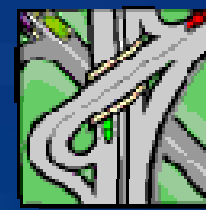


Economic evaluation of biofuels

Dr Elaine Booth

SAC BioEnergy Group





- Drivers for liquid biofuel development
- Transport biofuels available
- Current biofuel situation in Europe
- Key issues affecting the economics of biofuels
- Case study - Scotland
 - Bioethanol
 - Feasibility of different scales of biodiesel
- Conclusions



Factors driving liquid biofuel development



- Environmental issues - reduction in greenhouse gas emissions
 - Transport accounts for a significant, and growing proportion of energy demand
- Strategy - cost and availability of mineral fuel
 - Lower reliance on oil imports, increase revenue production
- Agricultural support
- EU Targets
 - Member States should achieve targets of biofuels as 2% of transport fuels by 2005 and 5.75% by 2010
 - Mandatory target of 10% by 2020 proposed



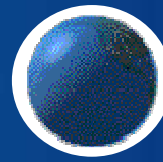
Liquid biofuel types

Renewable energy sources for transport are limited

Main biofuel types currently used:

- Bioethanol - *petrol substitute / additive*
 - from starch/sugar crops, eg cereals, potatoes, sugar beet
- Biodiesel - *diesel substitute / additive*
 - from oil crops (eg oilseed rape, soya, palm), used cooking oil, tallow





- 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*

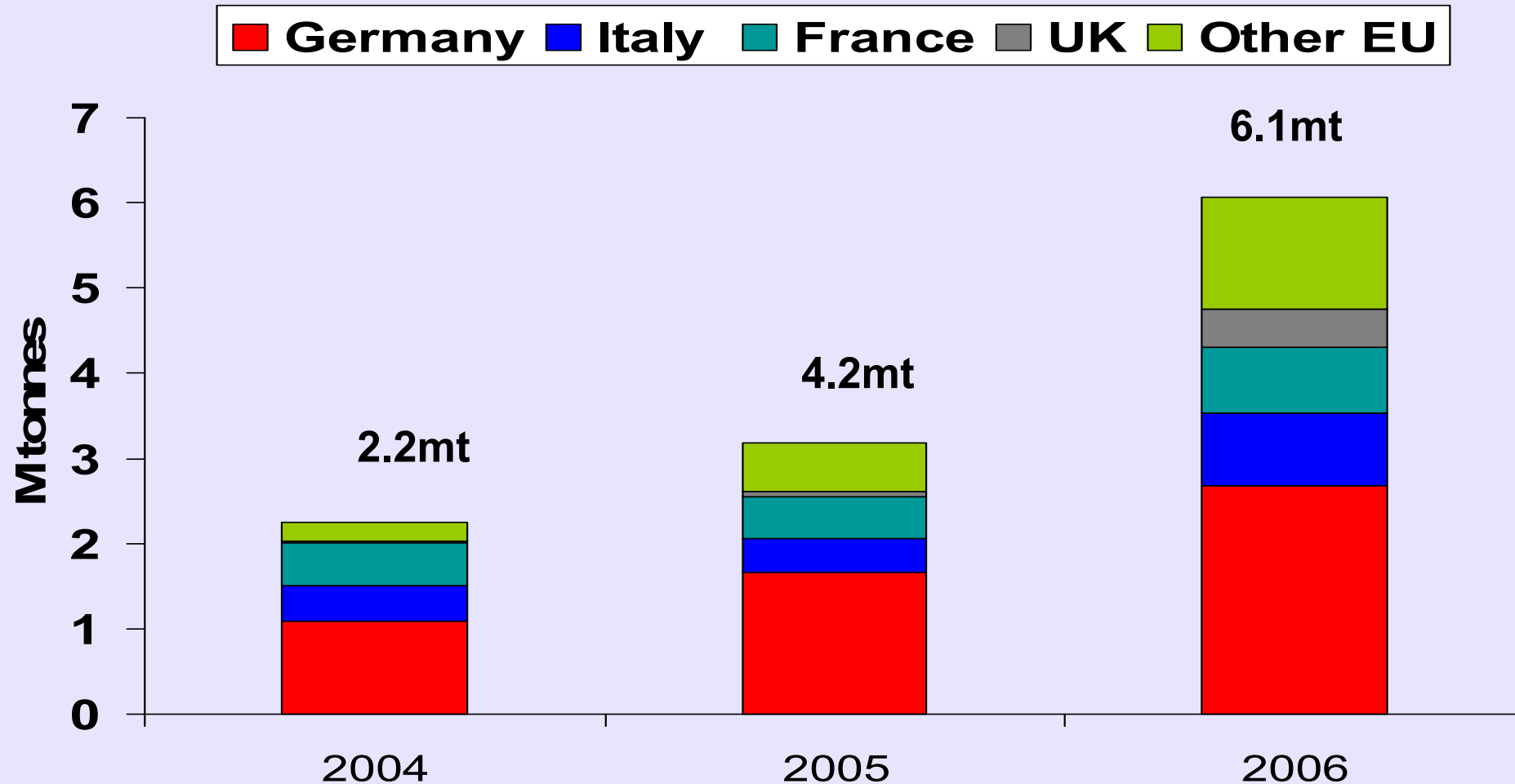
↓ *drying*

Bioethanol

animal feed & water

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)

