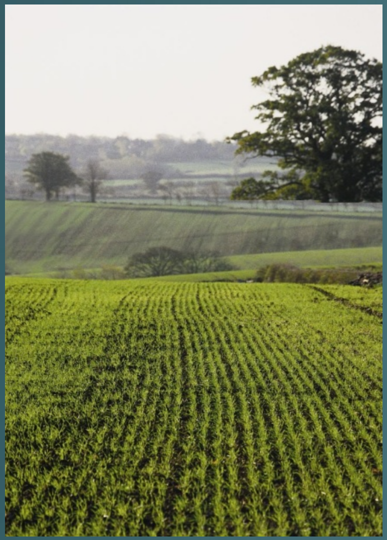
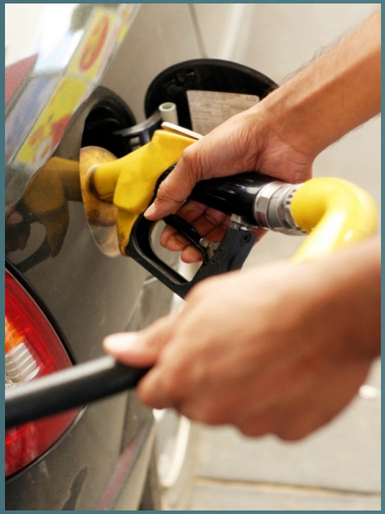
Building a world class bioethanol facility in the UK



The right biofuel, the right way



29th April 2008

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Why Biofuels?

- UK and EU want to cut fossil fuel consumption to
    - **Reduce greenhouse gases**
    - **Reduce the dependency on oil**
    - **To enhance the security of supply**
    - **Stimulate agriculture**
- Transport fuels are a significant source of greenhouse gas emissions and a major priority for improvement
- Biofuels

  Can be produced sustainably

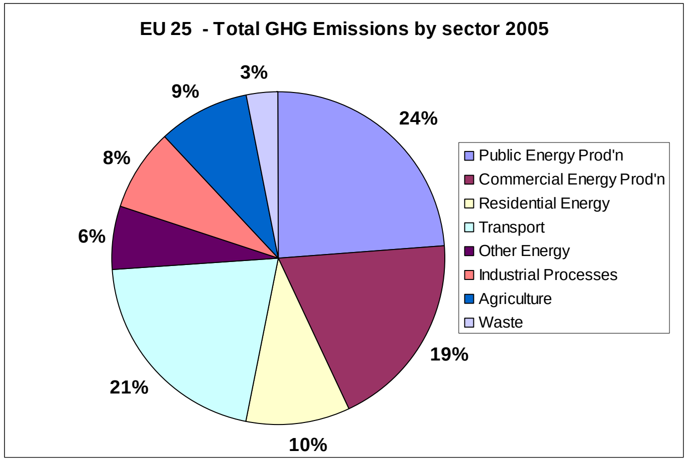
  Can significantly reduce greenhouse gases.
- UK RTFO targets 5% Biofuels by 2010 – equivalent to taking 1 million cars of the road

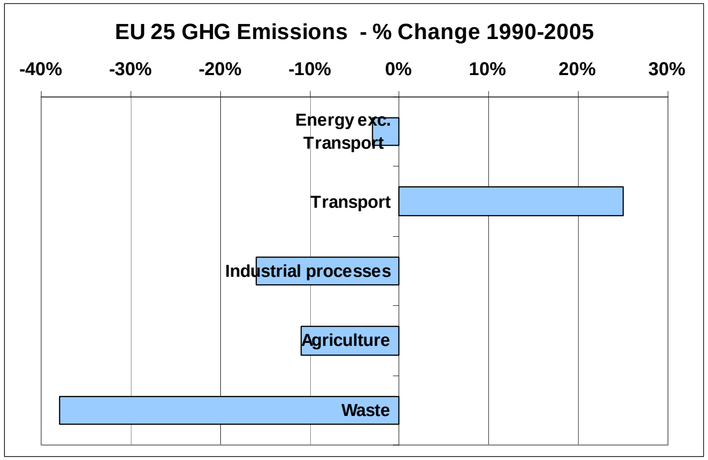
The Challenge

- Climate Change
- Energy Security
- Agriculture, rural development

The Context

- Transport fuels a significant and growing GHG emitter
- Multi pronged approach required
- Decarbonising transport fuels vital





Source: EEA 2006

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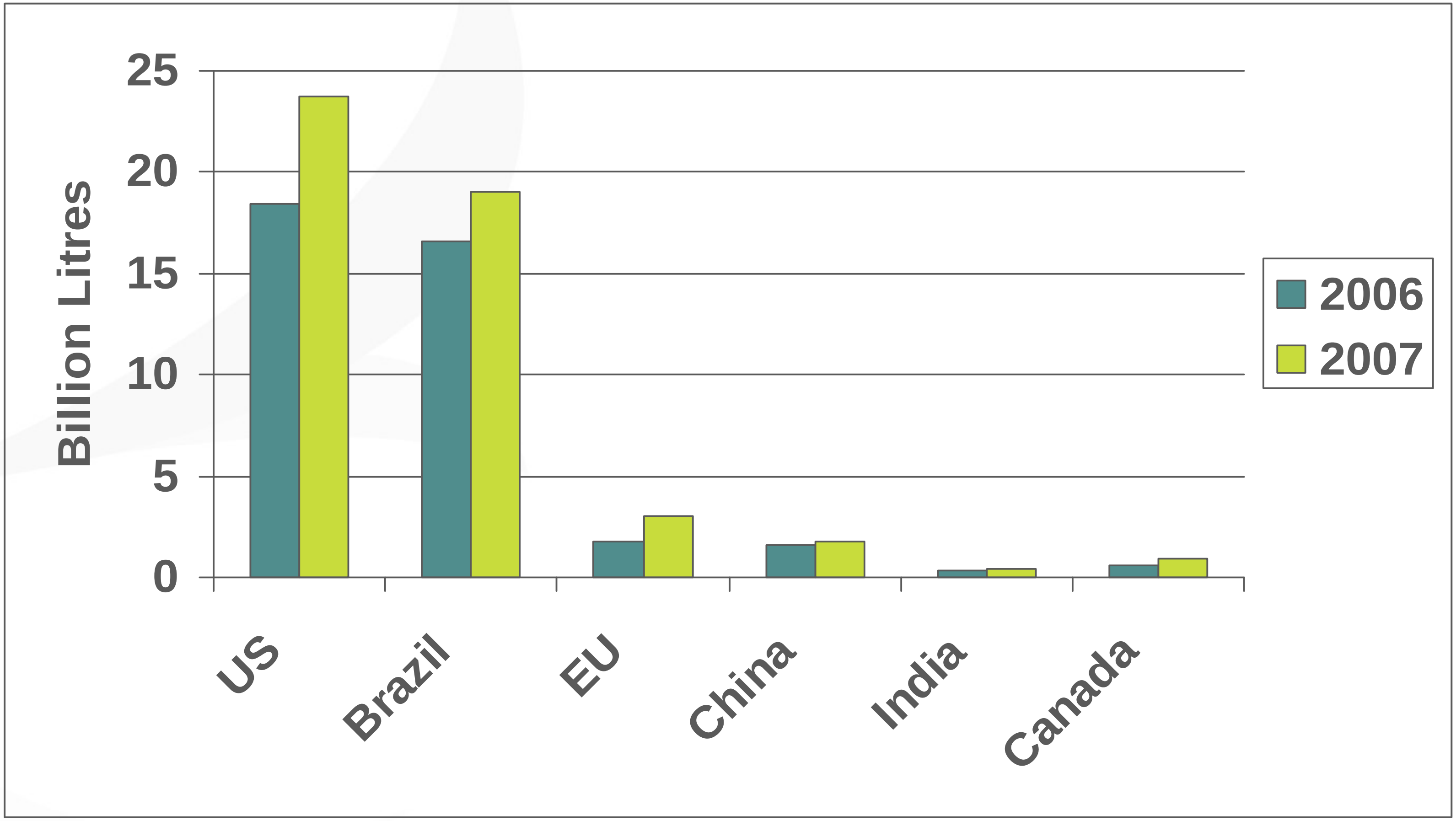
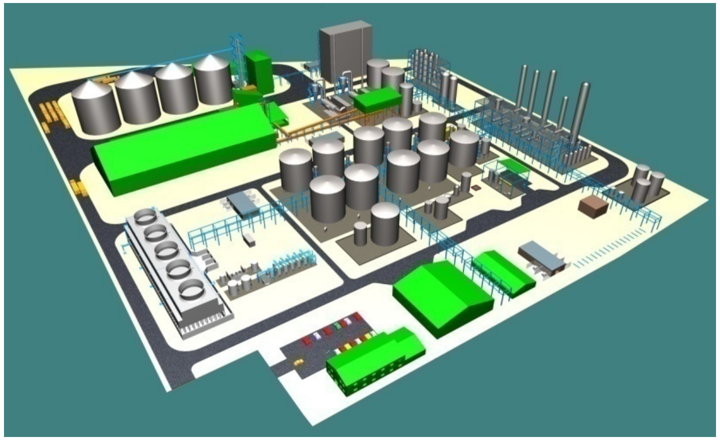
Fuel Ethanol Producing Countries – US & Brazil leading, EU lagging



