# Transport biofuels - drivers and options

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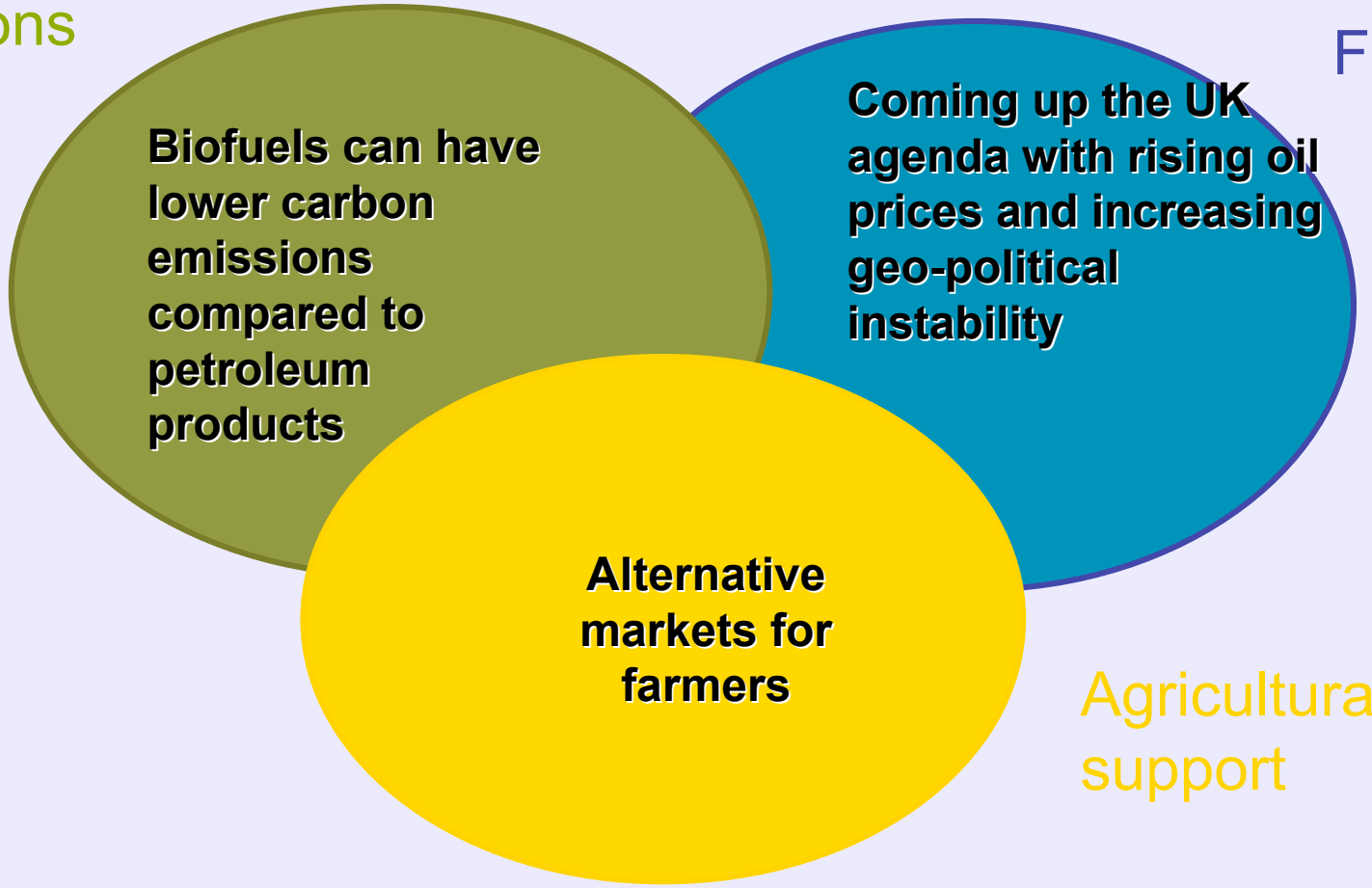
- Current transport biofuels
- Feasibility of different scales of biofuel production
- Environmental and feedstock issues
- Future options - new technologies
- Conclusions