Key issues for economic evaluation of biofuels



- Objectives for biofuel production
- Feedstock
 - Crops currently grown
 - Capability for additional production
 - Logistics of supply
- Scale
 - Economies of larger scale
 - Smaller scale offers greater distribution of benefits
- Support
 - Biofuels are generally more expensive than mineral oil fuels, some form of government support is required

Case study: economic evaluation of biofuel production in Scotland, UK



- Objectives for biofuel production
 - meet EU targets + obtain environmental benefits - important
 - agricultural support - less important
- Feedstocks
 - cereals and oilseed rape
- Scale
 - range of scales of interest
- Support
 - limited government support

UK government support for biofuels

- Fuel duty rebate of 20p/l (€0.29) has generated little development
- Further support from 2008: Renewable Transport Fuel Obligation
- Fuel suppliers failing to meet biofuel requirement will pay buy out price
- Up to 15p/l (€ 0.22) in 08/09



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



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	43.7K
15,000	2	Group	Biodiesel	5.55M
60,000	3	Medium	Biodiesel	14.7M
250,000+	4	International	Biodiesel	35.9M

- **Capital cost**
 - cost of plant, storage and installation → annual charge
- **Operating costs**
 - Labour, power, maintenance, consumables (eg methanol), overheads, interest on working capital
- **Income**
 - Rapeseed meal, glycerol

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



Option	Production cost	Retail margin	Duty	Sub-total	VAT 17.5%	Total cost
1	0.98	0.03	0.41	1.42	0	1.42
2	0.86	0.14	0.41	1.41	0.25	1.66
3	0.65	0.14	0.41	1.20	0.21	1.41
4	0.59	0.14	0.41	1.14	0.20	1.34

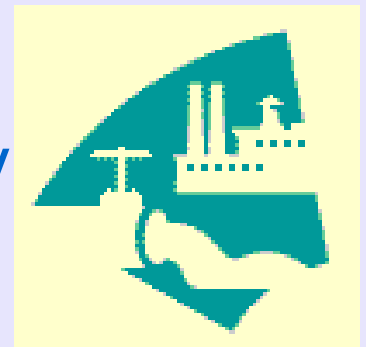
Note – mineral diesel at pump – €1.44 (Nov/07)

Note – RTFO buy-out price effect (€0.22 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 \leftrightarrow Processors \leftrightarrow Customers



Consider sensitivity of production costs: medium scale (60,000t OSR)

Budgeted production cost €0.59/l

- Utilisation of capacity (+/-10% = €0.034/l)
- Cost of feedstock (+/- €10 = €0.018/l)
- Value rapemeal (+/- €10 = €0.012/l)
- Grant assistance (+/- €1M = €0.009/l)
- Value of glycerol (+/- € 10 = €0.002/l)



Small scale production of biodiesel

- **Biodiesel**
 - can be used in un-modified diesel engines
 - handling methanol and catalyst on farm - health + safety, insurance implications
- **Straight vegetable oil**
 - crushing of oilseed only processing required
 - to use at high levels of inclusion, engine modification needed



Small scale (324 t rapeseed) costs of production (€)



Option	Production cost	Retail margin	Duty	Subtotal	VAT	Total
SVO	0.67	0.03	0.40	1.11	0.19	1.30
Biodiesel	0.97	0.03	0.40	1.41	0.25	1.65

Note – mineral diesel at pump – €1.44 (Nov/07)

Note – RTFO buy-out price effect (€0.22 advantage)

- On the basis of feedstock availability and other factors, bioethanol is currently not appropriate for Scotland
- Biodiesel is more expensive to produce than mineral diesel in Scotland, however with 20p/l fuel duty rebate bigger scales can compete
- Small scale – more expensive, but may suit some circumstances – SVO of interest
- RTFO and the introduction of a buy-out price stimulates the demand for biofuels

Lessons learned - factors to consider



- Feedstock
 - Which crop is most appropriate?
 - What level of production can be supported?
- Objectives in developing biofuel
- Support offered?
- Processing
 - Economies of scale - big effect
 - Possibility to work in groups (eg joint ventures)?
- Sensitivity to appropriate factors
 - eg utilisation of capacity, feedstock price, value of by-products

Thank you for your attention

elaine.booth@sac.co.uk

SAC BioEnergy Group