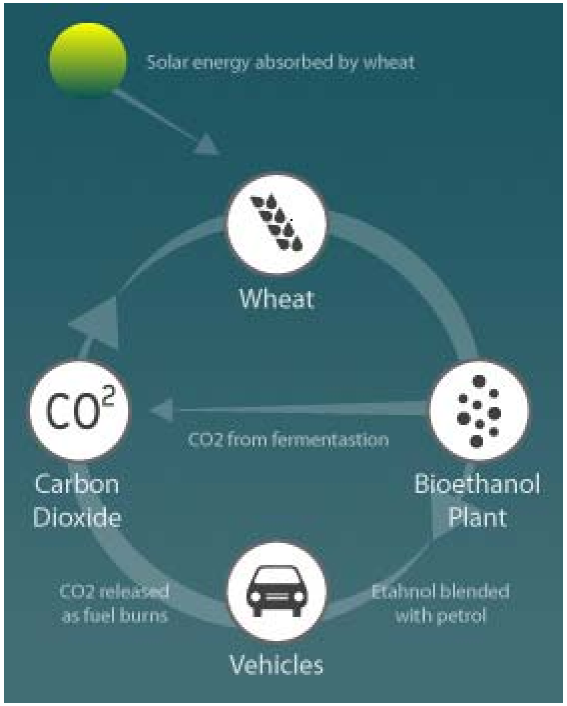
Background to Ensus

- Start up, formed in 2006
- Raised £250m finance in early 2007 to build first plant in UK
- Related party investments >£60m (CHP, tanks, CO_2 plant)
- Largest EU biorefinery
  - 400m litres per annum ethanol
  - Use wheat as a feedstock
    - Over 1 million tonnes per year
    - Wheat surpluses in UK and Europe
  - Also produce protein rich co-product for animal feed and CO_2 for food and energy industries
  - Commence operations early 2009



Ensus committed to maximising the environmental benefit

- Using CHP technology for energy – reduces carbon footprint
- Ensus is working with our partners to improve our carbon footprint – better ways to produce fertiliser, grow wheat, effective logistics etc
- Will use wheat whilst in surplus in EU, and will look to ways to improve the system and the technologies applied



Teesside represents an ideal location for Ensus 1

- Build on Wilton Site – integrated 2000 acre process industry complex - utilities and support services readily available
- Very good road and port access for both wheat and ethanol
- Good experience base of people and companies aligned to the needs of the process industry

Challenges to industry

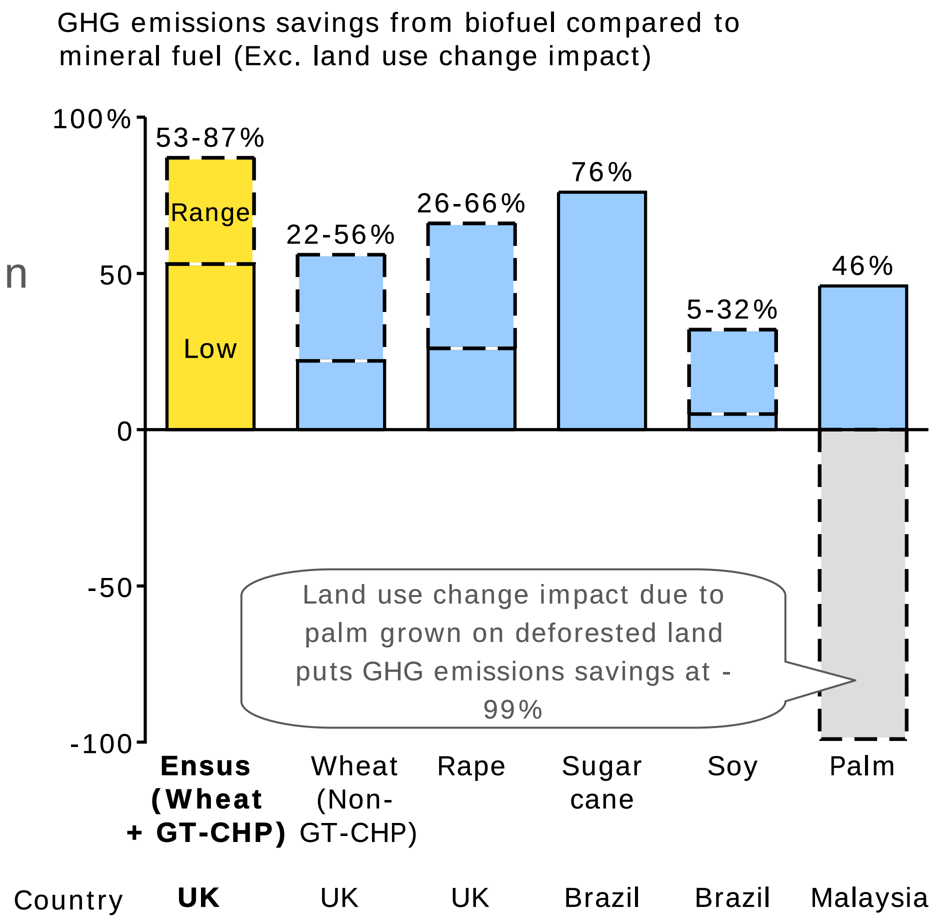
- Biofuels impact on the environment?
  - The question is not about whether biofuels are good or bad – it is about differentiating between good and bad biofuels
  - The principle issues include carbon footprint and sustainability
  - Require legislative framework that differentiates good from bad and encourages good to get better
- Food .v. Fuel or Food and Fuel?
  - Current prices primarily to do with bad weather & GM restrictions, not biofuels – EU ca 3m tonnes of wheat to bioethanol .v. market of 120 m tonnes
  - Biofuels allows US and EU to move away from subsidised grain markets – often argued by WTO as a major impediment to agriculture in the developing world
  - However, can a biofuel/transport fuel replacement growth strategy work without putting unacceptable pressure on the food supply chain?

The right biofuel, the right way

- Direct GHG savings for biofuels (no land use change)
- Food and Fuel – benefits of co-product including indirect land use change effects
- Land requirements to meet EU bioethanol targets
- GHG impacts when land use changes are taken into account

Ensus plant technology offers 53-87% direct greenhouse gas savings vs. oil

- Energy integration with Gas Turbine CHP[1] offers significant GHG savings
- Ensus GHG savings estimate includes GHG emissions credit for wheat protein concentrate co-product (DDGS)
- When done well, wheat ethanol using GT-CHP technology can deliver GHG savings comparable to cane ethanol, even before indirect land use benefits are considered
- Range of savings estimates based on methodology & assumptions



Note: GHG savings ranges for wheat, soy and rape based on assumptions for feedstock production and DDGS credit . Calculation methodology for Ensus plant has been peer reviewed.