# Drivers for biofuels worldwide

Carbon emissions

Fuel security




Agricultural support

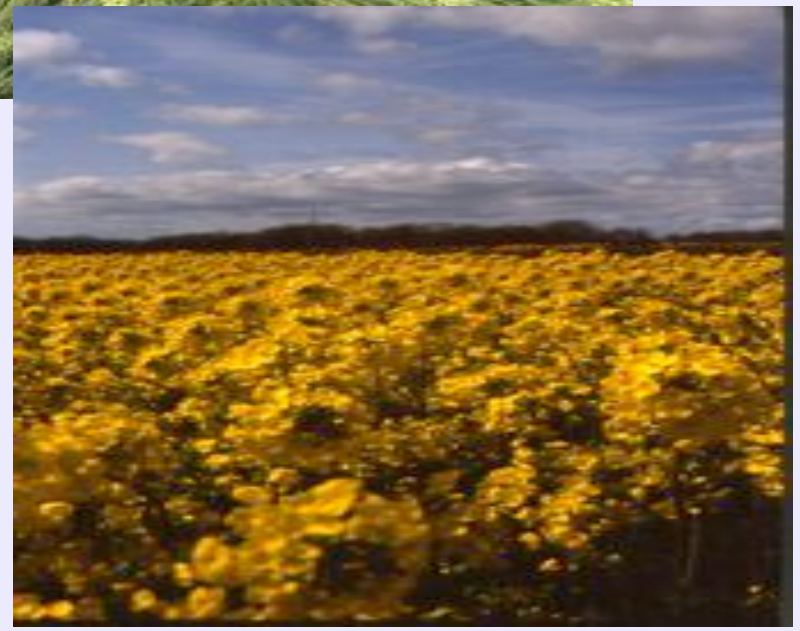
Emphasis varies by country

# Factors driving transport biofuel development in the EU and UK

- Transport accounts for a significant, and growing proportion of energy demand
  - In the UK - 25% of energy demand
- EU Targets
  - biofuels should achieve 2% of transport fuels by 2005 and 5.75% by 2010 (currently - 0.3%) for member states
  - proposal to oblige public bodies to allocate 25% of procurement for heavy vehicles to environmentally friendly vehicles
- UK targets
  - Renewable Transport Fuel Obligation
    - proposed start 2008, 5% by 2010
- Cost and availability of mineral fuel

# Current liquid biofuel types

- Renewable energy sources for transport are limited to 2 widely used types
- Bioethanol - *petrol substitute / additive*
  - from starch/sugar crops, eg cereals, potatoes, sugar beet
- Biodiesel - *diesel substitute / additive*
  - from oil crops, used cooking oil, tallow



# Future UK government encouragement for biofuels

- Fuel duty rebate of 20p/l (fuel duty of 27.1p for biofuels) extended
- In addition, a Renewable Transport Fuel Obligation will be introduced. Buy out price (price paid by fuel suppliers who fail to meet obligation) will be 15p/l in 08/09
- Combination of duty incentive and buy-out price at 35p/l guaranteed for 09/10, but will reduce to 30p/l in 10/11

# Transport biofuels – an easy introduction to bioenergy?

**Production**

- Agronomy well developed, no need for long term land commitment
- Production chain in place

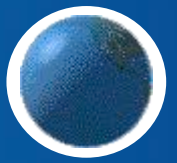
**Market**

- RTFO - large transport fuel market
- With high mineral fuel prices and government incentives liquid biofuels can compete

**Utilisation**

- Convenient use in current engines

# Bioethanol production worldwide



- USA - production since early 1980s using maize. 18 billion L in 2006.
- Brazil - production since 1975 using sugar cane. 16 billion L in 2006.
- Europe – 1.5 billion L in 2006. Spain biggest producer followed by Sweden, France, Germany. Other countries include Finland, Czech Republic, Ukraine, Poland. Feedstocks are wheat and sugar beet.

# Processing required; wheat to bioethanol

**Wheat grain**

↓ *milling*

**Coarse powder flour** & bran

↓ *hydrolysis, fermentation and distillation*

**Ethanol** & stillage

↓ *dehydration* ↓ *drying*

**Bioethanol** animal feed & water

# **UK bio-ethanol** – many large scale plants planned

| | Location | Size | Feedstock | Stage |
|---|---|---|---|---|
| British Sugar - bioethanol | Norfolk | 70 ML | Sugar Beet | Being built |
| Greenspirit - bioethanol | Somerset | 120 ML | Wheat | Finance in place |
| Greenspirit - bioethanol | Immingham | 240 ML | Wheat | Early planning |
| Bioethanol Ltd – bioethanol | Imm ingham | 120ML | Wheat | Early planning |
| Roquette - bioethanol | Midlands | 120 ML to 240 ML | Wheat | Early planning |
| BP/Dupont - biobutanol | England | 360 ML | Wheat | Early feasibility |

