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Economic Evaluation of Biodiesel Production from Oilseed Rape grown in North and East Scotland

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Clients:	**Aberdeenshire Council**	**Angus Council**
	Fife Council	**Highland Council**
	Moray Council	**Perth & Kinross Council**
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Glossary and Acronyms

Biodiesel	A biofuel produced from a fatty acid methyl-ester using vegetable or animal oil. Used as a diesel replacement or substitute
Bioethanol	A biofuel produced from the fermentation of sugar from a variety of crops. Used as a petrol replacement or substitute
CAP	Common Agricultural Policy (EU)
Crude oil	Mineral oil consisting of a mixture of hydrocarbons of natural origins
DEFRA	Department for Environment, Food and Rural Affairs
DfT	Department for Transport
Esterification	Chemical process for converting vegetable oils into biodiesel using methanol to remove the gylcerine.
Feedstock	Materials used for processing into biofuel
Ha	Hectare (area land = 2.471 acres)
HGCA	Home Grown Cereals Authority
IRR	Internal Rate of Return. Represents return to investors over project life, when NPV = 0.
L	Litre (volume)
Megawatt (MW)	1,000 kilowatts
M	Million
NGC	New Generation Co-operative
NFUS	National Farmers Union Scotland
NMS	New Member States. 10 new countries who joined EU in May 2005.
NPV	Net Present Value. Used in investment appraisal to convert future cashflows into present values.
OSR	Oilseed rape
PBT	Profit before tax
RTFO	Renewable Transport Fuel Obligation
RDR	Rural Development Regulations. EU Policy for development of rural areas
RME	Rape Methyl Ester. An ester derived from Oilseed rape used for biodiesel.
ROC	Renewable Obligation Certificates
SAOS	Scottish Agriculture Organisation Society. Development agency for rural co-operatives
SEERAD	Scottish Executive Environment & Rural Affairs Department
SFP	Single Farm Payment. Introduced Jan 2005 part of CAP Reform, subsidy payment for farmers
SH Funds	Shareholder funds
SME	Small Medium Enterprise.
SRO	Scottish Renewable Orders
t	Tonne (weight)
UCO	Used cooking oil
ULSD	Ultra Low Sulphur Petrol
VAT	Value added tax
$	US Dollars (currency)
€	Euro (currency)

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Executive Summary

1. Oilseed rape is well suited to Scottish growing conditions and produces high yields and oil contents. However, no processing facilities exist in Scotland and the crop must either be transported south or to the continent for crushing. The high haulage costs incurred result in lower prices for rapeseed in Scotland, placing Scottish growers of the crop at a disadvantage.

2. Environmental issues are driving the development of liquid biofuels. The EU Renewable Fuels Directive states that biofuels in member states should achieve a 2% share of the mineral transport fuels market by the end of 2005 and 5.75% by 2010. In the UK, the government recommends that carbon dioxide emissions are reduced by 60% from current levels by 2050. In 2005, the UK will only achieve 0.3% of transport fuels from renewable sources.

3. High prices for mineral fuels are also acting as a significant driver. Only liquid biofuels are suitable for use as transport fuels, with biodiesel and bioethanol being the most widely used types.

Study Objectives

4. The study was commissioned by Aberdeenshire Council, Angus Council, Fife Council, Highland Council, Moray Council, Perth and Kinross Council, Highlands and Islands Enterprise and the Scottish Enterprise Energy Team. The aim of the study is to identify the potential to add value to oilseed rape grown in the North and East of Scotland by conversion to biodiesel, and to stimulate economic activity through the establishment of processing facilities and the provision of end products from the process.

Bioethanol in Scotland

5. Bioethanol can be blended with, or can substitute for petrol, but as a fuel substitute requires engine modification, unlike biodiesel which can be used in unmodified diesel engines. Bioethanol production was considered to be less appropriate in Scotland as compared to biodiesel for several reasons: feedstock available in Scotland is less suited to bioethanol production; relatively inexpensive bioethanol can be imported to the UK; with a petrol over-supply and diesel deficit in Europe better markets exist for biodiesel.

OSR Supplies in Scotland

6. Oilseed rape production in Scotland has expanded since the early 1980s. The highest level of production was seen during the 1990s when up to 70 000 ha and 180 000 t was produced. Aberdeenshire, Angus, Fife, Highland, Moray, Perth and Kinross Council areas account for 76% of the area of the crop grown in Scotland.

7. The UK oilseeds crushing industry is highly concentrated and for economic viability plants are becoming larger. Crushing margins are volatile but have been high recently and it is considered that a new crusher would be subject to considerable competitive pressure.

8. Changes in support through the Common Agricultural Policy, and the removal of area support have reduced crop gross margins considerably, particularly for oilseed rape. Oilseed rape has been shown to give a number of benefits for the crop rotation as a

whole, notably enhancing the yield of following wheat crops, reducing nitrogen requirement of following crops, benefiting soil structure and spreading labour peaks. These benefits provide encouragement to retain the crop.

Use of grower contracts

9. Use of forward contracts in marketing arrangements is currently limited, but increasing. These can provide a number of benefits. A number of specific contracts for the energy crop market are now available. Transport costs to the designated plant will be at the grower's cost and give a significant reduction. For growers in Scotland this will account for £15–20/t, a significant reduction in the gross margin of the crop. Growers for energy crops are also eligible for the EU Energy Crop Initiative, which has a premium payment of 45 euros (£30) per hectare, with merchants retaining a significant portion (up to 50%) of this value to cover finance charges. Retention of a greater proportion of this payment by the grower if a different business structure were established, would give benefits for the overall return from the crop.

10. Production of oilseed rape in Scotland could be stimulated through the establishment of a local crushing plant, which would reduce transport costs ex farm, leaving a larger margin for the farmer in relation to the market price for the crop. Sharing information and potential returns through the local supply chain and establishing a stake in processing by involving a farmer co-operative in crushing biodiesel could all increase the return to farmers from the crop.

Biodiesel production

11. Biodiesel is produced by modifying vegetable oil by mixing with methanol to produce an ester in order to remove the glycerol from the oil. The resulting biodiesel can then be used in unmodified diesel engines. Rapid expansion of biodiesel production and utilisation has occurred in Europe, most notably in Germany, France and Italy, since the 1990s.

12. The use of pure plant oil has generated interest in Ireland and elsewhere. 'Pure' or unaltered oil can be used in diesel engines, providing the engine is first modified. There are several disadvantages to this approach in the UK, a major concern being that engine performance utilising this fuel is technically unproven over longer time periods. **Another important factor is that the use of pure plant oil does not currently qualify for the 20p/l tax rebate in the UK (see Section 10, Option 1, paragraph 10.1).**

13. Used cooking oil offers the potential of a cheaper feedstock but only small quantities are available in Scotland and there is likely to be competition for this from Argent Energy which has already established a biodiesel plant near Motherwell using this feedstock.

14. A further potential development for production of biodiesel involves use of a hydrogenation process to produce diesel standard fuel containing vegetable oil. However this technology is at very early stages of development and production is a number of years away, but progress should be monitored to assess competitive effects.

15. Crushing or pressing the seed for oil consists of several stages and for larger plants solvent extraction is used to maximise extraction of oil. It is of note that no solvent extraction plants with throughput of less than 1000t rapeseed per day are now being built in western Europe. The scale of rapeseed production in Scotland is unlikely to ever justify a solvent extraction plant and therefore mechanical extraction methods would be used.

Scotland's previous OSR crusher

16. Key lessons to be learned from the failure of the Arbroath crushing plant are that scale is important, quality control is paramount, efficient oil extraction is worthwhile and site selection is crucial.

Environmental aspects of biodiesel production from oilseed rape

17. A review of work investigating the link between allergenic and irritant responses of the oilseed rape crop found that there is no evidence of a causal association between exposure to the crop and allergic symptoms. Many of the symptoms attributed to oilseed rape can be explained in terms of allergy to pollen other than oilseed rape.

18. Cultivation of the oilseed rape crop has been shown to provide biodiversity benefits. A number of farmland birds favour the crop for nesting and feeding. In particular, oilseed rape is credited with helping to slow the decline in population of the linnet species.

19. Use of energy balance techniques assesses the amount of energy used in production of a biofuel compared to the amount of energy produced. Energy balance of biodiesel from rapeseed is positive and varies according to the range of by-products included in the energy output and the production system used. For typical situations the energy balance is in the region of 2 – 4 units of energy gained for each unit of input. Energy balance can be improved by the utilisation of the straw and with increased interest for use of biomass for co-firing in electricity generators there may be potential for development.

Environment regulations

20. For environmental regulation, a small to moderate crushing plant will be subject to Part B regulations concerning emissions to air. An esterification plant will be subject to Part A, more stringent regulations applying to air, water and land. This requires a higher cost for the permit and more costly measures to implement requirements.

UK Transport fuel market

21. The current record high mineral oil prices are closing the production cost differential between mineral oil and renewable biofuels. In the past renewable fuels were at least two times as expensive to produce.

22. A review was conducted of the UK transport fuel market. It showed the UK has the 4th largest refinery capacity in Europe with 9 major refineries. The entry of the multiple supermarkets over the last 10 years into fuel retailing has made a major impact. Supermarket fuel sales now account for 34% of the UK petrol market and 24% of the diesel market. Their entry has made the whole fuel market very competitive as their market share continually grows. The number of retail filling stations has fallen dramatically over the last 15 years from 22,000 to 10,300 (2004). Around 700 filling stations are closing every year due to competition. The independent filling stations are found mostly in rural areas and have low volumes.

23. Although the demand for road transport is growing and is expected to increase, the total consumption of road fuels has been virtually static since 1997. This is due to a

combination of more efficient engines and an increased proportion of diesel vehicles. The latest figures from the Energy Institute show that UK petrol consumption for 2004 was 19,068,020 tonnes, with diesel at 18,930,061 tonnes for the same period. One trend is that petrol sales have been falling since the peak in 1990, whilst diesel sales have been increasing. At present too much petrol spirit is produced whilst there is a shortage of diesel.

24. Fuel distributors play an important role in the whole supply chain of transport fuels. It is a fragmented sector with many local companies located throughout the country. Normally wholesale fuel products move from the refinery to port terminals by coastal tankers. Power in the market lies with the major refineries who control supplies. Margins for fuel distributors are falling with intense competition. The market for fuel distributors can be segmented into 5 main customers, which are:

- Commercial businesses
- Haulage
- Agricultural
- Marine
- Domestic consumers

Rebate of fuel levy

25. The UK Government provides a 20p/l rebate on the fuel duty for biofuels. This is only guaranteed on a 3-year rolling basis. Most analysts regarded the 20p/l rebate insufficient for biodiesel to compete with conventional diesel on the open market. At the time of its introduction in 2002, an additional 10-15p/litre (depending on scale of production) was required to make biodiesel competitive. Intense lobbying took place to try and get the rebate raised. However, analysis carried out for the DfT showed that the benefit of biofuels in terms of their contribution to carbon reduction was only worth the equivalent of 20p/litre. It is very unlikely therefore that Government will move from this stance.

UK Government and the RTFO

26. The major driver for the biodiesel industry is the EU Directive on Renewable Transport Fuel Obligation (RTFO). At present this is only indicative and not compulsory although this is likely to change in the future. It is unclear at present how quickly the UK Government will respond to the RTFO, but the general view is that an announcement relating to its introduction will be made this autumn. It is anticipated that any legislation would not come into place until 2007.

What will the major oil companies do?

27. A major threat for any UK biodiesel producer is the action taken by the multinational oil companies who currently operate refineries in the UK. The 'hydrogenation' process could potentially undermine the ability of biodiesel to compete if it is adopted by the oil refiners. The UK is unique in considering introduction of hydrogenation for this application at present. Hydrogenation would allow crude vegetable oil to be mixed with mineral oil at the refining stage and qualify for the rebate on the tax levy. From the UK's perspective this route does have attractions in that it uses existing distribution channels, ensuring continuity of supplies, and guarantees the quality of product. It would address the issue of 'backstreet' blending of biodiesel with the associated risks for quality that the oil companies have previously indicated as a potential problem. However, it should be stressed that this process is at the very early stages of development, with only a small-scale trial having been carried out in

Germany. Much further experimentation and development of the taxation system is required before its introduction.

By-products – rapeseed meal and glycerine

28. There are two principal by-products from the processing of OSR: rapeseed meal (from the crushing stage) and glycerine (from the esterification stage). Rapeseed meal is used by the animal feed manufacturers as a protein supplement for livestock rations. The price is set against the industry benchmark of soyabean meal. The inclusion rate of rapeseed meal is limited to 10-30% due to nutritional factors. The annual demand for rapeseed meal in Scotland is estimated at 30-40,000 tonnes. At present prices ex-mill are £90 /tonne. The trade expect prices to fall in the future due to increased supplies from an expansion in European OSR crushing capacity. Due to the large volume produced, rapemeal prices make an important contribution to the overall economic viability of a plant.

Glycerine is a by-product of biodiesel production and can be used in a wide range of existing markets, having over 1,500 end uses. Crude glycerine is 70% pure and is usually refined to further points of purity up to 99%. Supply in Europe has significantly increased since the mid 1990s and this has been strongly influenced by an increase in biodiesel production. Currently it is valued at just over £110/t but prices have become increasingly volatile. The volume of glycerine produced is relatively low so its value has a relatively low impact on economic viability.

Possible sites

29. An initial review of potential medium scale processing plant sites was undertaken. It was considered necessary to locate at a port to facilitate the movement of imports/ exports. If a Scottish plant could be supplied using solely domestic feedstock then a port location would not be so important. Port Authorities may view any processing developments as a threat as currently over 60% of the Scottish OSR crop is moved through ports. Seven ports in the North-East and East of Scotland were identified and evaluated using a matrix over a range of variables. Further detailed work to identify suitable sites would be required once a decision on the scale and type of development is taken.

Economic evaluation

30. The economic viability of a range of OSR processing options was assessed. The overall aim was to create a business which would provide benefits to the agricultural and wider rural community, add value, meet a market demand and provide a return to investors. To facilitate the analysis, five options were examined which represent a range of scales and different business structures to determine if a viable opportunity exists

Option	Description
Option 1A	Farm Scale –a farmer converting his own OSR (190t) into crude rape oil for own use.
Option 1B	Farm Scale –a farmer converting his own OSR (355t) into biodiesel for own use.
Option 2	Small Group –small group of farmers processing 1,030t OSR producing crude vegetable oil
Option 3	Group Scale – Large group of farmers (15,000t OSR) producing biodiesel
Option 4	Medium Scale – 60,000 tonnes OSR with 30,000 tonnes esterification plant producing biodiesel
Option 5	Large Scale – The benchmark for international competitiveness

The following table attempts to summarise the results from the evaluation of the five options and provide key comments across a range of variables.

Summary matrix showing economic evaluation of biodiesel production from oilseed rape grown in north and east Scotland

Option	Technology	Ease of supply	Capital cost	Planning/ Development difficulty	Production cost (p/L)	Key factors	Retail price (p/L)	Markets	Rural economy impact	Current examples
1A. Farm oil (190t)	Crush Pure plant oil	Good	£7.3K	Easy	57.9 p/l Oil	Low operating cost	107p/l	On farm	Good if lots	All
1B. Farm biodiesel (355t)	Crush Biodiesel	Good	£30.4K	Easy	61.3 p/l Biodiesel	Low operating cost	90.4 p/l	On farm	Good if lots	All
2. Small Group (1,030t)	Crush Pure plant oil	Good	£81.2K	Easy	39.6 p/l Oil	Engine mod' not included	107.75 p/l	On farm	Good if lots	Ireland
3. Group (15,000t)	Crush Biodiesel	Good	£3.86M	Envirn. Impact Required	55.2 p/l Biodiesel	Capital cost vrs. Output	108.45 p/l	Road fuel market, but small volume	Good if several	
4. Medium (60,000t)	Crush Biodiesel	Possible Scot crop 140,000t	£10.2M	Major industrial development	41.3 p/l Biodiesel	Scale benefits	92.12 p/l	Major local player.	Regional, not many direct jobs	Austria Germany
5. Large	Hexane Biodiesel	Difficult UK scale	Only multi-national	Major industrial development	38 p/l (Hexane = 4p/l cost benefit)	Scale and process benefits	88.24 p/l	Link to Nationals. Blend	Not rural	France

31. Sensitivity analysis was carried out to determine the impact of key variable on production costs. If the plant is to be successful it needs to be competitive in the market. Sensitivity analysis will also provide a better understanding of the key issues and the critical success factors for a successful OSR processing plant. The variables considered were:

- Raw material costs
- Plant utilisation
- Value of by-products
- Capital cost
- Grant assistance
- Market demand

The costs of feedstock and the plant utilisation were shown to be key variables having a major impact on production costs.

Competitors – UK Biodiesel plants

32. At present there are four biodiesel plants in the UK, which are either recently established, currently being constructed, or at a well advanced planning stage. The following table presents an overview of key factors.

Name	Location	Plant Size	Feedstock	Investment	Status
Argent	Motherwell	50ML	UCO Tallow	£15M	Operational
Northeast Biofuels, Biofuels Corporation	Teeside	284ML	Palm Soya OSR	£46M	In construction
Greenergy Fuels Ltd	Immingham	113ML	Palm Soya OSR	£12 – 15M	Late Planning
Global Commodities	Norfolk	30ML	UCO, rapeseed	Over £10M	Early planning

Key: UCO - used cooking oil

There are several biodiesel developments in operation or planned. If all go to fruition, combined they will produce over 470 M litres of biodiesel. Comprising only 2.75% of the UK's consumption of diesel, this still leaves ample scope for further development.

How can farmers get involved – co-operative investment

33. One of the main issues for a new venture such as oilseed rape processing is building an effective structure. In this case a joint venture involving a variety of potential partners would seem appropriate. This has the advantage of sharing risk, pooling resources and expertise. The conclusion is that any oilseed processing business is likely to be more successful if it is formed from a broad Joint Venture of interests. A New Generation Co-operative (NGC) would be the best vehicle to get farmers involved in a processing company.

Fiscal support for biodiesel production

34. There are two main reasons why biodiesel production is so well developed in the rest of Europe

- Many European countries receive full fuel tax rebate. (See following table for rates of excise duty levied on diesel. This demonstrates the high rate of duty levied in the UK compared to other European countries.)
- Plants in these countries enjoy economies of scale giving very competitive unit costs.

EU rates of excise duty on diesel, 2003 (€/L diesel)

Austria	0.282
France	0.390
Germany	0.486
Ireland	0.379
Italy	0.403
UK	0.826

Exchange rate, December 2003, 1€ = $1.25 (US)

35. The market is driven by the Renewable Transport Fuel Obligation (RTFO). At present, large scale biodiesel production plants (eg at least 60 000t rapeseed equivalent) could compete with mineral diesel based on crude oil values of more the $60/barrel, even without such legislation. However, should crude oil decline in value, biodiesel at the 20p/litre tax rebate would struggle to compete with mineral diesel. At present, Government seems unlikely to be receptive to calls for a higher level of rebate, due to the belief that 20p/L represents the carbon saving value of biodiesel and that biodiesel is currently viable through market forces.

It is in the interests of agriculture to see the introduction of the RTFO as it presents firmer opportunities for biodiesel. However, if, as part of the negotiation hydrogenation was included as an acceptable means of achieving targets it could present a risk to biodiesel production. Industry sources indicate technical issues and introduction appears to be some way off.

When the RTFO is adopted, sources of biofuels for blending with transport fuels must be found. Bioethanol is not a direct competitor with biodiesel as it used for blending with petrol, however, as a biofuel it will compete on its overall contribution to any UK RTFO target.

Scenarios to meet Renewable Transport Fuel Obligation (RTFO) in Scotland for diesel

RTFO Rate	Biodiesel ('000t)	OSR Feedstock ('000t)	Area OSR (ha)	% of Scottish OSR crop (2004)
2%	37,900	94,650	27,043	73%
3%	56,800	141,970	40,654	109%
4%	75,700	189,300	54,086	145%
5.75%	94,700	236,620	67,607	182%

Scotland has made a huge commitment to renewable energy. This would be one component in a range of renewable energy sources. The establishment of a biodiesel plant from Scottish OSR fits well with Scottish Executive and Scottish Enterprise's strategy.

Commercial opportunity – hybrid option (medium sized plant)

36. Following analysis of options, the best commercial opportunity for Scotland is the hybrid option. This establishes a medium scale OSR crushing mill (60,000t), however, the benefits of economies of scale and access to lower cost vegetable oils are achieved through having a larger capacity esterification plant. This plant structure fits in with the Scottish conditions and is nearer being internationally competitive - allowing for the cost of importing biodiesel.

37. A 10-year cashflow was prepared for the medium scale option (60,000t OSR). The conclusion of the investment appraisal analysis is that the expected return is in the order of 14% with payback in 5 years. While this is a reasonable return, given the considerable risks involved potential investors may not be attracted unless ways are found to reduce the inherent risks involved.

How competitive would a Scottish plant be?

38. It is believed current Germany biodiesel production prices are approximately 38p/litre. The cost of a tanker from North Germany (Hamburg / Lear) to Aberdeen is £40 per tonne. This would cover all charges (there is no FOB). This translates to an additional shipping cost of 3.5p / litre. The net imported price would then be 38.0p + 3.5p = 41.5p /litre. Based on the assumptions stated, the estimated production cost of a medium sized plant (60,000t) purchasing additional crude vegetable oil (10,000t) to maximise the utilisation of the esterification plant, was 41.3p /litre. This would indicate that the plant could potentially compete with imported biodiesel.

39. The rapemeal from the process represent a good opportunity to replace imported protein supplements. The size of plant proposed would produce 39,600 tonnes of rapemeal at 9% oil. This could compete with imported and domestic protein supplements to the benefit of the livestock sector.

40. The cost of feedstock has a major impact on production costs. There is potential benefit for OSR growers in Scotland and a crushing plant to work together. The crusher must source feedstock at the cheapest price, however, growers benefit from savings in transport costs (£8-£12/t) and being part of the supply chain.

41. Running a successful processing plant will involve a steep learning curve. This could be overcome by involving a partner who has prior experience in operating a biodiesel plant.

Recommendations

The study makes a number of recommendations with action required on two principal fronts, namely;

- Support for the development of a medium scale plant in Scotland
- Support for pilot studies into small scale biodiesel schemes.

Medium-scale plant support

1. Raise awareness of business opportunity

The study shows there are benefits to farmers and the wider Scottish economy if an OSR processing and biodiesel plant was established in Scotland. The economic appraisal demonstrates there is a business opportunity which is commercially viable.

Local Authorities and Development Agencies need to raise the awareness of this opportunity amongst farmers and the wider business community. Effort needs to be taken to bring interested parties together. This is a role that the Partner Councils in the study should play.

2. Facilitate businesses to form a joint-venture company

There are significant risks involved for a medium scale plant however these could be considerably reduced through the formation of a joint-venture company. Ideally partners should be drawn representing different sectors in the chain. These could be:

- farmers co-operative - to ensure supplies
- processing business – to operate the crushing and esterification plant
- regional fuel distributor - to handle the blending and distribution
- animal feed compounder – to allow rapemeal to be utilised in Scotland

It is recognised it will be a considerable challenge to bring potential partners together to form a joint-venture company. Any action the Study Partners could take to facilitate this would be desirable.

3. Enlist support of SAOS and NFUS to gain farmer commitment

Securing farmers involvement and commitment will be a major step in levering other companies to invest in the project. SAOS and NFUS could play a key role in convincing farmers of the benefits of the project. The New Generation Co-operative (NGC) model provides a good mechanism to get farmers involved. There are many good examples in the United States, Canada and New Zealand to show the benefits for farmers. Whilst a medium scale plant requires feedstock of 60,000 tonnes of OSR, it is not imperative all this tonnage is provided from a NGC. If a NGC could provide a core, of say 10,000 – 20,000 tonnes, the balance could be sourced on the open market through the trade. Whilst offering considerable support to a Scottish industry, this approach allows the benefits of optimising cost efficiency by allowing some procurement on the open market.

4. Provide firm commitment to source biodiesel from Scottish plant

The attractiveness of the project would be greatly enhanced if all the Local Authorities involved in the study were able to underwrite a firm commitment to source their diesel requirements from an established biodiesel plant. They would not be expected to pay a premium over market rates but simply guarantee a core demand.

5. The biodiesel produced should be branded.

It would be desirable to differentiate the biodiesel produced by branding it and also blending it at a higher inclusion level (above the market norm of 5%). Both these actions have the advantage of providing something unique to help protect markets from competition. It would also contribute more to the 'green' credentials of the product through lower emissions. If Local Authorities sourced a 10% blend, it has the added advantage of doubling sales and would also provide Local Authorities with a real opportunity to promote their efforts towards improving the environment. One potential obstacle for a 10% blend would be securing vehicle manufacturers acceptance, to ensure engine warranty. This is not believed to be a major obstacle and is already happening in many cases.

6. Approach existing OSR and biodiesel processors

Many regional fuel distributors showed interest in the project and it clearly had a lot to attract this sector. It is not anticipated that it would be difficult to secure a partner to a joint-venture company from fuel distributors. Potentially the most difficult area will be to recruit a partner for the processing side of the business. There are few companies who have experience in this sector. Approaches should be made to existing OSR and biodiesel processors to gauge their level of interest.

Pilot studies into small-scale production.

7. Pilot studies of small-scale biodiesel production

It is recognised that the development of a medium scale biodiesel plant will take time, establishment of a new business and considerable capital investment. In the meantime a few (2-3) small-scale plants could be supported through a series of pilot studies. The financial appraisal showed that small scale production for own use could be economically viable. Further work is required to test and confirm the costings. Pilot plants could be situated at a number of points within the major growing areas of oilseed rape, possibly at existing farmer co-ops and in different Council regions. This would provide huge benefits to the development of biodiesel production in Scotland. It would also provide confidence to potential investors. There is a real need to gain experience and develop a better understanding of the technology, relationships and cost structures in this whole area.

Engineering aspects of running a biodiesel plant will be assessed. To develop confidence in the fuel produced and enable expansion of the market it will be essential that biodiesel produced is of a sufficient quality. A programme to monitor quality of the biodiesel produced from these micro plants will be implemented. These studies could be for a 2-3 year period with lessons learned through a series of regular reports and visits made available. It would be an advantage to involve an equipment manufacturer in the pilot study.

1 Introduction

1.1 Background

Oilseed rape is grown principally for its oil, which has a range of uses within both the food and petrochemical industries, including as a fuel. The remainder of the seed left after oil extraction, or crushing, the meal, has a high protein content and is used as an animal feed supplement.

Oilseed rape is well suited to cultivation in Scotland. The long day lengths during the growing season, plentiful moisture and, unlike other areas at a similar latitude, freedom from excessive frosts in winter, lead to the production of high oilseed rape yields and high oil contents, the two important elements in the gross output of the crop.

Despite this agronomic suitability for Scottish growing conditions, no processing facilities exist for the crop in Scotland and it must either be transported south to oilseed crushers in England or exported to the Continent for crushing. In parallel, the extensive livestock industry in Scotland requires crop derived protein supplements and oilseed rape meal is transported to Scotland for this purpose. High haulage costs are incurred for both exercises, particularly for transport of the seed for crushing and this is reflected in lower prices for rapeseed produced in Scotland, placing Scottish growers of the crop at a disadvantage.

Recent changes to the Common Agricultural Policy have meant that oilseed rape production is no longer differentially supported compared to other enterprises. Combined with pressures on world market prices for arable crops in general, this factor is leading to increased scrutiny of the oilseed rape crop viability in Scotland.

At the same time, environmental issues are driving the development of liquid biofuels. The Kyoto Agreement seeks to reduce carbon dioxide emissions world-wide. More specifically in the UK, a Government target stated in the 2003 Energy White Paper is that carbon dioxide emissions should be reduced by 60% from current levels by 2050 (UK Government, 2003). The paper notes that biofuels can potentially represent an important route for reducing transport emissions. Targets set by the EU in the Renewable Fuels Directive act as a more immediate driver. The Directive outlines that biofuels should achieve a 2% share of the mineral fuels market by 2005 and 5.75% by 2010 in Member States (Department for Transport, 2002).

In addition, the current high prices of mineral oil are acting as a significant driver in the search for viable alternative energy sources. Biofuels suitable for use in liquid form for transport applications are currently limited to biodiesel from oil crops and animal by-products and bioethanol from starch or sugar crop sources.

Biodiesel production has expanded markedly in Europe since the first plants were initiated in Austria. Crushing and biodiesel technology is well developed and a range of scales exist. Additionally, several biodiesel initiatives are being progressed in the UK and an understanding of both the European and UK developments will help to inform a strategy for the North and East Scotland.

1.2 Principal study objectives

The study was commissioned by Aberdeenshire Council, Angus Council, Fife Council, Highland Council, Moray Council, Perth and Kinross Council, Highlands and Islands Enterprise and the Scottish Enterprise Energy Team.

The aim of this study is to identify the potential to add value to oilseed rape grown in the North and East of Scotland by conversion to biodiesel, and to stimulate economic activity through the establishment of processing facilities and the provision of end products from the process. Principal objectives are:

- To determine the optimum annual crop of oilseed rape and the proportion that could justifiably be utililsed as biofuel.
- To optimise the value of the oilseed rape crop to farmers in the North and East of Scotland through its conversion to biodiesel.
- To compare the economic viability of small and medium scale processing plants in terms of the wider rural economy, through adding value, minimising transport costs and optimising local rural employment.

1.3 Subsidiary objectives

A number of elements contribute to satisfying the principal objectives. These are outlined in the stages below.

Comparison of biodiesel and bioethanol production

The suitability of biodiesel and bioethanol production and processing will be compared by considering both systems in the Scottish context.