[1]GT-CHP - 'Gas Turbine Combined Heat and Power' re-uses waste heat from on-site gas turbine for process heat

Source: Ensus evidence to Royal Society, August 2007

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.. and there is further upside potential for GHG emissions, capital and operating costs

- Feedstock production
  - Improved wheat varieties (starch & protein content, area yield, nitrogen efficiency, conversion efficiency)
  - Cultivation and N application improvements to reduce N_2O emissions
  - N_2O abatement in fertiliser manufacturing process → 13%
- Feedstock conversion and co-product technology
  - Utilise all the crop (straw, non grain parts)
  - Separate valuable co-products (bran, wheat germ oil)
  - CO_2 sequestration → 38%
- Process technology
  - Improved energy and water efficiency
  - Improved digestibility and nutritional value of DDGS → 50%
  - New enzymes and microbes for enhanced conversion efficiency
  - Integrated biomass CHP
  - Continuous optimised operation

Increased GHG savings vs. mineral oil[1] (Selected examples)

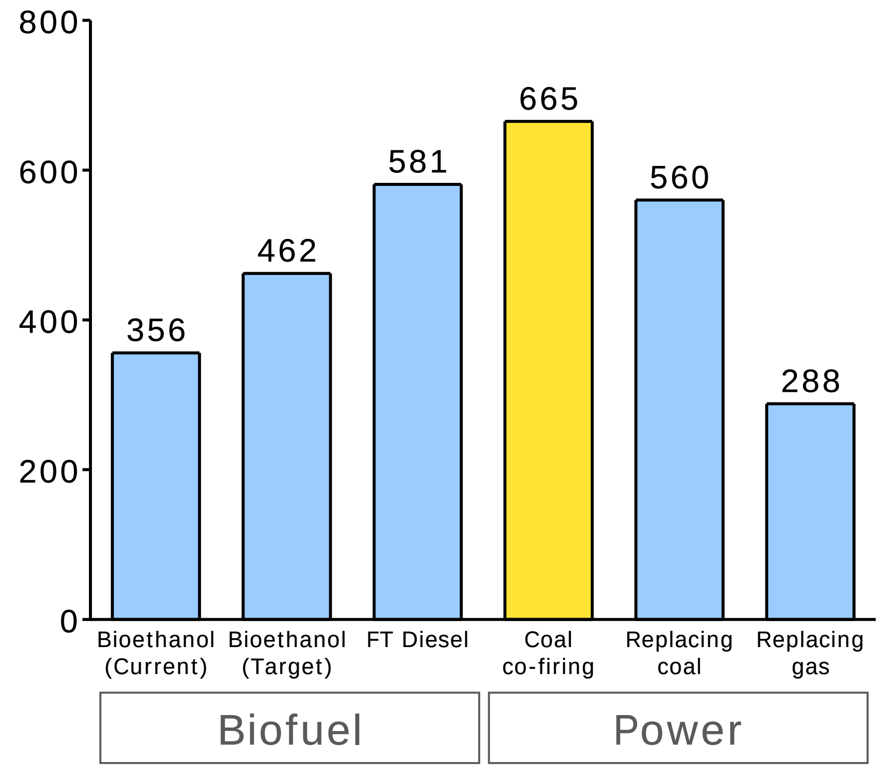
	Increased GHG savings
N_2O abatement in fertiliser manufacturing process	13%
CO_2 sequestration	38%
Improved digestibility and nutritional value of DDGS	50%

Source: [1]Ensus evidence to RFA, April 2008

What is the potential for second generation technologies?

- Today, “second generation” feedstocks (such as wood and straw) are more expensive to process to biofuels than grains such as wheat and maize
- In the short term, GHG savings from burning energy crops to co-fire coal power generation are greater than converting to biofuels
- Ongoing research programmes into biofuels from “second generation” feedstocks will lead to an important additional production route – aided by a vibrant “first generation” industry

GHG savings of ligno-cellulosic options (kg CO2 equivalent per tonne)



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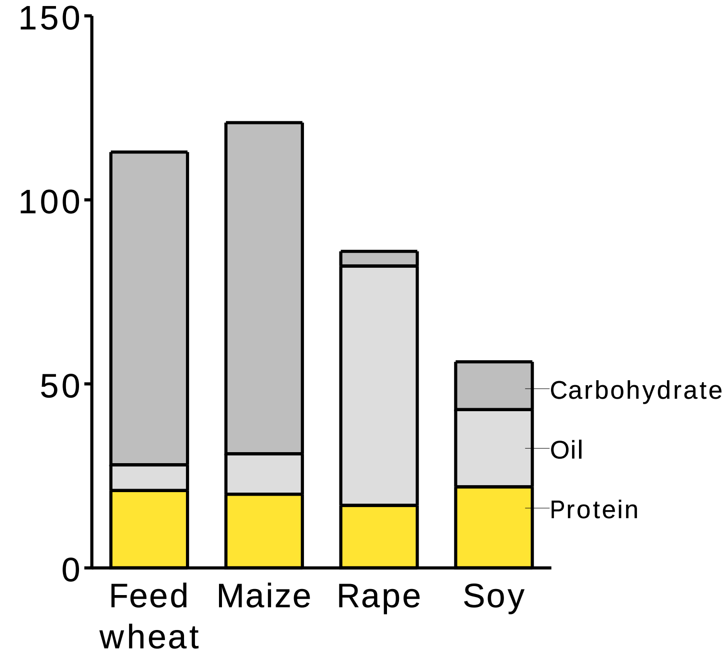
Wheat and maize are excellent feedstocks for biorefineries to meet both food and fuel needs