# Bioethanol production potential in Scotland

## Feedstock

- Surplus barley gives a feedstock opportunity, but has a poorer conversion rate than wheat feedstock
- Wheat has limited production potential and trades at a premium
- No sugar beet grown, potatoes are for high quality seed

## Scale

- Only large scale technology available with high capital requirement

## Markets

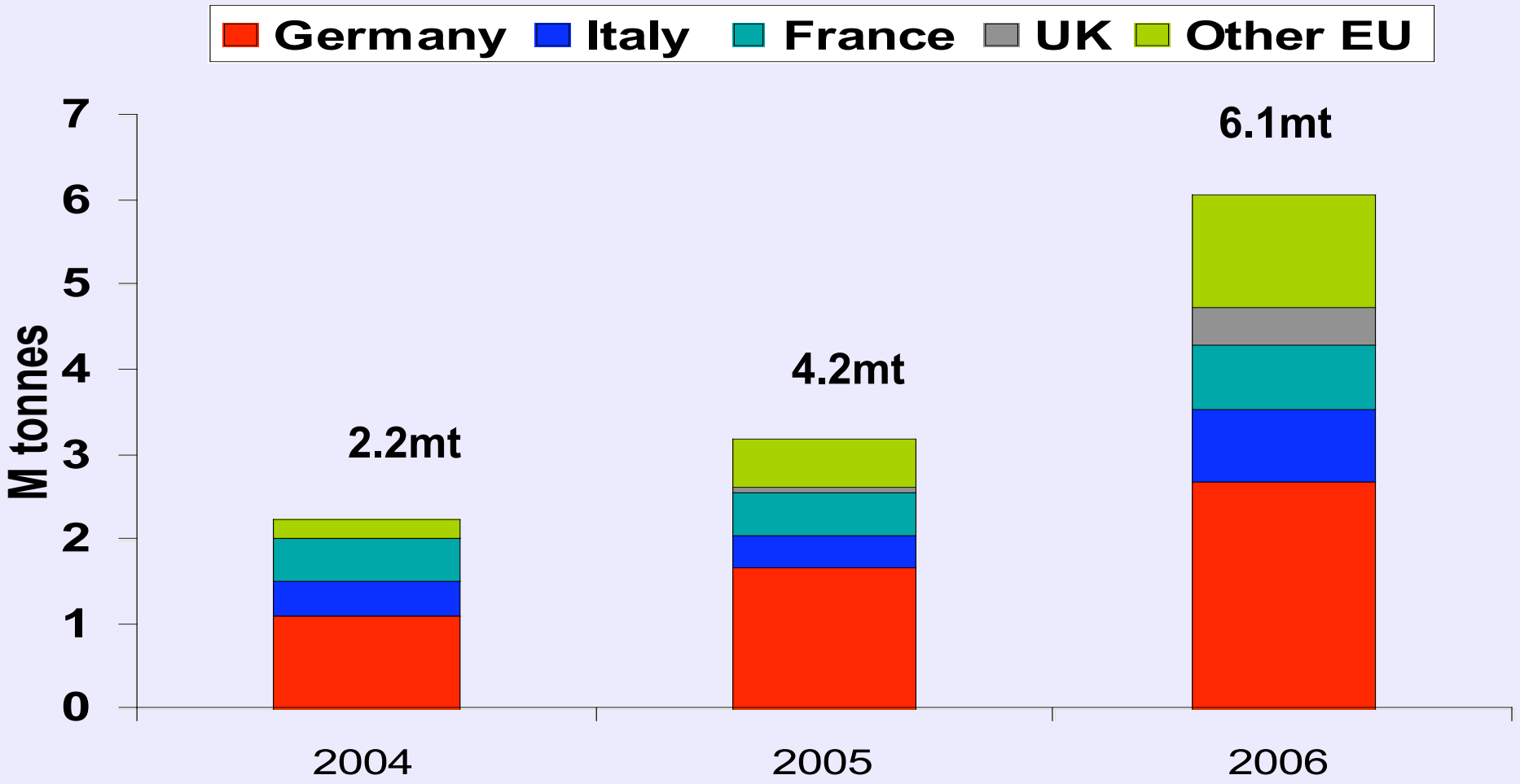
- Threat of cheap imports could disrupt markets

