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'Bioenergy and sustainability: measurements and markets

Imperial College London

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Key References:

Life Cycle Assessment – new basis for action

- UK-LCVP Consensus report (Rickeard et al, 2004:
  - ExxonMobil / British Sugar / Imperial College / North Energy / CONCAWE/JRC rpt
- LCVP – Linking Sustainability Assurance to a UK Renewable Transport Fuels Obligation (E4TECH/Imperial/ECCM; in progress) – (Bauen, Tipper, Howes & Woods; 2005)

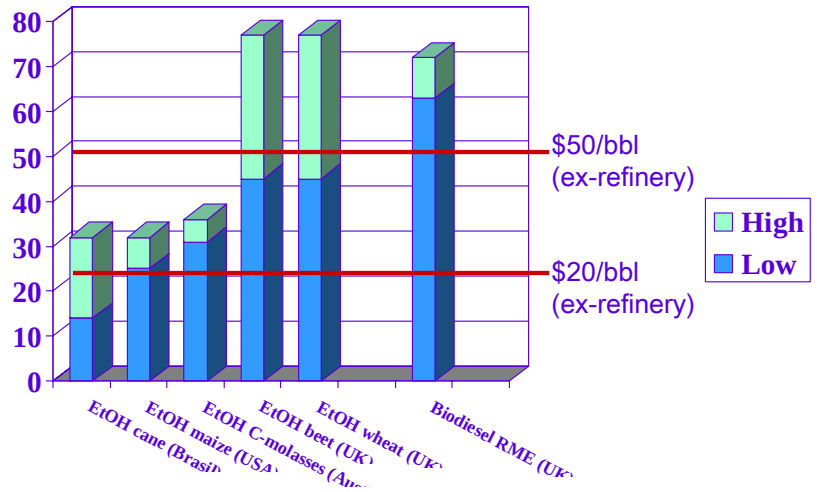
Peak Oil

- Campbell C. J.. Synthesis- What it all amounts to. In: *The Coming Oil Crisis*, edited by C. J. Campbell, Geneva:Multi-Science Publishing Company & Petroconsultants S.A., 1997, p. 173-182.

Climate Change

- IPCC –Third Assessment Report. 2001.
- Abrupt Climate Change (various e.g. Read et al. 2004; www.accstrategy.org)

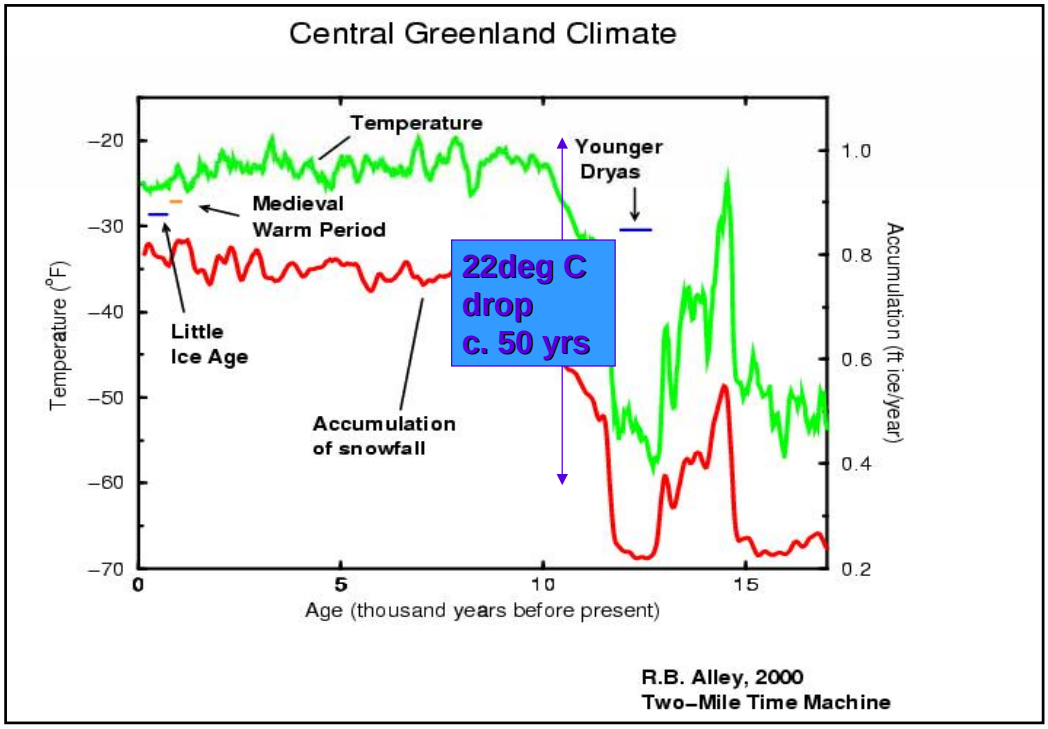
Changing Costs (USc per litre)