Determination of feedstock availability

Is necessary to gain an understanding of factors determining the cultivation of the oilseed rape crop in Scotland to estimate the likely supply of rapeseed feedstock for a processing plant. The area and production of oilseed rape grown since the crop was first cultivated in Scotland will be reviewed and the relationship between the prices of oilseed rape and the area of crop grown investigated. Comparison of gross margins will be carried out over the period of oilseed rape cultivation in Scotland and into the future to establish the relative financial returns compared to other crop enterprises. Utilisation of a range of forward contract models as a means of securing supply from the area will be examined. The extent to which savings in transport costs of the seed for crushing and meal for use in animal feed would result from a local processing plant for members of the production chain and the effect of this in enhancing economic attractiveness will be evaluated.

Crushing and biodiesel technology

There are a wide range of scales and a number of types of crushing and biodiesel processing technology and these need to be considered for suitability for North and East Scotland. Examination of the reasons for the failure of the Arbroath crushing plant, the last oilseed rape crushing plant to operate in Scotland will offer opportunities to improve the prospects of success of a new plant. Established biodiesel developments in Europe and new crushing and biodiesel enterprises in operation and planned for the UK will be considered with reference to their potential impact on a plant in North and East Scotland.

Market evaluation

Securing a place for biodiesel in the market is an essential element of development of a successful crushing and biodiesel production industry. Market segments and likely users of the fuel must be identified through an understanding of the fuel supply industry to enable establishment of a development strategy for gaining access to these markets. The potential role of the public sector in stimulating demand will be investigated. As a major driver for the continuing development of a market for alternative sources of energy, the outlook for mineral oil prices will be reviewed. The likely future market demand for the by-products of biodiesel manufacture – rapeseed meal and glycerol will be determined as this will have a major bearing on the financial viability of a project.

Environmental assessment

Assessment of the environmental implications of utilising oil produced by the oilseed rape crop as a fuel is an integral part of a study of the feasibility of establishing a biodiesel production facility. Environmental aspects of crop cultivation will be considered, including a review of energy balance studies which consider the amount of overall energy gain from biodiesel production compared to the energy expended during cultivation and processing. Fulfilling environmental regulation requirements will be essential for the operation of a crushing and biodiesel production plant and these will be outlined.

Infrastructure determination

The infrastructure required for a crushing and biodiesel plant will be determined utilising knowledge of biodiesel plants already established. The optimum location of a processing plant will be selected according to a range of factors including proximity to main areas of production, proximity to ports to ensure continuity of supply and for convenience of blending and distribution. A number of potential sites will be identified and assessed across a range of criteria. A matrix will be produced for the most viable locations highlighting the different issues to be considered for each site.

Business aspects

Business aspects will be considered with the objective of identifying opportunities to optimise the value of oilseed rape production to the primary agricultural industry. The feasibility of application of a co-operative structure for this venture will be investigated. Financing issues also require to be addressed and opportunities for grant support from a range of sources need to be determined to aid feasibility of the project.

Economic analysis

A full economic evaluation of biodiesel production based on rapeseed grown in the North and East of Scotland is required. Details of capital and operating costs of different scales of processing plant will be obtained. Rapeseed purchase costs and by-product income will be determined and the sensitivity of the resulting economic evaluation to changes in values of input and output costs will be calculated. A risk analysis in terms of capital outlay and likely return will be undertaken along with a full investment appraisal over a 10 year period. The sensitivity of the proposal to the fiscal arrangements and futures market for mineral oil will be examined.

1.4 Consultants team

A consortium has been formed to carry out the project. The team will be led by SAC with partners Peter Cook, Aberdeen Grain (Bruce Ferguson) and Harbro Feed Ltd (Peter Kenyon). The Austrian Biofuels Institute will act as consultant to the project partners.

2.0 Bioethanol production potential in North and East Scotland

2.1 Introduction

In Scotland, whisky is a well-known product of the fermentation process. This process can also be used to produce bioethanol for industrial applications. Bioethanol can be produced from a range of raw materials through fermentation of sugar using yeast to produce ethanol and the by-product carbon dioxide. In Europe wheat is the preferred cereal (though Scandinavian countries use some lignocellulosic raw materials). In the US, maize is the preferred product whilst in South America sugar cane is used. These preferences reflect the availability of relatively inexpensive raw materials.

2.2 Bioethanol feedstocks

The major potential feedstocks for bioethanol production can be divided into 3 categories: sugar-based sources, starchy sources and cellulosic/lignocellulosic (woody) sources. Feedstocks may be grown primarily for bioethanol production, or by-products from another process may be utilised.

The main sugar crops are sugar cane, sweet sorghum and sugar beet. Sugar beet has agronomic potential for cultivation in the UK and this crop has the advantages of producing high yields of sugar per hectare and high yields of beet pulp and beet top co-products. Sugar beet has not, however, been grown in Scotland since the processing plant in Fife closed in the late 1960s. Re-introduction of sugar beet would be possible but would require knowledge of agronomy in Scottish conditions to be updated for new varieties and growing practices. Familiarity of growers with the crop would require to be re-established, and in many cases initiated. Growers would need to re-tool with consequences for fixed costs. Within the trade, knowledge would also need to be re-established to facilitate provision of appropriate inputs and market links.

An advantage of using starchy feedstocks for bioethanol production is that storage is easier than for sugar juice. A disadvantage is that starch has to be broken down into sugar before fermentation, but the cost of this process is relatively small. Maize has been used on a large scale for bioethanol production in the USA. Potential starchy feedstocks in Scotland are wheat, barley and potatoes. An important factor in the choice of starchy feedstock is the starch content with wheat and potatoes containing relatively high starch levels compared to maize.

Potato production in Scotland tends to be focussed on high value seed production rather than maximisation of yield that would be required for bioethanol production. This reduces the attractiveness for utilising the potato crop.

Although Scotland has frequently held world records for cereal production, these are from areas with the best growing conditions and average yields for cereals across the country are lower than those in England. Barley is by far the most widely grown crop in Scotland, accounting for around 55% of cropping area, but process yields of bioethanol from this crop are lower than from wheat, putting it at a disadvantage. Scotland is in deficit for wheat, giving it an enhanced value in Scotland with prices the highest in the UK. Value for barley tends to be set at a £10/t discount to wheat in Scotland. This would tend to favour barley as the preferred feedstock for bioethanol production in Scotland. From an economic point of view the value of barley would have to be the same as wheat in England to justify use in a Scotland based bioethanol plant rather than transporting English wheat north. In addition, there is a risk that production of alcohol from cereals in Scotland may not find favour with all sectors of the established distilling trade, such as the Scotch Whisky Association who have developed a high quality image for their product. The whisky industry generates some £3 billion in sales per year, approximately 4% of Scotland's gross domestic product (Scottish Enterprise, 2005). It is clearly important to maintain this substantial contributor to Scotland's economy.

Woody, lignocellulose and cellulose containing materials may represent a large potential resource for bioethanol production available at a low cost. Sources of cellulosic materials can be divided into waste products such as agricultural residues e.g. cereal straw, forestry residues and municipal solid waste, and materials grown specifically for fuel production, such as woody or herbaceaous high productivity energy crops or trees produced by conventional forestry. The UK government has expressed interest in utilising woody material for bioethanol production, however much further development is required to optimise the process using this feedstock. Analysis of technical developments suggest that large scale production of bioethanol from woody feedstocks, including municipal waste, will not be commercially viable for a number of years (personal communication, A. Armstrong, Heriot Watt University, 2004).

Considering feedstock crops for bioethanol with biodiesel it is known that Scottish conditions favour oilseed rape and this crop has an advantage of producing higher average yields than those in the rest of the UK. This factor would seem to favour oilseed rape in the selection of a candidate crop for liquid biofuel production in Scotland.

2.3 Fuel characteristics of bioethanol

Bioethanol has been used as a petrol additive, a petrol substitute and can potentially be used as a diesel substitute, although this latter application does not appear to be developed in practice. Unlike biodiesel, bioethanol is associated with the disadvantage of requiring some engine modification for use of ethanol as a petrol substitute.

As a petrol additive, bioethanol can extend the fuel and increases the octane number and oxygen content. Fuel economy can be increased by around 2% in terms of distance travelled per unit volume of fuel, and 5% in distance per unit of energy. Bioethanol is therefore suitable for use as an octane enhancer in unleaded petrol. However the use of alcohols, such as bioethanol, as octane enhancers is associated with the disadvantage in that petrol/alcohol blends will absorb water necessitating care to ensure water does not enter the fuel distribution system.

The energy balance of a biofuel can be defined as the ratio of the energy used in its production to the energy value of the fuel produced and of any used by-products. For a biofuel to be sustainable, it is essential that the energy ratio is 1: >1. If the energy ratio is 1:<1 there will be a net loss of energy in the production of the fuel thereby negating its status as a renewable energy source.

Energy balance varies according to a range of input and output conditions with respect to factors such as yield, different fertiliser and pesticide application and variation in grain moisture content at harvest (Table 2.1). When bioethanol was the only output considered in the calculation, the energy balance was less than one under all scenarios (i.e. less energy was obtained from the fuel than that used to produce it) (Batchelor et al., 1994). This option of biofuel production is clearly not sustainable.

Where distillers dried grains with solubles, a by-product of distilling, were also considered in the calculation, the energy balance became positive under good conditions, but was still low. If the use of straw as a fuel was included in the calculation, the energy balance was positive under all conditions, but the highest ratio was only 1:1.78.

Table 2.1. Energy ratios for bioethanol production from wheat considering a range of scenarios and outputs

Output	Best case	Intermediate		Worst case
Bioethanol	1:0.78	1:0.69	1:0.62	1:0.47
Bioethanol + DDGS	1:1.21	1:1.06	1:0.95	1:0.72
Bioethanol + DDGS + Straw	1:1.78	1:1.70	1:1.54	1:1.31

More recent energy balance calculations, reflecting the continuing increase in crop yields and improvements in efficiency of fertiliser manufacture indicate a slightly better energy balance of 1.11 for bioethanol where straw is left unutilised in the field (Richards, 2000). The energy balance improved to 2.51 where the straw was burned as a fuel.

Overall the studies available do not indicate a particularly favourable outcome for the energy balance of bioethanol.

2.4 Development of bioethanol production in the UK

Like oilseed rape, processing facililties for sugar beet do not currently exist in Scotland. The closure of the Scottish sugar beet processing plant led to the demise of sugar beet cultivation in Scotland and it is considered that re-establishment of such a plant seems unlikely. Some excess distilling capacity exists for cereals, and this may be suitable for fuel bioethanol production, although this capacity is distributed across several plants. Co-ordination within the industry would be required to make use of any excess capacities and there are currently no signs that this will progress. Establishment of a new facility dedicated to bioethanol production would allow the use of enzymes not permitted for potable alcohol. Capital costs of an economically sized processing facility are reported to be considerably higher than that required for a biodiesel facility (House of Commons, 2004). This is due to a more complex processing plant requirement. An estimate of between £50 – 100 million, depending on technology used, was given at a recent biofuels conference (Emerson, 2004).

A potential UK bioethanol industry is also constrained by the availability of substantially less expensive bioethanol on the international market. A recent review estimated that costs for bioethanol derived from sugar cane grown and processed in Brazil were in the order of 16 p/L (in 2002), including transport and distribution costs to the filling station in the UK, but before fuel duty and VAT (Department for Transport, 2003). This compared with an estimated cost of 48p/L for bioethanol produced from Brazilian sugar cane but processed in the UK, before tax and VAT. Industry sources indicate that Brazilian produced and processed bioethanol is also considerably lower than estimated costs of production from sugar beet and cereals in the UK (personal communication, A. Sidwell, British Sugar, 2004). Bioethanol now qualifies for the same level of duty rebate (20p/litre) as biodiesel, however this had not given a large enough incentive for the operation of bioethanol production plants so far. There are now plans to establish a bioethanol producing facility using wheat as the feedstock by Wessex Grain. This plant will be situated in the South West of England and is due to initiate production in 2006. Recent announcements indicate that a further bioethanol plant using sugar beet is to be established at British Sugar's Wissington site in Norfolk. It will produce 55 000 t bioethanol per annum and is due to come on stream in the first quarter of 2007.

Europe is in surplus for petroleum and exports petrol to the USA. Where there is no differentiation of bioethanol from fossil fuels, production of bioethanol will contribute to the already fully supplied petrol compatible fuel market and risks being viewed by petrol companies as reducing the market share for petrol. In contrast Scotland is in deficit for diesel, giving a market opportunity for a diesel compatible alternative.

2.5 Bioethanol summary

In summary key points are as follows:

- Production of feedstocks for bioethanol in Scotland is less competitive than in England.
- Bioethanol process yields from barley, the predominant cereals crop in Scotland, are lower than from wheat.
- Scotland is already in deficit for wheat with the result that prices for wheat are higher than in other parts of the UK.
- Use of cereals for bioethanol production may impact on whisky image, a valuable contributor to the Scottish economy.
- Bioethanol is associated with a relatively poor energy balance.
- Farms are not tooled up for sugar beet, a potentially high yielding feedstock crop.
- Imports of bioethanol are far cheaper than Scottish produced product.
- Petrol products are oversupplied, in contrast to the under supply of diesel.

3.0 Feedstock Supplies

3.1 Background to cultivation of oilseed rape Scotland

3.1.1 Establishment of oilseed rape as a Scottish crop

During the 1960s and early 1970s, oilseed rape had only a minor place in British agriculture with a relatively low market value and served as a break crop in intensive cereal rotations. A world protein shortage coincided with the UK's entry to the EEC in 1973 and access to the EEC's support policy for farm prices of oilseeds encouraged an expansion of the area grown in England. Production of the crop in Scotland expanded when winter cereals were introduced to the rotation providing a sufficiently early autumn entry for survival of the oilseed rape crop throughout the winter. The area increased markedly from the early 1980s (Table 3.1). The support system at that time was a deficiency payment system, with a target price being fixed annually, representing what was regarded as a fair return to the grower. The difference between the world price and the target price was the deficiency payment paid to the crusher.

Financial support for oilseed rape meant that it was an attractive option for growers and resulted in increases in the oilseed rape area cultivated. This in turn led to pressure on the EC budget and a stabiliser system was introduced from 1981/82. This allowed limited reduction of the target price if the rolling 3 year average exceeded a Maximum Guaranteed Quantity (MGQ) of rapeseed produced in the EU. During the 1980s the market price of rapeseed rose to over £300/t and further expansion of the area grown followed. More stringent price stabilising measures were introduced in 1988/89, with any annual production in excess of the MGQ attracting unlimited reduction in support prices.

3.1.2 Effect of changes in market support and value on production in Scotland

In 1989, the EU oilseed regime was found to be non-compliant with GATT rulings and in 1992 a transitional scheme led to the removal of the deficiency payment, and the introduction of a payment to farmers based on area of crop grown. This resulted in the price per tonne falling sharply to as low as £100/t, however area payments increased the average financial return to a level broadly similar to those of pre reform levels. The area payment led to increased financial returns from spring oilseed rape which throughout the early to mid 1980s was grown on a relatively small proportion of land allocated to oilseed rape each year due to its low yield. By 1992 production had increased in Scotland to an extent that it was included as a separate entity in census data. In 1993, wider Common Agriculture Policy reform combined cereal, oilseed and protein (COP) crops under the Arable Payments Scheme, offering area payment to COP crop farmers to compensate for the drop in support prices. The scheme provided the capability to reduce payments if base areas were exceeded. EU/US agreement imposed a further measure to limit EU oilseeds area. This imposed a Maximum Guaranteed Area of oilseeds in the EU distributed across member states according to historic yield. Penalties in area aid were triggered according to national overshoots.

Further reforms of the CAP, Agenda 2000, led to a cut in subsidies with the differential between higher payments for oilseeds compared to cereals being eroded. This was combined with a reduction in market price per tonne from over £160/t in 1998 to an average of below £130/t in 1999 and 2000 (Figure 3.1). A reduction in cultivated area of oilseed rape followed. Since then, and until 2004, prices for rapeseed improved and prices for cereals tended to decline, favouring a recovery in oilseed rape area grown.

Table 3.1 Areas of oilseed rape grown in Scotland

			Winter Oilseed rape			Spring Oilseed rape		
Year	Total Area	Total Product'n (t)	Area (ha)	Yield (t/ha)	Product'n (t)	Area (ha)	Yield (t/ha)	Product'n (t)
1982	1,611			*				
1983	3,963			*				
1984	11,037	42,051	11,037	3.81				
1985	23,159	63,687	23,159	2.75				
1986	22,106	68,086	22,106	3.08				
1987	45,026	144,533	45,026	3.21				
1988	41,576	131,796	41,576	3.17				
1989	36,080	120,507	36,080	3.34				
1990	45,213	162,767	45,213	3.6				
1991	49,911	160,713	49,911	3.22				
1992	56,859	175,759	38,184	3.46	131,949	18,675	2.35	43,810
1993	59,925	122,323	32,371	2.74	88,549	27,554	1.23	33,774
1994	69,614	180,592	31,758	3.24	102,740	37,856	2.06	77,852
1995	52,122	143,092	31,133	3.33	103,803	20,989	1.87	39,289
1996	49,290	148,171	30,521	3.53	107,662	18,769	2.16	40,509
1997	59,338	156,479	33,248	3.44	114,316	26,090	1.62	42,163
1998	65,116	181,587	42,001	3.26	136,950	23,115	1.93	44,637
1999	51,173	161,070	37,670	3.46	130,323	13,503	2.28	30,747
2000	36,406	110,993	28,174	3.43	96,541	8,232	1.76	14,452
2001	34,848	105,894	27215	3.33	90,601	7,633	2	15,293
2002	30,901	103,823	26,432	3.61	95,421	4,469	1.88	8,402
2003	35,179	120,790	29,899	3.73	111,507	5,280	1.76	9,283
2004	39,341	130,398	34,165	3.51	119,858	5,176	2.04	10,540
5-yr Avge	35,335	114,380	29,177	3.52	102,786	6,158	1.89	11,594

Source: SEERAD
Note: From 1992 data was spit between winter and spring oilseed rape
* - No data available

Prices of rapeseed have altered markedly over the time that oilseed rape has been cultivated in Scotland, with a high of £300/t available in the 1980s to a low of around £100/t in the early 1990s. It is evident that these fluctuations and changes in support policy have been strong drivers in influencing the area of oilseed rape grown in Scotland. The area of oilseed rape grown in Scotland peaked in 1994 at approximately 70 000 hectares, when the economics for growing the crop were very favourable. It is suggested that this area may be close to a natural ceiling of oilseed rape cultivation in Scotland, above which additional cultivation would be difficult to achieve. It should be noted that at this time a large proportion of the area was taken up with the lower yielding spring oilseed rape. Substitution of spring oilseed rape for winter oilseed rape may potentially allow some scope to increase production above the 1994 180 000 tonne production level. The overall mean yield for winter oilseed rape of 3.34 t/ha would suggest that a maximum total production of up to 230 000t may be possible, although a portion of this area will be less productive land, so constraining yields that can be achieved.

The area of oilseed rape cultivated, considered at a county basis, shows that 38%, the largest portion, is grown in the North East Scotland (Table 3.2). Within the Aberdeenshire, Angus, Fife, Highland, Moray, Perth and Kinross Council areas 76%

of the total area of the crop is grown. This information will be of relevance, along with other factors, in the assessment of potential sites for processing operations.

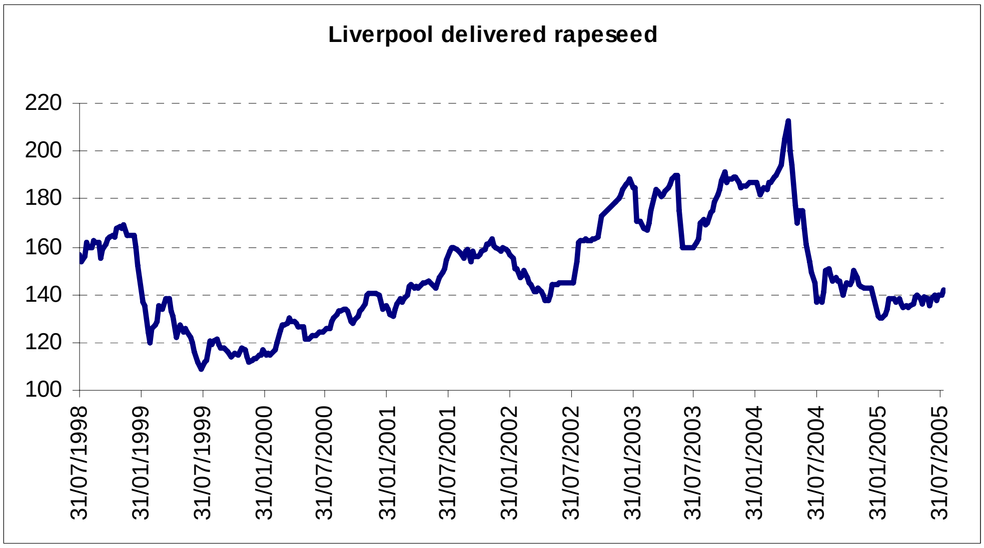


Figure 3.1 Value of rapeseed (£/t) at Liverpool

Table 3.2 County distribution of oilseed rape – 2003 harvest

	Oilseed rape					
	Winter		Spring		Total	
	Holdings	Hectares	Holdings	Hectares	Holdings	Hectares
Shetland	0	0	*	*	*	*
Orkney	0	0	0	0	0	0
Eileanan an Iar	*	*	*	*	*	*
Highland	69	1,497.52	26	320.96	89	1,818.48
NE Scotland	443	11,647.65	123	1,671.84	537	13,319.49
Tayside	318	6,863.65	70	1,116.39	369	7,980.04
Fife	148	3,016.07	47	643.27	179	3,659.34
Lothian	101	2,168.55	14	232.24	108	2,400.79
Scottish Borders	146	4,174.80	45	807.56	166	4,982.36
East Central	13	300.08	21	353.79	34	653.87
Argyll & Bute	0	0	*	*	*	*
Clyde Valley	*	*	*	*	5	61.49
Ayrshire	*	*	*	*	*	*
Dumfries & Galloway	9	184.15	7	92.67	14	276.82
Scotland	**1,254**	**29,899.24**	**360**	**5,280.08**	**1,506**	**35,179.32**

Source: SEERAD

3.2 The oilseeds processing industry in the UK

The oilseeds balance in the UK shows that, for the 6 year average of years 1999/00 to 2004/05, the total amount crushed in the UK was 1 412 000t. A total of 313 000t were imported with 158 000t being exported and 190 000t being used for feed and seed.

Table 3.2	UK Oilseeds balance 1999-2005 ('000 tonnes)						
	1999/00	2000/01	2001/02	2002/03	2003/04	2004/05	6-yr avg
Area ('000 ha)	537	402	451	432	542	558	487
Yield (t/ha)	3.2	2.9	2.6	3.4	3.3	2.9	3.1
Production	1,718	1,166	1,173	1,469	1,789	1,618	1,489
Opening stocks	4	17	12	20	5	18	13
Imports	324	288	605	327	136	199	313
Total availability	2,046	1,471	1,790	1,816	1,930	1,835	1,815
Feed & seed	238	174	288	108	220	110	190
Crush	1,510	1,339	1,377	1,338	1,360	1,550	1,412
Exports	275	50	18	207	272	124	158
Total usage	2,023	1,563	1,683	1,653	1,852	1,784	1,760

Source:DEFRA updated 27 Jan 2005 and Trade

Within the EU, crushing capacity has been increasingly concentrated, with plants becoming fewer and larger. The industry has also become more concentrated in the UK with currently only 3 crushers operating, a reduction from 5 in 1992. In addition to rapeseed, other oilseeds such as soya are processed by UK crushers. ADM Ltd operate a crushing plant at Tilbury, reputed to be the largest in Europe, with a capacity of 800 000t, and Cargill have 2 crushing plants; at Liverpool and Hull, with capacities of 600 000t and 150 000t respectively. The total crush capacity in the UK is 1 550 000t. With a total production of 130 000t in 2004 and a maximum production of 170 000t, in 1992, volumes of rapeseed in Scotland are not large by comparison. Crushing margins are volatile, with value for oil and meal not always directly following that of the seed. Recent experience has been of high crush margins, and crushing has been very profitable. These existing, large, well established crushers could exert considerable competitive pressure on procurement of seed with consequences for a new rapeseed crushing facility.

3.3 Financial return to oilseed rape growers and the alternatives

Reform of the Common Agricultural Policy has led to the abolishment of area payments which used to favour oilseed rape production. The financial returns from oilseed rape must now compete directly with other crop enterprises. Tables 3.3a – c show the gross margin for oilseed rape using figures from 1999, with arable area payments (AAP) included (Table 3.3a), from the current year with area payments removed (Table 3.3b) and as projected for 2006 (Table 3.3c). These are typical figures and will differ from farm to farm. In 1999, the figures show that winter oilseed rape gross margin, at £625/hectare, including area payment and a price for seed produced of £140/t, was above that of spring barley. Winter barley and particularly wheat gave more favourable gross margins, with spring oilseed rape giving the poorest gross margin. Removal of the area payment in 2005 combined with an increase in fertiliser input costs resulted in a substantial reduction in gross margin for all crops, with winter oilseed rape now leaving £224/hectare, less than spring barley. Predictions for 2006 indicate that prices for rapeseed will remain close to £140/t with fertiliser prices increasing further and slightly less being spent on seed and sprays to give the same gross margin as 2005 and with crops continuing to retain the same ranking order.

Table 3.3a Gross margin of a range of crop enterprises – harvest 1999 (£/hectare)

	Spring oilseed rape	Winter oilseed rape	Wheat	Spring barley	Winter barley
Grain yield (t/ha)	2.1	3.5	8	5.5	7.5
Oil bonus[1] (%)	2	3			
Straw yield (t/ha)			5	4	5.5
Output					
Seed[2] (£/t)	294	490	640	440	525
Oil bonus[1] (£)	6.3	15.8			
Straw[3] (£/t)	0	0	100	100	138
Total output (£)	300	506	740	540	663
Variable costs (£/ha)					
Seed	37	35	53	55	48
Fertiliser	50	80	90	53	85
Sprays	5	120	95	49	57
Contract	42	42	0	0	0
Other crop expenses	0	0	7	5	9
Total variable costs (£/ha)	134	277	245	162	199
Gross Margin (£/ha)	166	229	495	378	464
Arable area payment (£/ha)	396	396	240	240	240
Gross Margin with subsidy (£/ha)	562	625	735	618	704

[1]Oil bonus is typically £1.50/t for each 1% oil above 40% oil.
[2]Seed prices; spring and winter oilseed rape - £140/t; wheat - £80/t; spring barley - £80/t; winter barley - £70/t.
[3]Straw prices; wheat – £20/t; spring and winter barley - £25/t.

Table 3.3b Gross margin of a range of crop enterprises –harvest 2005 (£/hectare)

	Spring oilseed rape	Winter oilseed rape	Wheat	Spring barley	Winter barley
Grain yield (t/ha)	2.1	3.5	8	5.5	7.5
Oil bonus[1] (%)	2	3			
Straw yield (t/ha)			5	4	5.5
Output					
Seed[2] (£/t)	294	490	600	385	480
Oil bonus[1] (£)	6.3	15.8			
Straw[3] (£/t)	0	0	125	120	165
Total output (£)	300	506	725	505	645
Variable costs (£/ha)					
Seed	34	42	58	54	51
Fertiliser	65	104	117	67	109
Sprays	11	88	101	53	63
Contract	48	48	0	0	0
Other crop expenses	0	0	14	11	18
Total variable costs (£/ha)	158	282	290	185	241
Gross Margin (£/ha)	142	224	435	320	404

[1]Oil bonus is typically £1.50/t for each 1% oil above 40% oil.
[2]Seed prices; spring and winter oilseed rape - £140/t; wheat - £75/t; spring barley - £70/t; winter barley - £64/t.
[3]Straw prices; wheat – £25/t; spring and winter barley - £30/t.

Table 3.3c Gross margin of a range of crop enterprises – harvest 2006 (£/hectare)

	Spring oilseed rape	Winter oilseed rape	Wheat	Spring barley	Winter barley
Grain yield (t/ha)	2.1	3.5	8	5.5	7.5
Oil bonus[1] (%)	2	3			
Straw yield (t/ha)			5	4	5.5
Output					
Seed[2] (£/t)	294	490	592	385	480
Oil bonus[1] (£)	6.3	15.8			
Straw[3] (£/t)	0	0	125	120	165
Total output (£)	300	506	717	505	645
Variable costs (£/ha)					
Seed	26	32	58	47	54
Fertiliser	72	117	122	81	121
Sprays	11	85	101	46	63
Contract	48	48	0	0	0
Other crop expenses	0	0	14	11	15
Total variable costs (£/ha)	157	282	295	185	253
Gross Margin (£/ha)	143	224	422	320	392

[1]Oil bonus is typically £1.50/t for each 1% oil above 40% oil.
[2]Seed prices; spring and winter oilseed rape - £140/t; wheat - £74/t; spring barley - £70/t; winter barley - £64/t.
[3]Straw prices; wheat – £20/t; spring and winter barley - £25/t.

Although the figures indicate that the cultivation of oilseed rape is less attractive from a direct financial point of view, growing oilseed rape is associated with several advantages for the grower:

- Choice of a break crop from cereals is extremely limited in Scotland due to climatic constraints and oilseed rape provides a good break option.
- Yield of wheat sown after oilseed rape has been shown to benefit considerably with yield advantages over other breaks. Trials show yield advantages of 35% compared to continuous wheat, compares with a yield advantage of 25% with beans, maize or potatoes (Wimberley, 1996).
- Nitrogen requirement for wheat after oilseed rape is estimated to fall by 45 kg/ha.
- Cultivation of oilseed rape allows growers an opportunity to spread labour peaks of harvest and sowing over a longer period.
- Oilseed rape allows an earlier entry for wheat, more timeous seed bed preparation with less problems of soil compaction etc.
- The crop has a deep tap root and is credited with benefiting soil structure by breaking up plough layers.
- Oilseed rape helps to reduce disease pressures within the rotation.
- Inclusion of oilseed rape in the rotation allows a good opportunity to reduce populations of wild oat and barren brome through application of graminicides.