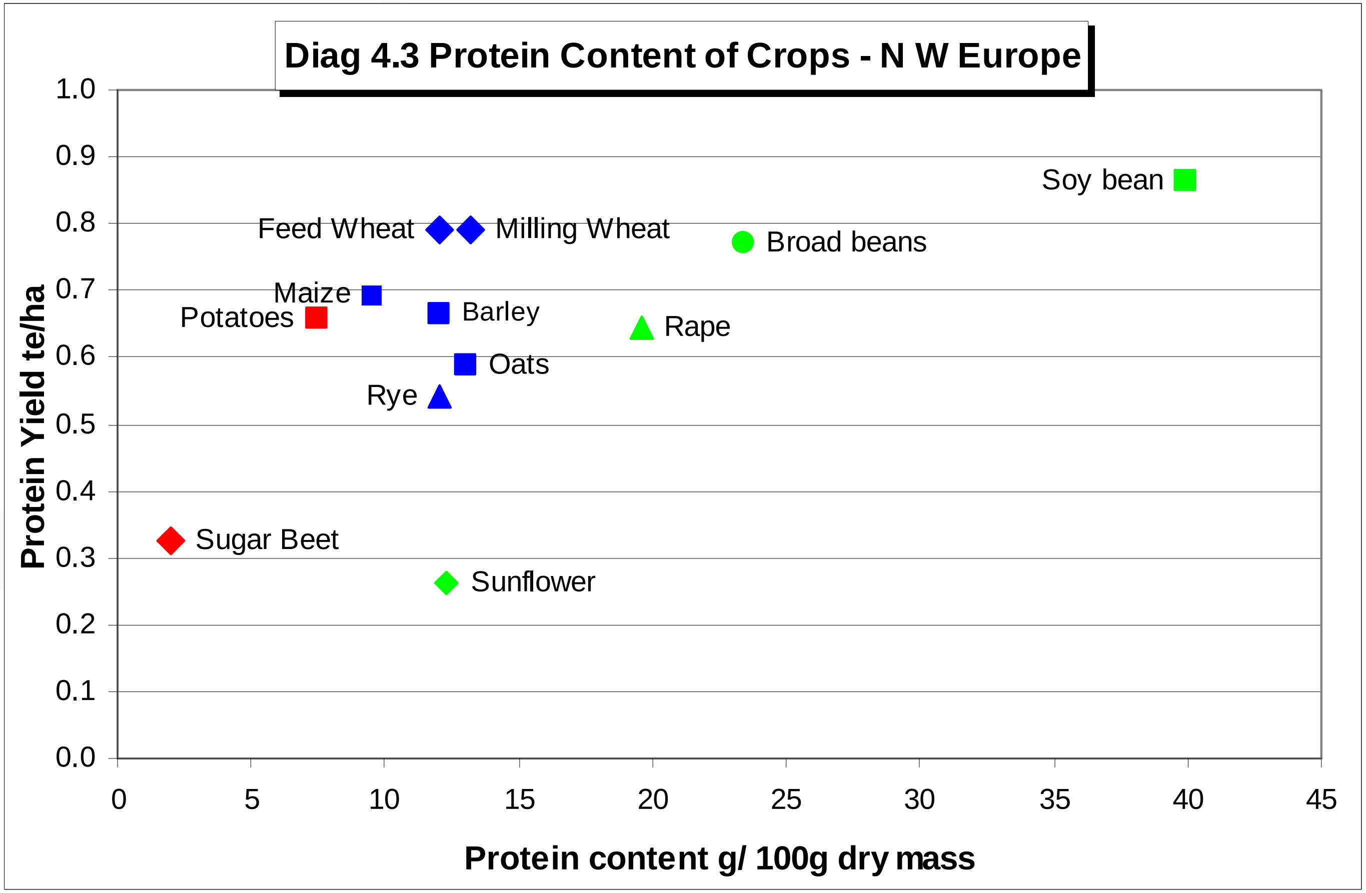
- Wheat and maize are more efficient at absorbing the sun's energy and CO_2 than soy
- Protein (a key element for food) yields about 0.8t/ha regardless of the crop – in addition, fermentation of grains adds more protein
- Wheat/maize refineries utilise whole crop
  - Fermenting the starch to biofuel
  - Concentrating the protein for animal feed
  - Capturing CO_2 for food and industrial use

Utilisation of primary plant energy (GJ/ha)



	Feed wheat	Maize	Rape	Soy
Plant protein yield (t/ha)	0.79	0.70	0.68	0.86

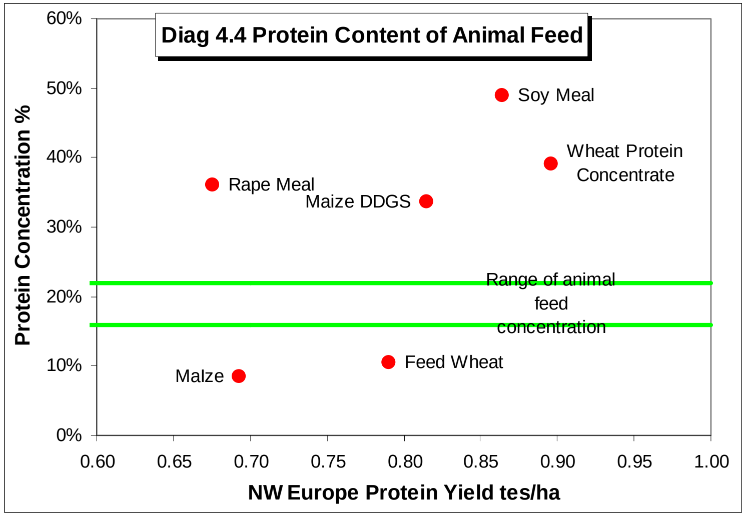
Source: Ensus evidence to RFA, April 2008 (A 2.1)

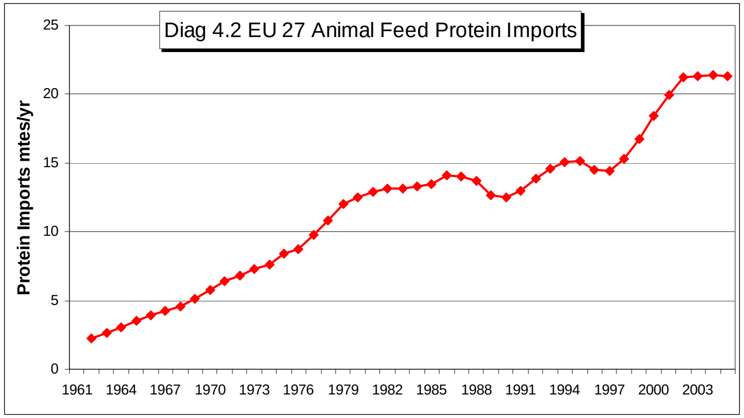


Diag 4.3 Protein Content of Crops - N W Europe
Protein Yield te/ha
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
5
10
15
20
25
30
35
40
45
Protein content g/ 100g dry mass
Soy bean
Feed Wheat
Milling Wheat
Broad beans
Maize
Potatoes
Barley
Rape
Oats
Rye
Sugar Beet
Sunflower

Biorefining wheat can help meet EU's growing requirement for animal feed protein

- Intensive animal production needs ~20% protein in diet
- Although almost 50% of cereals are used for animal feed, they alone cannot meet the requirement
- Need to add protein concentrates to wheat or maize - often soy meal - imports to EU risen to over 40 million tonnes per year (20Mt protein)
- Cereal refineries produce a high protein co-product which can displace soy meal
  - Much more efficient at meeting feed requirements
  - Wheat/maize yields (~8t/ha) much greater than soy yields (~2.5t/ha)





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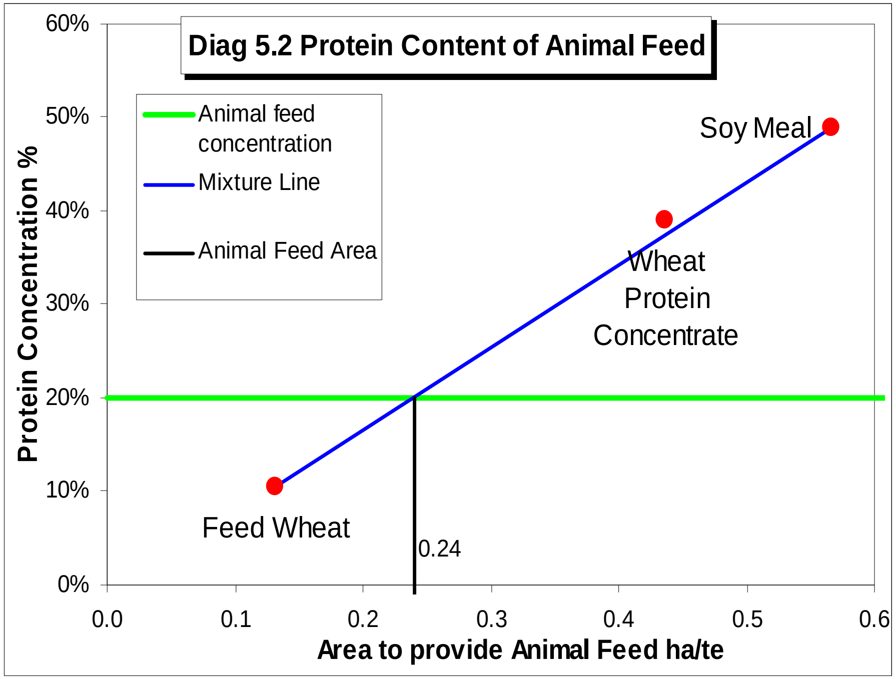
Source: Ensus paper 'Tackling Climate Change', December 2007

.. and theoretically requires no net increase in land

- 1 tonne of animal feed (20% protein) using a mix of soy meal & wheat requires 0.24 hectares of land to produce
- The same feed using wheat protein concentrate in place of soy meal also requires 0.24ha