## Conclusion

- The case for bioethanol from wheat/barley in Scotland is poor

# EU-25 bio-diesel production

## growing strongly - Germany dominates




*Source: EBB (Feb 2007)*

# Processing required; rapeseed to biodiesel

**Rapeseed**

↓ *crushing*

**Crude oil** & rape meal

(→ animal feed)

↓ *esterification (add methanol in presence of catalyst)*

**Biodiesel** & glycerol

(→ petrochemical industry)

# Use of rapeseed oil as biofuel

- Biodiesel eg Germany, Austria
  - removal of glycerol from vegetable oil prevents engine ‘coking’
  - biodiesel can be used as a diesel substitute or blend in **un**modified diesel engines
  - frequently included as 5% blend to fit with engine warranties

# Rapeseed oil as a biofuel (2)

- Pure Plant Oil / Straight Vegetable Oil (SVO), eg Ireland, Germany
  - Unaltered oil can be used as a diesel replacement, but engine modification needed
  - Now eligible for duty incentive in UK
  - Questions over long term engine performance

# **UK bio-diesel** - large plants operating / in development

| | Location | Size | Feedstock | Stage |
|---|---|---|---|---|
| Argent - biodiesel | **Motherwell** | 50 ML | UCO Tallow | Operating |
| Biofuels Corp – biodiesel | Teeside | 284 ML | Palm soya OSR | Operating |
| Greenergy - biodiesel | Imming-ham | 113 ML | Palm, soya OSR | Being built |
| DMF - rape crush (& bio-diesel ?) | **Rosyth** | 140ML | OSR,(palm, soya) | Planning stage |
| Ineos -biodiesel | **Grange-mouth** | 110ML(2008) 500ML(2010) | OSR, palm, OSR | Planning stage |

# Context of biodiesel production from oilseed rape in Scotland

- Oilseed rape production in Scotland
  - approx. 35,000 ha cultivation, third most widely grown crop, after spring barley and wheat
  - highest average yields in Europe
  - high oil content
    - due to northerly latitude and temperate conditions
- Processing
  - currently there is no crusher in Scotland
  - availability of wide range of processing scales
  - Scottish OSR prices lowest in UK

# Processing options considered - Scottish context

| OSR (tonnes) | Option | Scale | Product | Capital cost (£) |
|---|---|---|---|---|
| 355 | 1 | Farm | Biodiesel | 30.4K |
| 15,000 | 2 | Group | Biodiesel | 3.86M |
| 60,000 | 3 | Medium | Biodiesel | 10.2M |
| 250,000+ | 4 | International | Biodiesel | 25M |

# On-the-road price for 5 biodiesel options (p/litre)

| Option | Production cost | Retail margin | Duty | Sub-total | VAT 17.5% | Total cost |
|---|---|---|---|---|---|---|
| 1 | 0.68 | 0.02 | 0.28 | 0.99 | 0 | 0.99 |
| 2 | 0.60 | 0.10 | 0.28 | 0.98 | 0.17 | 1.15 |
| 3 | 0.45 | 0.10 | 0.28 | 0.83 | 0.15 | 0.98 |
| 4 | 0.41 | 0.10 | 0.28 | 0.79 | 0.14 | 0.93 |

Note – mineral diesel at pump – £1.00 (Nov/07)

**Note – RTFO buy-out price effect (£0.15 advantage)**

# Commercial opportunity for **Scottish rapeseed** - biodiesel

- Large scale – lower cost/litre, but need to balance with availability of feedstock
- Medium scale plant (60,000t OSR crushed) (+ 10,000t oil) + esterified - produces 33ML of biodiesel
  - realistic estimate of share of osr production in Scotland vs economies of larger scale
  - 14% return with pay-back by year 6, but considerable inherent risks involved
  - mitigate risk through formation of joint-venture company
    - Farmers⇔Processors⇔Customers

# Consider sensitivity of production costs

Budgeted production cost 41p/l

- Utilisation of capacity (+/-10% 2.4p/l)
- Cost of feedstock (+/- £10 1.8p/l)
- Value rapemeal (+/- £10 1.2p/l)
- Grant assistance (+/- £1M 0.9p/l)

- Value of glycerol (+/- £10 0.2p/l)

# Small scale production of biodiesel

- Possibility for local fuel production?
- Equipment available and small scale production technically possible
- Opportunity for greater domestic benefits
- Look carefully at costs
- May be worthwhile for some:
  - Ready market for biodiesel
  - Utilise meal on-farm
  - Use existing buildings/labour
  - In area where diesel, feed particularly expensive
- SVO – lower costs of production – more suited to small scale?