3.4 Encouraging farmers to grow oilseed rape – contracts

The aim of this section is to identify the key issues with respect to contracts and to consider how farmers could be encouraged to grow oilseed rape.

The use of forward contracts for growing cereals and oilseed rape is slowly increasing but a significant proportion of farmers still produce crops without a guaranteed price or market. The exception would be the malting barley market where up to 60% of the crop is grown on a buy-back arrangement. It is estimated by the trade that less than 50% of the UK's oilseed rape crop is grown on forward contracts. Many growers still sell their oilseed rape at harvest without any marketing agreement. In many cases there is still a lack of understanding of the specification required by the market and how growers can influence this. Equally there is not enough transparency or effort put into educating growers by the trade on the premiums available for moisture content, oil content and admixture for example.

It must be recognised that by its very nature oilseed rape does present some additional challenges compared to cereals. Of all the arable crops oilseed rape is the most demanding in terms of sowing date, and is subject to more volatile yields compared to cereals. As it has a tight sowing window (winter oilseed rape must be sown by end of Augustin most Scottish conditions), growers may also not be able to establish their planned area due to the weather. In addition, oilseed rape market prices have fluctuated widely over recent seasons, which in turn causes problems. Although there may be some differentiation between genetically modified (GM) and non-GM sources of oilseed rape, it is a commodity, traded on the world market amongst all the other protein/oil crops, with soyabean being the main driver in the market. For all those reasons, oilseed rape is perceived as a more risky crop to grow than cereals. Many farmers also take a short-term view with ad hoc decision making depending on recent experiences. So cropping plans vary with current yields and prices rather than considering the longer-term view. Oilseed rape has the advantage that it plays an important role as a break crop for cereal production but on the downside it should be grown on rotation (normally once every 3 - 5 years) to prevent build up of soil borne disease. All these agronomic, market and practical issues influence the production of oilseed rape in the country.

3.4.1 Growers requirements of contracts

The following provides some of the key criteria growers are looking from forward contracts

- To have a secure market outlet
- Achieve a price that leaves a margin
- Full transparency on bonuses and penalties against specification
- The contracting company is financially secure
- There is flexibility for accessing drying/storage facilities if required – not all growers can handle wet oilseed rape.
- Local facilities for delivery – reduces risk of extra haulage costs through rejection

3.4.2 End user requirements from contracts

Like the growers, the end users have a number of needs they would like to be fulfilled from contracts. These include the following:

- Guaranteed supply of a specified quality over a number of years
- Structured procurement – when delivered and paid
- An input price that leaves a margin
- Often all year round delivery
- Reliable delivery important
- Full traceability of oilseed rape
- Working with committed professional growers – information flow to improve product and reduce costs

3.4.3 Common types of oilseed rape contracts available

The options for oilseed rape contracts are limited with three main types. The following provides a brief description of the main contract types.

1. Pool Marketing

This is the most common type of contract used for oilseed rape and is provided by the main grain merchants. Here all the oilseed rape is pooled together and the merchant markets it to the best advantage. Growers would commit a certain tonnage to the pool, however the final price is unknown at the time. The grower can specify when they wish movement, normally over 4 periods (harvest, Oct-Dec, Jan-Mar, Apr-July). Payment is normally made a month after the pool period. Merchants then market the pool, in some case 18 months ahead of delivery period. The advantage of this type of contract is that it reduces marketing risk and provides access to key marketing information through professional grain traders. Whilst never returning the peak of the market price over a season, it does provide some hedge on market prices.

2. Fixed contracts - forward selling

This is more common with the larger, more independent grower (producing over 200t). Here the grower agrees a fixed contract to deliver a specific tonnage, at an agreed price, meeting the customers quality specification. This is normally an ex-farm price with the merchant responsible for transport to the end user. For example, oilseed rape growers can lock into August 2006 at £136 - £138 per tonne at present. Problems can be encountered with fixed contracts when quality does not meet specification, leading to possible default in contract and penalties. So with fixed contracts the grower undertakes his own marketing and most of the risk therefore he needs to be confident he can meet the quality standards. In theory, the grower can hit the higher market prices but this depends on timing.

3. Central Storage Pool

This system is common for co-operatives/groups with large central stores. Here a grower delivers his oilseed rape to the central store, it is sampled for quality and weighed on entry. Drying and cleaning may also be undertaken. The co-op/group will be responsible for marketing the produce to the best advantage. Growers can decide on a number of payment options, to help cashflow. For example, in Aberdeen Grain's case, a pre-payment of 50% is paid in September, followed by a further advance of 40% in October with the final settlement occurring at the end of the season (July/Aug) when all the oilseed rape is sold and bonuses received. This arrangement gives the grower full flexibility and takes risk out of storage and marketing. It provides access to professional marketing to ensure price achieved is above average prices.

3.4.4 Possible ways ahead with grower contracts

There is still a lack of commitment to a dedicated supply chain for the benefit of all in the chain. Still too many players in the chain are looking short-term with no real commitment. Many players in the chain still think about 'winners and losers'. There is a lack of trust and a poor flow of information and transparency along the chain. In some way merchants can be viewed as an obstacle, however, they provide an important service in sourcing and bulking supplies for the major customers. They carry out this function quite efficiently.

A number of companies and merchants already have produced specific oilseed rape contracts for the energy crop market. These include for example, Grainfarmers (for the Greenenergy plant), Grainco (for the Teeside plant) and Springdale Crop Synergies (for a power station in Yorkshire). Although the precise details vary, in general the contracts are very similar. The majority are also flexible offering either fixed, open or pool contracts to suit growers needs. Currently they are all offering a delivered price of around £150 per tonne for August 2006, with monthly increments (£1/month) for later agreed delivery periods. A key point to note is that the transport cost to the designated plant is at the grower's cost, although merchants normally will organise the uplift. For growers in the East of Scotland this is likely to cost anything from £15 -£20 per tonne depending on distances.

Growers of oilseed rape for energy crops are also eligible for the EU Energy Crop Initiative of €45/ha. The actual payment rate by the EU is guaranteed up to a maximum area of 1.5M hectares within the EU, with payments scaled-back if claims exceed that area. This payment is directed solely to the farmer, but in order to qualify for receipt of this payment, the farmer must have a contract for processing the crop. Merchants offering these contracts are currently retaining up to 50% of the value of the Energy Crop Initiative to cover finance costs. In practice, merchants may also transfer the energy crop obligation to another oilseed rape crop, which is allowed within the scheme rules. There would be potential for a larger portion, if not all, of the Energy Crop Initiative payment to be retained by the farmer if a suitable business structure, with some farmer involvement with processing of the crop could be developed. This could contribute to improving the return to the grower.

3.4.5 What are current oilseed rape energy contracts worth to a grower?

Assuming the grower is in the Angus area and is considering a contract to deliver oilseed rape to Yorkshire next August (2006) at £150 /tonne. The ex-farm price would be as follows:

	£ per tonne
Contract price	£150.00
Oil bonus (42%)	4.50
Energy crop supplement	4.13
Less transport costs	(15.00)
Ex-farm price	**£143.63**

Notes:
1. Oil Bonus paid for crops above 40% at 1.5% price/+1% oil
2. Energy Crop Supplement €22.40/ha at exchange rate 0.689. Average yield 3.75 t/ha

To date many growers have been reluctant to commit to these types of contracts. Farmers are looking to secure a premium over conventional oilseed rape markets, whilst the operators of biodiesel plants are looking to secure feedstock at the lowest market price to remain competitive with fossil fuels.

3.4.6 What can be done to stimulate oilseed rape production?

It is recognised that there is a limit to the area of oilseed rape that can be grown in Scotland for the reasons previously stated. Within those constraints, the challenge is to get farmers to grow more oilseed rape and commit production to a Scottish plant. The following provides a number of possible suggestions to stimulate the production of oilseed rape in Scotland.

- A local oilseed rape crushing plant in Scotland would deliver considerable savings in transport costs. With haulage from Scotland to crushers in England costing £15 – 20/t, depending on location, this is likely to be £8 - £14 per tonne. This represents a substantial saving.
- Growers need to be more aware of the benefits of being part of a supply chain. They have access to an alternative non-food market. There is considerable scope to improve performance and reduce costs by sharing information throughout the chain. Growers have also the opportunity to form agronomy and benchmarking groups to improve performance. Having access to a local plant would also reduce the potential problems of rejected loads. In this case, alternative markets could be found at a reduced cost.
- Achieving involvement of a farmer co-operative with a crushing/biodiesel plant will provide commitment to any development and help guarantee feedstock supply. Having a stake in any proposed development means that a portion of the benefit (in terms of financial return) could then go back to the growers.

3.5 Feedstock summary

- The extent of oilseed rape production in Scotland has been closely related to the financial returns achieved and this has been influenced both by support systems and market price.
- The peak of production occurred in the 1990s, when up to 70 000 ha and 180 000t was produced. This may form a guide to the ceiling of production in Scotland.
- Oilseed rape is an important crop in the North and East of Scotland, with 76% being grown within the Aberdeenshire, Angus, Fife, Highland, Moray and Perth and Kinross areas.
- The UK oilseeds crushing industry is based on a small number of very large players. Crushing margins are volatile but have been high recently and it is considered that a new crusher would be subject to considerable competitive pressure.
- Changes in support through the Common Agricultural Policy has reduced crop gross margins considerably, particularly for oilseed rape and challenges the justification for growing the crop on a purely financial basis.
- Oilseed rape has been shown to give benefits for the crop rotation as a whole and these do provide encouragement to retain the crop.
- Use of forward contracts in marketing arrangements is currently limited, but increasing. These can help to provide a number of benefits.
- Oilseed rape contracts include pool marketing; enabling benefits of marketing a much larger tonnage of crop product, fixed contracts; where a specific tonnage and price is agreed for future sales and a central storage pool; where the oilseed rape is delivered to a central store for group management and marketing.
- A number of specific contracts for the energy crop market are now available. Transport costs to the designated plant will be at the grower's cost and gives a significant reduction. For growers in Scotland this will account for £15 – 20/t.
- Growers for energy crops are also eligible for the EU Energy Crop Initiative, but it has been established that merchants retain up to 50% of this value to cover

administration, reducing return to the grower. Retention of a significantly larger portion of this may be possible in a processing business with more grower involvement. This could help to increase the returns for the oilseed rape crop.

- Production in Scotland could be stimulated by establishment of a local crushing plant through minimisation of transport costs, sharing information through the local supply chain and establishing a stake in processing by involving a farmer co-operative in crushing biodiesel.

4.0 Crushing and biodiesel production technology review

4.1 Background to rapeseed oil as a biofuel

Vegetable oils are composed of a glycerol molecule backbone with 3 fatty acid molecules – the triglyceride. Glycerol will tend to 'coke up' un-modified engines resulting in poor performance. This problem can be avoided by esterification, ie chemical modification of the oil to remove the glycerol, allowing the resulting product to be used in unmodified engines. Esterification is achieved by mixing the vegetable oil with an alcohol (usually methanol) in the presence of a catalyst (usually potassium hydroxide) to produce the methyl ester. This material is sometimes referred to as Fatty Acid Methyl Ester (FAME) or when derived specifically from rapeseed oil, as rape methyl ester (RME). It is also known as **biodiesel**. Conversion of the oil to its methyl ester and removal of glycerol allows the resulting biodiesel to be used in most diesel engines, without the need for engine modification.

4.2 Developments in biodiesel production

Most vegetable oils can be converted into biodiesel. In Europe, rapeseed is the preferred material producing rape methyl ester (RME). In the United States, soy oil is the source for biodiesel, producing soy methyl ester, whilst in South East Asia, the readily available palm oil is the preferred raw material. Each raw material produces a biodiesel of differing specification. For example palm oil produces an ester with a very high freezing point which could lead to difficulties in cold climates and would fail the European standard.

The first trials with rape methyl ester were conducted in Austria in 1982 and showed promising results. This was followed in 1985 by a pilot plant and then in 1990 the first industrial biodiesel plant was constructed with a capacity of 10 000 tonnes. From there capacity grew and biodiesel production spread across Europe. In France, a demonstration plant with a capacity of 150 000 t biodiesel/year was constructed in 1993. In 1995 commercial scale biodiesel production began in Germany. By 2002, production across Europe had risen to over 1 million tonnes (Table 4.1) and production capacity increased further to close to 2 million tonnes in 2004. The substantial rise in production capacity has been supported by favourable excise duty regimes in many countries. For instance, Germany has no excise duty on biofuels and France and Italy do not levy excise duty on biofuels within a quota of production. In France, assistance is offered for capital expenditure on a regional basis, drawing together fuel manufacturers, refiners and producers. In the UK, a fuel duty rebate of 20p/litre of biodiesel is offered, but the remaining portion of duty, 47.1p, is still payable.

Although production of biodiesel in Germany and Austria was initiated with small scale plants, economic pressures have forced an increase in scale of plants for them to stay in business. The economies of scale which can be achieved from a larger plant have been found to be increasingly important and new units now are bigger and more efficient. New plants are typically constructed at a scale of 250 000 – 500 000 tonnes biodiesel production. Smaller scale plants have diversified their feedstock to include a portion of used cooking oil in a bid to stay economic.

A number of different marketing strategies have been used for biodiesel. Biodiesel can be used to fully substitute for diesel as a 100% biodiesel product. This is the approach taken in Austria and Germany. In France, the approach has been to blend

5% biodiesel with mineral diesel and market without branding as a biofuel. In the US, biodiesel has been blended with diesel and is branded as a biodiesel fuel.

Table 4.1 Biodiesel production in the EU (000 tonnes)

	2002	**2003**	**2004**
Germany	450	715	1,035
France	366	357	348
Italy	210	273	320
Austria	25	32	57
Spain	-	6	13
Denmark	10	41	70
United Kingdom	3	9	9
Sweden	1	1	1
Czech	-	-	60
Slovakia	-	-	15
Lithuania	-	-	5
Total	**1,065**	**1,434**	**1,933**

Source: European Biodiesel Board

4.3 Pure plant oil as a biofuel

Unmodified vegetable oil can be used as transport fuel providing some modifications to the engine are undertaken. Interest has expanded greatly recently and there are reports that this form of utilisation is developing quickly in parts of Germany. Engine conversion kits are available from a range of manufacturers and consist of fuel pre-heating, extra filtration, increased injection pressure and replacement injectors. Kits cost from £500 to the region of £2000, depending on specification.

The Irish government has recently approved an amendment to their Finance Act which allows the introduction of a scheme for Mineral Oil Tax (MOT) relief. This will allow relief from MOT on biofuel used in approved pilot projects and includes pure plant oil produced from oilseed rape and used in modified diesel engines, biodiesel blended with mineral diesel and bioethanol blended with petrol.

Very little development of biofuels has taken place in Ireland so far and the government indicates that, with a base of only 0.0003% biofuels in transport fuel, fulfilling the Biofuels Directive requirements is extremely challenging (G. Luddy, Department of Communications, Marine and Natural Resources, Irish Government, personal communication, 2005). The scheme is designed to provide a first step towards stimulating market development. In Ireland, the use of pure plant oil is seen to offer a number of advantages. Fuel processing and industry start-up costs are kept to a minimum, with production plants requiring low capital investment. The production of glycerol as a by-product of the process is also avoided.

Several groups have been awarded excise relief in the pure plant oil category. These include 2 projects involving collaborative work between farmers/farm co-operatives and the local community to run local transport fleets.

Technical performance of engines running on this fuel has been reported as satisfactory. However further investigation indicates that there is a lack of long term studies of the effect of pure plant oil on engine performance (Lance and Andersson, 2004). Concerns have been expressed that even with engine modification, the degree of sophistication of today's diesel engines may lead to problems when pure plant oil is used as a fuel (J. Andersson, Ricardo Consulting Engineers, personal communication, 2005). The greater viscosity of pure plant oil compared to diesel means that it does not flow through injectors in the engine so freely, leading to unburned oil remaining in the chamber which may compromise engine performance. With the uncertainties over long term performance, it is considered that use of pure plant oil seems likely to place engine warranties at significant risk.

On UK experience, the necessity of installing a special conversion kit to enable utilisation of a fuel would also be a significant discouragement to its use. Parallels can be drawn to the introduction of LPG in the UK, which was claimed to be a more environmentally friendly alternative to conventional fuels, but which required engine and fuel tank conversion. Despite a significantly lower price at the pump, LPG has never taken a significant share of the market. It should also be noted that pure plant oil does not qualify for fuel duty rebate in the UK, hence fuel duty could be applied at the mineral fuel rate of 47p/litre. The benefits of reduced capital costs due to lack of esterification requirement will be offset by the addition of this level of duty per litre of fuel unless the Government were persuaded to extend the relief on duty to this product.

4.4 Used cooking oil and tallow as biofuel feedstocks

Used cooking oil (UCO) from the catering industry can also be esterified and used as a biodiesel after cleaning. This product offers the potential of a substantially cheaper feedstock than virgin rapeseed oil and is used in some biodiesel plants on the Continent in combination with other oils to reduce overall costs.

Used cooking oil is collected and cleaned for re-use by a network of companies across the UK, which are all members of ACORN (the Affiliated Cooking Oil Reclaimers Nationwide). The oil is collected by individual companies, cleaned and sent, through brokers, for further refining. Approximately 120 000t of UCO is produced in the UK each year with only around 10 000 t available in Scotland. Due to the dispersed nature of the population in Scotland, this quantity is situated over a wide area. Competition for utilisation of this material is expected with Argent Energy who aim to use a significant share of the UK UCO production in their biodiesel plant at Motherwell (See section 4.9.1). Cost of the refined material is currently £185/t delivered in bulk, but the market is volatile.

The oil collectors interviewed (3 of the 4 companies in Scotland), cite concerns at current technical difficulties in processing UCO to biodiesel. Some concerns about the utilisation of biodiesel made from this feedstock in the modern diesel engine, with its sophisticated fuel injector systems, have also been expressed. Blending of the biodiesel with mineral diesel may ameliorate these concerns and may allow quality standards to be achieved.

In the UK the market for tallow collapsed in 1996 following the BSE crisis and the ban of UK exports of beef and bovine products. The UK continues to be prevented from exporting tallow with only a restricted market existing for UK tallow in feed, pharmaceuticals and oleochemical production. Values of UK tallow are significantly depressed with UK tallow trading at roughly one third of world trading prices (UK Renderers Association, 2004). Use of tallow for biodiesel production provides a method of disposal of the otherwise unmarketed tallow, with the benefits of energy generation. Argent Energy are already utilising a significant portion of Scottish produced tallow as feedstock for biodiesel.

4.5 Development of a diesel standard fuel containing oil using the hydrogenation process

A duty incentive that would allow oil refineries to produce a diesel standard road fuel containing an element of biofuel is proposed by HM Revenue and Customs. Raw vegetable oils such as rapeseed would be integrated into the diesel fuel in a process known as hydrogenation during the refinery process. Hydrogenation would effect some changes to the chemical composition of the oil to enable integration and would take place at the established petroleum oil refineries. This produces a diesel standard fuel almost indistinguishable from ultra low sulphur diesel (ULSD). It is claimed that this process potentially allows much larger scale production since it will be more attractive to the main oil companies and will involve less processing and chemical input (HM Revenue and Customs, 2005). Industry sources indicate that there are a number of technical issues to be resolved before this system can be used in practice. Issues include corrosion of equipment and life of the catalyst used in the process.

The resulting fuel would be classified as ULSD for tax purposes and therefore would not qualify for the duty incentive offered for biodiesel. The government is keen to support the development of this fuel using the taxation system and state that it is hoped that this will augment and work alongside biodiesel manufacture. The process of developing a tax system for this fuel being at very early stages with a pilot project for suggestions of ways to operate the tax system only just having gone out to tender in August 2005. This factor, together with the need to address technical issues and thereafter encouraging uptake of the process in refineries, imply that production of a diesel standard fuel incorporating vegetable oil using the hydrogenation process is some years away.

4.6 Brief description of processing technology

4.6.1 Production of oil from rapeseed; the options

Extraction of oil from rapeseed can be carried out by mechanical means or by incorporating a solvent extraction stage into the process. Solvent extraction is associated with several disadvantages compared to other oil extraction methods; equipment required is more expensive, mechanical maintenance is more costly and power requirement is high, fire and explosion risks are associated with the use of the solvents and there are also dust explosion risks due to the dusty nature of the low oil meal. Nevertheless for a high oil content material such as rapeseed at high volumes (eg 3000 t rapeseed/day), use of solvent extraction is more economic as it allows extraction of a greater proportion of the oil. It is of note that no solvent extraction crushing plants of less than 1000t/day are now being built in western Europe. Considering the scale of rapeseed extraction likely to be required in Scotland, mechanical pressing would appear to be the appropriate technology to use for crushing of rapeseed for biofuel production.

For biodiesel production, the crude oil must first be removed from the seed by crushing or pressing (Figure 4.1). Some refining of the oil is necessary before the oil is passed to the esterification process. The 3 processes of refining, crushing and esterification may all be carried out in separate plants on different sites or 2 or all 3 processes can be combined on one site.

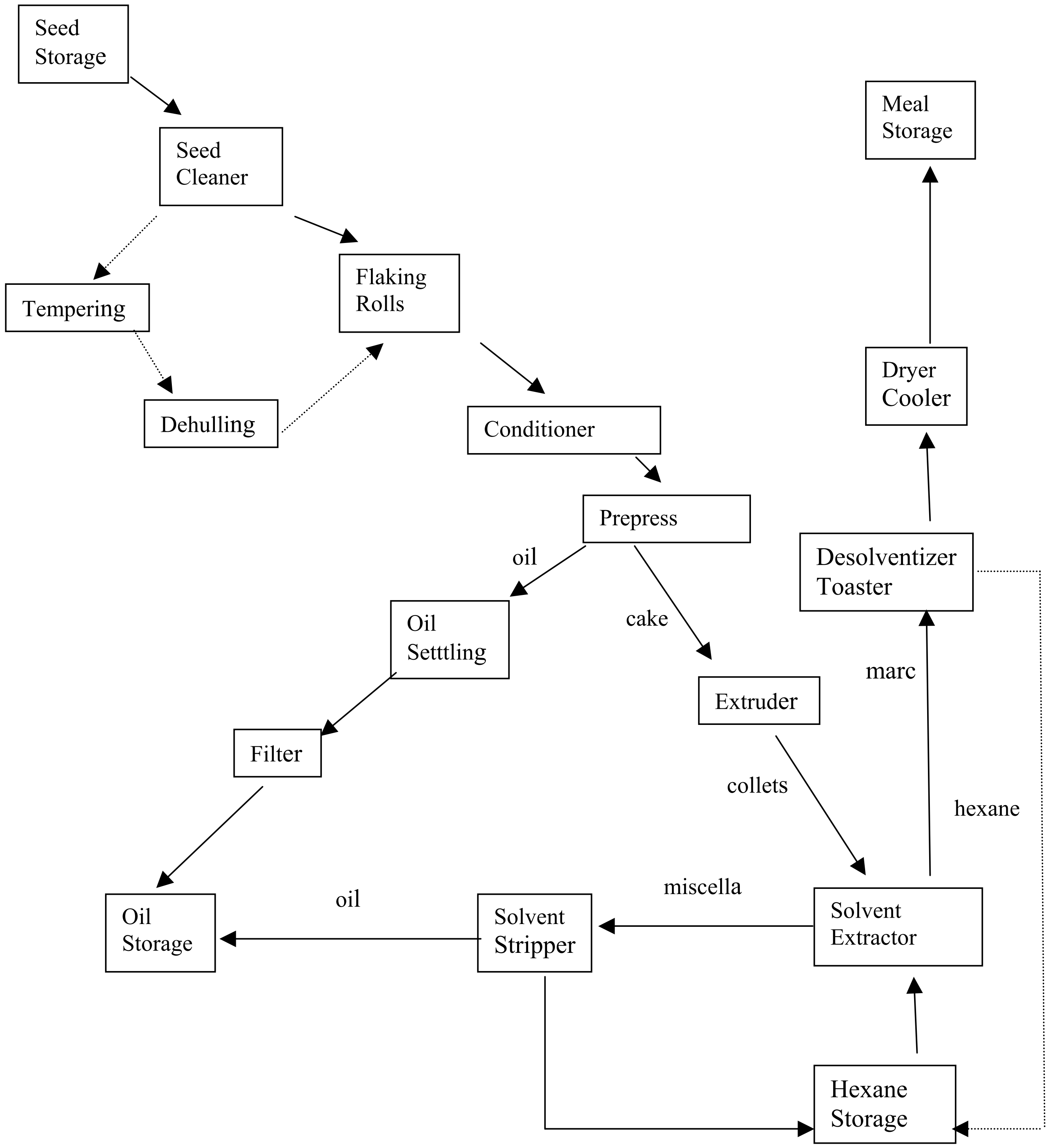


Figure 4.1: Oil extraction from rapeseed

4.6.2 Crushing

Current commercial rapeseed oil extraction or crushing involves a number of steps including:

- Seed cleaning - removal of foreign matter
- Tempering - pre-heating of the seed to improve ease of oil extraction – optional
- Dehulling - removal of seed coat
- Flaking - flaking seed to increase surface area to facilitate oil extraction
- Conditioning - heating the flaked seed, again to facilitate oil extraction
- Mechanical extraction - by pre-pressing and extrusion and/or expansion
- Solvent extraction for maximum extraction of oil, economic at very large scale only

4.6.3 Refining

Refining vegetable oil for food involves 4 processes – degumming, neutralisation, bleaching and deodorising. Degumming involves the removal of natural phosphorus based gums and pigments. Neutralisation involves the removal of free fatty acids. Both of these processes are necessary to prepare oils for esterification and are often conducted together. Removal of phospholipids is important as these compounds can damage the engine. Free fatty acids should be removed to protect the catalyst used during esterification. The third step, bleaching, to improve oil colour and clarity is not necessary in biodiesel production as these criteria are not important for a fuel. Similarly, deodorisation to scrub out volatiles which give the oil an unpleasant smell is not necessary for biodiesel production. Deodorisation can account for half the refining costs, so exclusion of this step can lead to considerable cost savings.

4.6.4 Esterification

Esterification is conducted by the adding of a monohydric alcohol to the oil in the presence of a catalyst. The triacylglycerols in the oil are transformed into fatty acid esters and glycerol. Normally methanol is the alcohol used in this reaction. The catalyst promoting the reaction may be acid or alkali. In most modern plants, the preferred catalyst is alkali for the main esterification process but a pre-esterification step may be used with an acid catalyst for the conversion of free fatty acids. This reaction will take place at room temperature and the esterification reaction results in the separation of the heavier glycerol which has a density of 1.26 from the lighter ester (density 0.88). Separation can be conducted as a batch process in settling containers but in large plants it is usually a continuous process involving tube settlers or other separation technology. The biodiesel may contain traces of soaps and some excess methanol and these are removed by centrifuge for the former and by distillation for the latter. The biodiesel is then ready for use.

4.7 Small scale oil pressing

Several companies manufacture small scale oilseed crushers. Straehle have supplied these plants to a number of companies in Ireland for farm and co-op scale oilseed rape pressing. Straehle oil presses can be operated continuously on a 330 days/year basis.

They range in scale from a throughput of 15 kg/hour (@24 hours x 330 days = 119 t/year) to 500 kg/hour (@24 hours x 330 days = 3960 t/year).

The plant layout and processing steps associated with the Straehle presses are shown overleaf. Seed will be fed from the storage silo, through a magnetic separator for seed cleaning to a preheater before being pressed in the endless screw press at a temperature of 15°C. The resulting oil will then be immediately transferred to a filtering installation for removal of suspended solids and will be allowed to cool before being stored in the clean oil tank. The cake, or rapeseed meal, by-product will be cooled and then transferred to the storage container.

Greenfuels are also offering small scale esterification plants. These produce 150 or 300 litres of biodiesel per day and several of these modules can be purchased to increase capacity. Greenfuels are working in conjunction with Alvan Blanch who have developed a small scale oilseed crusher capable of pressing 150 kg rapeseed per hour. It is planned that crusher and esterification plant will be fully integrated for automatic operation shortly.