⇩

- In theory, no net increase in land use
- The starch in the wheat is also available to make biofuel and the amount of soy imports can be reduced



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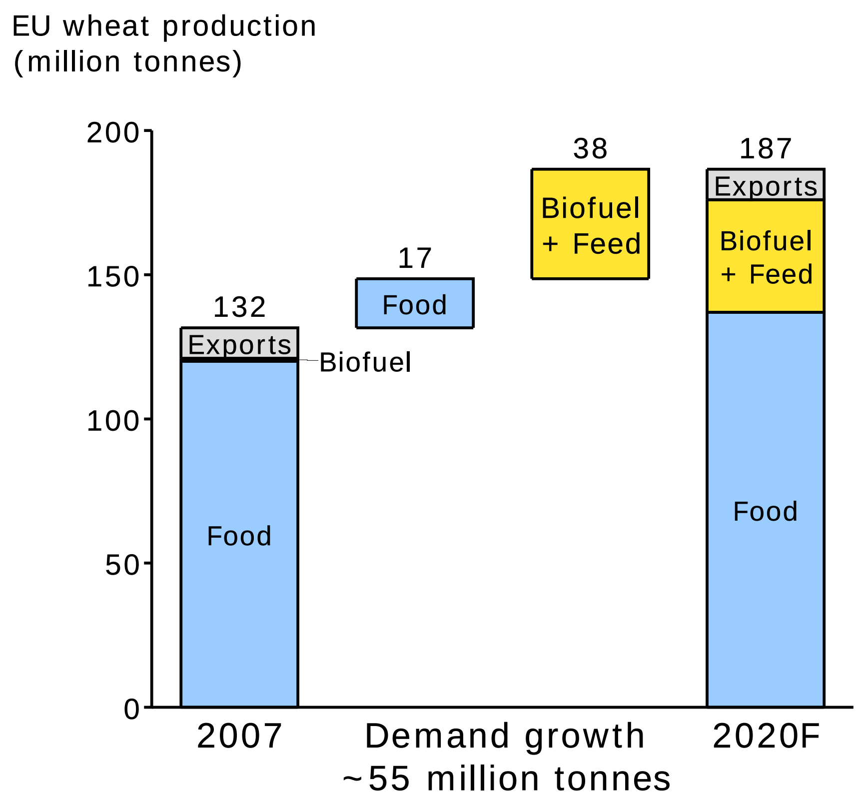
Source: Ensus paper 'Tackling Climate Change', December 2007

EU can increase wheat output to meet 2020 target of 10% bioethanol and meet food demand

- Yield increases in EU can deliver most of output growth needed
  - Yield gap improvement in Eastern Europe
  - Continuing 1% p.a. historic yield growth
- In addition it is assumed that some of the set-aside land continues to be used
- No impact on Europe's high carbon stock forest and pastureland
- Additional production of protein rich animal feed will reduce soy imports



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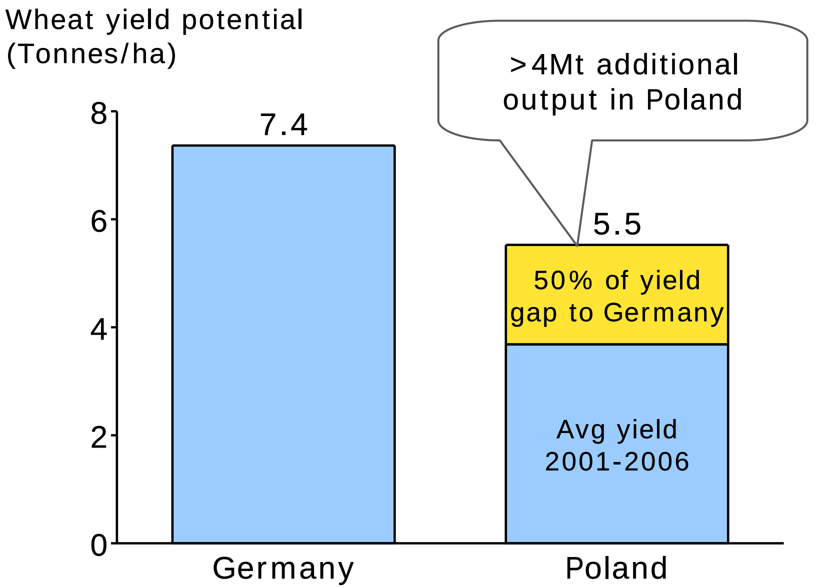
Source: EC 'Prospects for agricultural markets and income', Ensus analysis

EU27 yield increases offer potential 33 million tonnes additional wheat output by 2020

- Eastern European wheat yields are below levels achieved in similar climate & soil conditions elsewhere
- Improved agricultural practices have the potential to significantly increase yields. Reducing the yield gap with Western Europe by 50% would increase output by 16 million tonnes
- Ongoing yield improvements across EU at forecast rate of 1% p.a. would deliver a further 17Mt output by 2020

Yield gap improvement - Poland example



"Crop yields in the central and eastern European countries have historically lagged behind their western counterparts for a number of reasons. However, if the changes that have taken place in eastern Germany over the last decade are an indication of what can be expected, then western and central European yields will converge over time."

USDA Foreign Agricultural Service

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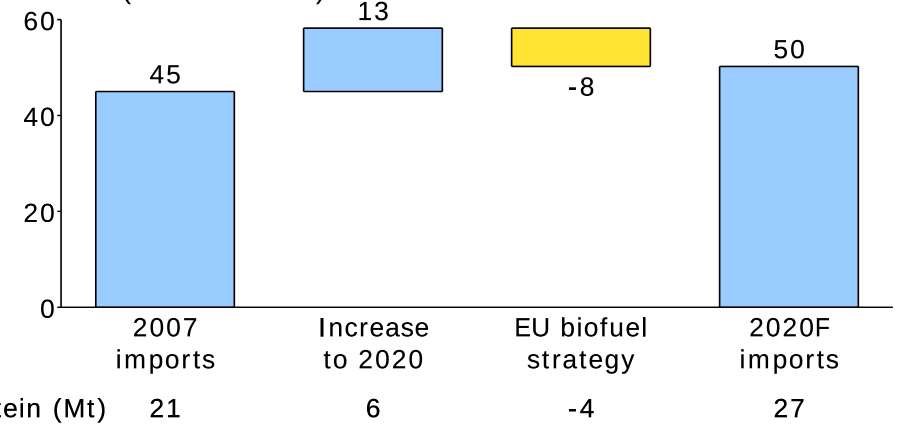
Source: FAOSTAT, USDA, Ensus analysis

Meeting EU's 10% 2020 bioethanol target reduces demand for imported soy and, globally, requires no net increase in land use

- Increased production of Wheat Protein Concentrate within EU will reduce soy meal imports
  - EU biofuel strategy will create 4Mt of animal feed protein and displace 8Mt of soy meal imports
- Globally there is no increase in land to meet targets
  - Increase in EU wheat area is offset by reduction in soy production for imports
- Vital that biofuel strategies take account of land use change effects - in particular where there is a risk of increased pressure on high carbon stocks e.g. rainforests

EU animal feed meal import requirement (Million tonnes)