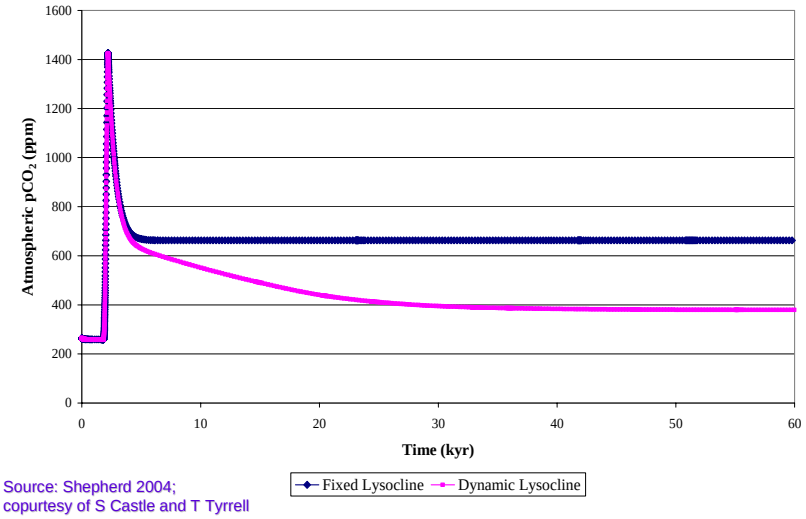
Source: based on Bennett;M. 2005

Overview – System Boundaries

- Background: scientific basis for action
  - Climate Change versus Energy Security?
- Markets
  - Oil and carbon
  - Intra and extra- regional
- Understanding Sustainability
  - System boundaries / reference systems
  - Environmental criteria
  - Economic criteria
  - Social criteria
  - Safety, standards and regulation
- Conclusions – opportunities & threats

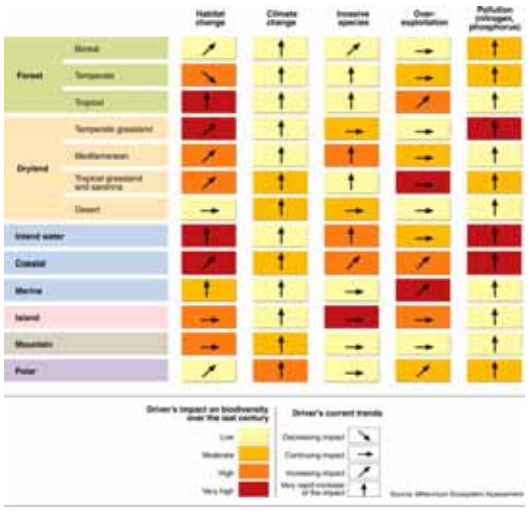


Variation of atmospheric *p*CO2 as a result of burning 3000 Gt of fossil fuels



Source: Shepherd 2004;
copurtesy of S Castle and T Tyrrell

Millennium Ecosystem Assessment: Direct drivers growing in intensity



•Most direct drivers of degradation in ecosystem services remain constant or are growing in intensity in most ecosystems