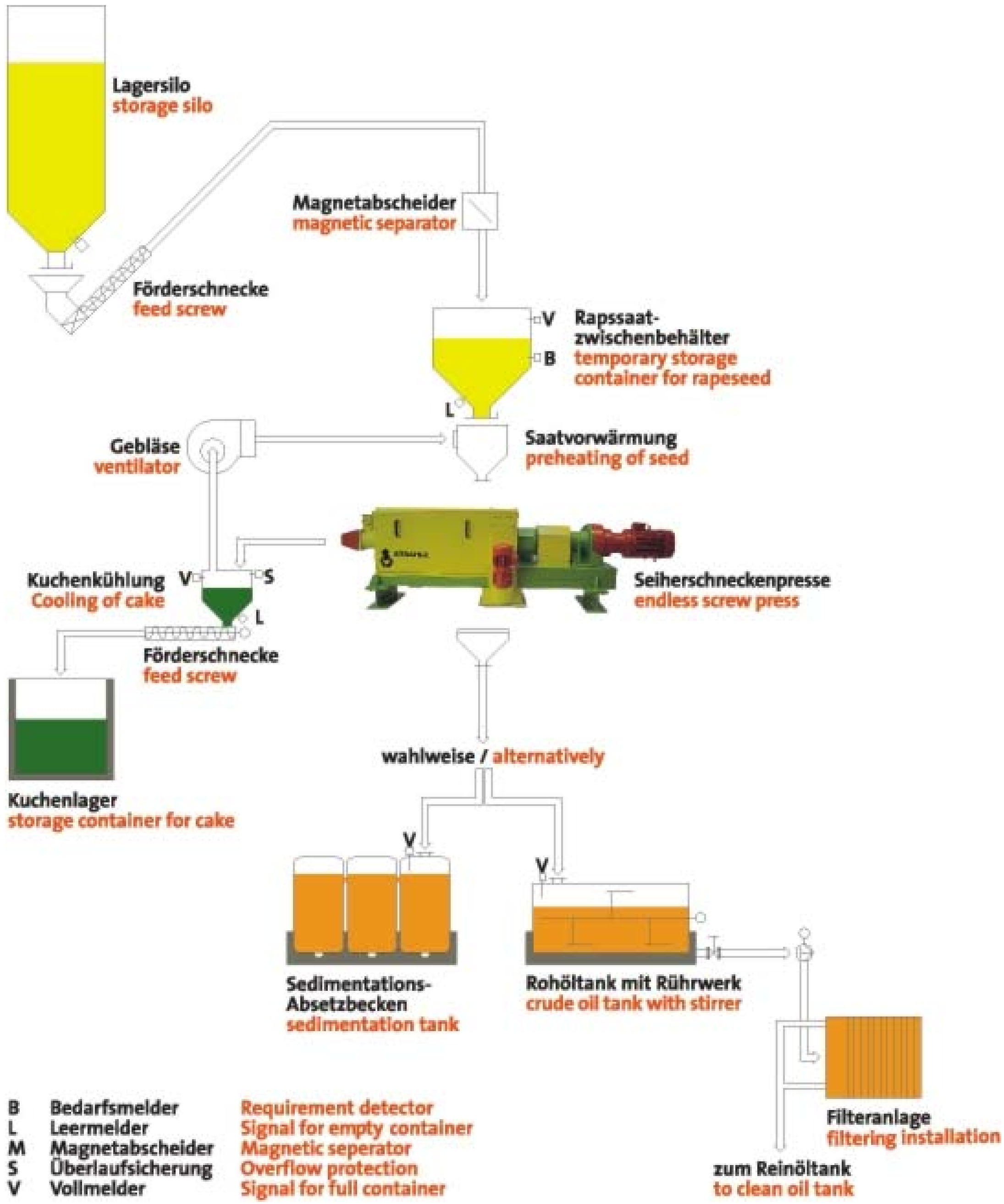


Figure 4.2 Small scale oil press plant layout

4.8 Lessons from the Arbroath crushing plant

The aim of this section is to review the previous oilseed rape crushing plant based at Arbroath and to better understand why it failed. Lessons learned from the business may still be relevant today.

The plant traded as 'Seed Crushers Scotland Ltd' and was owned by Agra Walla brothers from Glasgow. They had previous experience of operating a soyabean crushing plant in Glasgow which had failed, with the business going bankrupt. Louis Dreyfus purchased the Glasgow crushing plant and operated it for a number of years before selling it to Cargill, who closed it down. Agra Walla purchased the old plant, had it converted to handle rapeseed and installed in Arbroath. It is likely that some grant support was received to locate there.

Seed Crushers Scotland only operated for three seasons from 1996-1999 before closing with financial problems. It is believed the plant could operate at a capacity of 10-12 tonne/hour. The technology used was quite old and inefficient basically being a mechanical press. As a result the oil extraction from the rapeseed was low leaving the meal with a high oil content. Although high oil rapemeal would have a higher energy content and therefore be worth more, a premium was never achieved from the animal feed industry. The rape oil produced was poor quality and may have needed further refining depending on the market.

From discussions with a number of sources, principally firms dealing with the plant, a number of alleged problems were identified. These were as follows:

- Inefficient technology, giving low extraction of oil from rapeseed.
- The whole plant was small scale with little efficiency of scale and was therefore low value and high cost. At that time there was a period of poor oil prices, producing negative crushing margins. The two big multinationals (ADM and Cargill) operated aggressive competitor pricing policies. Crushing margins are notorious for fluctuating so a business needs reserves to weather any downturn.
- The rape oil had to be hauled to Dundee to store and shipped to customers which incurred extra costs.
- The oil and meal were traded as commodities often at discounted prices. No refining facilities were available on site, so oil had to be sold on, to one of the limited number of companies, such as competitors ADM or Cargill, for refining.
- The rapemeal became contaminated by salmonella, which was a major concern for the animal feed industry. It was thought to have occurred through inadequate cooling of the meal. Treatment of the plant for salmonella was very expensive.
- Some feed firms stated the high oil meal produced problems with flowability. It often bridged in bins causing problems. There was a concern too regarding its ability to keep beyond 10-14 days. Often the meal would be warm.
- In general, quality was alleged to be very variable through out the plant. This presented challenges to the plant's operators when trying to market the output.
- The plant ran into environmental problems through complaints from residential houses regarding smell and noise.
- The trade viewed the company suspiciously because of its previous history.

Key lessons

The main messages from the review of the Arbroath plant were:

1. Scale is important unless can secure niche markets.
2. Quality control is paramount.
3. The oil is the most valuable component, so the most efficient extraction technology is worthwhile providing cost effective.
4. Site selection is crucial to keep costs down and minimise any problems at a later date.

4.9 Review of UK biodiesel developments

At present there are four biodiesel plants in the UK at different stages ranging from recently established or being at the planning stage. The following section provides a brief review of each plant. In summary the key aspects are shown in Figure 4.3, as follows:

Table 4.3 Summary of UK Biodiesel plants

	Location	**Plant Size**	**Feedstock**	**Investment**
Argent	Motherwell	50ML	UCO, tallow	£15M
Northeast Biofuels, Biofuels Corporation	Teeside	284ML	OSR, Palm Soya	£46M
Greenergy Fuels Ltd	Immingham	113ML	OSR, Palm Soya	£12 – 15M
Global Commodities	Norfolk	30ML	UCO, rapeseed	Over £10M

In addition, there are plans for further biodiesel plants currently under discussion in the UK, but little information is available about these.

4.9.1 Argent

Argent Energy Limited was established in 2001 to investigate methods for adding value to animal by-products from the Argent By-Products rendering businesses. Argent Energy has recently built the UK's first large scale biodiesel plant near Motherwell. The company, along with animal renderer William Forrest was spun off from parent company Argent Group Europe to raise funds for expansion.

State of play
Production of biodiesel started in April 2005 and the plant was due to be fully operational a few weeks later. There are plans to set up at least another 2 plants in other parts of the UK and the company could be listed on the Alternative Investment Market to raise this cash.

Feedstock used
Used cooking oil (UCO) and animals fats (tallow).

Size
The plant will be capable of producing 4 200 000 L biodiesel per month (50 000 000 L per year).

Technology
UCO and tallow are converted to fatty methyl esters. The plant has been constructed by Mowlem plc with Biodiesel International, an Austrian firm.

Capital investment
£15 million investment, supported by £1.2 million in Regional Selective Assistance supported by the Scottish Executive and a further £2.18 million from Europe to fund research and commercially assess the operation. The venture capital firm Cinven owns 60% of the parent group.

Employment
Fifteen skilled staff in addition to the management team.

Competition issues
None of the other new biodiesel plants planned for the UK will use used cooking oil or tallow feedstocks hence they will not be competing for this feedstock. The Argent plant can accept lower specification feedstocks.

Contracts on offer
Production of biodiesel offers a means of disposal for tallow for which no value is currently attached, and to used cooking oil which has a comparatively low value. Argent doubt whether they will ever pay for tallow, but point out they offer a cheaper means of disposal to the agricultural industry.

Infrastructure
Situated within easy access to William Forrest Renderers.

Permissions/consents required
In Scotland major industrial plants are currently regulated by SEPA through the Integrated Pollution Prevention and Control Regulations.

Market/disposal of by-products
By-products are glycerol and potassium sulphate derived from the catalyst which can be used as a fertiliser.

Marketing of biodiesel produced
Most of Argent Energy's production will go into a blend of 5% biodiesel and 95% mineral diesel. It is sold to Teeside based Petroplus and marketed under the Bio-plus brand on filling station forecourts. It is claimed that Petroplus could buy upwards of 25 000 t of biodiesel from Argent. This is shipped to refineries at Grangemouth and Teeside for blending. Argent are committed to ensuring adherance to European standards for biodiesel, mineral diesel and blended biodiesel.

Lessons to be learned
Utilising tallow, for which no payment is required can give significant advantages to the economics. Feedstocks are variable and Argent stress adherence to quality standards.

4.9.2 Teeside Developments

Northeast Biofuels is a cluster group of companies and organisations seeking to develop transport biofuels in the North East of England. Northeast Biofuels are planning to set up a crushing plant at Teeside and are aiming to develop supply chains for biofuels. The Sectors and companies involved in Northeast Biofuels are as follows:

Farming – East Durham Biofuels Ltd, Farmway Limited, Monsanto UK Limited
Chemicals – Terra Nitrogen (UK) Limited, Agrovista
Fuels – Petroplus
Utilities – SembCorp, Simon Storage, Vopak
Engineering – K Home International Limited
Project development – North East Process Industries Cluster
Public sector – One Northeast, Renew Tees Valley Limited.

In addition, a separate company, the Biofuels Corporation plc, is building a biodiesel processing plant at Seal Sands, Middlesbrough, Teeside. This company was set up by 2 Australians who saw an opportunity to develop biodiesel in the UK. It has recently been floated on the Alternative Investment Market. The Biofuels Corporation plc plan to develop further plants as soon as practical and state that they intend to be Europe's leading biodiesel producer.

State of play
A site has been selected for the crushing plant and North east Biofuels are in the process of arranging finances for the project. It is planned that the plant will be ready to crush in January 2007.

At the time of writing, at the beginning of August, construction of the Biofuels Corporation biodiesel plant is well under way. Full initial production of biodiesel is due by the end of September 2005.

Feedstock used
The crushing plant will be rape optimised, but North east Biofuels also intend to crush palm and soya. The quantity of rapeseed used will be a function of the price, but suitability of the resulting oil to meet the biodiesel standard will also be a dictating factor. Temperature will also influence the blend of oils to be used with lower amounts of palm used in colder period of the year.

The Biofuels Corporation also plan to use a number of vegetable oil crops for biodiesel production Initially the primary feedstock was planned to be the cheaper imported palm oil. The blend policy may be changed in view of quality issues associated with palmoil biodiesel for Northern climates.

Size
Northeast Biofuels plan to crush 1500 t per day, equivalent to 500 000 t/year.

Production equivalent to 284 million litres of biodiesel per annum, 21 000 tonnes per month, is planned at the Seal Sands site.

Technology
The crushing plant will be rape optimised and will use solvent extraction. Northeast Biofuels are in discussions with engineers de Smet for construction.

Energea biodiesel technology will be used in the Biofuels Corporation biodiesel plant.

Capital investment
The crushing plant is expected to cost £16 – 18 million.

The biodiesel plant is expected to cost just over £28 million. It is supported locally by One North East with a £1.2 million grant. The preliminary results for the year ended 31 March 2005 indicate that financing is in place with £13 million and additional £22.5 million facilities available.

The Biofuels Corporation Group was floated on the Alternative Investment Market in 04/05 in order to raise £14 million and commenced construction at Teeside. Subsequently a further £8m was secured on the AIM market to cover additional construction requirements. The company anticipate a pre-tax loss of £10 million in the year to 31 March 2005 due to commodity hedge arrangements and other exceptional costs.

Employment
Total number of employees at the biodiesel plant is now up to 40 and the plant will be run on a continuous shift basis.

Competition issues
The Northeast Biofuels crusher will seek to procure rapeseed from Scotland, as well as south of the border, and so would provide an element of competition to any Scottish processor.

Contracts on offer
Contracts for rapeseed are currently being offered by the company GrainCo. This organisation is 50% owned by Northeast Biofuels member Farmway and 50% by Tyne Grain. Both are co-operatives. The plan for contracts as outlined in 2004, was to tie growers into 3 year arrangements with stipulated prices and a requirement to utilise specific varieties, fertiliser and crop chemical inputs from partner companies. However it was concluded that these would not be sufficiently attractive to growers. Current contracts are priced at £150/t delivered to Teeside but ex farm price is uncertain as destination can be changed at the buyers option to anywhere else in UK and any additional haulage is charged to the farmers account. Bonuses for oil, moisture content and admixture will apply. The farmer will qualify for the Energy Crop Payment and undertakes to pass 50% of this to the merchant to cover administration costs. This is a 3 year contract and there will be several selling options (fixed/open/pool price) for 2007 and 2008. For years 2 and 3 either party can cancel the contract if construction of the crusher at Teeside is delayed.

Infrastructure
Biofuels Corporation site is situated at a deep water port with well established infrastructure. The crusher is planned to be situated at the other side of the Tees.

Permissions/consents required
Key authorisation required for running the biodiesel plant, the Integrated Pollution Prevention and Control permit was granted in June 2005.

Market/disposal of by-products
It has been suggested that meal produced from the crusher may be sold to a power station for electricity generation.

Glycerine is produced as a by-product from the biodiesel plant .

Marketing of biodiesel produced

Preliminary results for the Biofuels Corporation for the year ended 31 March 2005 indicate that sales contracts are now in place for 64% of start up production. The company are confident of securing a market for the remaining 7 500 tonnes per month remaining to match full production, with a strong list of hot leads for 25 000 tonnes per month. The group intend to supply markets where biodiesel is already established and to develop further markets, both in transport and other sectors.

Lessons to be learned

The large size of the crushing plant is stressed as of prime importance to its feasibility. Successful biodiesel plants on the Continent have become larger in scale. A key comment in reports from this group is that 'Biodiesel industry has moved from being driven by agriculture to being driven by petrochemical market.' Northeast Biofuels have suggested that there is an opportunity for Scottish biodiesel interests to invest in Teeside operations.

4.9.3 Greenergy Fuels Ltd (GFL)

State of play.

Greenergy is a leading fuel importer, blender and distributor which is 25% owned by Tesco. GFL has been at the forefront of introducing low sulphur fuels and more recently developing retailing of biodiesel and ethanol via Tesco (branded as Globaldiesel), other supermarkets and local authorities. GFL are at an advanced stage of planning a 100,000 t biodiesel plant at Immingham connected to tank storage and import facilities provided by Simon Storage. Planning permission has been granted and building is expected to begin in 3rd quarter 2006.

Feedstock used

The plant will have flexibility in oil feedstock usage but is expected to use 65% rapeoil equivalent to circa 160 000 tonnes of OSR. The balance could be a combination of palm oil and soya oil and used cooking oil depending on price.

Size

Initially 100 000 tonnes of biodiesel but with the option to double capacity on site should market circumstances dictate.

Technology

Provided by Desmet Ballestra who have built several biodiesel plants in the EU.

Capital investment

Plant investment is estimated between £12-15m

Employment

Up to 20 people

Competition issues

GFL have developed a pool of growers via major merchants such as Grainfarmers and Frontier plus some smaller regional players. They have developed good retail outlets via Tesco who is now a shareholder. The plant capacity represents 10% (20% if capacity is doubled) of the potential biodiesel demand based on the 5.75% target for blending.

Contracts on offer
Growers, via their merchant, are offered a 2 year option to supply the plant. Pricing by mutual agreement. Biodiversity guidelines are provided and growers are requested to supply details of energy usage in crop production for carbon certification

Infrastructure
The Immingham site is well provided for in terms of import facilities, storage and refining.

Permissions/consents required
The site is brown field and normal consents are believed to be well advanced

Market/disposal of by-products
The plant will not crush oilseeds so has no meal for disposal.

Marketing of biodiesel produced
GFL have created demand by developing the retail outlets in advance of building the plant.

Lessons to be learned
Develop distribution and retail outlets. Secure oilseed feedstock but ensure crushing capacity is available locally to minimise logistical costs.

4.9.4 Global Commodities

Global Commodities UK Limited produce biodiesel from their factory in Dereham, Norfolk.

State of play
The company was established in 2001 and has been producing biodiesel, branded driveECO, since 2002.

Feedstock used
Currently, used cooking oil. There are plans for expansion to use rapeseed oil grown by local farmers.

Size
The current capacity is 30 000 000 L/year. Reports in 2004 indicate that 12 000 000/year was produced. A new factory with a capacity for 180 000 000 L was planned for 2006 (as reported in 2004). There was to be a 60 000 000 L capacity in year 1, rising to 180 000 000 after 3 years.

Capital investment
For new factory - £10 million.

Competition issues
Competition possible – if plans to expand are realised.

Contracts on offer
Centaur Grain was to offer contracts for harvest 2005.

Infrastructure
A port facility for the planned plant had to be discounted in January 2004 due to unresolved environmental issues.

Permissions/consents required
Granted low emission Integrated Pollution Prevention and Control permit by the Environment Agency.

Marketing of biodiesel produced
Sold under the name of driveECO in bulk purchase to the transport industry and also fuel forecourts throughout East Anglia. DriveECO is a 5% biodiesel; 95% diesel mix.

Lessons to be learned
This biodiesel project does not seem to be progressing from a used cooking oil operation at the moment.

4.10 Summary of technology

- Vegetable oil is modified to biodiesel (Fatty Acid Methyl Ester) by treatment with methanol to remove glycerol.
- There has been a rapid expansion in biodiesel production in Europe linked to duty exemptions.
- The use of pure plant oil as a biofuel in modified diesel engines has generated interest in Ireland and elsewhere. Several doubts over its development in the UK: the effect on modified engines is technically unproven over longer time periods; likely take-up of engine modification kits is unclear; and importantly it does not qualify of tax rebate in the UK.
- Used cooking oil offers the potential of a cheaper feedstock but only small quantities are available in Scotland and there is likely to be competition for this from Argent Energy which has already established a biodiesel plant using this feedstock.
- Development of a diesel standard fuel containing oil, using the hydrogenation process is at the early stages. HM Customs and Revenue are presently consulting regarding a taxation system to be used and uptake of this process is likely to be some years away.
- Crushing or pressing the seed for oil consists of several stages. For larger plants solvent extraction is used to maximise extraction of oil. The scale of rapeseed production in Scotland is unlikely to ever justify a solvent extraction plant.
- Small scale presses are available from a number of companies, and a small scale esterification plant model is also now on the market.
- Key lessons to be learned from the failure of the Arbroath crushing plant are that scale is important, quality control is paramount, efficient oil extraction is worthwhile and site selection is crucial.
- There are several biodiesel developments in operation or planned. These present varying competitive implications for procurement of rapeseed for a Scottish crusher (Table 4.4).
- If all go to fruition, combined they will produce over 477 M litres of biodiesel. This is set in the context of UK consumption of diesel at 17.7 M t (20.1 billion L). Potential biodiesel production would be 2.27% of UK diesel requirement, indicating that there is still ample scope for UK production of biodiesel to meet the 5.75% Government target. This target includes petrol consumption, and bioethanol production is less well advanced than biodiesel, giving greater confidence that there is scope for further biodiesel developments.
- If all the planned biodiesel production was to be derived from rapeseed it would account for almost 400,000 ha of rapeseed. This is compared to a current annual production of approximately 450,000 ha of rapeseed in the UK implying that expansion of the UK area or susbtitutioon of conventional markets is required.

However, a substantial amount of feedstock will be used cooking oil and imported soya and palm oils, relieving pressure on rapeseed production.

- It is of note that all proposed biodiesel plants using virgin oils will be located in port locations to allow flexibility of feedstock supply.

Table 4.4 Competitive factors relating to UK Biodiesel plants

	Location	**Likely competitive effect**
Argent	Motherwell	Competition limited as different feedstock used.
Northeast Biofuels, Biofuels Corporation	Teeside	Competition for rapeseed feedstock likely. Stated intention to procure rapeseed from south of Scotland.
Greenergy Fuels Ltd	Immingham	Will compete for rapeseed. Although rapeseed oil will be used as the feedstock, GFL will compete for procurement of rapeseed across the UK through the marketing chain.
Global Commodities	Norfolk	Plans for a plant do not seem to be progressing, hence little competitive effect at present.

5 Environmental Assessment

5.1 Human health implications relating to the cultivation of the oilseed rape crop

There is anecdotal evidence relating exposure to oilseed rape with allergic and irritant responses with the oilseed rape crop during its growing cycle. Symptoms may include hay fever type responses of sneezing, eye and also throat irritation and headaches. A number of trials have been carried out to investigate this link. In 1997, a systematic review was reported by the Medical Research Council Institute of Environment and Health to assess possible health effects of the crop. The review (Courage et al., 1997) made several conclusions which are outlined below.

There was evidence that some people may have an allergic response to oilseed rape pollen. This response appears to be confined to individuals who are already sensitive to other pollens or common allergens. It was suggested that sensitisation to oilseed rape pollen alone, in the absence of sensitisation to other pollens or other allergens appears to be rare. From a review of the information available there was no evidence that symptoms were any different, or more intense than those caused by other allergens.

Oilseed rape pollen is comparatively heavy and trials show that unlike plants such as grass which are primarily wind pollinated and have pollen which is distributed very widely, the bulk of pollen from oilseed rape remains close to the crop with very limited distribution in the air. It does not generally contribute greatly to the total amount of pollen in the environment at the time oilseed rape flowers.

Like may other flowering plants oilseed rape emits volatile organic compounds (VOC) at flowering. Relative proportions of VOC vary according to different species and may be large in a crop of flowering oilseed rape due to the high density of flowering heads. Studies of subjects who considered their symptoms were due to oilseed rape were tested for their reaction to oilseed rape compounds. Very few had positive tests to the oilseed rape allergen. However, the same tests showed an elevated incidence of positive allergen scores for oilseed rape from subjects in areas where oilseed rape was grown, compared to areas with no oilseed rape. It was noted that there are many possible explanations which may not be due to oilseed rape and it was concluded that there was no direct evidence to suggest that VOC are responsible for the adverse health effects reported to be associated with oilseed rape.

The agrochemicals used on oilseed rape were investigated. Most are also used on other crops to which no widespread allergic responses were attributed. There was no evidence that these were responsible for any health effects.

Fungal pathogens can be associated with oilseed rape, as with other crop species. The report concluded that there was no evidence that the fungi found on oilseed rape are linked to any effect on health not observed following exposure to these fungi from other species.

The final conclusion from the review was that many of the symptoms reported can be explained in terms of allergy to pollen other than oilseed rape. No causal association between exposure to oilseed rape and non specific hyper-responsiveness could be established.

5.2 Effects of oilseed rape on farmland birds

An important driver for the cultivation of oilseed rape as an energy crop is for the environmental benefit it offers as a renewable source of energy. In the environmental analysis of biodiesel from oilseed rape it is also important to consider the impact on agricultural ecosystems. Relatively little research has been carried out on the biodiversity value of bioenergy crops but the likely effect of a range of bioenergy crops on farmland birds, an indicator of biodiversity, has been undertaken by the Royal Society for Protection of Birds (Anderson et al., 2004).

Oilseed rape is known to provide feeding and nesting resources for a range of farmland bird species. Birds nesting within oilseed rape include skylark, yellow wagtail, sedge warbler, reed bunting and corn bunting. Reed buntings, whose numbers declined during the late 1970s and early 1980s, were found to favour oilseed rape fields compared to other crops for nesting. A study in Nottinghamshire showed 60% of oilseed rape fields were occupied by breeding reed buntings compared with just 10% of winter wheat, 5% barley and 20% set aside (RSPB website, 2005). The suitability of the crop for open field nesting sites does however decrease with crop growth during the season. Productivity of reed bunting (and it was considered, probably other species) could be increased by desiccating rather than swathing so that the crop remains standing for as long as possible.

Oilseed rape supports relatively high numbers and species diversity of insects compared to cereals and set aside during the summer and a range of bird species, including tree sparrow, reed bunting and yellow hammer use the crop for invertebrate foraging during the breeding season. Linnets and whitethroats have shown preferences for hedgerow nesting sites adjacent to oilseed rape fields and a study of 18 bird species has found that the incidence of bird species was consistently increased by the presence of oilseed rape crops adjacent to the hedgerow.

Granivorous birds such as the house sparrow, greenfinch, bullfinch and linnet feed on rape seeds from the standing crop. It is considered that the availability of oilseed rape as a seed resource during the 1980s may have helped slow the decline of the linnet population. Potential fluctuation in area os oilseed rape is seen as a constraining factor in further recovery of the linnet population.

Skylarks prefer autumn sown oilseed rape crops for over-wintering to autumn sown cereals. It is also noted that rape stubbles are a favoured wintering habitat for granivorous passerines.

All in all, it is concluded that oilseed rape provides biodiversity benefits for a number of farmland specialist bird species, whose numbers have been in decline. Spring sown crops with associated over-winter stubbles will give particular benefits. If the area of oilseed rape was to increase the overall impact on farmland bird species would depend on a number of factors including the habitats the crop replaces, geographic distribution and spatial arrangement within the landscape.

5.3 Assessment of the fuel characteristics and exhaust emissions of biodiesel

When compared with mineral diesel, biodiesel is found to have a 13% lower energy value in terms of MJ/kg and a 7% lower level in MJ/dm^3 (as the density is higher). See Table 5.1.

Table 5:1 Calorific value and fuel efficiency

Fuel	Density	Energy Value		Efficiency degree
	g/cm^3	MJ/kg	MJ/dm^3	% at 1200 rpm
Diesel	0.83	42.9	35.6	38.2
Biodiesel	0.88	37.2	32.9	40.7
Variation from diesel		-13.3%	-7.6%	+6.5%

Source: Walter (1992)

On an analytical basis biodiesel differs most markedly from mineral diesel in that it contains virtually no sulphur. Diesel however contains no oxygen compared with 10-11% in biodiesel. It is the presence of oxygen that is claimed to explain the improved combustion in terms of energy efficiency and reduced emissions as indicated in Table 5.2.

There have been many studies conducted across the world comparing the efficiency of biodiesel with diesel and different results are produced according to the engine test cycle, the engine design, and the quality of the biodiesel (Goetz, 1994; Havenith, 1993). On balance there appears to be little difference in potential power output but there is an increased fuel consumption of approximately 5% within the range of -5% to +14% (Schafer, 1991; Sams and Schindlbauer, 1992; Walter, 1992). Other factors of note are dilution of sump oil ranging from +1% to +10%. The move to low sulphur mineral diesel fuels results in poorer lubricity of the fuel causing adverse scoring and wear of the cylinder and piston. Here biodiesel offers significant advantages and the addition of biodiesel to mineral diesel has significant benefits in this respect.

In the same way that engine efficiency studies vary according to test cycle, engine, biodiesel, etc., so emissions comparisons vary. See Table 5.2.

Generally speaking, results tend to indicate most emissions are down except for NO_x which are generally up by around 3-5% (Mittelbach and Tritthard, 1988). As NO_x is a greenhouse gas that is particularly damaging, more detailed studies have shown how engine timing adjustments specifically for biodiesel use can improve the NO_x figure (Table 5.3).

By contrast, combustion of pure plant oil results in an increase in emissions compared to biodiesel and diesel. Tests show that the level of engine emissions from pure plant oil is higher than from diesel or from a blend of biodiesel and diesel. Hydrocarbon and carbon monoxide levels were significantly increased as well as polycyclic hydrocarbons (Lance and Andersson, 2004). Many of these higher emissions, with resulting undesirable environmental effects, were associated primarily with poor atomisation due to the high viscosity/molecular weight of the oil altering flow through injectors in the engine, with the result that oil remains unburned.

Table 5.2 Exhaust emissions* from direct injection engines of biodiesel compared to mineral derived diesel

Reference	SO_2	CO	HC	PAH	NO_x	Particulate	Smoke
Long		> 10% lower		60% lower	> 10% lower		50% lower
Patcher	almost zero	lower or higher	50% lower		slightly higher		
Austria			lower	much lower	slightly higher		
FOP		65% lower	12% lower		16% lower		57% lower
Koch	90% lower		lower	lower		lower	lower
Wade	90% lower	10% lower	40% lower	higher	10-12% lower		

* Exhaust emissions: HC = unburnt hydrocarbons
PAH = polycyclic aromatic hydrocarbons
NO_x = nitrogen oxides
Smoke levels are measured on the Bosch Index

Source: Culshaw and Butler 1992

Table 5.3 Emissions from Austrian bus trials, biodiesel relative to low sulfur fossil diesel

Emission	SO_x	CO	NO_x	NO_x*	PM	VOC	BS
% reduction with biodiesel	-99	-20	+1	-23	-39	-32	-50

*NO_x result for an engine adjusted for biodiesel use
Source: Sams 1996

5.4 Energy balance of biodiesel production

Table 5.4 provides the energy ratio for biodiesel and by-products from winter oilseed rape compared with spring oilseed rape (Culshaw and Butler, 1992). Table 5.5 gives the energy ratio for biodiesel under a range of scenarios (Batchelor et al 1995).

Table 5.4 Energy ratios for biodiesel from winter and spring oilseed rape (Energy output/energy input)

Product	Winter	Spring
Biodiesel only	1.35	1.35
Biodiesel + meal	2.55	2.55
Biodiesel + meal + glycerol	2.62	2.61
Biodiesel + meal + glycerol + straw	3.77	3.77
Biodiesel + straw	2.50	2.50

Source: Culshaw and Butler, 1992

Table 5.5: Energy ratios for biodiesel production from winter rape

Outputs included	Best case scenario	Good intermediate scenario	Poor intermediate scenario	Worst case scenario
Biodiesel only	1:2.23	1:1.58	1:1.12	1:0.674
Biodiesel + rapemeal	1:3.83	1:2.22	1:1.60	1:0.88
Biodiesel + rapemeal + glycerol	1:3.95	1:2.30	1:1.65	1:0.91
Biodiesel + rapemeal + glycerol + straw	1:9.18	1:5.46	1:3.92	1:2.22

Source: Batchelor et al., 1995

In both analyses energy inputs include not just inputs on farm but also those for equipment manufacture, processing, commodity transport, etc. In both cases, the energy output for biodiesel without any by-product credits is 1.3 - 1.35 units of energy out for each unit supplied. The different values credited for the rape meal reflect the varying approaches taken by the two studies. In the Culshaw and Butler study the full thermal credit of the straw is included whereas in the study by Batchelor et al the metabolisable energy content is used for all but the best case scenario. In both studies, the energy contribution from the glycerol is small. The inclusion of a credit for the straw is to a large extent academic as relatively little rape straw is used - most will be ploughed back into the soil. Consequently in terms of biodiesel + used by-products (meal + glycerol), the energy balance is in the region of 2-2.6 units of energy out per unit of energy in. A further review of energy balances from biodiesel (Turley et al., 2005) gives the energy balance as ranging from 2.3 and 4.4 for biodiesel from oilseed rape, broadly agreeing with the figures shown here. It is of note that by comparison, figures indicate that the energy used to extract, refine, and transport diesel products from crude oil is 5 units out for 1 in (Boustead, 1997), showing that the energy balance for mineral fuel is of the same magnitude.