Million hectares required for wheat and soy production

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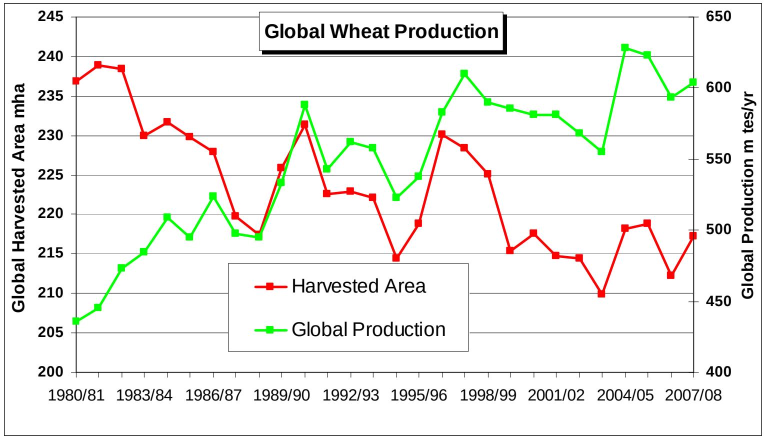
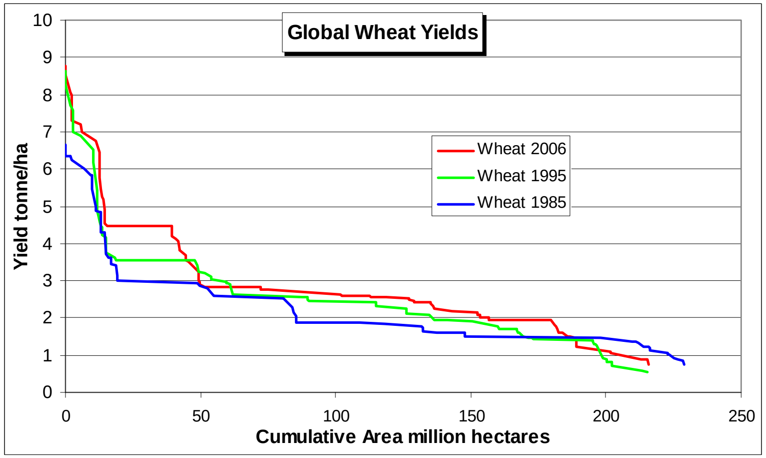
Source: EC 'Prospects for agricultural markets 2007-2014', FAOSTAT, Ensus analysis

What are global land use change implications from increased demand for wheat for biofuels?

- Historically the world has grown more wheat without increasing land usage
- Global wheat production has increased due to higher yields - harvested area has reduced
- There is considerable potential to continue increasing yields globally and in EU27





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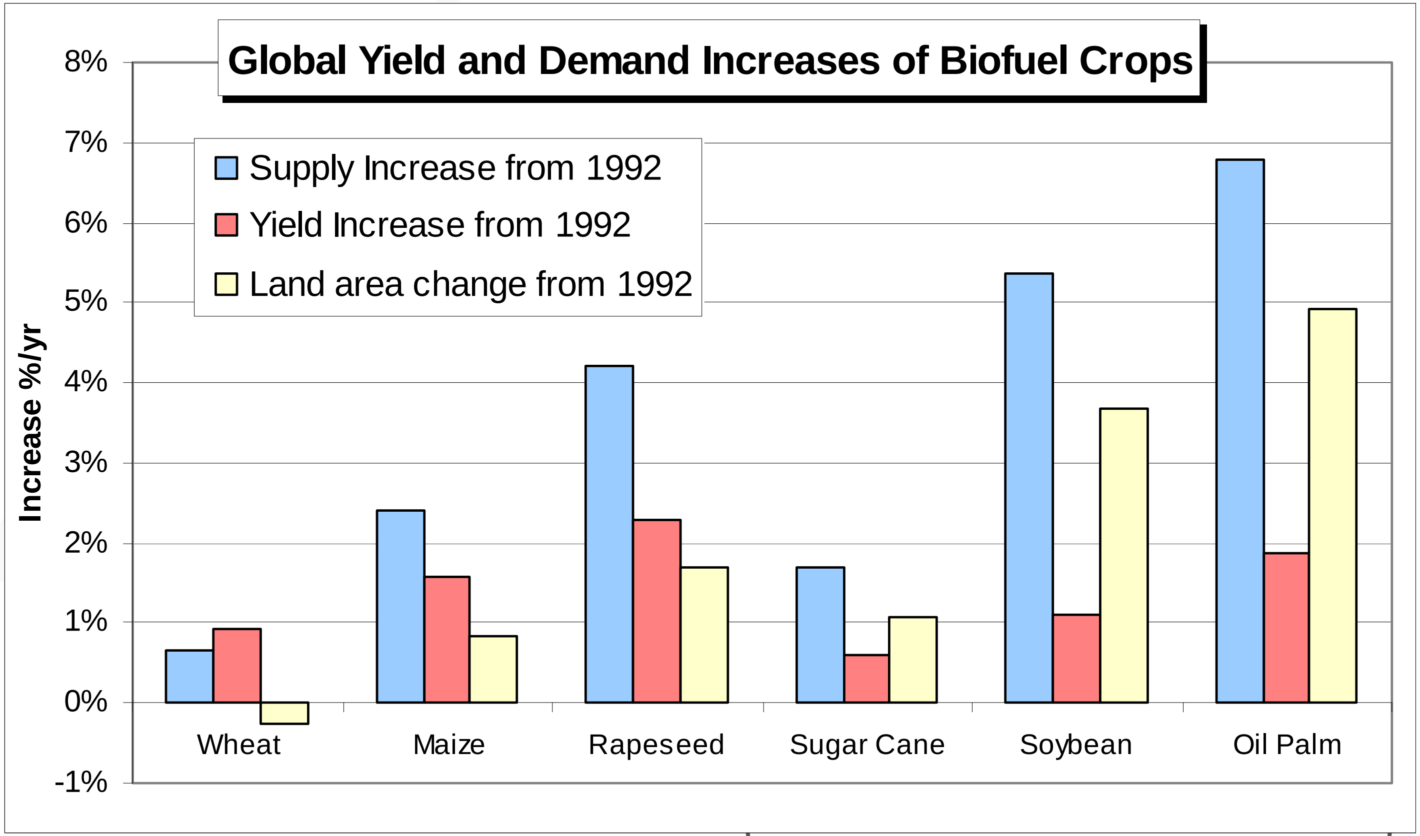
Source: FAOSTAT

Increase in demand for crops has been met from a combination of yield and land area change



Historic increase in demand for soy, palm and sugar cane met primarily by land area increase

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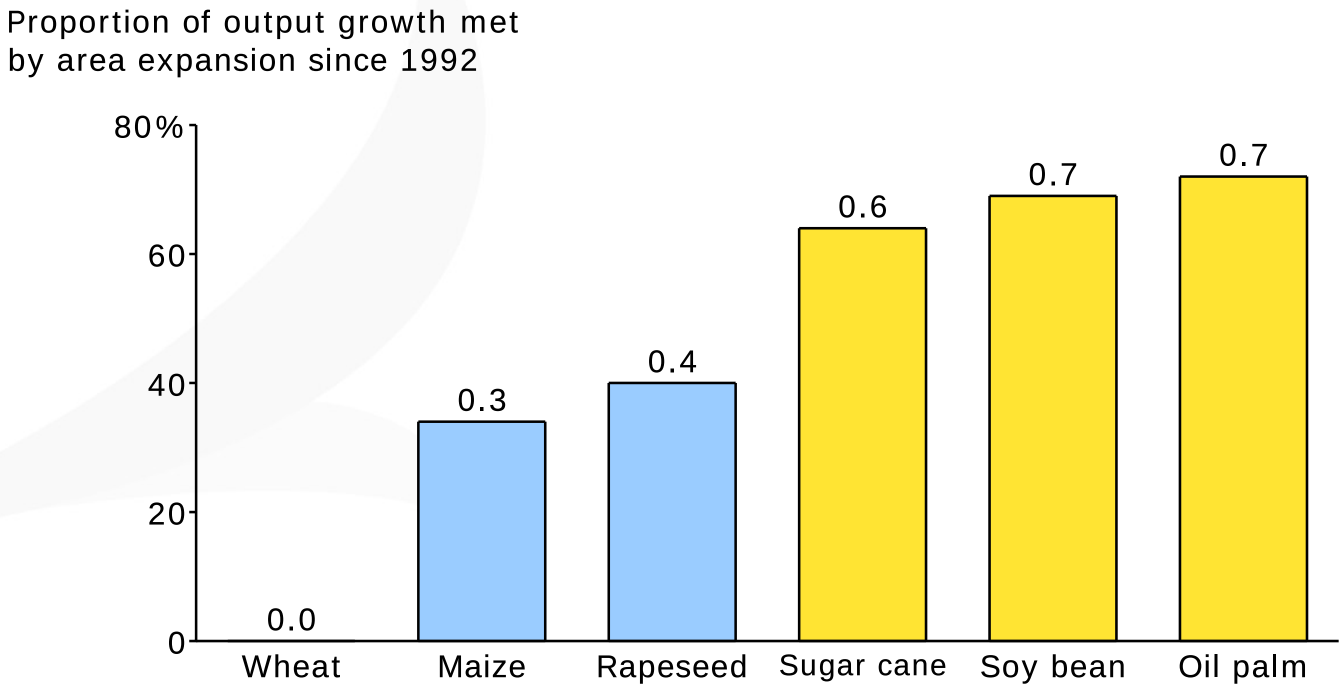
Note: Land area change is difference between output increase and yield increase