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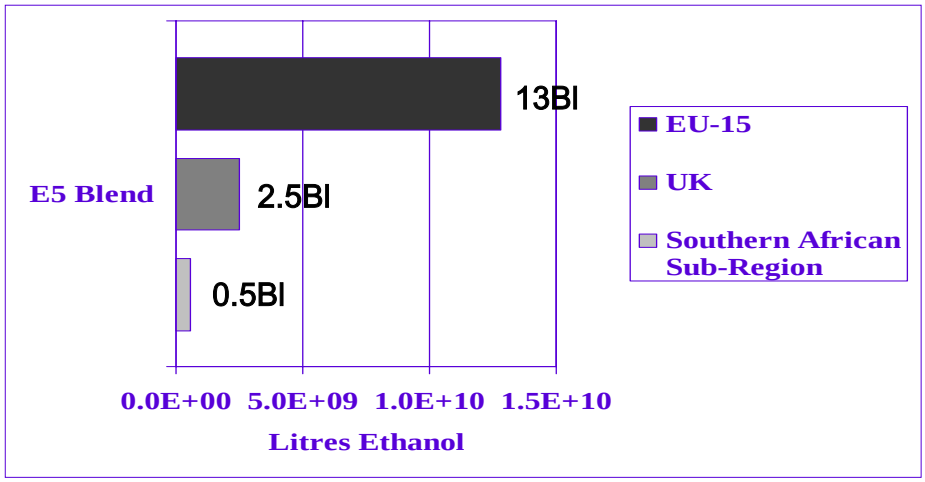
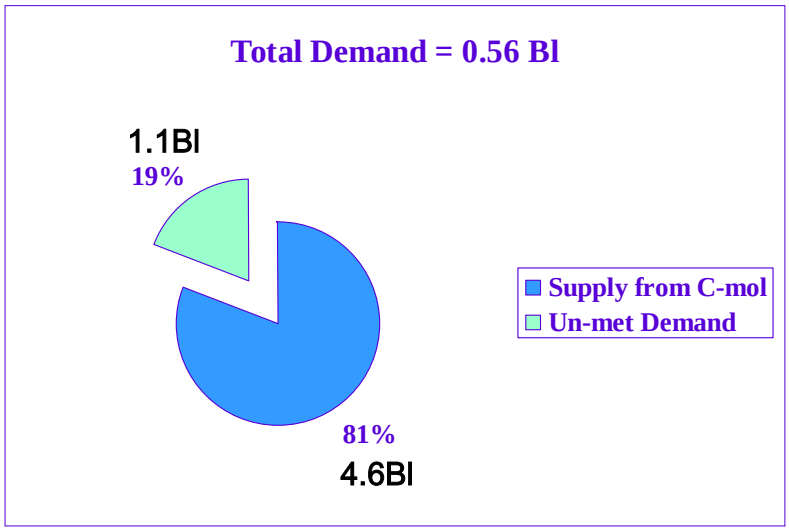
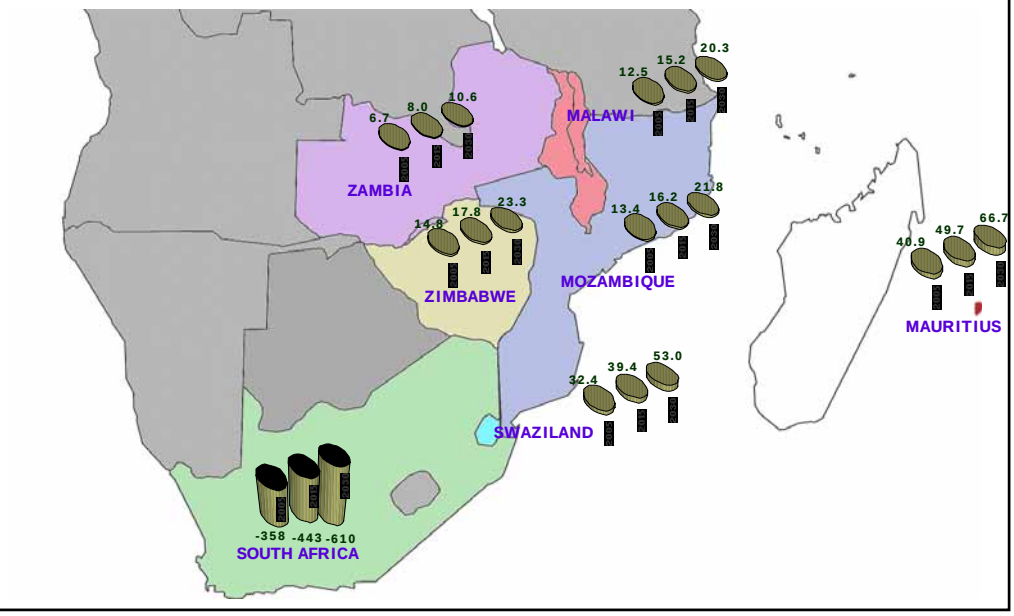
Potential Demand (e.g. E5 Blend)