The very large differences between energy ratios calculated by Batchelor et al (1995) under the best case and worst case scenarios highlight the fact that the energy ratio for biodiesel should not been seen as a static value, but is subject to variation depending on the prevailing conditions. The vast majority of energy used in the production of biodiesel is consumed during the growing of the crop rather than in processing to biodiesel. The input for nitrogen fertiliser varies from 10% in the best case scenario to 27.5% and 20.7% in the intermediate scenarios and 43.5% in the worst scenarios. The importance of nitrogen fertiliser inputs to the energy balance suggests that modification of agricultural practice could have a notable effect on the energy ratio of biodiesel production. In particular, the use of organic wastes, e.g. sewage sludge, could have a great significance for the energy balance (Batchelor et al 1995).

Within processing, esterification accounts for a significant portion of the energy requirement. Avoiding the energy intensive esterification step could potentially means that the energy balance of pure rapeseed oil used as a biofuel will be significantly better than for biodiesel.

5.5 Greenhouse gas emissions from biodiesel

In a review of greenhouse gas emissions from biodiesel (Hamelinck *et al.*, 2004) found that, from a range of papers reviewed, total greenhouse gas emissions from biodiesel are around 50% of that of conventional diesel, the majority of estimates falling between 30% and 50% of the conventional diesel emissions. The same work also found that esterification accounts for 70% of the emissions from the total biodiesel production stage showing that there were environmental advantages from utilising pure plant oil.

5.6 Environmental regulations relating to a biodiesel processing plant

Industrial processing plants have the potential to cause severe impact on the environment due to waste emissions to air, water and land. Control of emissions is regulated in Scotland by the Scottish Environment Protection Agency (SEPA). Processes which are expected to have a ‘medium’ pollution risk are commonly known as Part B processes and generally include smaller plant such as heating boilers, small waste incineration plants and vehicle body shops. It has been indicated by SEPA that a small to moderate scale crushing plant may fall into this category, although details of the plant would have to be examined before a final determination was made.

Part B processes are concerned with implications for air pollution and emissions from a plant such as odour and particulates would be of relevance. Control of Part B processes is exercised through a legally binding authorisation defining in detail many aspects of the process and setting limits on the emissions. Self monitoring is widely employed. There are around 1000 Part B authorisations in force. A flat rate application fee is charged, currently £2163, for an authorisation.

Esterification plants are likely to be regarded as being included in the ‘Part A’ category due to the involvement of chemicals in the process. Discharges to land, air and water are regulated for Part A through integrated pollution control (IPC) authorisations operated by SEPA. Part A processes are generally larger and more complex processes including power generation, oil refineries and chemical manufacturing. There are around 200 Part A authorisations in force in Scotland. Authorisations can be highly complex and enforcement powers are available under IPC. Application fees have an initial component of £2804 which is multiplied by a factor reflecting both the environmental impact and the scale of the operation. Inspection, monitoring and enforcement is covered by a subsistence charge which varies according to the monitoring programme.

5.7 Environmental assessment summary

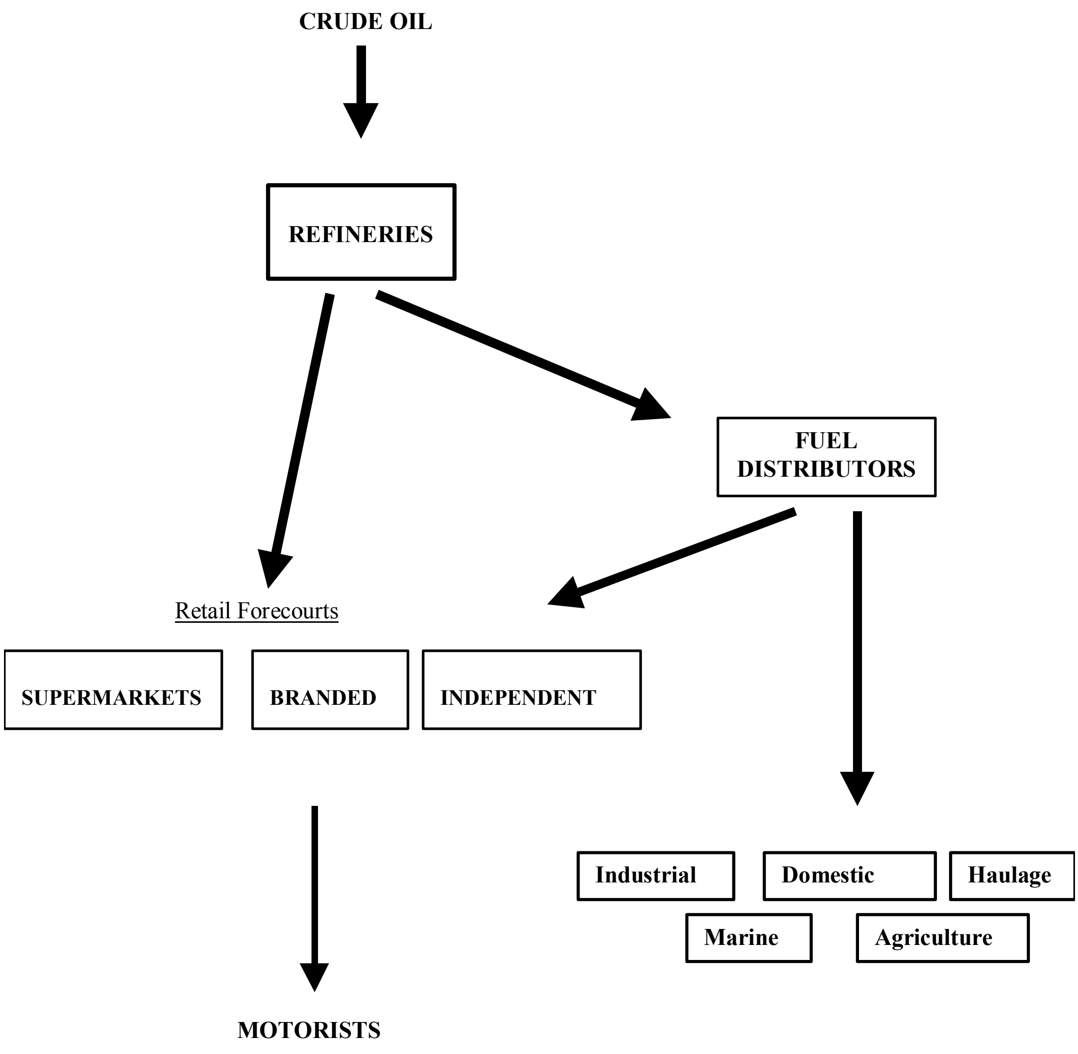
- A review of work investigating the link between allergenic and irritant responses and the oilseed rape crop found that there is no evidence of a causal association between exposure to the crop and non-specific hyper responsiveness.
- The oilseed rape crop gives important biodiversity benefits for many farmland bird species. It provides preferred feeding and nesting resources for a range of species such as the skylark, yellow wagtail, reed bunting, tree sparrow, yellow hammer and greenfinch. It has helped to slow the decline of some species such as the linnet.
- Biodiesel gives little different in potential power output but fuel consumption is increased by approximately 5% compared to biodiesel.
- Results indicate that on combustion, most emissions from biodiesel are reduced compared to mineral diesel. Sulphur in particular is reduced. An exception is NO_x emissions, but this can be improved by engine timing adjustments.
- The energy balance of biodiesel varies according to the range of by-products included in energy output and the scenarios applied in production. It is positive – 2 – 4 for most situations. This could be improved by the utilisation of the straw or by the use of organic fertiliser.
- Esterification accounts for a large portion of energy input. Utilisation of pure plant oil as a biofuel can prevent the need for esterification but is associated with technical difficulties as discussed in chapter 4.
- Greenhouse gas emissions are reduced compared to fossil fuel usage.
- For environmental regulation, a small to moderate crushing plant will be subject to Part B regulations concerning emission to air.
- An esterification plant will be subject to Part A, more stringent regulations applying to air, water and land. This requires a higher cost for the permit and more costly measures to implement requirements.

6.0 Biofuel Market

6.1 UK Fuel distribution

Figure 6.1 below shows a flowchart for the movement of light fuels from the refineries, through the main distribution network, to the principal customer markets. The UK has the 4th largest refinery capacity in Europe with 9 major refineries with a combined production of over 1.5 million barrels per day. These refineries, which are located around the UK coastline (see Fig 6.2) are largely operated by the major multinational oil companies.

Fig 6.1 Flowchart of the UK Fuel Distribution market



The eight companies which operate the UK refineries are as follows:

BP Oil UK	Chevron Texaco
Shell UK	Conoco Phillips
Total UK	Murco Petroleum
Esso Petroleum	Petroplus

The majority have no downstream activities, with the exception of Total and Petroplus. The North Sea produces around 72% of the crude oil consumed by the UK refineries. Crude oil is traded internationally in $ per barrel so the price UK refineries pay is the world market price. Naturally the exchange rate of $:£ is important. Refineries produce a range of products which are transported by a variety of methods to customers. These include; pipeline to storage depots, coastal tankers, road and by rail (losing importance).

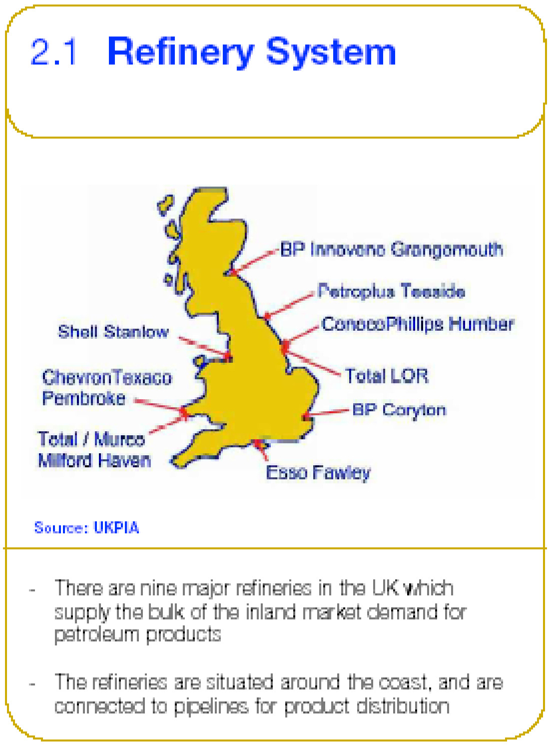


Fig 6.2 The UK petroleum refinery system

For the multinational oil companies all the profit is made upstream in crude oil production. The downstream activities involving distribution and retailing are very competitive. Many oil companies are now getting rid of their petrol forecourts.

Retail petrol filling stations in the UK can be split into three main segments:

- Supermarkets
- Branded stations
- Independents

The entry of the major supermarkets chains over the last 10 years into fuel retailing has made a major impact. Supermarket fuel sales now account for 34% of the UK petrol market and 24% of the diesel market. Their entry has made the whole fuel market very competitive as their market share continually grows.

There are approximately 6,300 major oil companies branded filling stations, with half owned by independent retailers under an exclusive supply contract. These supply contracts are limited under legislation to a maximum of 5 years.

The number of retail filling stations has fallen dramatically over the last 15 years from 22,000 to 10,300 (2004). Around 700 filling stations are closing every year due to competition. The independent filling stations are found mostly in rural areas and have low volumes.

Although the demand for road transport is growing and expected to increase, the total consumption of road fuels has been virtually static since 1997. This is due to a combination of more efficient engines and an increased proportion of diesel vehicles. The latest figures from the Energy Institute show that UK petrol consumption for 2004 was 19,068,020 tonnes, with diesel at 18,930,061 tonnes for the same period. One trend is that petrol sales have been falling since the peak in 1990, whilst diesel sales have been increasing. At present too much petrol spirit is produced whilst there is a shortage of diesel. Demand for diesel across Europe is also rising and the UK would have to import diesel to meet peak demand.

Figure 6.3 shows the demand for road fuels over the last 35 years and diesel's increasing share of the market.

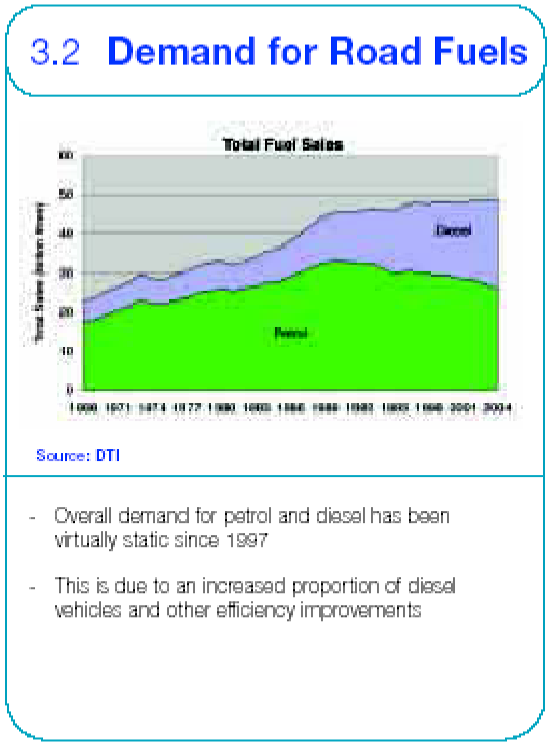


Fig 6.3 Demand for road fuels

Fuel distributors play an important role in the whole supply chain of oil products. It is a fragmented sector with many local companies located throughout the country. Normally fuel products move from the refinery to port terminals by coastal tankers.

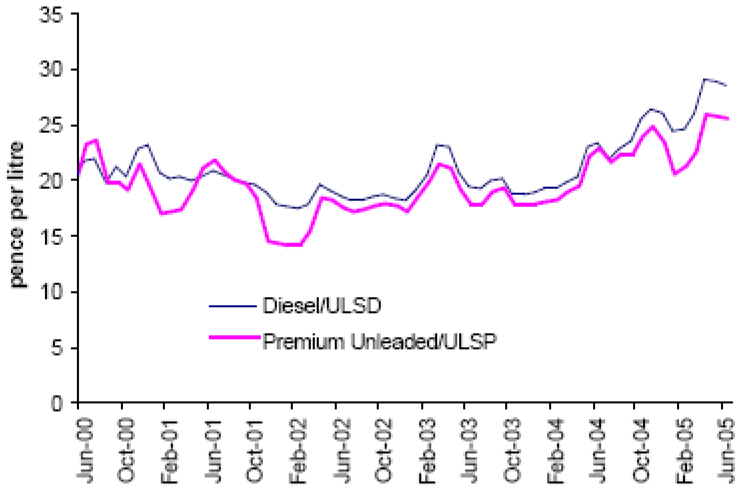
Road transport is the preferred method of delivery for most customers. The fuel distributor would pick up supplies from the port terminal by road tanker (usually 44 tonnes). Some companies have their own storage tanks while others have none, relying on regular deliveries from the storage depot. The market for fuel distributors can be segmented into 5 main customers, which are:

- Industrial / Commercial businesses
- Haulage
- Agricultural
- Marine
- Domestic consumers

Depending on the product range stocked, some companies do not serve all the market segments.

Fuel prices; the cost of motoring and prices for unleaded petrol and diesel

Fig 6.4: Typical Retail Prices of Motor Fuels from June 2003 to June 2005



Source:DTI

Premium unleaded petrol and diesel costs in the UK are amongst the highest in Europe (Figs 6.6 and 6.7). In March 2005 a litre of unleaded petrol cost 7.7p less than in the next highest priced country, The Netherlands and was 30.6p more expensive than Estonia which has the lowest price. During the same month the tax and duty component of the pump price was 73 per cent in the UK compared to the next highest of 71 per cent in Finland and Germany. The lowest tax and duty component was in Latvia at 49%. Interestingly, the pre-duty and VAT price in the UK was the second lowest in Europe at 22.4 pence per litre. The Czech Republic had the lowest with 21.7 pence per litre, while Malta had the highest price at 29.8 pence per litre.

UK diesel prices at the pump are also among the highest in Europe. In March 2005 a litre of diesel cost 86.1 pence per litre and was 34.6 pence higher than Latvia, which had the lowest price at 51.5 pence per litre. The tax and duty component of the pump price was 70 per cent in the UK compared to a range of 44 to 60 per cent in the rest of the EU. The excluding tax price in the UK was the lowest in the EU, whilst Italy had the highest price at 33.5 pence per litre.

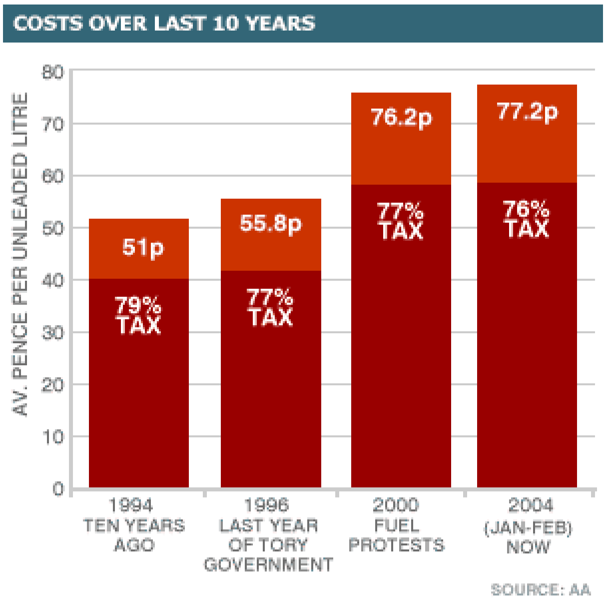


Fig 6.5 Costs of unleaded petrol over the last 10 years

The above diagram (Fig 6.5) does support the Government's argument that it was the increase in the cost of raw product that resulted in a rise in the cost of fuel at the pump.

Figure 6.6 Average EU Premium Unleaded Petrol Prices in Pence Per Litre as at March 2005

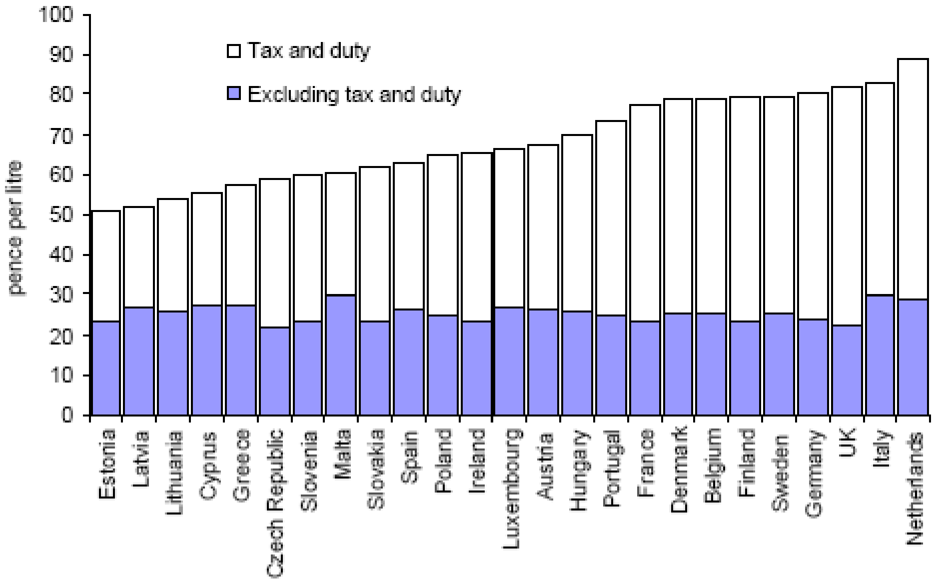
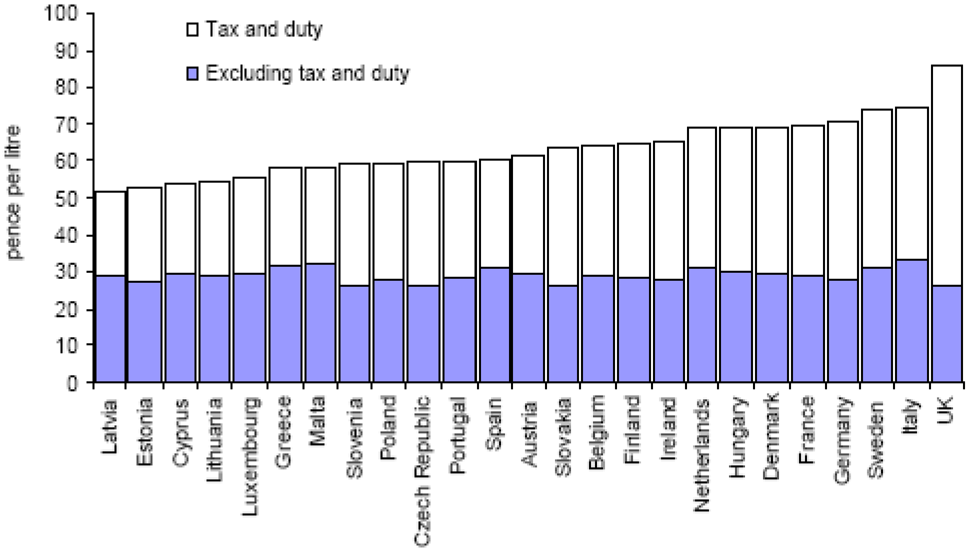


Figure 6.7 Average EU Premium Diesel Prices in Pence Per Litre as at March 2005



Source: DTI

There are numerous elements that comprise the final price of fuel. The main three are:

- The wholesale fuel price
- Government duty and VAT
- The retail margin (gross fuel margin)

In addition, other factors such as exchange rates, competition, seasonal factors and business objectives will also influence prices. The fuel margin is the difference between the wholesaler's fuel price and the retail price. It has to cover the following costs and leave a profit for the distributor.

1) Cost of transport from storage terminal to depot/ filling station/ or customer.
2) Operating costs (staff, property expenses, overheads, etc)
3) Marketing and promotion costs

Fuel retailing has increasingly become a low margin, high volume business. In the UK, excise duty and VAT accounts for nearly 75% of the retail price of petrol or diesel. VAT is charged on the on-road price at 17.5%.

Effective rates of duty on transport fuels

The current rate of duty for the main transport fuels in the UK are as follows (Table 6.1):

Table 6.1 Rate of duty on main transport fuels in the UK

Product	**Duty rate** Pence per litre
Petrol (ULS)	47.10
Diesel (ULS)	47.10
Regular Diesel	53.27
Biodiesel	27.10
Biodiesel (off road)	3.13
Red diesel	5.22

Source: HM Revenue and Customs

Wholesale prices

The main driver of fuel prices is the price of the crude oil. Any increase in oil price will quickly work its way through to the retail price. As a rough guide, every $2 per barrel change in the crude oil price translates to 1p/litre on the retail fuel price (petrol & diesel).
(A barrel of brent crude = 42 gallons = 191 litres)

6.2 The market for biofuel

Biofuel definitions

The Statutory Instrument Biofuel Regulations (2004) came into force on 31st December 2004 and provide the definition of "biodiesel" and other terms used in the process.

- "biofuel" means liquid or gaseous fuel for transport produced from biomass
- "biodiesel" means biofuel from a fatty acid methyl-ester produced from vegetable or animal oil
- "blend" means motor fuel containing mineral oil derivatives and any biofuel

At present the market for biofuel is in its infancy. The total sales of biofuels in the UK was 20.99 million litres in 2004 (DfT). As a total of total road fuel sales, biofuels only contributed 0.04%

The UK Government set a realistic target of 0.3% of total UK fuels sales for biofuels by the end of 2005. Sales are increasing mainly through the imports of Brazilian bioethanol. The EU RTFO Directive target was 2% for 2005 rising to 5.75% by 2010.

The Energy Act 2004 included legislation enabling the introduction of RTFO in the future.

Diesel and biodiesel standards

There are two main standards relating to biodiesel production:

- Biodiesel standard EN 14214 (Table 6.2)
- Mineral Diesel standard EN 590 2004

"B5" relates to a blend of 5% biodiesel and 95% mineral diesel. This is the common blend used in the UK. The use of B5 ensures that no changes are required to vehicle engines.

In Germany and Austria the use of pure biodiesel (B100) is the most common form (70%).

Table 6.2 Proposed EU Biodiesel specification (EN 14214)

		Limits		
Property	Unit	minimum	maximum	Test method*
Ester content	% (m/m)	96.5		prEN 14103b
Density at 15% C	kg/m^3	860	900	EN ISO 3676 EN ISO 12185
Viscosity at 40oCc	Mm^2/s	3,5	5,0	EN ISO 3104
Flash point	^{o}C	above 101	-	ISO/CD 3679c
Sulphur content	mg/kg	-	10	
Carbon residue (on 10% distillation residue)e	% (m/m)	-	0,3	EN ISO 10370
Cetane number		51,0		EN ISO 5165
Sulfated ash content	% (m/m)	-	0,02	ISO 3987
Water content	mg/kg	-	500	EN ISO 12937
Total contaminationk	mg/kg	-	24	EN 12662
Copper strip corrosion (3 h at 50o C)	rating	class 1		EN ISO 2160
Thermal stabilityIi				
Oxidation stability, 110^{o}C	hours	6	-	prEN 14112h
Acid value	mg KOH/g		0,5	prEN 14104
Iodine value			120	prEN 14111
Linolenic acid methyl ester	% (m/m)		12	prEN 14103b
Polyunsaturated (>=4 double bonds) methyl estersg	% (m/m)		1	
Methanol content	% (m/m)		0,2	prEN 14110
monoacylglycerol content	% (m/m)		0,8	prEN 14105k
diacylglycerol content	% (m/m)		0,2	prEN 1410k
triacylglycerol content	% (m/m)		0,2	prEN 14105k
Free glycerolb	% (m/m)		0,02	prEN 14105k prEN 14106
Total glycerol	% (m/m)		0,25	prEN 14105k
Alkaline metal (Na+K)l	mg/kg		5	prEN 14108 prEN 14109
Phosphorus content	mg/kg		10	prEN 14107m

a If CFPP is –20oC or lower, the viscosity measured at –20oC shall not exceed 48 mm2/s. In this case EN ISO 3104 is applicable without the precision data
b CEN/TC 307 publication of NF T 60-703:1997
c Apparatus equipped with a thermal detection device shall be used
Suitable test methods to be proposed by CEN/TC 19
e ASTM D 1160 shall be used to obtain the 10% distillation residue
f Pending development of a suitable method by CEN/TC 19, EN 12662 shall be used. The precision of EN 12662 is however poor for FAME products
g Suitable test method and limit to be proposed by CEN/TC 19
h CEN/TC 307 publication of ISO 6886 modified
i CEN/TC 307 publication of NF T 60-701 (procedure A) and DIN 51608 (procedure B)
k CEN/TC 307 publication of NF T 60-704: 1997
l Extension of this limit to cover additional elements, eg Ca and Mg to be considered
m CEN/TC 307 publication of NF T 60-705 1997
n Suitable test method to be developed

6.2.1 Consumers attitude to biofuel

There has been limited work looking at the attitude of consumers to biofuels. Research however, was conducted by Oxford Partnership on behalf of HGCA examining consumer perceptions of biofuel. The study had 4 main objectives namely:

- To evaluate consumers understanding of biofuel
- To identify the strongest communication message
- To establish propensity to purchase biofuel and at what price
- To establish favourable methods for promoting whole grain

The market research was conducted under MRS and BMRA guidelines and involved a sample of 1,100 adults, with 682 car drivers, in September 2004.

Key results from the survey were as follows.

Q. Which of the following would you use to describe the term biofuel?

Biofuel is a renewable road fuel that can be manufactured from UK grown crops	21%
Fuel that biodegrades	13%
Fuel made from natural sources produced on a small scale	16%
Biofuel is a man made fuel	9%
Biofuel can improve the performance of your vehicle	3%
Never heard of it	37%
Don't know	9%

Q. If the manufacturers of biofuel were to advertise, which one of the following messages do you think would be the strongest to use in the promotion of biofuel?

It is better for the environment – safer and cleaner – less polluting than fossil fuels	37%
It makes economic sense	10%
It is sustainable/renewable energy – fossil fuels are finite	12%
It is better for the future – for future generations	10%
It is locally produced by British Framers – reducing the dependence on oil imports	10%
None	3%
Don't know	16%

Q. If a litre of unleaded petrol for your car cost 80p, what would you be prepared to pay for a litre of biofuel?

Up to 59p	13%
60 –69p	5%
70 –79p	8%
80p – the same	33%
81 –89p	9%
90 –99p	5%
£1	4%
Don't know	23%

The mean response for this question was 75p. Groups prepared to pay the least were: 17-24 year olds (av. 71p), 35-54 year old (av. 73p), male (av. 73p), social group C2DE's (av. 73p) and Midlands (av. 72p)

Groups prepared to pay the most were: 25-34 year olds (av. 83p), AB's (av. 80p), Females (av. 78p) and South (av. 77p).

Q. Which of the following source of information on biofuel would you see as being most trustworthy?

Government	9%
Independent company	14%
Scientist	21%
Pressure group	14%
Existing fuel company	17%
Supermarkets	9%
No-one	7%
Don't know	9%

Q. Assuming that your usual petrol retailer did not sell biofuel but another local one did, and at an acceptable price to you, how likely would you be to use it?

