vegetable oil consumption in 2007
- Global production has increased from 3 Mtpa in 1974 to 40 Mtpa in 2005
- Global land use has increased from 3.77 Mha in 1990 to 9.42 Mha in 2005

Greenhouse gas issues fo. PKE

- Land-use change is key

Pay back periods for biodiesel production from Indonesian palm oil[1]

Land converted from cropland	Land converted from forestland	Land converted from grassland
0	98	55

- Is PKE a waste? A byproduct? Better used as animal feed? Or is the market for PKE influencing palm production

1 Upham et al., "Substitutable biodiesel feedstocks for the UK: a review of sustainability issues with reference to the UK RTFO, Journal of Cleaner Production, 2009

Sustainability issues for PKE

- Issues are the same as those for palm plantations, so the status of PKE as waste, byproduct or market driver is critical
- Deforestation – greenhouse gas emissions, impacts on biodiversity
- Conversion of habitats e.g. drainage of peatlands
- Conflict and land tenure in Indonesia

1 Thornley et al., "Sustainability constraints on UK bioenergy development", Energy Policy, 2009

Managing palm production impacts

- GHG methodology depends on waste/product status
- Energy sector is very small component of palm market, but growing
- Indirect displacement of production is a key issue Institutional capacity may limit verification
- Site specific verification of the previous carbon store and future sequestration potential is needed
- Loss of habitat and biodiversity impacts – certification?
- Land tenure and conflict more difficult

More information

1. Supergen biomass and bioenergy consortium, “Theme 6 resource assessment feedstock properties”, available at www.supergen-bioenergy.net
2. Thornley et al., “Sustainability constraints on UK bioenergy development”, Energy Policy, 2009
3. Upham et al., “Substitutable biodiesel feedstocks for the UK: a review of sustainability issues with reference to the UK RTFO, Journal of Cleaner Production, 2009
4. Thornley et al., “Integrated assessment of bioelectricity technology options”, Energy Policy, 2009
5. Thornley et al., “Assessing the sustainability of bioelectricity supply chains”, BIOTEN conference 2010
6. Thornley et al., “Cost effective carbon reductions in the bioenergy sector”, BIOTEN conference 2010
7. Gilbert et al., “The influence of organic and inorganic fertiliser application rates on UK biomass crop sustainability”
8. Thornley, Rogers & Huang, “Quantification of employment from biomass power plants”, Renewable Energy 2008

More information

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www.supergen-bioenergy.net