Source: FAOSTAT

Since 1992 over 50% of historic output growth of cane, soy and palm has come from increased area



Note: Land area change is difference between output increase and yield increase

Source: FAOSTAT

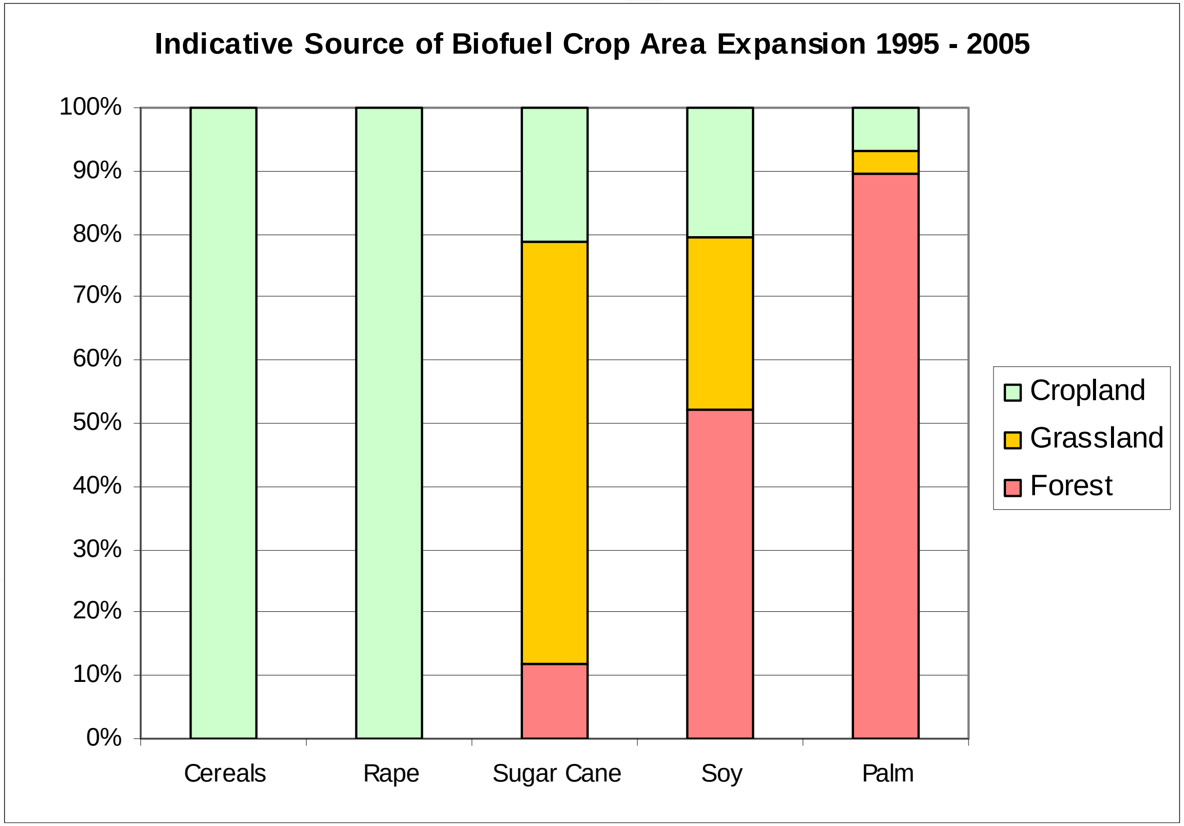
We need to make an assessment of the nature of land used where there is an increase

Calculation example for palm

Palm - Land Use Change 1995 - 2005						
	Change in Land Area Mha			Ratio of Historic Land Use Change		
	Palm	**Forest**	**Permanent Grassland**	**Forest**	**Grassland**	**Cropland**
Malaysia	1.4	-1.1	0.0	79%	0%	21%
Indonesia	2.5	-18.7	-0.6	97%	3%	0
Nigeria	0.5	-4.1	-0.9	82%	18%	0
Average				**90%**	**4%**	**7%**

- Three countries account for 84% of global increase of land used for palm since 1995
- As per Searchinger analysis, assume that the increase in land for palm for each country is allocated between forest and grassland in proportion to decreases in land area for each
- Method extended for palm area increase in Malaysia to take account of greater use of cropland or idle land

Extending methodology to other crops shows proportion of cropland, grassland and forest used to meet land increase requirements



"Accelerating demand for palm oil is contributing to the 1.5% annual rate of deforestation of tropical rainforests in [Indonesia and Malaysia]

"An estimated 27% of concessions for new palm oil plantations are on peatland tropical rainforests, totalling 2.8Mha in Indonesia

"Brazilian Cerrado is being converted to sugar cane and soy beans, and the Brazilian Amazon is being converted to soybeans"

J. Fargione et al.
Land clearing and the biofuel carbon debt (2008)

Note: [1] Weighted average land use changes in countries where feedstock area expansion has occurred

Source: FAOSTAT, Ensus analysis

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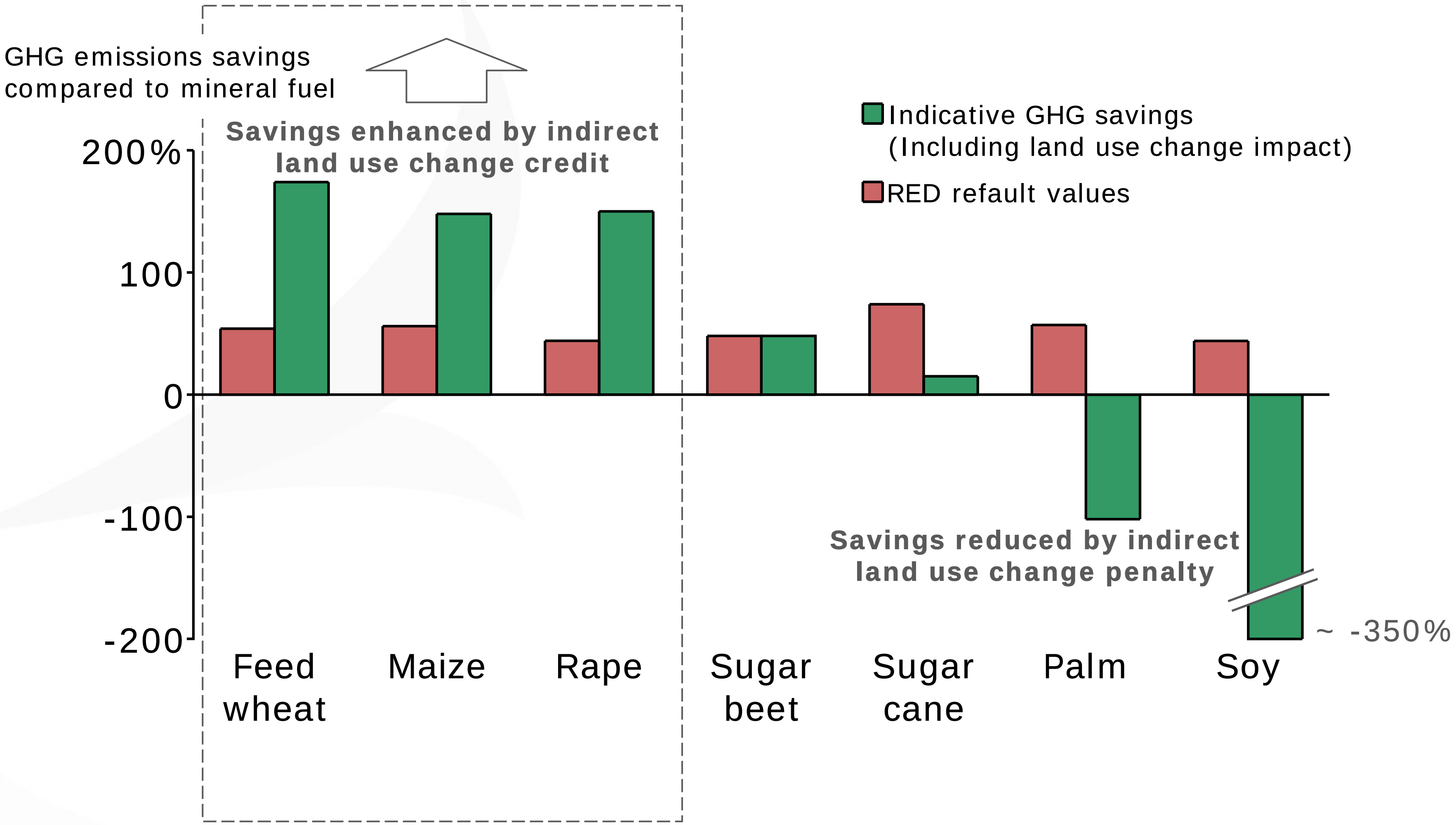
Methodology for calculating GHG effects of Land Use Change