# Small scale (324 t rapeseed) costs of production (£)

| Option | Production cost | Retail margin | Duty | Subtotal | VAT | Total |
|---|---|---|---|---|---|---|
| SVO | 0.46 | 0.02 | 0.28 | 0.79 | 0.13 | 0.90 |
| Biodiesel | 0.67 | 0.02 | 0.28 | 0.98 | 0.17 | 1.15 |

Note – mineral diesel at pump – £1.00 (Nov/07)

**Note – RTFO buy-out price effect (£0.15 advantage)**

# Environmental issues relating to biofuels

Several factors need to be considered:

- energy balance
- greenhouse gas emissions
- feedstock - crop type and source
  - implications for biodiversity
  - social implications of production

# Environmental indicators for biofuels

## Energy balance

- Biodiesel using UK oilseed rape
  - positive, between 2 and 3 units out :1 unit in
- Bioethanol using UK wheat
  - 1 - 2 energy units out: 1 unit in

## Biodiversity implications

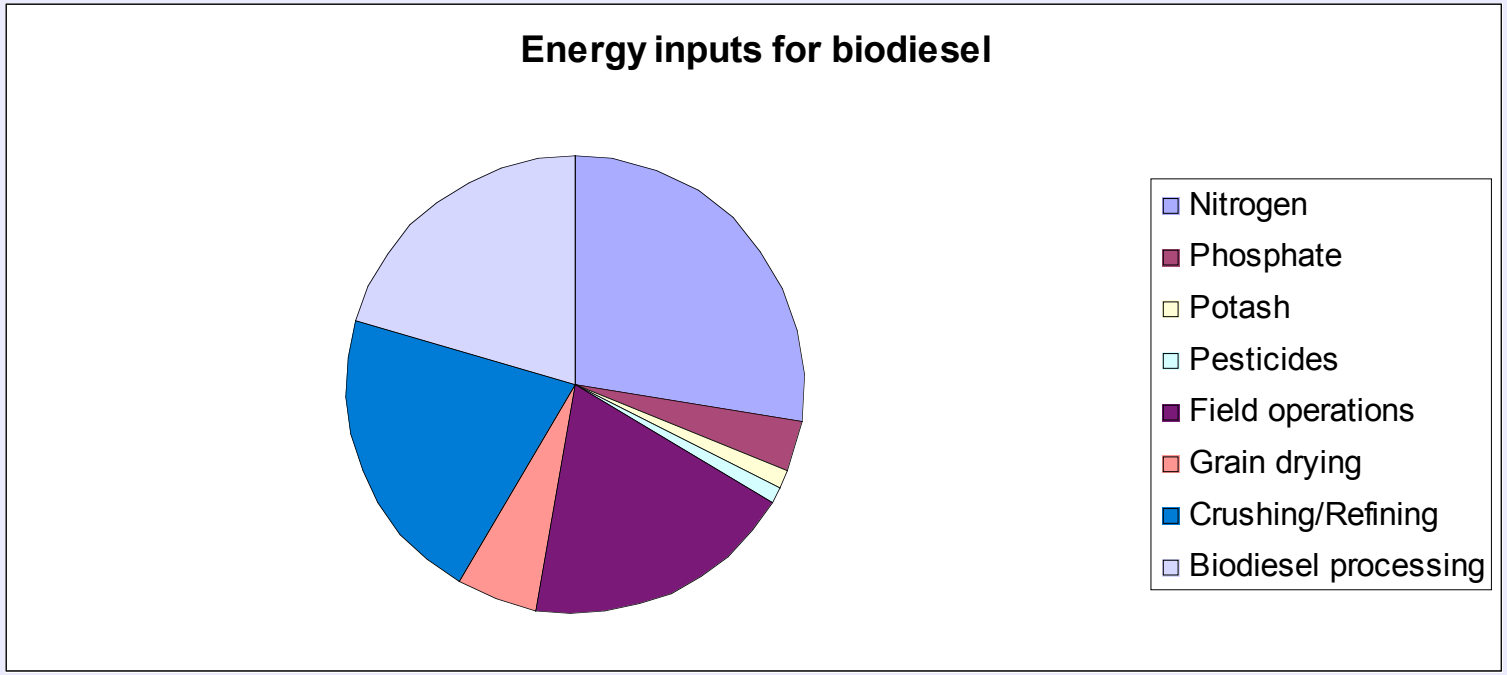
- heavy source influence
- little effect if from established farming rotation eg European osr, wheat
- potential large effect in the future if using virgin land, eg some tropical oils