Potential EtOH Supply – e.g. from C-molasses



Sub-Reginoal Potential Ethanol Balances from C-molasses & E5 Ethanol Demand (million litres)



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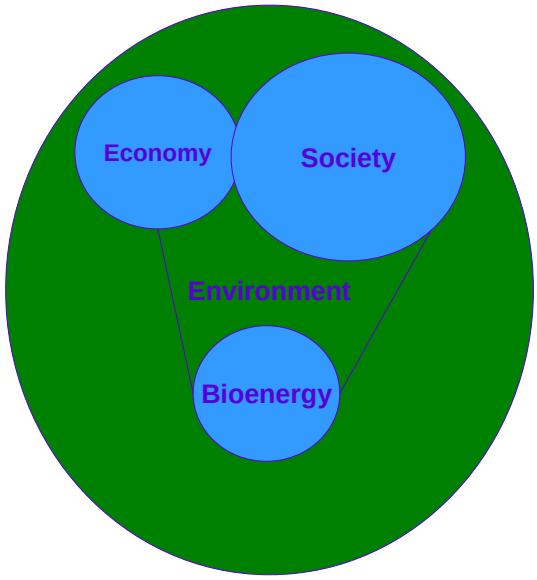
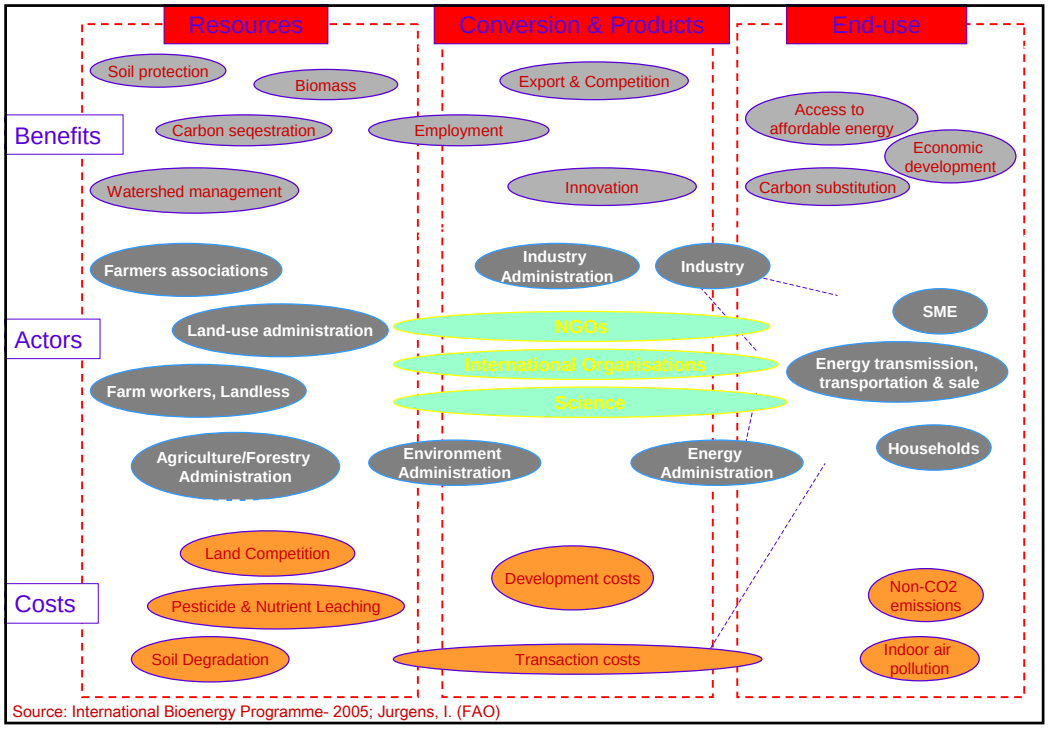
Sustainability:

Bioenergy **must** link the three legs of Sustainability

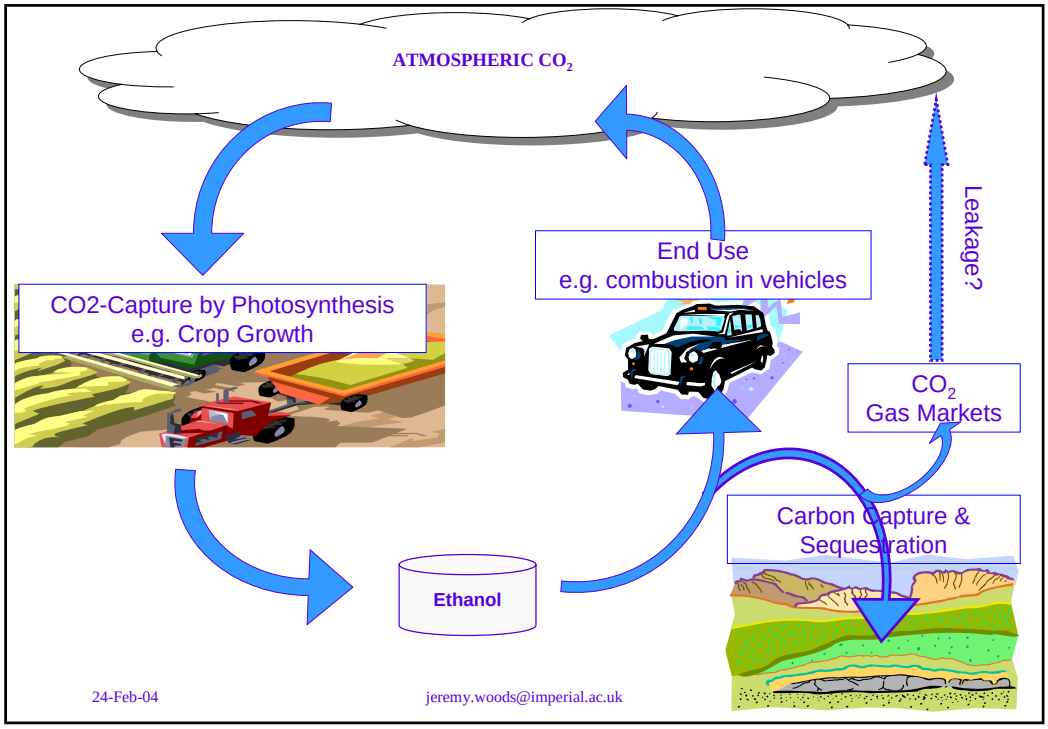
BUT

Can seem very far from Industrial reality!





Source: International Bioenergy Programme- 2005; Jurgens, I. (FAO)



Assessment Procedure (WTW)

Fuel production & Supply (WTT)

Fuel infrastructure (WTT)

Vehicle operation (TTW)

- **Performance**
- **Environment**
- **Economy**
- **Society**
- **Safety & regulations**

Adapted from PREMIER framework

Dealing with Uncertainty (WTT)

- Environmental Criteria:
  - N_2O emissions from agriculture
  - CH_4 emissions from agriculture
  - Land-use change:
    - Changes in Biomass Stock (deforestation)
    - Changes in soil carbon (e.g. grassland)
- Co-product allocation methodology

Land-use change: deforestation

'… where deforestation has occurred, one-off emissions in the range of 200 to 1000 t CO2 /hectare associated with the combustion and/or rapid decomposition of above-ground biomass[1] will negate any GHG benefits from the production of biofuels for a period of at least 50 years.'

[1] IPCC Good Practice Guidelines for Land Use, Land Use Change and Forestry, 2000, Intergovernmental Panel on Climate Change.

Land-use change: UK agriculture

According to DETR (1997):

'… soils in England, Wales and Scotland contain some 21.78 billion tonnes of carbon, of which 16.4 GtC is in Scottish peat uplands[1], leaving 5.4BtC (*19.8 Gt CO_2*) in the soil of the remaining UK land where agriculture is the primary land use. Most of this is contained in grasslands. Arable soils in the UK contain 592 MtC (*2.17GtCO_2*; Smith *et al).*'

According to Edwards,R. (JRC, 2004):

'Grassland has 49 to 54 t/ha higher soil C (*180 to 198 tCO_2/ha*) content than a wheat-field with straw ploughed back.'

[1] Soil Assoc. (2005) quoting: Indicators of Sustainable Development in the UK, DETR, 1997.