Very likely (2)	33%
Quite likely (1)	41%
Neither (0)	18%
Not very likely (-1)	5%
Not at all likely (-2)	3%

The mean score to the question was +0.95. Most likely to change were from 25-44 year olds; AB's; those from larger households; in Midlands. Least likely were from 17-24 year olds; C2DE's; smaller households; those not working; in South.

Conclusion from the HGCA consumer research

- Over 46% of respondents had never heard of biofuel or could not describe it. There is a clear need to educate and raise the awareness of consumers / motorists about the benefits of biofuels.

- The strongest message to promote biofuel should be 'it is safe for the environment'. This message is best communicated by scientists and existing fuel companies. Interestingly, respondents did not rate the Government as trustworthy.

- A third of respondents expected biofuels to be the same price as fossil fuel. A small group (18%) were willing to pay a premium for biofuel. This suggests a niche market may exist.

- Nearly three-quarters (74%) of respondents would be likely to change garage for their biofuel, if it was at an acceptable price to them.

It must be noted that the survey was conducted when oil prices were approx. $40 /barrel, with retail prices at 80p per litre. At the current retail fuel price of over 90p per litre would the results be the same? One would have to question if some respondents would still be willing to pay a premium.

[Grateful acknowledgement is given to HGCA for their permission to use the study]

Highland Fuel Limited commissioned a small study looking at the economic viability of selling and distributing biodiesel throughout the Highland and Islands of Scotland. This study was conducted in the spring of 2005 involving both the general public and commercial businesses in the region. A survey was conducted in 3 areas; Orkney, Ross-shire and Inverness, involving 100 consumers and 77 businesses. The main findings from the study include:

- There was an awareness and concern regarding environmental issues amongst the general public.
- The awareness of biodiesel was poor. This was identified as a barrier for the commercial introduction of biodiesel
- The survey found evidence for the demand of biodiesel from the region
- Consumers were willing to pay a premium of 1.8p per litre for biodiesel over standard ULSD diesel.
- Commercial businesses were only willing to pay a small premium (0.7p per litre) for biodiesel.

[Grateful acknowledgement is given to Highland Fuels Ltd for their permission to use the study]

Table 6.3 Estimate of the cost implications at the pump of implementing an obligation

Estimates of the cost implications at the pump of implementing an obligation

	With 20 ppl duty differential		Without duty differential	
	Pump price ppl	Difference from conventional fuel ppl	Pump price ppl	Difference from conventional fuel ppl
1% blend				
Biodiesel	78.85	0.1	79.09	0.24
Bioethanol	77.68	0.1	77.91	0.24
2% blend				
Biodiesel	78.86	0.2	79.33	0.49
Bioethanol	77.69	0.2	78.16	0.49
3% blend				
Biodiesel	78.87	0.3	79.58	0.73
Bioethanol	77.69	0.3	78.4	0.73
4% blend				
Biodiesel	78.88	0.4	79.82	0.98
Bioethanol	77.7	0.4	78.64	0.98
5% blend				
Biodiesel	78.89	0.5	80.07	1.22
Bioethanol	77.71	0.4	78.89	1.22

Source: DfT

The table (Table 6.3) shows the impact of biodiesel and bioethanol blended at different inclusion rates and their influence on the retail prices at the pump. It clearly shows that with the 20p tax rebate and at 5% the impact of biofuels adds only 0.5p per litre to the final price.

6.3 Brief Review of the Mineral Oil Market

Crude oil is the world's most actively traded commodity. Big movements in price have significant consequences around the world, affecting various domestic and industrial fuels. Much like other commodities, the price swings in times of shortage or oversupply. However a common feature in the shift of oil price is that it is due to a major global event, examples include oil shortages (1973), political uncertainly (1990/1 and present-day) and general over supply coupled with weak Far East demand (1998). The largest trade markets are in London, New York and Singapore. However crude oil and refined products - such as petrol and heating oil - are sold all over the world.

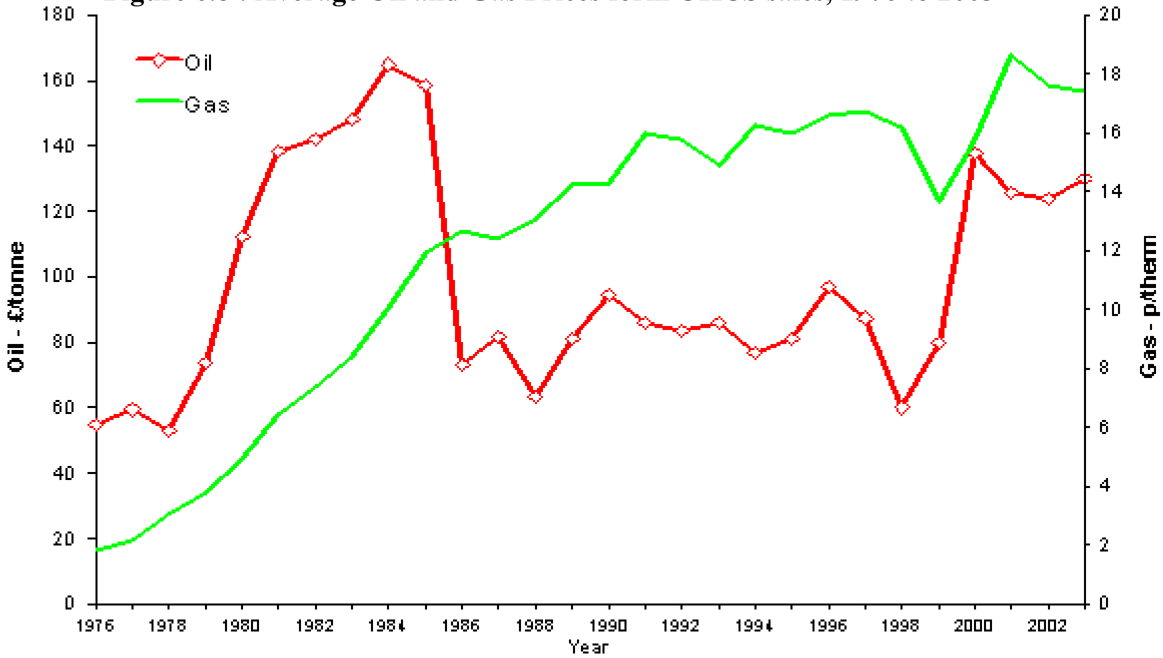
When an oil price appears in UK and European media and no other information is given, it usually refers to the price of a barrel of Brent blend crude oil from the North Sea rigs, sold at London's International Petroleum Exchange.

There are four key methods in which an oil price is agreed and oil is traded: Futures Contract, World Benchmark, US Benchmark and OPEC Basket.

Crude Oil Prices 1995 - 2005

The annual average price for **UK Continental Shelf (UKCS)** oil received by producers rose speedily between 1978 and 1984, but fell sharply reaching a low in 1988 (Fig 6.8). Oil prices then moved with a £77- £97 per tonne price range before hitting a fifty-year low in December 1998, due to a general over supply. Prices improved three fold from £50 per tonne in early 1999 to £154 per tonne. Prices dropped in 2001 and 2002, and in 2003 the price was £130/tomne.

Figure 6.8 : Average Oil and Gas Prices form UKCS sales, 1976 to 2003

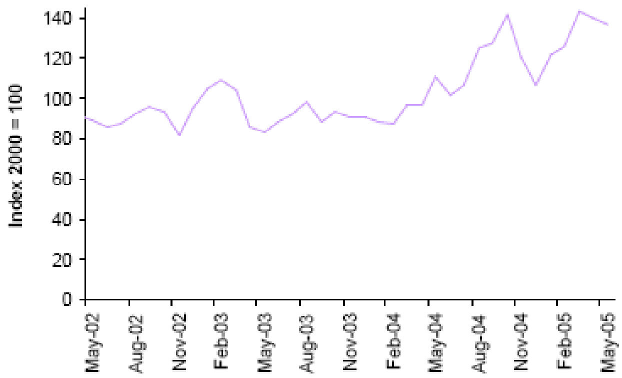


Source: DTI

In order to tackle the over supply and weaker Far East demand, key oil producers agreed to cut production which inevitably led to an increase in sale price. Prices peaked at almost $34 per barrel, which gave rise to the fuel crisis during the summer of 2000, before falling to $22 per barrel in early 2001. Prices fluctuated at around $25 per barrel for the most part of 2001, until 9/11 when the price of a barrel fell sharply by $7 within two weeks. The terrorist attacks of 9/11 lead to concerns on stunted global economic growth, thus negatively impacting on oil demand. As the threat of war in Iraq loomed prices began to rise. In March 2003 the prices reached $33 per barrel. OPEC agreed to maintain production levels and promised a secure supply in the event of war in Iraq.

Prices rose steadily in 2004 due to the strong rise in global oil demand. By mid August prices reached a staggering $40 per barrel due to the situation in Iraq and lack of spare capacity with OPEC. By the end of 2004, prices fell by over $10 per barrel, as stocks increased due to increases in US crude stocks and a return to production in the Gulf of Mexico.

Prices in 2005 are continuing to rise at higher levels than in previous years (Fig 6.9) and the price of a barrel of oil has now broken the $60 level. This is predominantly due to geopolitical concerns in certain key producing countries, capacity tightness along the chain, and continued robust oil demand growth.



- The average cost of crude oil acquired by refineries has decreased by 2.3 per cent in May 2005, compared to April 2005.
- Compared to a year ago, the price in May 2005 is 23.8 per cent higher.

Figure 6.9 : Index of Crude Oil Prices, May 2002 to May 2005

Source: DTI

Oil Reserves

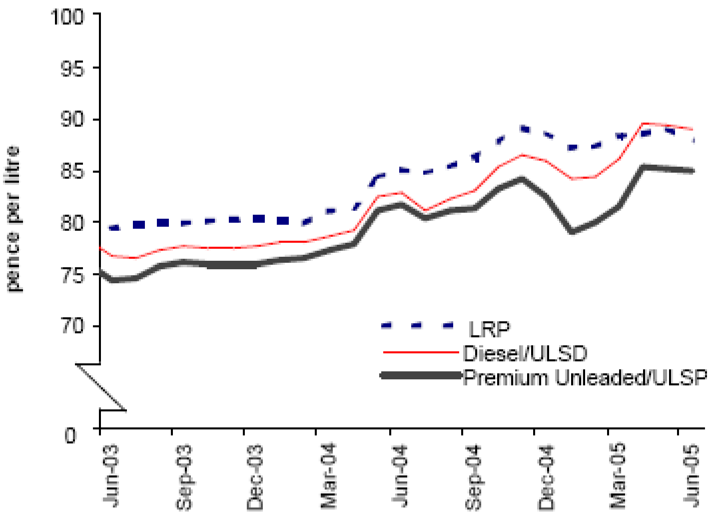


Figure 6.10 Oil reserves on the UK Continental Shelf, 2005

Reserves data was recorded from each UK Continental Shelf operator in January and February 2005 (Figure 6.10). Oil reserves included oil and the liquids and liquefied products obtained from gas fields, gas-condensate fields, and the associated gas in oil fields. Oil reserve data is collected from sanctioned fields and other significant discoveries that have not been fully appraised. Sanctioned field refers to field in production or approved fields under development but not in production. This indicates that oil reserves estimates figures are catagorised as being proven, probable and possible, depending on confidence levels. Proven reserves refer to reserves on which available evidence are certain to be technically and commercially producible. Probable reserves are those which are not yet proven, but are estimated to have a greater than 50% chance of being technically and commercially producible. Possible reserves are those which cannot as yet be regarded as probable, but which are estimated to have a significant but less than 50% chance of being technically and commercially producible.

The following table (Table 6.4) provided figure for UK Oil Reserves at 31 December 2004.

Table 6.4 UK oil reserves - 2004

Oil reserves units - million tonnes	**Proven**	**Probable**	**Proven & Probable**	**Possible**	**Maximum**
Fields in production or under development	533	213	747	393	1139
Total Oil reserves in million tonnes	**533**	283	816	512	1328
Cumulative Oil Production to End 2004	3005				
Ultimate recovery in million tonnes	3538	283	3821	512	4333

Source: DTI

From the table, it is can be seen that actual proven reserves stand at 533 million tonnes, which is 38 million tonnes less than at year-end 2003. The change in the figure for UK oil reserves during 2004 arose from a combination of:

- Production during the year
- Reserves revisions in established fields
- Reserves additions from new field development

The 2004 annual oil production- (including condensate and natural gas liquids) - was 95million tonnes. Probable oil reserves have decreased slightly by 3 million tonnes, perhaps due to the reallocation of probable to proven reserves. Possible oil reserves have increased by 102 million tonnes. This reflects an increase in reserves in existing fields following technical and economic reassessments. UK oil ultimate recovery refers to oil reserves and cumulative production and increased during the year by 57 million tonnes to reach 3,538 million tonnes. Oil production in 2004 was 30% lower than the record production level on 1999 and 10% lower than 2003. Although six new field commenced production in 2004, the output levels from these fields was insufficient to compensate the decline in production from older established fields.

World Reserves

Oil currently supplies about 40% of the world's energy and 96% of its transportation energy. Since the shift from coal to oil, the world has consumed over 875 billion barrels. Another 1,000 billion barrels of proved and probable reserves remain to be recovered.

From now to 2020, world oil consumption will rise by about 60%. Transportation will be the fastest growing oil-consuming sector. By 2025, the number of cars will increase to well over 1.25 billion from approximately 700 million today. Global consumption of petroleum products could double.

The two countries with the highest rate of growth in oil use are China and India, whose combined populations account for a third of humanity. In the next two decades, China's oil consumption is expected to grow at a rate of 7.5% per year and India's 5.5%. (Compare to a 1% growth for the industrialised countries). It will be strategically imperative for these countries to secure their access to oil.

China accounted for 40% of the growth in oil demand over the last four years according to the US Energy Information Administration.

Proven oil reserves are those quantities of oil that geological information indicates can be with reasonable certainty recovered in the future from known reservoirs. Currently there are over one trillion barrels in reserves. These are located throughout the world:

- 6% are in North America,
- 9% in Central and Latin America, 2% in Europe,
- 4% in Asia Pacific,
- 7% in Africa,
- 6% in the Former Soviet Union.

Today, 66% of global oil reserves are in the hands of Middle Eastern regimes: Saudi Arabia (25%), Iraq (11%), Iran (8%), UAE (9%), Kuwait (9%), and Libya (2%).

As reserves in non Middle Eastern countries are depleting faster than those in Middle Eastern Countries and by projecting 2001 production levels, it is estimated that by 2020 83% of global oil reserves will be controlled by Middle Eastern regimes.

Future Trends and Drivers

- According to the World Energy Outlook Report 2004, fossil fuels will continue to dominate global energy use, accounting for some 85% of the increase in world demand. The report also states that there are enough reserves to meet this demand until 2030. Then something will have to change.
- Return to Coal: Before oil supremacy, coal was king. It played a vital role in the industrial ages of Europe and North America. There are amounts of coal reserves in existence, however, coal is not environmentally friendly and emits large quantities of gases responsible for climate change.
- China’s global hunt for oil: In 2003, China became the world's second largest consumer of petroleum products after the US. Chinese officials are very welcoming to OPEC countries' dignitaries and have secured deals to develop oil fields in Iran. They have also entered into discussions with Venezuela and Cuba, which is startling the US.
- With a surge in demand for energy, this can potentially lead to a 60% rise in climate destabilising carbon dioxide emissions. Most of these emissions will be from cars, trucks and power stations. Pollution is a real future threat.
- Another future trend and one that will push the oil price higher, will be the cost of extraction and delivery. To meet projected demand, the sector will return over $13 trillion investment form 2003 to 2030 according to the International Energy Agency. Middle Eastern countries will struggle to meet the investment challenge due to their relative economy and level of oil reserve.

7.0 The By-products Market

7.1 The glycerine market

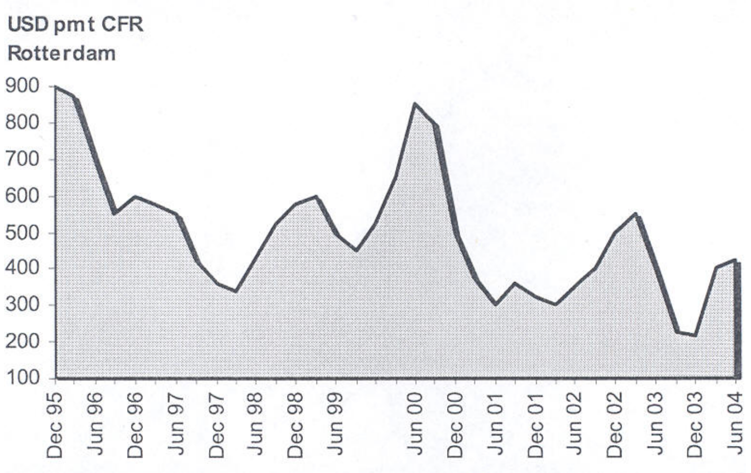
Glycerine is a by-product of biodiesel production and can be used in a wide range of existing markets, having over 1 500 end uses. Pharmaceuticals, toothpaste and cosmetics account for around 28%; tobacco 15%; foods 13% and polyether polyols for urethanes 11% of its market with the remainder being used for alkyd resins, cellophanes, explosives and other miscellaneous uses throughout industry.

Glycerine is derived from a number of industrial processes. Fatty acid production and soap production are together responsible for 65% of global glycerine production, with fatty esters and alcohols production, synthetic petrochemical manufacture and biodiesel production accounting for the remaining 35%. Crude glycerine is 70% pure and is usually refined to further points of purity up to 99%.

Supply in Europe has significantly increased since the mid 1990s and this has been strongly influenced by an increase in biodiesel production. However this has been combined with a 20% increase in consumption since 2000 due to several factors, including the development of new markets for glycerine.

Prices have become increasingly volatile (Figure 7.1). Over the period since 1995, prices for good quality 80% crude glycerine have varied from highs of \$900 (£504)/t at the end of 1995 and \$850 (£476)/t in 2000, to lows of \$350 (£196)/t in December 1997, \$300 (£168)/t in June 2001 and \$200 (£112)/t in December 2003. Spot prices in June 2004 for poor quality biodiesel crude glyercine were €340 (£233)/t, with the price falling to €190 (£106)/t in January 2005, attributed to increasing biodiesel production in Europe. Prices are anticipated to recover to \$250 (£140)/t for the end of 2005. The longer term estimate is for prices of \$200 (£112)/t for 2008.

Figure 7.1 Rotterdam price development of 80% crude glycerine, 1995 – 2004



Source: HBI, taken from Oleoline Glycerine Market Report, June 2004.

NB. average price of all grades of crude glycerine, basis 80% concentration calculated on a CFR Rotterdam basis.

In addition to conventional markets, glycerine could be fed to livestock, especially pigs on liquid feed systems. Nutrition specialists indicate that there is potential for it to be included in sow rations and may attract a price of around £190 per tonne. Although this market would need to be more fully tested, it may provide a useful alternative for glycerine disposal.

7.2 Market for rapeseed straw

At present no market exists for rapeseed straw. A major barrier is that it is bulky and expensive to transport. Some straw may be used on farm for animal bedding, but it is a poorer bedding material than cereal straw and it is rarely traded. Most straw is chopped off the combine at harvest and incorporated with the soil at cultivation. Some farmers have been using OSR straw as a fuel source for central heating systems for the last 10 years.

Rapeseed straw may also be of interest to electricity generators for co-firing. Technical issues relating to the suitability of rapeseed straw for burning remain to be investigated. It is anticipated that a reasonably flexible burner will be needed and other aspects relating to practicalities of handling and efficiency of burning must be considered. Obtaining a market for OSR straw would give a significant boost to the gross margin of the crop at farm level and would improve its viability.

7.3 The rapeseed meal market

A by-product of the production of biodiesel, from the crushing of the OSR for oil, is rapeseed meal. Rapeseed meal is used by animal feed compounders in the manufacturing of animal feed. The meal has a high protein content and good energy value. Its principal use in animal feed is as a protein source to balance rations, and as such will compete against the main protein meal – soya bean meal. The nutritional analysis of rapeseed meal and other protein sources, for comparison, are shown in Table 7.1. Soya bean meal has a higher protein content and is more digestible. In the past OSR was grown from varieties which contained high erucic acid and glucosinalates values. These anti-nutritional factors made the rapeseed meal unpalatable and could cause taints in milk/eggs when used at high inclusion levels. As a result there was a historical bias against rapeseed meal by the animal feed industry. New double ‘zero’ varieties however, are now available which contain low erucic acid and glucosinalates values. Never-the-less the inclusion rate of rapeseed meal in livestock would still be limited. For monogastric animals (pigs & poultry), diets would be typically limited to maximum inclusion of 10-15%. The inclusion rates for ruminant diets are higher, typically to a maximum of 30%.

Table 7.1: Nutritional value of a range of protein sources

Straight	DM %	CP%	DCP	DE	ME	Price
Rapeseed Meal - low oil	88.0	40.0	32.0	13.2	12.0	£99
Rapeseed Meal - high oil	90.0	37.2	29.0	14.8	13.4	£100
Soya Bean Meal	90.0	55.0	52.0	17.5	13.5	£163
Fish Meal	92.0	70.0	69.0	18.5	14.2	£
Distillers Dark Grains (Wheat)	90.0	34.0	26.0	12.0	13.5	£

Source: Feeds Directory

Key: DM – Dry matter %
CP – Crude Protein %
DCP – Digestible Crude Protein
DE – Digestible Energy MJ/kg DM –pig diets
CF – Crude Fibre MJ/kg DM – ruminant diets

Animal feed compounders will use rapeseed meal in their diets based on its relative value against other protein sources, particularly soya bean meal. Least-cost rations to meet a diet specification, allowing for inclusion rate parameters, are the norm within the feed industry. In general, the feed industry would favour soya bean meal, as it is a more consistent product. The quality of rapeseed meal in contrast is variable depending on the oil manufacturing process. Rapemeal produced from a mechanical crushing process with no solvent extraction, would have a high oil content (e.g. 10%). As the table shows, as a result, this type of meal is higher in energy terms. At present feed compounders pay little premium for high oil rapemeal, it may attract an extra £2 Theoretically, in terms of its extra energy contribution, this would be worth £8-£10 per tonne. For cattle rations rapeseed meal would compete with a number of protein sources (e.g. distillers grains), while in pig/poultry diets with soya bean meal.

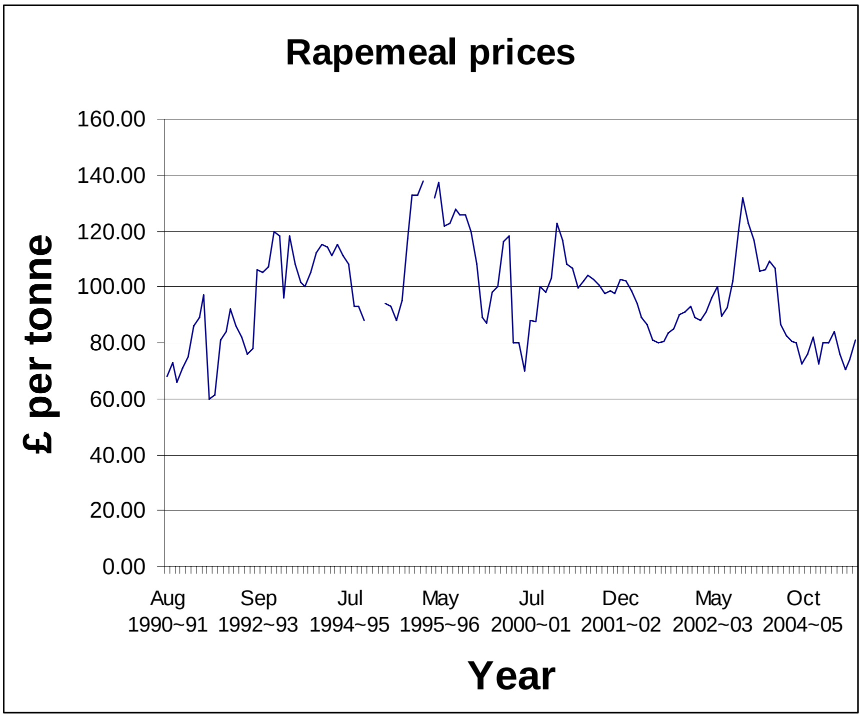
7.3.1 The demand for rapeseed meal in Scotland.

The demand for rapeseed meal in Scotland from the animal feed sector varies but is estimated by the trade to be 30,000 – 40,000 tonnes per year. Rapeseed meal in the South of Scotland is typically supplied from the OSR Crushing mills at Liverpool and Hull. Deliveries from these mills would normally be by road transport. Feed compounders in the North and East of Scotland typically source their rapeseed meal from crushing mills coming from either Antwerp, Hamburg, Poland, France or UK, arriving by boat to the main ports.

7.3.2 Outlook for rapeseed meal prices

Prices for rapeseed meal are shown in the following figure. Over the last five years values have ranged from £60 to £140 per tonne. The outlook for future prices will principally depend on demand and supply. It is known that considerable expansion is planned from Europe OSR crushers, particularly in Germany and France. This increase in supply will undoubtedly put pressure on the value of rapeseed meal. On the demand side the key determinant will be livestock numbers. CAP reform, the threat of cheap meat imports from developing countries (e.g. beef from South America), changing farming systems, will all have a downward influence on the quantity of protein supplements required. The other major factor will be the relative price of rapeseed meal against soya bean meal. This sets the benchmark against which all other protein sources are priced in the market. The expectation is that prices will weaken in the future. International raw material shippers recommend to budget rapeseed meal prices in the range £60 (min) to £100 (max) per tonne over the next 5-year period.

Fig 7.1 Rapeseed meal prices 1990-2005 ex-Liverpool mill.



7.3.4 Renewable energy market for rapeseed meal

Electricity generators must now use a proportion of renewable raw material in the generation of electricity, and 'co-fire' renewables with fossil fuels in order to meet their Renewable Obligations. This has led to a developing market for biomass and generators now use a variety of products to satisfy this requirement. Products have included wood processing by-products and various crop residues after oil extraction. Prices paid for rapeseed meal by one generator have been in the region of £65/t and there may be scope to enhance this value further. If the crop is grown as a dedicated energy crop, its value in terms of Renewable Obligations Certificate will be greater and part of this may be passed to the grower. It may also be possible for the producer to benefit from a share of the revenue generated from the Climate Change Levy Exemption and Carbon value. Development of this market for UK produced meal is currently in its very early stages, but it does seem to offer the potential of a viable alternative market for rapeseed meal.

8.0 Infrastructure Considerations

The aim of this section is to conduct an initial review to identify potential sites for any future development. This will concentrate on processing plants and options that require significant investment and infrastructure, Some of the options which will de described in detail later in the report are small scale and as such envisaged will largely utilise existing facilities either on farms or central grain stores.

A fundamental decision with respect to site location is whether to go for a port location. It is recognised that logistic handling and transport costs are major issues in any commodity business exposed to global competition. Transport costs are increasingly seen as a major disadvantage to Scottish businesses given their general remote locations and distance form the main markets either in England or abroad. The handling and movement of goods add considerable costs to any supply chain and effort should be taken when designing new business models to minimise these costs where possible. With this in mind and the need to ensure flexibility of feedstock supplies and movement of by-products it was decided that any future medium sized plant would really need to be located at a port.

In some situations, existing grain co-operatives or un-utilised grain stores would also make attractive sites reducing the investment required.

Careful thought needs to be given to this decision as it is not clear cut. It largely hinges on the level of trade expected out with the domestic market of Scotland. If a future biodiesel plant could be supplied from Scottish OSR feedstock, the rapemeal utilised by Scottish livestock sector and the biodiesel distributed in Scotland then there is no real requirement to be located at a port. In the scenario described, any prospective port would also not be interested in attracting the plant as there would be very little shipping activity.

Being located at a port has advantages in terms of ease of acceptance of industrial businesses particularly the 24-hour operation, access to existing infrastructure and potential to tap into major ports labour pool. There are also some serious disadvantages associated with a port location. In general sites are limited in ports, with quayside access at a premium. The rentals that ports sites commands reflect this and are generally high. Access to the major ports of Dundee and Aberdeen by road haulage can be a problem due to the general traffic congestion associated with cities resulting in lengthy delays.

Port Authorities and Harbour Trusts are also potential partners in any possible joint venture arrangements that may form the business structure of any future development.

8.1 Plant requirements

An oilseed crushing and biodiesel plant would require a range of infrastructure facilities and provision of a good utility supply. This would include mains water, and significant 3-phase electric power. In addition access to storage for the OSR, and rapemeal would be an advantage. Similarly, tanks for storing the vegetable oil and biofuel would also be desirable. Utilising existing facilities would reduce the capital requirement of the project.

8.2 Possible sites

Accepting the decision that a port site would be the first consideration, suitable ports along the eats of Scotland were assessed with respect to their ability to handle different types of vessels and their maximum laden weight. The services of stevedores with elevators and grabs to load and unload vessels was also assessed. The following table attempts to summarise the results of each ports capabilities.

It should be noted that every effort was made to contact all listed ports to verify the following figures but that was not possible in all cases (contact was not made with all the smaller ports)

Potential Ports in North and East Scotland

Port	Max size (tonnes)	Loading cap (tonnes/day)	Port Authority	FOB £/tonne
Rosyth	25,000	4,000	Forth Ports	£3
Dundee	25,000	4,000	Forth Ports	£3
Montrose	6,000	2,000	Trust	£2
Aberdeen	15,000	3,500	Trust	£2
Peterhead	2-6,000	3,000	Trust	£2
Fraserburgh	2-3,000	2,000	Trust	£2
Buckie	2,000	2,000	Trust	£2

8.3 Evaluation of sites – matrix

In an effort to discriminate between ports and highlight some of the key issues involved, a matrix was constructed listing principal factors for consideration. It must be stressed this is not a rigorous objective assessment but rather an initial qualitative assessment to identify serious contenders for further detailed investigation at a later stage. The factors are also not of equal importance and subject to change over time so the situation could change in the future.