## GHG savings

- Biodiesel
  - Oilseed rape - 47%
  - Soya - 63%
- Bioethanol
  - Maize - 24%
  - Wheat - 47%
  - Sugar cane - 89%

# Ensure positive environmental footprint for UK biodiesel

- Environmental credentials will be linked to RTFO
- N fertiliser accounts for a large proportion of energy input
- Opportunity to improve environmental credentials through management e.g. reduce N



# Current biofuels - feedstock supply issues

**RTFO in the UK - requiring 5% biofuels**

- Will demand 2.5M tonnes of bio-fuel by 2010 (x 20 current UK bio-fuel sales)
- = 3Mt of wheat and 3Mt of oilseed rape!
- An issue particularly for rapeseed availability - present production of osr is 1.9 Mt

EU expected to **increase target for biofuel** to 10% transport fuels by 2020 … ability to meet target with current biofuel types??

# Second generation transport fuels - biomass crop feedstock

Short rotation coppice

Giant grasses

- perennial crops - potential to offer benefits
- reduction in use of energy and greenhouse gas emissions in establishment, over life of crop
- grow on lower grade land
- reduce food vs fuel controversy?

# Second generation biofuels - processing

2 pathways - thermochemical and biochemical

- thermochemical
  - gasification → syngas, advanced catalyst conversion using Fischer Tropsch process → liquid transport fuel
  - or pyrolysis → bio-oil
- Biochemical
  - pre-treatment - biomass → cellulose, hemicellulose + lignin
  - breakdown of cellulose difficult - customised enzymes
  - fermentation of glucose → ethanol

# Second generation biofuels pros and cons

## Positives

- Enables whole plant to be used - more efficient
- Would enable greater quantities of biofuels to be produced
- Great potential for GHG saving compared to conventional liquid biofuels

## Negatives

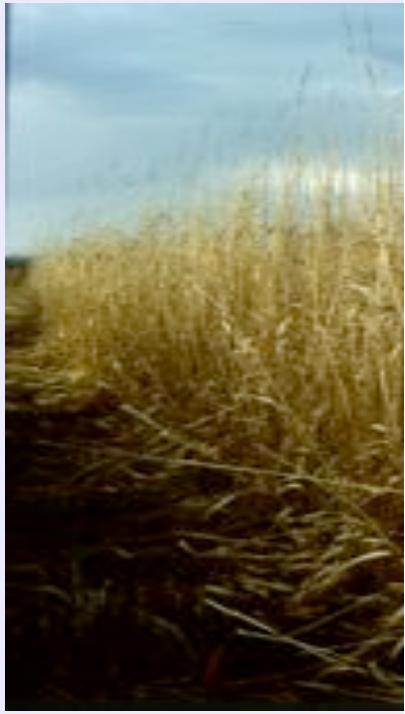
- Biomass feedstock is bulky for transport
- Parts of the technology are at development or demonstration stage
- Capital cost of plant currently x 3 or 4 corn grain bioethanol plant
- Timing for commercial viability - 10 - 15 years??

# Conclusions

- Demand for transport biofuels around the world is being driven by need to reduce GHG emissions, address security of supply issues and to support domestic agriculture
- First generation biofuels use oilseed and cereal feedstocks - opportunity to get production chain established
- More expensive to produce than mineral fuels - need continuation of fiscal incentives
- Economies of scale offered by larger processing plants, but less local benefits
- Biodiesel - best option for processing in Scotland

# Conclusions 2

- Current biofuels can offer environmental positives
  - GHG saving (biodiesel and bioethanol)
  - positive energy balance (biodiesel)
  - UK, and many European derived biofuels produced on established farmland appear to have little implication for biodiversity
- Second generation transport biofuels
  - potential to improve environmental gains and meet biofuel requirement
  - technology not fully commercialised