- Ensus agrees with the principle developed by Searchinger of including indirect land use change effects alongside direct land use change
- Ensus has built on this work, and has identified other important considerations to be taken into account when determining overall GHG effects of land use change

Methodology for Calculating GHG effects of Land Use Change		
	Searchinger	**Ensus**
Protein Co-products		
Replace	Cereal	Cereal + soy meal
Replacement basis	Metabolisable Energy	Metabolisable Energy and protein content
Source of increased marginal production	Increased land area	Yield Increases + Increased land area
Types of land converted to biofuel crop	Assigned in proportion to historic land conversion	
GHG penalty for deforestation		
One -off	LUC spread over 30 yrs	LUC spread over 25 yrs
Ongoing	Growing forest	Mature forest

- The effect of the Ensus enhancements of the Searchinger work is to substantially reduce the overall land use change emissions for cereals & rape feedstocks, but to maintain them where yield considerations & co-product benefits apply much less, if at all (i.e. for soy, palm & sugar cane)

GHG savings for some crops are greatly increased after factoring in the associated reduction in land use for soy



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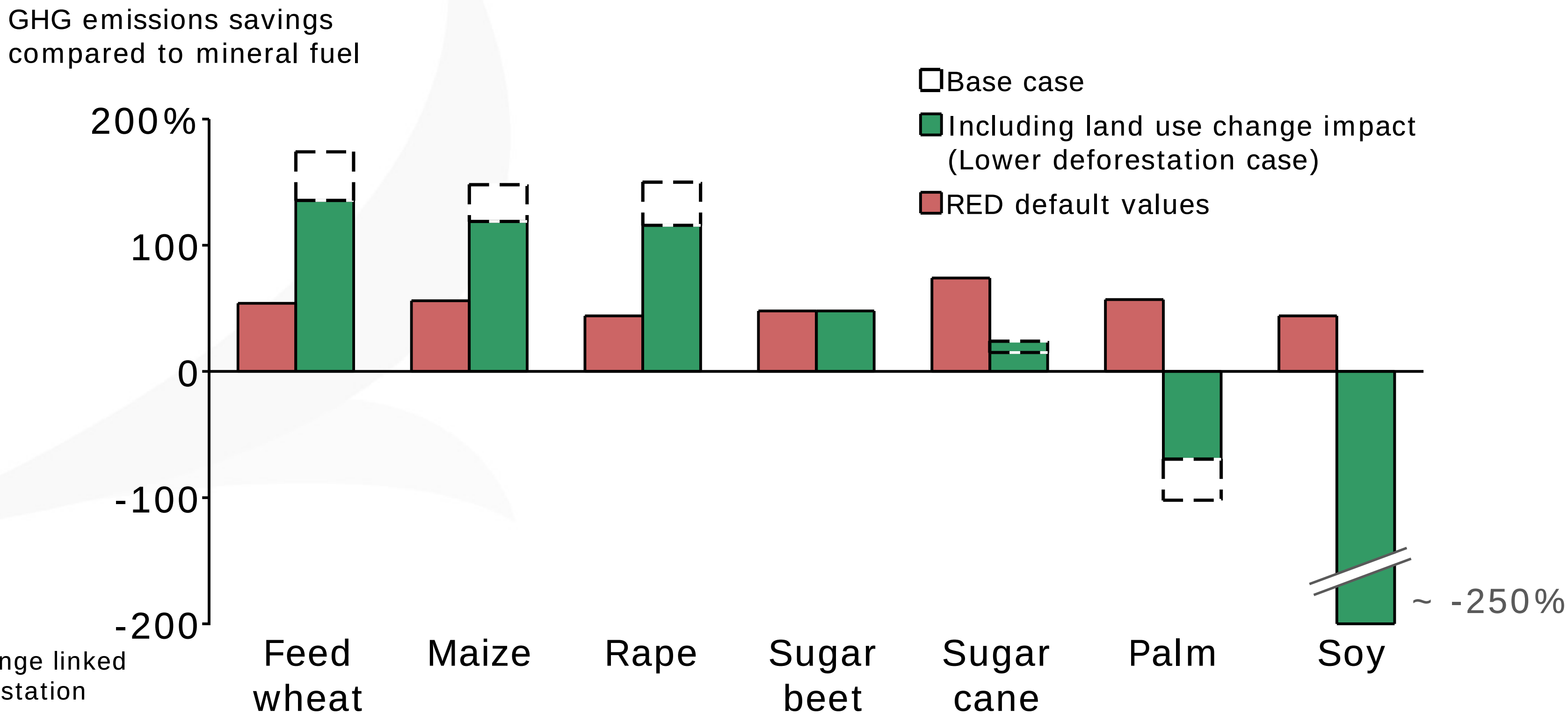
Note: GHG savings (Excluding land use change penalty) based on RED methodology and default values

Source: Ensus evidence to RFA, April 2008

Although the extent of GHG emissions due to indirect land use change is uncertain, the conclusions are robust to uncertainties in the assumptions



Area change linked to deforestation	Feed wheat	Maize	Rape	Sugar beet	Sugar cane	Palm	Soy
Base case	-	-	-	-	12%	90%	52%
Lower case	-	-	-	-	6%	45%	26%

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Note: GHG savings (Excluding land use change penalty) based on RED methodology and default values

Source: Ensus evidence to RFA, April 2008

Summary

- Direct GHG savings for wheat and maize, done efficiently, are comparable to sugar cane
- The protein rich co-products from wheat, maize and rape are vital to the animal feed market and lead to a reduction of soy imports into the EU
- EU has capacity to expand wheat output to meet 2020 10% bioethanol target as well as meeting food requirements; it will become more self sufficient in food and fuel
- Wheat, maize and rapeseed can be expanded with minimal land use change effects and reduce the demand for soy and hence the pressure on deforestation (overall positive land use change effects)
- In contrast, soy, palm and sugar cane require increased land to meet demand and the nature of this land results in negative land use change effects
- The analysis supports and builds on Searchinger and confirms the importance of taking account of the indirect effects of land use change. The conclusions are robust to uncertainties in the assumptions.