The following matrix was assessed from the perspective of a medium scale plant of 60,000 tonnes. If the development was for a smaller scale, many of the factors noted in the matrix would then become irrelevant.

Assessment of potential sites

Factors	Rosyth	Dundee	Montrose	Aberdeen	Peterhead	Fraserburgh	Buckie
Site availability	2	2	2	2	2	2	3
Access to road network	2	1	2	2	3	3	4
Infrastructure facilities	2	1	2	1	2	3	3
Planning & Environment aspects	2	2	2	2	2	2	2
Grant potential	1	1	3	3	3	3	2
- eligible RSA	√	√	X	X	X	X	X
Proximity to Feedstock	3	2	2	2	3	4	4
Labour pool	2	2	2	2	1	1	2
Proximity to Feed mills	2	2	3	3	4	4	4
Fuel blending & distribution	1	1	2	1	2	3	3
Biodiesel Markets	1	1	2	1	2	3	3

Ranking factors

Score 1 - Excellent
2 - Good
3 - Satisfactory
4 - Poor / weak

RSA = Regional Selective Assistance

This was a subjective assessment gathered by consulting a range of people who have operating experience in these ports.

Conclusion of matrix.

- Although no clear decisions should be taken on the basis on this analysis, it does provide some initial indicators of potential sites.
- The relative remoteness and poorer facilities at Fraserburgh and Buckie would indicate they are not prime sites.
- Dundee and Aberdeen would appear to be the main contenders although both are busy commercial ports which does have drawbacks.
- Peterhead and Montrose have attractions having less commercial pressure and more vacant sites but also have disadvantages. It was noted that GlaxoSmith Kline are currently offering for sale a large 19ha manufacturing site near Montrose harbour which is of potential.
- The port of Rosyth has attractions including the highest RSA (20%). It is also located near the Central Belt with its high population would provide access to the main fuel market in Scotland.
- Further detailed work is required to identify potential sites once a decision is made regarding any development and its scale.

9.0 Grant support

The aim of this section is to identify and review possible grants and other types of assistance, to support any development. Financial assistance could play a key role in determining the overall viability and whether or not the proposal would proceed. There are a number of potential sources of support, the principal ones being:

- European Union
- Scottish Executive
- Scottish Enterprise Network

A review of the principal sources and a search on the Scottish enterprise 'Grantfinder' database revealed 5 potential schemes, these were as follows:

1. Scottish Executive: Scotland Rural Development Plan
2. Scottish Executive: Regional Selective Assistance
3. SEERAD: Processing & Marketing Grant
4. SEERAD: Farm Business Development Scheme
5. Scottish Enterprise: Economic Development

9.1 Rural Development Plan

The current grant schemes under the Rural Development Regulation (RDR) are nearing the end of their life (2006) so we are in a period of uncertainty. Proposals for the next European Agricultural Fund for Rural Development (EARFD), which would operate from 2007-2013, have still to be agreed by the EC. This fund will support rural development under 'pillar 2' of the Common Agricultural Policy (CAP). The programme will focus on the objectives of improving competitiveness of agriculture, enhancing the environment, and improving quality of life and diversification. Support from EAFRD normally requires match funding by the Member State. The rate of support is undecided and is likely to vary depending on objective and priority, up to a maximum of 55%.

9.2 Regional Selective Assistance

The other major grant support emanating from the European Community is Regional Selective Assistance (RSA). RSA is a national scheme to stimulate investment and job creation in areas of Scotland designated for regional aid under EC law (the assisted areas). The scheme is administered and funded by the Scottish Executive, Department for Enterprise and Lifelong Learning but is a 'notified' grant scheme subject to EC rules. The current Assisted Areas map expires at the end of 2006. It is anticipated the EC's regional aid settlement map for Scotland for 2007 onwards will cover a smaller area and at a reduced rate. RSA is a discretionary grant with the exact amount for eligible projects depending on a number of factors (e.g. size of project, number and quality of jobs created or safeguarded). In Scotland there are 4 levels of grant support depending on location: 10%, 15%, 20% or 30%.

RSA comes under State Aid rules so all public funding needs to be accounted, so it is the cumulative aid that is subject to maximum rate. The scheme is discretionary but not competitive. In order to qualify for RSA the project must meet all of the criteria listed below:

- Must take place in an Assisted Area
- Must directly create or safeguard jobs within the business

- Must not be simply offset by job losses elsewhere
- Must involve an element of capital investment
- Must be a viable business
- Must be mainly funded from the private sector
- Must prove a need for RSA support

Generally agricultural activities are restricted by EC regulations but in this case the processing of produce would be eligible for consideration.

Considering the seven potential sites highlighted in the previous section, only two were eligible for RSA. These were Dundee at 15% and Rosyth at 20%.

As the planned business would be classified as a 'Small Medium Enterprise' in could be eligible for a higher rate of grant up to 20-22%. (SME's are defined as having less than 250 employees, turnover of less than £25 million and assets less than £17 million.)

9.3 Processing and marketing grant

Support is provided under the EU's European Agricultural Guidance and Guarantee Fund (EAGGF or commonly known as FEOGA) for the processing and marketing of primary agricultural produce. It is open to either ndividuals, partnerships or groups of producers. There are two schemes; one for the Highlands and Islands, the other for Lowland Scotland. In this case, given the location the Lowland scheme is applicable. The Lowland Scotland Scheme was launched in July 2001 and will grant aid capital investments up to a maximum of 40% of eligible costs. It is a competitive scheme being assessed by a project committee who decide which schemes merit support and how much – up to the maximum 40%. There is no minimum or maximum level set for the project costs.

The committee (consisting of 8 – 10 people) would judge the project on; its ability to add-value to produce, the benefits to producers, shortening of the supply chain and dealing direct with customers. It will also consider non-capital assistance. A key issue in this case is the view from Project Assessment Committees (PAC) that the scheme should support only *food processing projects.* There is an attempt here to link with Scottish Enterprise's Food and Drink strategy, so non-food processing projects such as this may not be considered. This is a collective decision by the PACs, however, a case could be presented to get a final decision.

The scheme has an annual budget of £4 million to allocate. In general with projects exceeding £100,000, the rate of grant has tended to be less than 40% - more likely to be 20%. The panel would meet 4 times per year. As stated, the scheme is budget limited and competitive, for example, for the next round, applications have been received totally £15 million. The scheme ends in December 2006 although a further two years is allowed to make payment to successful projects. There will be a new scheme under the RDR which may be more attractive to any potential development.

9.4 Farm Business Development Scheme (FBDS)

The FBDS provides assistance towards the development of a new diversified business, or improvement of existing diversification enterprise, based either on or off-farm with the aim to increase the income generation of the farm. This therefore is normally the main grant used by farmers going into a diversified business. There are 2 schemes: one for the Highlands and Islands (ABDS), and one for Lowland Scotland (FBDS). In this case, it is the lowland scheme which is likely to be applicable. Changes where just introduced in June 2005 to increase the grant ceiling from £25,00 to £30,000 per eligible business, and to include certain capital projects making it more attractive for farmers. This is a competitive scheme being assessed by a local Project Assessment Committees (PACs) chaired by SEERAD. The level of grant awarded is up to 50%. There are 5 PAC areas in Scotland, with Aberdeenshire being in the East (North) area. The budget is not ring fenced so funds could flow to any of the 5 PACs. For example, in the past Dumfries & Galloway and the Borders received more assistance due to the aftermath of the foot and mouth disease. FBDS will close to new applicants at the end of 2006, although funding is available for a further two years to allow approved projects to complete. The budget for the next three years has been set at £26.9 million.

Although the scheme was envisaged to support individual farm businesses, it may be possible to support this project. It may be possible for farmers in a co-operative business, to pool their individual FBDS entitlement, to provide significant capital funding for part of the project. For example, it may be possible to create a FCB to operate the OSR crushing plant, which could be supported by FBDS. For example, a Farmer Controlled Business (FCB) of 20 farmer members, may be eligible for FBDS support at 20 @ £30,000 each = £600,000.

9.5 Scottish Enterprise: economic development

Scottish Enterprise through its Local Enterprise Companies provides a variety of economic development, inward investment and training services to support business start-ups or expansion. In this case, SE Energy Team has budget that could be allocated to support projects such as this subject to a number of criteria being satisfied. Normally Scottish Enterprise support would be viewed as 'gap funding', between private and other public grant schemes.

9.5.1 Highlands and Islands Enterprise – Moray

One of the potential sites for any future development considered was Buckie harbour. As such, Buckie falls into the HIE area rather than the Scottish Enterprise Network. Buckie is not in an assisted area so eligible to the normal SME support. The proposal would not be eligible for support under agriculture rules, so therefore qualifies for the lower rate of grant at 15% of capital expenditure. This is subject to the de minimis rules of maximum of €100,000 for public sector support.

Any grant support would be discretionary and subject to a viable business plan. An application would be assessed in terms of its impact on the economy of Moray. Issues such as; the quality of employment, inward investment, skills brought into the area, and spin-off for other sectors in the economy all being important.

9.6 Conclusion and implications for any development

The main conclusion from the review of potential grant sources are as follows:

- There are a number of potential grant schemes which may support a project as planned.
- The majority of grant schemes are coming to the end of their programmes under the current RDR.
- Details for the next round of RDR (2007 – 13) are yet not available. Due to the modulation of the new Single Farm Payment, the RDR budget is expected to significantly increase in the future. Future schemes may be more flexible to accept non-food projects and may possibly be at a higher rate.
- Scottish Enterprise – Energy was identified as one of the most likely funders.
- EU State Aid Rules would limit any potential grant assistance. Each scheme generally has a State Aid clearance from Brussels. It would be realistic to budget for a maximum grant of 15% of eligible costs.

10.0 Economic appraisal of options

The aim of this section is to compare the economic viability of a range of scales of OSR processing plants which would create a viable business. The overall objective is to create a business which would provide benefits to the agricultural and wider rural community, add value, meet a market demand and provide a return to investors.

To facilitate the analysis, five options will be examined which represent a range of scales with different business structures to determine if a viable opportunity exists. The risks involved in any development will also be considered through sensitivity analysis. Through the analysis a better understanding of the key issues and relationships of variables will be developed. This is a rapidly developing market and future competition is likely to be intense. The five options considered in the analysis are as follows.

10.1 Description of the five options costed

Option 1 – Farm scale
This option assesses the economic viability of a very small plant which would allow a farmer to convert his own OSR into either unmodified vegetable oil or biodiesel (RME) for his own use. The unmodified oil option fits the scenario where a farmer may wish to use crude vegetable oil as a straight replacement for diesel. In this case a modification kit would be required to be fitted to the vehicle. Vegetable oil is not considered a biodiesel and therefore not eligible for the fuel duty rebate of 20p. Alternatively the rape oil could be further processed to produce biodiesel (RME) which could either be blended with diesel or as a straight replacement. The technology required for this process is now readily available with a number of small plants already been operational in the UK. The equipment is now widely advertised in the press and attracting interest from farmers and others. The precise costs and value of such systems as yet have been evaluated.

Option 2 – Small group
This option tries to consider the impact and implications if a small group of farmers combine together to pool their resources to produce vegetable oil from their OSR crops. In this case, the OSR would only be processed by mechanical crushing to extract the crude oil. Given the scale, no esterification would be undertaken so the final product would be crude vegetable oil. The crude oil could be blended with diesel for own use or retailed. Although this option can operate as blended diesel and is suitable for unmodified engines it does not qualify for the rebate in the fuel duty of 20p/litre.

Option 3 – Group scale.
This option examines the scenario of a larger group of farmers, perhaps an existing grain marketing group or a number of grain groups, coming together to pool their resources and produce biodiesel. In this case, the feedstock would be 15,000 tonnes of OSR, which represents just over 10% of the Scottish production or some 4,300 ha. This would require a group of 80 –100 growers depending on exact area grown to come together. The biodiesel produced could either be sold on open the market or blended by a local fuel distributor for retailing as biodiesel in the region.

Option 4 – Medium scale
This option looks at a medium scale plant of 60,000 tonnes OSR. This would account for nearly half of the Scottish OSR production which would be a challenge to secure.

Considered here as medium scale, however, internationally this would be considered relatively small scale and marginal. The biodiesel (RME) produced would likely be blended with diesel and marketed throughout the region.

Option 5- Large scale.
This option is not costed in the analysis in any detail, however, it is crucial to consider such plant's cost structures and final biodiesel production cost. In the future any development in Scotland would have to compete with these types of businesses in the market. This represents the most common size of biodiesel plants being erected in Europe and elsewhere. The size of crushing plant would be at least 250,000 tonnes per year and incorporate hexane solvent extraction to increase the oil recovered and plant work rates. The two plants currently being constructed by Biofuels Corporation (Teeside) and Greenenergy (Immingham) in the UK eventually would be a similar scale although at present they do not include any OSR crushing. This option would be the benchmark to determine the competitiveness of the other options.

10.2 Financial analysis of each option

A full detailed analysis showing all the assumptions and sources of information is provided in the following pages.

Option 1A – Farm scale (producing vegetable oil)

This option produces unmodified vegetable oil from a small crushing press provided by Straehle (SK60/2) that processes 70kg OSR per hour. Therefore in an 8-hour day the press will crush 560kg, producing 120 litres of crude oil. This is from a single cold press, power is from a 6KW motor. The mill would operate for 330 days per year. The cake produced has a high oil content of ~11% and therefore higher nutritional value. This could be used on the farmer's own farm and may be worth up to £100 per tonne,

Mass Balance for Straehle SK60/2 per year

190t Rapeseed

↓ → **125t Rapemeal**

63t crude oil

↓

40,890 litres oil

@ 0.88 g/ml density

Option 1A: Estimate of production cost

Option 1: Farm Scale - Producing oil		
Produces pure veg oil only		
Capital cost		
	£	
Oil press and filter	4,800	
Installation costs	2,500	
Total cost	**7,300**	
		Cost /l Pure Oil
Operating costs	**£**	(£ / litre)
Annual charge capital	1,832	0.045
Cost of feedstock	29,450	0.720
Labour (share)	2,310	0.056
Power	456	0.011
Annual maintenance	183	0.004
Overheads	295	0.007
Interest on av. working capital	151	0.004
Total	**34,677**	0.848
Income		
OSR Meal	11,000	0.269
Total income	11,000	0.269
Net Cost	**23,677**	**0.579**

Assumptions

1. Source of capital costs: Staehle (model SK60/2)
2. Installation cost assumes utilising existing buildings with an allowance for any fitting works
3. Annual capital charge: Repayment over 5 years @ 8%
4. Cost of feedstock:190t OSR @ £155/t delivered
5. Labour: 1 hour/day @ £7 operating 330 days per year.
6. Power: 40KWH/t @ 6p
7. Annual maintenance: 2.5% of capital cost
8. Overheads: 10% of all operating costs
9. Interest on average working capital for 4 months @ 7%
10. Rapemeal (11% oil) 125t @ £90/t ex-farm

Option 1B – Farm scale (producing biodiesel)

This system produces biodiesel from a 'cottage scale' processing plant. There are two distinct processes. A small crushing press produced by Alvan Blanch that processes 150kg OSR per hour. Therefore in an 8-hour day will crush 1 tonne, producing 300 litre of crude oil. This is from a single cold press, a double press would extract another portion of oil but as yet it is not tested. The cake that is left has a high oil content of 10% and therefore higher nutritional value. This could be used on the farmers of farm and may be worth up to £100 per tonne. Power is from a 9.2KW motor.

The second process uses a Greenfuels (Fuel Meister) biodiesel system. It treats 300 litre of oil per day using methanol and a NaOH catalyst.The operator would have to manually transfer the oil to the biodiesel process. It is a batch system which would take approx. 60 minutes per batch. The small plant would be installed into an existing covered building on the farm, requiring an area of 4 x 2 metres.

Mass Balance for Green Fuels plant per year

355t Rapeseed

↓ → **248t Rapemeal**

90t crude oil

↓

102,600 litres oil

@ 0.88 g/ml density

Option 1B: Estimate of production costs

Option 1B: Farm Scale (355t)

Produces biodiesel

Capital cost		
	£	
Alan Blanch Press	5,600	
Fuel Meister	12,800	
Installation & infrastructure	12,000	
Total cost	**30,400**	
		Cost /litre biofuel
Operating costs	**£**	(p / litre)
Annual charge capital	7,630	0.074
Cost of feedstock	55,025	0.536
Labour (share)	10,000	0.097
Power	1,704	0.017
Annual maintenance	760	0.007
Consumables	8,200	0.080
Overheads	1,246	0.012
Interest on av. working capital	658	0.006
Total	**85,224**	0.831
Income		
OSR Meal	22,320	0.218
Total income	22,320	0.218
Net Cost of Biodiesel	**62,904**	**0.613**

Assumptions

1. Source of capital costs: Greenfuels and Alvan Blanch
2. Site & infrastructure assumes utilising existing buildings with an allowance for any fitting works
3. Annual capital charge: Repayment over 5 years @ 8%
4. Cost of feedstock:350t OSR @ £155/t delivered
5. Labour: 1 man (share)
6. Power: 80KWH/t @ 6p
7. Annual maintenance: 2.5% of capital cost
8. Consumable: methanol 8p/l, NaOH catalyst 0.2p/l
9. Overheads: 10% of all operating costs
10. Interest on average working capital for 4 months @ 7%
11. Rapemeal (10% oil) 248t @ £90/t ex-mill

Option 2 – Small group

This system produces crude OSR oil using a Straehle press (SK 130/3). Prices include a seed cleaner, seed warmer, cake cooler, oil press including cake pelletiser and special tools (without electric), raw oil tank, filter and fine filter. The operator would not be fully occupied so the cost may be shared in many cases.

Mass Balance for SK 130/3 plant, for year

1,030t Rapeseed

↓ → **689t Rapemeal**

343t crude oil

↓

390,000 litre oil

@ 0.88 g/ml density

Option 2: Estimate of production costs

Option 2: Small Group (1,000t)		
Produces pure veg oil only		
Capital cost		
	€	
Oil press/ filter / etc	90,000	
Exchange rate (€: £0.68)	61,200	
Site & infrastructure	20,000	
Total cost	**81,200**	
		Cost /litre crude oil
Operating costs	**£**	(p / litre)
Annual charge capital	20,381	0.052
Cost of feedstock	159,650	0.410
Labour	22,500	0.058
Power	4,800	0.012
Annual maintenance	1,530	0.004
Overheads	5,766	0.015
Interest on av. working capital	1,669	0.004
Total	**216,297**	**0.555**
Income		
OSR Meal	62,010	0.159
Total income	62,010	0.159
Net Cost	**154,287**	**0.396**

Assumptions

1. Source of capital costs: Straehle (model SK/130/3)
2. Site & infrastructure assumes utilising existing buildings with allowance for conversions and fitting works
3. Annual capital charge: Repayment over 5 years @ 8%
4. Cost of feedstock: 1,030t OSR @ £155/t delivered
5. Labour: 1 man (not fully occupied)
6. Power: 80KWH/t @ 6p
7. Annual maintenance: 2.5% of capital cost
8. Overheads: 20% of all operating costs
9. Interest on average working capital for 4 months @ 7%
10. Rapemeal (9% oil) 689t @ £90/t ex-mill

Option 3 – Group scale

This option processes 15,000 tonnes of OSR. The technology and equipment is provided by Green Fuels who are the UK agents for German manufactures RHB GmbH. They have a number of biodiesel systems operating in Germany and Austria. Again there are two processes in the system, a mechanical warm press followed by the esterification plant. The components are modular so the whole system can be expanded as required. This allows considerable flexibility when designing systems. Storage tanks are also included for the raw oil, methanol, glycerine and biodiesel. Other facilities such as office accommodation, washing facilities and laboratory.

Mass Balance for plant per year

	15,000t Rapeseed		
	↓	→	**9,900t Rapemeal**
	5,100t crude oil		
	↓		
Esterification	**4,980t refined oil**	→	**600t Glycerine**
550t methanol			
	↓		
	4,700t RME		**5,340,000 litres**
			@ 0.88 g/ml density

Option 3: Estimate of production costs

Option 3: Group scale (15,000t)		
Produces biodiesel		
Capital cost		
	£	
Crushing plant	450,000	
Transesterification plant	1,200,000	
Storage & infrastructure	600,000	
Site & construction	1,610,000	
Total cost	**3,860,000**	
		Cost /litre RME
Operating costs	**£**	(£ / litre)
Annual charge capital	968,860	0.181
Cost of feedstock	2,325,000	0.435
Labour (6)	155,000	0.029
Power	76,260	0.014
Annual maintenance	77,200	0.014
Overheads	92,538	0.017
Consumables	122,000	0.023
Interest on av. working capital	29,687	0.006
Total	**3,846,545**	**0.720**
Income		
OSR Meal	891,000	0.167
Glycerine	60,000	
Total income	951,000	0.178
Net Cost of Biodiesel	**2,895,545**	**0.542**

Assumptions

1. Source of capital costs: Green Fuels Ltd
2. Site & infrastructure assumes
3. Annual capital charge: Repayment over 5 years @ 8%
4. Cost of feedstock: 15,000t OSR @ £155/t delivered
5. Labour (6): 4 men @ 25,000 + secretary £15,000 + Plant Manager £40,000
6. Power: 80KWH/t for crushing + 40KWH for sterification @ 4.65p x 1.2
7. Annual maintenance: 2% of total capital cost
8. Overheads: 30% of all operating costs
9. Interest on average working capital for 4 months @ 7%
10. Rapemeal (9% oil) 9,900t @ £90/t ex-mill
11. Glycerine 600t @ £100/t

Option 4 - Medium scale biodiesel production

This system is designed around two manufacturers, De Smet Rosedowns (crushing plant) and Ballestra of Italy (esterification plant). At 60 000t with fairly dry seed (7%), press, dry press cake, press again – double press. Can do both cold or cold first and hot second to increase oil extraction and reduce gums in oil. Storage adds considerably to any plant so ideally should aim to restrict and utilise on-farm storage.

De Smet Rosedowns can supply presses for a range of sizes, but avoid doing so if they do not think the proposed operation isviable. They state project costs are almost irrelevant, it is the crushing margin that is important.

The esterification plant is designed to process 30,000 tonnes of oil per year. The company state a 30,000t plant is small, 50 – 100,000t biodiesel is more usual. By increasing the size of the esterification plant from 20 to 50 000t biodiesel, costs are only increased by 25%. There is the same labour requirement for a 20 and a 100 000t biodiesel plant. For crushing at least 500t/day is needed. No new plants are going up in Europe of less than 2000t/day.

In this option, the additional capacity of the biodiesel plant will be utilised by purchasing 10,000 of crude vegetable oil to improve efficiency and lower costs. It is anticipated that a mix of soya oil and palm oil would be used a feedstock based on price.

Mass Balance for medium scale plant per year

	60,000t Rapeseed		
	↓	→	**39,600t Rapemeal**
	20,400t crude oil		
	↓		
Esterification	**19,920t refined oil**	→	**3,600t Glycerine**
	+		
Plus extra	**10,000t Soya/Palm Oil**		
	↓		
	29,300t RME		**33,300,000 litres**
			@ 0.88 g/ml density

Option 4: Estimate of production costs

Option 4: Medium scale 60,000t		
Produces biodiesel		
Capital cost	**£**	
Crushing press + partial-refining	1,000,000	
Esterification plant	2,400,000	
Site, works, infrastructure	6,800,000	
Total cost	**10,200,000**	
		Cost /litre RME
Operating costs	**£**	(£ / litre)
Annual charge capital	2,560,200	0.077
Cost of feedstock	9,300,000	0.279
Cost additional crude Oil	3,500,000	
Crushing:		
Labour (10)	255,000	0.008
Power	267,840	0.008
Esterification:		
Labour (10)	285,000	0.009
Power	66,960	0.002
Consumables	575,000	0.017
Annual maintenance	357,000	0.011
Overheads	542,040	0.016
Interest on av. working capital	137,737	0.004
Total	**17,846,777**	**0.536**
Income		
OSR Meal	3,564,000	0.107
Glycerine	540,000	
Total income	4,104,000	0.123
Net Cost of Biodiesel	**13,742,777**	**0.413**

Assumptions

1. Source of capital costs: De Smet Rosedown (crusher) and Ballestra (Esterification)
2. Site & infrastructure assumes two times equipment cost
3. Annual capital charge: Repayment over 5 years @ 8%
4. Cost of feedstock: 15,000t OSR @ £155/t delivered
5. Additional 10,000t of crude oil (50% each palm oil and soya oil) @ 350/t

6. Labour (20): crushing in 4 shifts @ 2 men at £25k, RME plant 4 shifts @ 2 men £25k, Manager £40k, Supervisor £35k, 1 Lab £25k, and secretary £15k
7. Power: 80KWH/t for crushing x 1.2 and 40KWH/t for RME plant x 1.2 all at @ 4.65p
8. Annual maintenance: 3.5% of total capital cost
9. Overheads: 30% of all operating costs
10. Interest on average working capital for 4 months @ 7%
11. Rapemeal (9% oil) 39,600t @ £90/t ex-mill
12. Glycerine 3,600t @ £100/t

10.3 Retail price for the 5 options

The following table shows the estimated retail price for the vegetable oil or biodiesel produced from each option. It includes the gross retail margin, the fuel duty and VAT charged for each option where applicable. In the small scale options, if the biodiesel produced is for own use, there will be no VAT charge. VAT is only charge at point of sale. If the farmer subsequently sold the biodiesel on to a third party then VAT would have to be added. It should be noted that the fuel manufacturer will be required to declare the number of litres made and will be liable for payment of the appropriate rate of duty at the point of use. VAT will be charged on the sub-total including production cost and duty levied.

Table 10.1 provides a useful comparison of the final retail price for each option and facilitates a comparison with mineral diesel prices at the pump. The current (1st Oct 2005) cost of mineral diesel in Scotland varies from 90p-93p/litre. At this level, options 4 and 5 would be considered to be within a similar price range and therefore potentially competitive. Small scale plants for own use incurring no VAT would also appear competitive but this would need to be tested to confirm assumptions.

Table 10.1: On the road retail prices for 5 options (p/litre)

Option	Production cost	Retail Margin	Duty	sub-total	VAT 17.5%	Total Cost
1A	57.9	2	47.1	107	0	107.00
1B	61.3	2	27.1	90.4	0	90.40
2	39.6	5	47.1	91.7	16.05	107.75
3	55.2	10	27.1	92.3	16.15	108.45
4	41.3	10	27.1	78.4	13.72	92.12
5	38.0	10	27.1	75.1	13.14	88.24

Note:
The retail margin has to cover the costs associated with transport and distribution to the retail outlets. For options 1A and 1B it was assumed production would be own-use, with the 2p/l cost to cover storage and handling costs. In option 2, it was assumed half would be for own use with the balance retailed.

10.3.1 Summary of production costs

The following table (10.2) attempts to summarise the results from the evaluation of the five options and provide key comments across a range of variables.

10.2 Summary Matrix showing economic evaluation of biodiesel production from oilseed rape grown in north and east Scotland

Option	Technology	Ease of supply	Capital cost	Planning/ development difficulty	Production cost (p/L)	Key factors	Retail price (p/L)	Markets	Rural economy impact	Current examples
1A. Farm oil (190t)	Crush Pure plant oil	Good	£7.3K	Easy	57.9 p/l Oil	Low operating cost	107.0 p/l	On farm	Good if lots	All
1B. Farm biodiesel (355t)	Crush Biodiesel	Good	£30.4K	Easy	61.3 p/l Biodiesel	Low operating cost	90.4 p/l	On farm	Good if lots	All
2. Small Group	Crush Pure plant oil	Good	£81.2K	Easy	39.6 p/l Oil	Engine mod not included	107.75 p/l	On farm	Good if lots	Ireland
3. Group (15,000t)	Crush Biodiesel	Good	£3.86M	Envirn. Impact Required	55.2 p/l Biodiesel	Capital cost vs. Output	108.45p/l	Road fuel market, but small volume	Good if several	
4. Medium (60,000t)	Crush Biodiesel	Possible Scot crop 140,000t	£10.2M	Major industrial development	41.3 p/l Biodiesel	Scale benefits	92.12 p/l	Major local player.	Regional not many direct jobs	Austria Germany
5. Large	Hexane Biodiesel	Difficult UK scale	Only multi-national	Major industrial development	36 p/l (Hexane = 4p/l cost benefit)	Scale and process benefits	88.242 p/l	Link to Nationals. Blend	Not rural	France

10.4 Full Budget for Option 4

The assessment of the various scales of operation in the previous section showed that option 4 had commercial potential. The production cost for option 4 was comparable to the costs associated with an international scale plant and competitive with the current mineral diesel price. A plant looking to source 60,000 tonnes of OSR from the total production of 130,000t in Scotland is ambitious but not impossible. It was therefore decided to select this option for further more detailed financial analysis which will include a 10-year cashflow, sensitivity analysis and investment appraisal.

10.4.1 10-year cashflow for option 4 – medium scale biodiesel plant.

The following cashflow shows the budgeted income and costs associated with the medium scale option. This for a plant that processes 60,000 tonne OSR to produce rape oil which is esterified into biodiesel. Additional vegetable oil is also purchased to increase the biodiesel produced and help drive down unit costs as described previously.

Assumptions used in cashflow

1. All the previous assumptions for option 4 (p 86 and 87) hold.
2. Successful grant award £1,540,000
3. Equity capital £2,540,000
4. A loan of £6,120,000 is required which will be repaid over 5 years @8%
5. Construction of the plant takes in year 1 with operation commencing in year 2.
6. In the first year of operation (year 2) the plant will operate at 80% of capacity and thereafter at full capacity.
7. The wholesale value of the biodiesel is 41p.
8. The value of the rapemeal is £85/t in the first 3-years of production, there after reducing to £80/t
9. The value of glycerine over the 10 years reduces from £100/t to £50/t, reflect its expected declining market value.
10. Rental value of the site £50,000 per year
11. No allowance has been made for inflation it is assumed it affects both income and costs equally.