# Environmental advantages of perennial bioenergy crops

- Diversity of landscape
- Local biodiversity
  - SRC provides different stages according to coppicing pattern
  - 3 tiers of habitats
- Lower pesticide use and less cultivations than conventional crops
- Better energy balance
  - eg 20 - 30:1 for perennials, compared to:
  - Biodiesel 2- 3:1
  - Bioethanol from temperate cereals 1:1
- Greenhouse gas savings, compared to use of fossil fuels
- ‘Disposal’ of ‘waste’ products – farm slurry, sewage waste water

# How much biodiesel could a farm produce?

- 3t OSR → produces 1t biodiesel (1,136L)

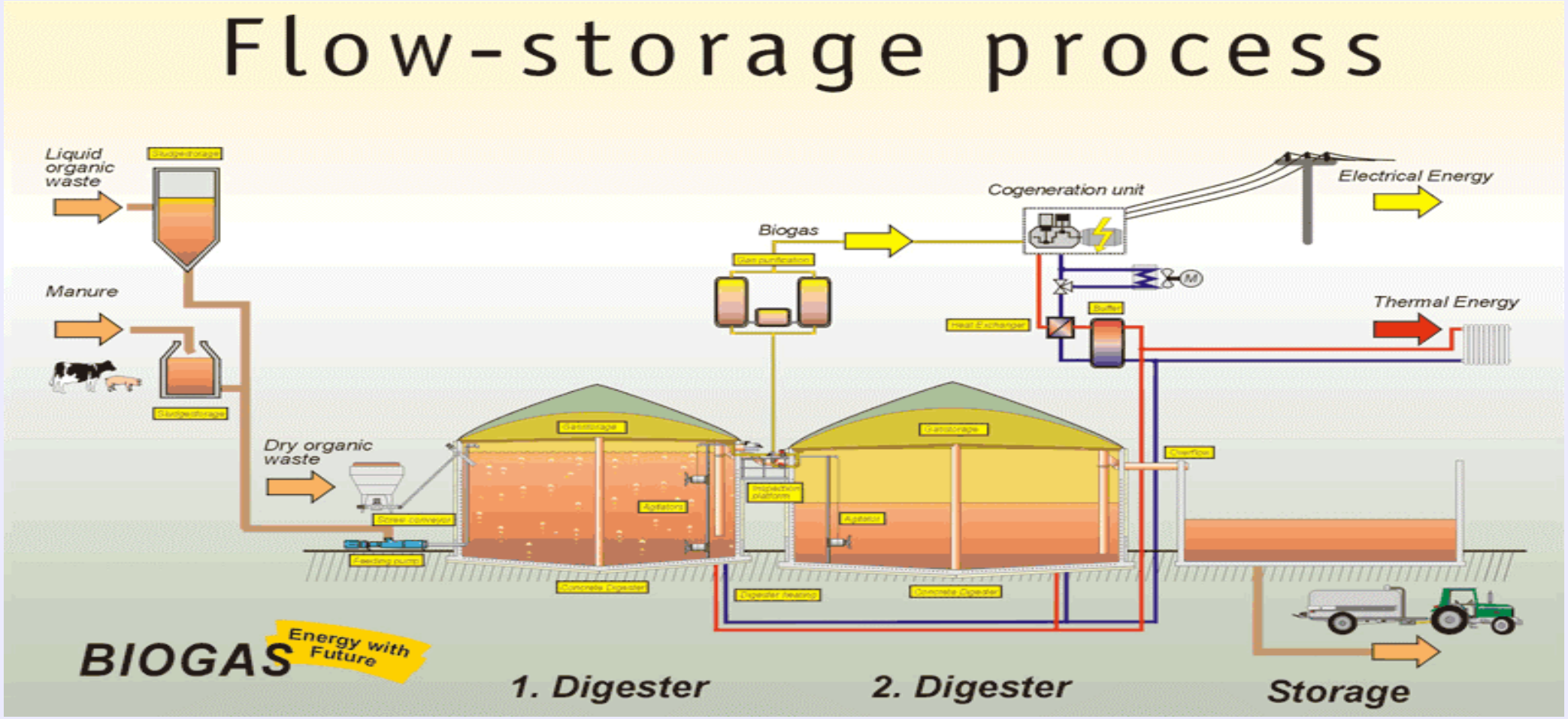
- 25 ha (62ac) OSR → 100t OSR → 67t rapemeal