Farm level calculation tool: outputs

	Straw ploughed back		**All straw removed**	
	Gp/ha	Kg CO2eq/ha	Gp/ha	Kg CO2eq/ha
Diesel for Cultivation	4.730	356.6	6.071	450.2
K fertiliser	0.428	21.0	1.523	74.8
P fertiliser	0.648	29.1	0.842	37.8
N fertiliser	7.511	1238.0	10.271	1693.0
Pesticides	1.198	23.6	1.371	27.0
Seed Material	2.498	160.4	2.498	160.4
N2O emissions		1290.6		1764.2
Total Farm	**17**	**3119**	**23**	**4207**
Rest of Chain	50.466	3024.4	52.563	411.0
% Total Chain	25%	51%	30%	91%

Environmental Impacts (WTW)

- Global warming
  - Greenhouse gas emissions (CO_2, CH_4, N_2O, H_2O…),
- Health
  - Regulated emissions (CO, HC, NOx, PM)
  - Unregulated emissions (aldehydes, ??, …)
  - Noise
- Use of resources
  - Primary energy (fossil, nuclear, renewable)
  - Materials (recycling)

Economic Impacts (WTW)

- Fuel Production & Supply
  - Investment costs for infrastructure
  - Employment & Wages
  - Costs & Margins
  - Opportunity costs (e.g. Food versus fuel?)
- Fuel Distribution
  - Investment costs for infrastructure
  - Employment & Wages
  - Costs & Margins
  - Incentives and taxation (net cost to society)
- Vehicle Production & End-Use
  - Investment costs for infrastructure
  - Employment & Wages
  - Costs & Margins

Social Impacts (WTW)

- Main Criteria
  - Employment & Wages
  - Child labour
  - Health and welfare, etc.
- Two Key International Activities
  - SAI 8000:2001
    - Well established assurance and certification procedures
    - National and international basis
  - ISO 26000
    - Under development
    - Standard due to be published in 2008

Social Impacts (cont'd)

- Main Criteria (SAI 8000:2001)
  - Rights to associate and belong to a trade union.
  - Safeguarding equal opportunities (gender and disability).
  - Avoiding or managing child, youth and forced labour.
  - Occupational health and safety.
  - Working conditions (salary, hours, hygiene, health care, housing, etc).
  - Worker training.
  - Effects on local community.
  - Reporting on and monitoring of social issues.

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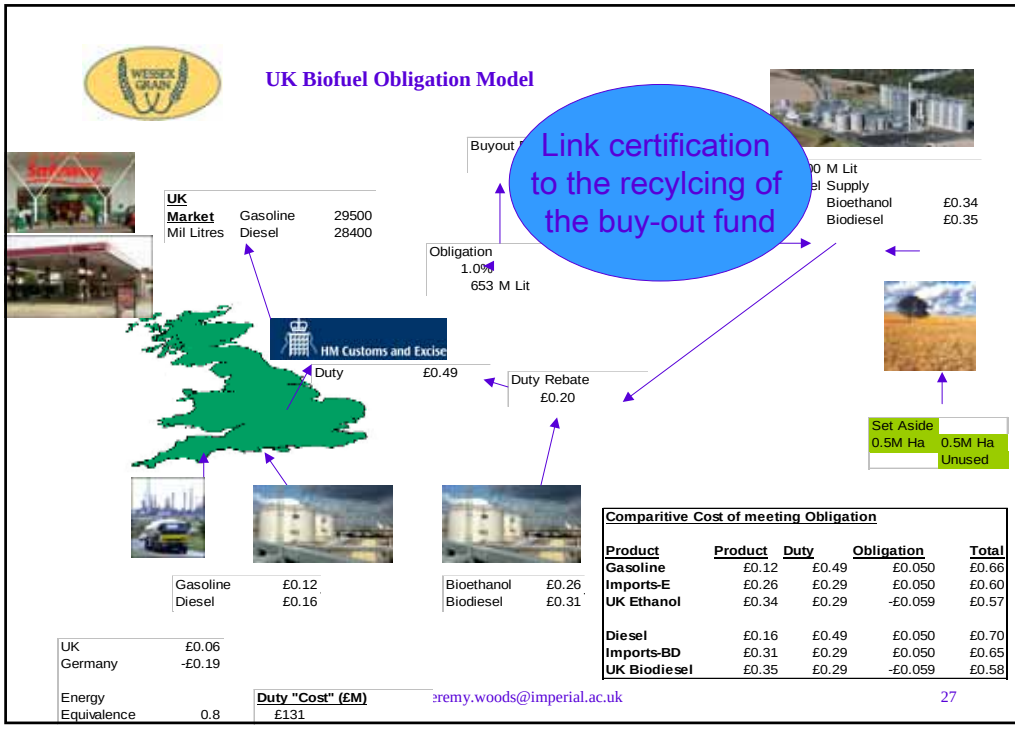
Conclusions

- Stimulating demand without sustainability assurance is dangerous
- Mitigating climate change is likely to emerge as the dominant policy driver
- More land will need to be brought into production if a substantive market is to emerge
- 4 policy tools are available to stimulate the renewable transport fuels market but an obligation mechanism is likely to be the most efficient



Vehicle Technologies

ETHANOL:
Ford Focus FFV
1.6l
E0 to E85 (in UK)

BIODIESEL:
Does not need specialised vehicles- Some problems Have been experience at high blends

I THANK YOU!

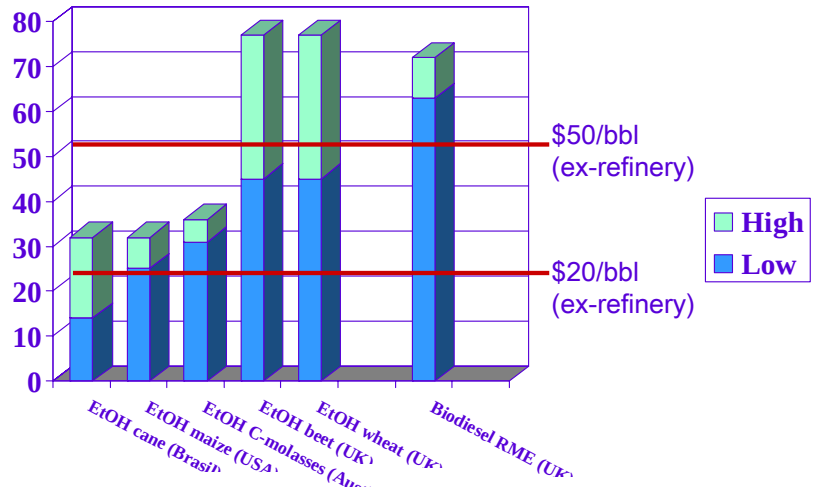
Potential WTW Impacts of BioEthanol Fuels

ENERGY BASIS Energy Supply Model for fermentation & distillation plant	E100 Without BECS*			E100 With BECS		
	GHG Emissions			GHG Emissions		
	WTT*** Kg CO_2eq / GJ EtOH	2 MJ per km (WTW***) g CO_2eq / km	% of petrol	WTT*** Kg CO_2eq / GJ EtOH	2 MJ per km (WTW***) g CO_2eq / km	% of petrol
Natural Gas Boiler + Heat Recovery	26.3	53	27.4%	-1.77	-4	-2.1%
Straw + Boiler	22.9	46	23.8%	-5.1	-10	-6.1%
	E85 Without BECS			E85 With BECS		
Natural Gas Boiler + Heat Recovery	26.3		40.9%	-1.77	-4	-2.1%
Straw + Boiler	22.9		38.1%	-5.1	-10	-6.1%
	E10 Without BECS			E85 With BECS		
Natural Gas Boiler + Heat Recovery	26.3	165	86.1%	-1.77	-4	-2.1%
Straw + Boiler	22.9	165	85.9%	-5.1	-10	-6.1%

Notes:
* - BECS (BioEnergy with Carbon Sequestration)
** - 2 MJ per km = 39 MPG petrol
*** - WTT 'Well (or field) to Tank' - WTW 'Well (or field) to Wheel'.

Car Performance Indicators		
35.00 MPG	**40.00 MPG**	**2.000 MJ/km**
9.25 M/lpetrol	10.57 M/lpetrol	38.76 MPG
0.067 lpetrol/km	0.059 lpetrol/km	10.24 M/lpetrol
2.215 MJ/km	1.938 MJ/km	0.061 lpetrol/km
160 gCO2 per km	140 gCO2 per km	O2 per km
192 gCO2eq per km	**168 gCO2eq per km**	**O2eq per km**

Changing Costs (USc per litre)



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