↓

33t biodiesel (37,500L)

*enough to run 18 small cars for 1 year*

# **Biogas** – anaerobic digestion of waste or crops to produce methane for heat and/or electricity generation



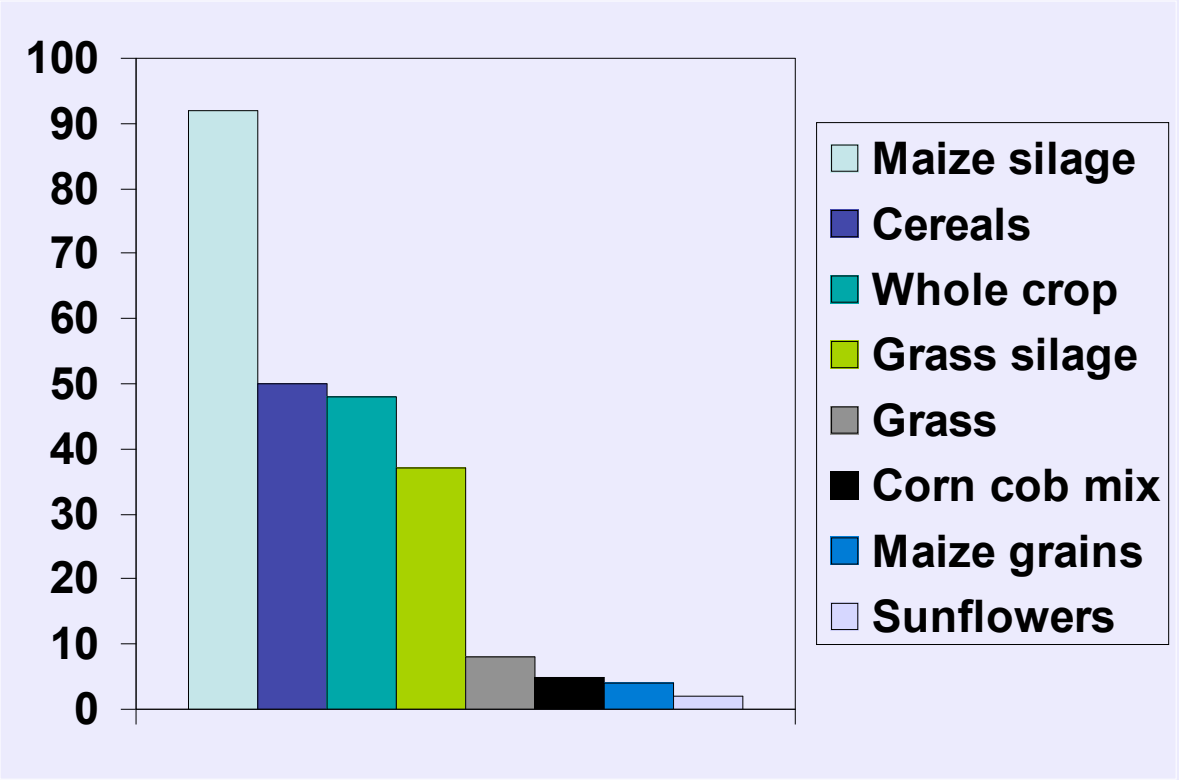

***Source: www.biogas-nord.de***

# Biogas
## – potential output from different feedstocks

| | Net electric kWh | Net heat kWh | Electric Value @9.5p | Heat value @3.5p | Total value/t |
|---|---|---|---|---|---|
| Cattle slurry | 30 | 56 | £2.89 | £1.95 | £4.84 |
| Food waste | 77 | 140 | £7.30 | £4.91 | £12.21 |
| Maize silage | 402 | 734 | £38.16 | £25.70 | £63.86 |
| Grass silage | 133 | 243 | £12.63 | £8.50 | £21.13 |

***Source: SAC***

# **Biogas** – frequency of energy crops in German biogas plants




***Source: SAC***

# Anaerobic digestion summary

- Commercial operation of AD facilities are at an early stage in the UK and there is limited information on operation and efficiency
- Economics are difficult to predict, but to be viable on animal manure only a plant needs to be of substantial size to cover costs
  - Aided by double ROC payment for electricity produced
- Crop products are of interest – need to evaluate viability for this use in UK conditions
- Extra income potential from disposal of organic wastes