Table 10.3 Budgeted Cashflow for Medium scale plant

Medium scale plant	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Assumptions										
Value of biodiesel (p/l)		41	41	41	41	41	41	41	41	41
Tonnage rapemeal		31,680	39,600	39,600	39,600	39,600	39,600	39,600	39,600	39,600
Value of rapemeal (£/t)		85	85	85	80	80	80	80	80	80
Tonnage Glycerine		2,880	3,600	3,600	3,600	3,600	3,600	3,600	3,600	3,600
Value of Glycerine (£/t)		100	90	80	70	60	50	50	50	50
INCOME										
Biodiesel		10,922,400	13,653,000	13,653,000	13,653,000	13,653,000	13,653,000	13,653,000	13,653,000	13,653,000
Rapemeal		2,692,800	3,366,000	3,366,000	3,168,000	3,168,000	3,168,000	3,168,000	3,168,000	3,168,000
Glycerine		288,000	324,000	288,000	252,000	216,000	180,000	180,000	180,000	180,000
Grant	1,540,000									
Bank Interest	0	0	0	8,295	28,666	39,331	46,329	113,613	183,588	256,362
Bank Loan	6,120,000									
TOTAL INCOME	**£7,660,000**	**£13,903,200**	**£17,343,000**	**£17,315,295**	**£17,101,666**	**£17,076,331**	**£17,047,329**	**£17,114,613**	**£17,184,588**	**£17,257,362**
EXPENDITURE										
Capital Expenditure										
Crushing plant	1,000,000									
Esterification plant	2,400,000									
Site works & infrastructure	6,800,000									
Total Capital Expenditure	***10,200,000***	***0***								
Purchase of feedstock										
Oilseed rape	0	7,440,000	9,300,000	9,300,000	9,300,000	9,300,000	9,300,000	9,300,000	9,300,000	9,300,000
Additional vegetable oil	0	2,800,000	3,500,000	3,500,000	3,500,000	3,500,000	3,500,000	3,500,000	3,500,000	3,500,000
Operating costs										
Power costs		321,408	334,800	334,800	334,800	334,800	334,800	334,800	334,800	334,800
Annual maintenance		306,000	357,000	408,000	459,000	510,000	510,000	510,000	510,000	510,000
Consumables (methanol & catalyst)		460,000	575,000	575,000	575,000	575,000	575,000	575,000	575,000	575,000
Management (2)	35,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000
Labour costs (18)		440,000	440,000	440,000	440,000	440,000	440,000	440,000	440,000	440,000
Overheads										
Rent	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000
General overheads (30%)	50,000	480,722	534,540	549,840	565,140	580,440	580,440	580,440	580,440	580,440
Loan Repayment (8%)		*1,536,120*	*1,536,120*	*1,536,120*	*1,536,120*	*1,536,120*				
Total Operating Costs	***135,000***	***13,909,250***	***16,702,460***	***16,768,760***	***16,835,060***	***16,901,360***	***15,365,240***	***15,365,240***	***15,365,240***	***15,365,240***
TOTAL EXPENDITURE (before interest)	**10,335,000**	**13,909,250**	**16,702,460**	**16,768,760**	**16,835,060**	**16,901,360**	**15,365,240**	**15,365,240**	**15,365,240**	**15,365,240**
Overdraft Interest @ 8%	20,000	123,638	148,466	37,264	0	0	0	0	0	0
NET CASHFLOW	**-2,695,000**	**-129,688**	**492,074**	**509,272**	**266,606**	**174,971**	**1,682,089**	**1,749,373**	**1,819,348**	**1,892,122**
OPENING BALANCE	**2,540,000**	**-155,000**	**-284,688**	**207,386**	**716,657**	**983,263**	**1,158,234**	**2,840,323**	**4,589,696**	**6,409,044**
CLOSING BALANCE	**-155,000**	**-284,688**	**207,386**	**716,657**	**983,263**	**1,158,234**	**2,840,323**	**4,589,696**	**6,409,044**	**8,301,166**

10.5 Sensitivity analysis

To assess the risks involved for any development, sensitivity analysis was carried to determine the impact of key variables on production costs. If the plant is to be successful it needs to be internationally competitive in the market. Sensitivity analysis will also provide a better understanding of the key issues and the critical success factors for a successful OSR processing plant.

Commercial processors must constantly look to improve operational efficiencies, drive down costs to improve margins and profitability. In this case the key variables examined are:

- Raw material costs
- Plant utilisation
- Value of by-products
- Capital cost
- Grant assistance
- Market demand

10.5.1 Raw material costs

The cost of feedstock will have a major bearing on the crushing margin and overall cost of biodiesel production. One of overall aims of the project is to pay farmers as high a price for OSR as possible. However, the processing plant needs to source feedstock at market rates to remain competitive.

The following table shows the impact on biodiesel production costs for the medium scale plant (Option 4) using 60,000 tonnes of rapeseed plus an additional 10,000 tonnes of crude vegetable oil, producing 34 million litres of biodiesel.

Table 10.4. Impact of feedstock cost on production costs

Feedstock price (OSR)	biodiesel p/l
£170	44.0
£160	42.2
£150	40.4
£140	38.5
£130	36.7

The table shows that the cost of feedstock has a major impact on production costs. Every £10 change per tonne represents on average 1.8 p/litre on production costs.

There is also the challenge of securing 60,000 tonnes of OSR from Scottish farmers. Growers would only sell to the plant if the net price was as high or better that the market, or alternatively if that they had a stake in the business.

A local OSR processing facility does have the advantage of reduced transport costs which would be worth £8-£12 per tonne to the grower.

10.5.2 Plant utilisation

The efficiency of plant utilisation and the ability to work to full capacity has an major impact on production costs. Any plant that is not fully utilised will incur higher production costs from the fixed cost element. The following table shows the impact. The situation gets progressively worse, eg dropping from 70% to 60% utilisation incurs a penalty of 4.1 p/l on to the production cost.

Table 10.5. Impact of plant utilisation on production costs

Plant Utilisation	biodiesel p/l
100%	41.3
90%	43.3
80%	45.7
70%	48.8
60%	52.9

10.5.3 By-product value

The revenue earned from the by-products of the crushing and RME process make a crucial contribution to the overall viability and competitiveness of the plant.

Every £10 change in rapemeal price represents on average 1.2 p/litre on production costs.

Table 10.6: Impact of rapemeal value on production cost

Rapemeal value	Biodiesel p/l
£110	38.9
£100	40.1
£90	41.3
£80	42.5
£70	43.7

The value of glycerine has little impact on overall production costs.
Every £20 change in glycerine price represents on average 0.2 p/litre on production costs.

Table 10.7: Impact of Glycerine on production cost

Glycerine value	Biodiesel p/l
£170	41.1
£150	41.3
£130	41.5
£110	41.8

10.5.4 Capital costs

The following analysis looks at how changes in capital expenditure impact on the overall production costs. If there was an overspend of 25% would it put the whole project at risk? The following table shows that within reason the capital cost is not a critical factor. For every additional £1 million it would add a further 0.9 p/l to the production cost.

Table 10.8: Impact of capital expenditure on production cost

Capital cost	Biodiesel p/l
£13.2M	43.9
£12.2M	43.1
£11.2M	42.3
£10.2M	41.3
£9.2M	40.4

10.5.5 Grant assistance

The impact of grant assistance on the project and its net effect on production costs are considered in the following table. It shows that for every £1million of grant support, production costs are reduced by nearly 1p per litre. This suggest grant has a modest effect on production costs, however grant support could play a crucial role in securing the necessary equity to embark on any project in the first place. Therefore the significance of grant support is likely to play a key role if the project is to become a reality.

Table 10.9: Impact of Grant Assistance on production cost

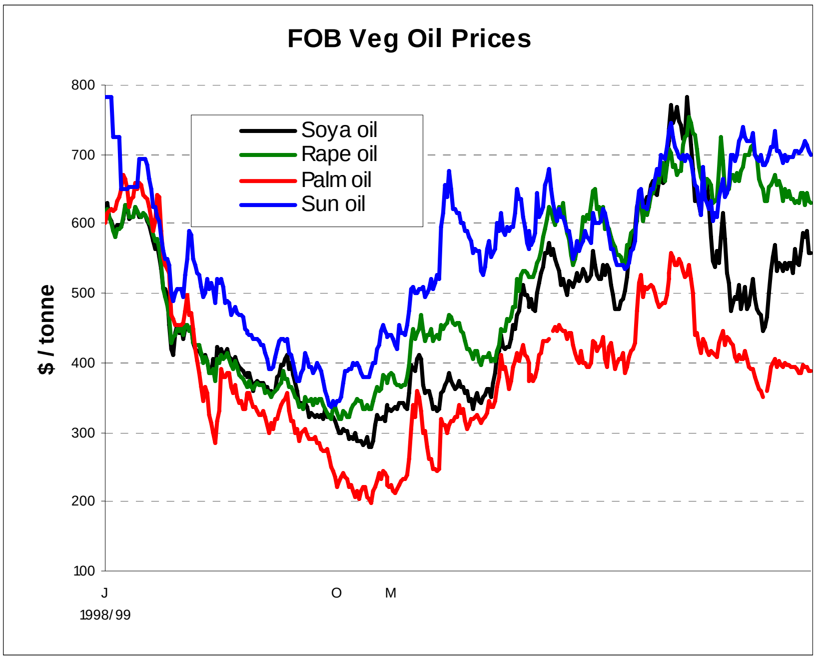
Grant support	Biodiesel p/l
£0.5M	40.9
£1.0 M	40.4
£1.5M	40.0
£2.0M	39.5

10.5.6 Value and use of various vegetable crude oils for RME production

The following figure shows the value of the four main vegetable oils for the period 1998 –2005 expressed in US$ per tonne FOB.

Note: It would not be economic to transport oilseeds to the UK as the energy density of seeds is much lower than that of vegetable oils. UK processing costs are likely to be similar or more likely higher than costs in other countries due to economies of scale.

Fig 10.1 Vegetable oil prices ($ /t) 1998-2005 (ex Rotterdam)



10.6 Market demand

The final two major risks are market demand and competitor reaction. The overall market demand ultimately will depend on Government's action and whether they agree to the Renewable Transport Fuel Obligation (RTFO) and pass legislation to enforce it. Without this, it is unlikely a significant market will develop where customers will pay a premium for 'green' fuel over fossil derived fuel. The current UK diesel market is 18.930 million tonnes (2004). At the 5.75% RTFO target, it would require 1.088 million tonnes of biofuels, which if totally derived from OSR would require a crop of 736,000 ha or 131% of the current UK total OSR area.

The following two tables show the impact of different inclusion rates of RTFO and their affect on OSR demand if that was the sole source of feedstock. Table 10.10 shows the UK situation while 10.11 shows the Scottish situation. In the Scottish situation, it is noted that we have a limited production of OSR which would meet less than 3% of the RTFO target. Clearly the potential market size is vast and likely to grow.

Table 10.10: UK Scenarios to meet Renewable Transport Fuel Obligation (RTFO) for diesel only

RTFO Rate	Biodiesel ('000 tonnes)	Area OSR ('000 ha)	% of UK OSR Area
2%	380	257	46%
3%	570	385	69%
4%	760	514	92%
5.75%	1,090	736	131%

Table 10.11: Scenarios to meet Renewable Transport Fuel Obligation (RTFO) in Scotland for diesel

RTFO Rate	Biodiesel ('000 tonnes)	OSR Feedstock ('000 tonnes)	Area OSR (ha)	% of Scottish OSR crop
2%	37,900	94,650	27,043	73%
3%	56,800	141,970	40,654	109%
4%	75,700	189,300	54,086	145%
5.75%	94,700	236,620	67,607	182%

10.7 Potential market competition

There are two distinct competitors and major threats to any potential biodiesel plant. These are:

1. Fossil crude oil refineries
2. International Biodiesel plants

10.6.1 Fossil crude oil refineries

The competition from fuel derived from mineral oil is high. It must be acknowledged that production costs for biodiesel are higher than mineral diesel. In the past, biodiesel was considered to be twice as expensive to produce compared to diesel. However with the current high oil prices this gap has narrowed. The following table attempts to shows the competitiveness of biodiesel compared to diesel

Table 10.12: Pump prices for diesel and biodiesel

	Diesel	Diesel	Biodiesel	Biodiesel	Biodiesel
Wholesale price	**19.00**	**25.00**	**40.00**	**42.00**	**44.00**
Gross retail margin	5.00	5.00	10.00	10.00	10.00
sub-total	24.00	30.00	50.00	52.00	54.00
Excise duty	47.10	47.10	27.10	27.10	27.10
sub-total	71.10	77.10	77.10	79.10	81.10
VAT @ 17.5%	12.44	13.49	13.49	13.84	14.19
Price on road	**83.54**	**90.59**	**90.59**	**92.94**	**95.29**

Source: HGCA and Industry

The gross retail margin for biodiesel has been estimated at 10p/litre in recognition of the additional blending and distribution cost, which potentially may be over longer distances. In practice this be an over-estimate and a lower gross retail margin may be achieved. This demonstrates areas that need further attention and where costs could be saved making biodiesel more competitive.

There is no doubt that mineral diesel is very competitive compared to biodiesel. Legislation and the introduction of the RTFO by UK government actually negates some of the competition from fossil derived products as eventually it will forces the market to use a renewable fuel – biofuel - irrespective of relative price.

The major driver for the biodiesel industry is the EU Directive on Renewable Transport Fuel Obligation (RTFO). At present this is only indicative and not compulsory although this is likely to be strengthened in the future. It is unclear at present how the UK Government will respond to the RTFO.

What will the major oil companies do?

A major threat for any UK biodiesel producer is the action taken by the multinational oil companies who currently operate refineries in the UK. The adoption of the 'hydrogenation' process could seriously undermine the ability of RME plants to compete. It effectively means crude vegetable oil could be mixed with mineral oil at the refining stage and qualify for the rebate on the tax levy. From the UK's perspective this route does have attractions in that is uses existing distribution channels, ensuring continuity of supplies, and guarantees the quality of product. It would address the issue of 'back-street' blending with the associated risks for quality that the oil companies have previously indicated as a potential problem. However, it should be stressed that this process is at the very early stages of development, with only a small-scale trial having been carried out in Germany. Much further experimentation and development of the tax system is required before introduction.

10.7.2 International biodiesel plants

The UK Biodiesel Industry is in its infancy at present. There is a real concern whether future UK demand for biodiesel will be satisfied from an indigenous national industry or alternatively, biodiesel could be imported on the world markets. Increasingly biofuel will become a commodity to be sourced on the global market based on price. Imported biofuel (either bioethanol or biodiesel) therefore is a real threat to any UK biodiesel plant.

Within the EU potential suppliers to the UK could from any of the New Member States (NMS) e.g. Poland is establishing biodiesel plants specifically for export to the EU-15. Germany with over 50% of the current biodiesel production is also a potential source although it is likely its domestic market would still soak up supplies.

How competitive is the medium scale plant (option 4) to imported biodiesel?

It is believed current Germany biodiesel production prices are approximately 38p/litre. The cost of a sea freight from North Germany (Hamburg / Lear) to Aberdeen is £40 per tonne. This would cover all charges (there is no FOB). This would translate to an additional shipping cost of 3.5p / litre. The net imported price would then be 38.0p + 3.5p = 41.5p /litre.

Based on the assumptions stated, the estimated production cost of a medium sized plant purchasing additional crude vegetable oil to maximise the utilisation of the esterification plant, was 41.3p /litre. This would indicate that the plant could compete with imported biodiesel.

Clearly an important factor on the competitiveness of UK production and the threat of imports is the exchange rate of sterling (£) against the major currencies. Another factor would be incentives provided by a country's government to stimulate renewable biofuel production.

Examples of relative prices in Germany and Rotterdam market (February 2005)

Fuel Prices	**Price**
Biodiesel EN 14214 Ex Germany excl VAT	€62 per 100 litre (42.1p /l)
Brent crude Oil	44.22 US$ per barrel
Retail price biodiesel in Germany	€86 per 100 litres (58.48 p/l)
Retail price diesel in Germany	€95 per 100 litres (64.60 p/l)
Diesel Fuel EN590 FOB Rotterdam	375 US$ pmt

Source: Oleoline.com

The following two graphs (Figs 10.2 and 10.3) illustrate the relationship between biodiesel price and rape oil price, and the price differential of diesel and biodiesel in Germany. There is a good correlation between rape oil and biodiesel prices. As the value of rape oil increases so does the biodiesel price.

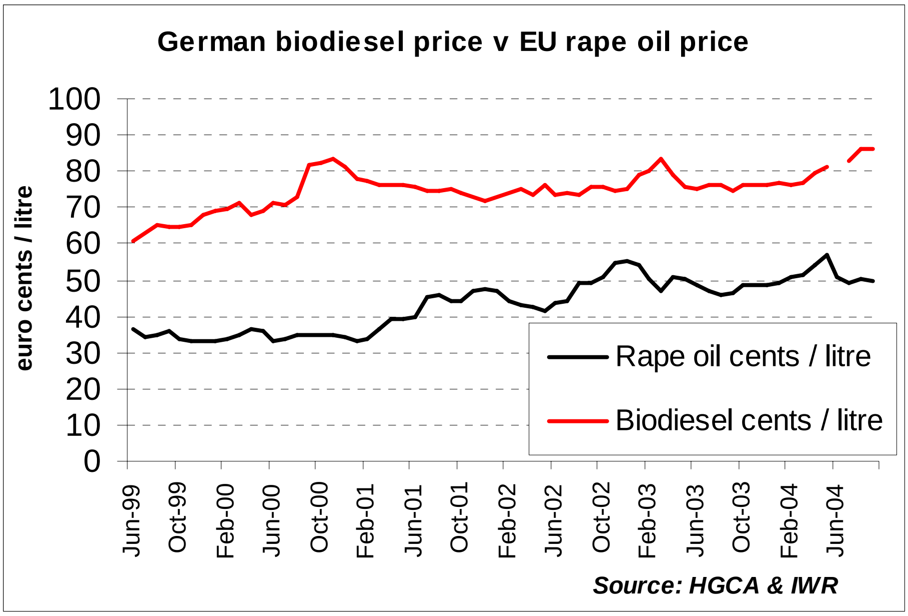


Fig 10.2 German biodiesel price and EU Rape oil price (1999-2005)

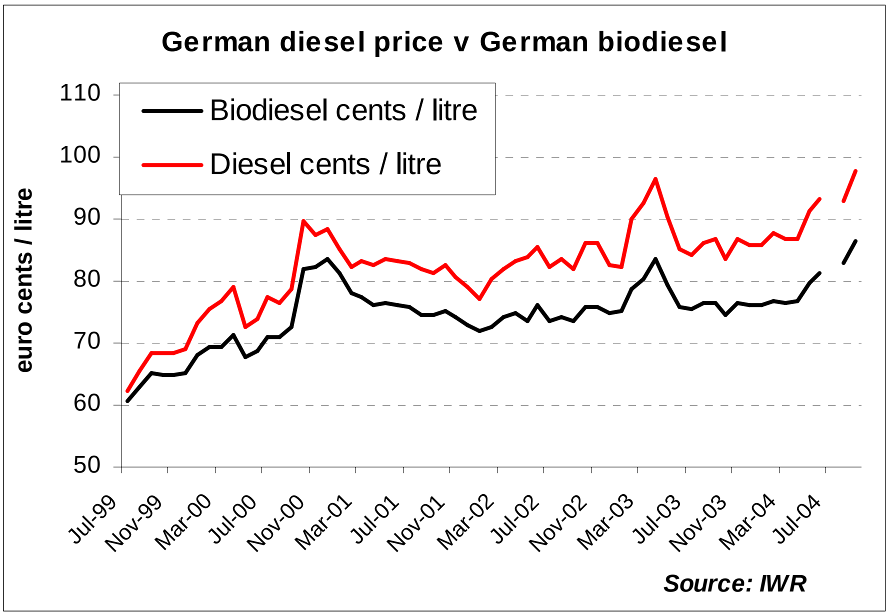


Fig 10.3 Comparison of German diesel and biodiesel prices (1999-2005)

10.8 Investment appraisal

Investment appraisal analysis was carried out for the medium scale plant using the 10-year budget financial model produced in page 90. The following two tables (Tables 10.13 and 10.14) presents the return to investors over two key variables; biodiesel value and OSR cost.

Table 10.13 Investment appraisal results over changing biodiesel value

Biodiesel price	NPV (real rate 5%)	IRR	Pay-back
39p	-£823,277	2.6%	End year 8
40p	£1,370,509	8.7%	End year 6
41p	£3,564,296	14.1%	End year 5
42p	£5,758,083	18.9%	End year 4
43p	£7,951,869	23.5%	End year 4

Table 10.14 Investment appraisal results over feedstock (OSR) price

Feedstock OSR price	NPV (real rate 5%)	IRR	Pay-back
£175	-£4,341,242	-10.4%	Not in life
£165	-£399,473	2.9%	End year 6
£155	£3,564,296	14.1%	End year 5
£145	£7,517,065	22.6%	End year 4
£135	£11,469,834	30.3%	End year 4

The analysis of the budgeted financial model (page 90) shows that with the assumptions stated, the project is expected to yield an internal rate of return (IRR)

14.1% and achieve payback at the end of year 6. Given the considerable risks involved commercial investors may consider this to be low.

The results of the investment appraisal in tables 10.13 and 10.14 clearly demonstrate the importance of the biodiesel value and feedstock price on the economic viability of the project. If the biodiesel retail price increased by one pence to 42p/litre, the impact is substantial. In this scenario, the IRR increases to 18.9% and payback is achieved a year earlier (year 4). Conversely if the biodiesel value fell to only 39p /litre, the return is very low – IRR 2.6%.

Similarly, the cost of feedstock has a major bearing on the viability of the project. If the delivered price of OSR was reduced by £10 to £145/t then the IRR would be 22.6% with payback at the end of year 4. However if the cost of feedstock increased by £10 to £165/t, then the return would only be 3.9%.

The conclusion of the investment appraisal analysis is that the expected return is in the order of 14% with payback in 5 years. While this is a reasonable return, given the considerable risks involved potential investors may not be attracted unless ways are found to reduce the inherent risks involved. This would be best achieved through the formation of a joint-venture involving partners across the whole supply chain.

10.9 Conclusion of the economic evaluation

- Initial analysis of production costs for 5 different scales of operation showed that production cost significantly fell with increasing scale. This was also confirmed by comments from manufacturers and the industry that economies of scale were crucial for competitiveness.
- Of the options considers, Option 4 – medium scale plant processing 60,000 tonnes of OSR – achieved the lowest production cost and at a level which was internationally competitive. A full 10-year cashflow was budgeted for this option.
- Sensitivity analysis was carried out which showed there were considerable risks involved. Of the variables considered, the full utilisation of plant capacity and the costs of feedstock (OSR) were shown to be the key factors affecting production costs. The next most critical factor was the value of the rapemeal by-product. The value of the glycerine by-product was not that significant. The capital cost and grant assistance had a modest impact on production costs. This stressed the importance of operating margins and efficiency over capital costs/grants.
- Investment appraisal analysis for the medium scale plant (option 4) showed an IRR of 14.1% with payback at the end of year 5. It was noted the value of the biodiesel produced had a major bearing on the overall project viability. If the price increased by only one pence/litre over the budgeted 41p, then the IRR increased to 18.9% with payback in year 4.

11.0 Farmer co-operation – structure & issues

11.1 Introduction to farmers' co-operatives

Scotland is home to some of the most innovative and successful agricultural co-ops in the UK. Their common purpose and shared investment enables producer members to respond to the challenges of the market place, with innovative products, systems and processes.

The result is that co-ops and their members in most sectors are expanding their market share and output. Changes to the Common Agricultural Policy is likely to result in another growth surge for co-operations, as most farmers join forces to secure profitability and sustainability from their market position.

Scotland has around 90 farmers' co-ops, and the table below sets out the size of sector. The figures are taken from audited accounts to financial periods ending at various dates during 2004.

Sector Summary	Throughput £'000	PBT £'000	SH Funds £'000	Employees	Members
Aquaculture	33,490	31	1,811	416	33
Cereals	486,387	1,207	22,964	279	6,391
Dairy	545,673	5,314	18,722	351	4,067
Fruit and Vegetables	10,621	49	468	8	1,316
Livestock Marketing	176,826	388	27,398	592	13,598
Machinery Rings	24,430	89	878	34	5,277
Organic	318	107	229	3	576
Pigs	73,748	12	749	23	310
Potatoes	20,215	(61)	1,986	30	180
Specialist Services	133,027	2,437	23,367	536	350
Supply	123,512	698	9,465	186	15,662
Timber	674	(6)	41	0	25
	1,628,921	**10,264**	**108,079**	**2,458**	**47,785**
Previous year's totals	1,353,119	7,361	96,107	2,363	46,924

The above table confirms that the sector is growing and is a significant employer in rural areas generating economic activity to the benefit of rural communities.

Co-operation is long established amongst farmers throughout the world, notably in European countries, the USA, Canada, Australia and New Zealand. Through their co-operatives, farmers in these countries have created global businesses and brands marketing a vast range of products. Familiar brands may include Tulip bacon from Danish Crown, cranberry juice from Ocean Spray, various islands cheeses from First Milk and Scotch Premier beef from ANM Group.

Co-operation has the ability to improve the profitability of farmers. Working together they may remove the requirement for intermediaries in supply and marketing chains, and ensure that markets work properly by preventing other companies from profiteering at the expenses of farmers, growers and other rural interests.

Capital, machinery and skills can be organised more effectively through co-operation, and over a period of time farmers can expect their co-ops to help them achieve one or more of the following:-

- Lower costs
- Provide competitive prices for their produce.
- Achieve a share in the added value to their produce
- Increase security of market access and payment
- Opportunities to supply new products
- Opportunities to supply new markets

Co-operatives are different from other forms of enterprise in that the primary purpose is to benefit members through their use of the co-ops facilities and services. Return on capital invested in the co-op, although important, is not the main purpose and is not the primary success measure for members. For example, farmers measure the effectiveness of their co-ops by the profitability of their farm enterprises, achieved by participation in their co-ops.

However, there are issues concerning farmers investing in their co-operatives, particularly downstream investment for adding value, where the investment required may be high and the margins available to add value to the primary product narrow. The main issue is the dichotomy between making the investment on-farm verses making the investment off farm. The question that is asked by farmers is: Will the investment off-farm provide me with a greater value to my primary product than the same investment on-farm?

11.2 Co-operative investment (in oilseed rape processing)

As can be seen in the previous table, 6,400 farmers have invested nearly £23 million of shareholder funds in processing and marketing of cereals. Processing concerns mainly drying and storage activities that traditionally can take place on the farm. The members of the Co-operatives: Highland Grain Ltd, Aberdeen Grain Ltd and East of Scotland Farmers Ltd, for example, have all made and continue to grow joint facilities which lower the cost of drying and storage, provide bulk shipments and excellent quality control. The total throughput figure of £486 million relates to the amount of grain marketed by these and other marketing-only co-operatives to include the vast bulk of grain that is dried and stored on-farm.

The investment that is required to process 60, 000 tonnes of oilseed rape of circa £10.2 million has to be seen in context of the above figures; in that, the tonnage processed is relatively low and the investment required is relatively high – approximately £170 per tonne. A farmer looking at the investment opportunity will calculate the cost of the investment directly against the potential value gain for his primary oilseed crop. If the potential value gain is calculated through lower haulage costs (£8) and a higher share of the EU Energy Crop Supplement (£2.75), a combined value of £12.75 per tonne, the return of circa 6% would be regarded as too low commensurate with the investments risk.

It is important to note that the actual business of processing and marketing of oilseed rape into other products such as biodiesel is not a farming business. It relates to different products that is not a natural extension of farm activity. Any profits that come from the processing and marketing function of biodiesel are not directly related to the farming activity. It is a separate business function and will be regarded as such by any organisation or person who invests in the business.

However, the above investment scenario is restricted to the farmer meeting the full costs of the investment; that rarely happens in practice. The real question for the farmer is – How little can I invest to ensure a plant is built and commits to taking my oilseed – a new market outlet - and pays a premium? In this case the farmer is looking to extend the Joint Venture to beyond that with only other farmers, and to include forms of finance and JV ownership with others who are able to process the product and market the output.

One of the main issues for a new venture such as Oil Seed Rape processing is building an effective structure. Each potential Joint Venture partner will have differing weightings on the components of an effective structure, for instance a venture capitalist will have an absolute focus on return on capital invested, while a banker will focus on having a strong asset cover over his lending. In general an effective Joint Venture structure will: -

- Deliver the purpose of business
- Ensure sufficient investment funds
- Encourage and reward participation & investment
- Create strong sense of member/share ownership and concern for success and the future
- Ensure active accountability and democracy
- Enable members of the business grow and realise their stake
- And for farmers, secure the services and benefits provided by the co-operative stake

In conclusion, any oilseed processing business is likely to be more successful if it is formed from a broad Joint Venture of interests, where one of the key stakeholder / investor groups are farmers, who are looking to secure a local outlet for their oilseed. This has to be balanced against other stakeholder / investor groups who may have business objectives that potentially conflict with those of the farmers. The fundamental business conflict is that the profitability of the processing business will increase when the oilseed feedstock can be procured at the lowest price.

Where the business planning process is driven by shareholder investors the objectives are weighted in favour of profitability / return on capital invested. Where the process is driven by farmers the objectives tend to be weighted towards achieving the best price for the primary produce feedstock.

There is a consistent body of work produced from around the world to try and solve this fundamental conflict. Arguably the most successful is what is called the 'New Generation Co-op' form of business that is used in the USA, Canada and New Zealand.

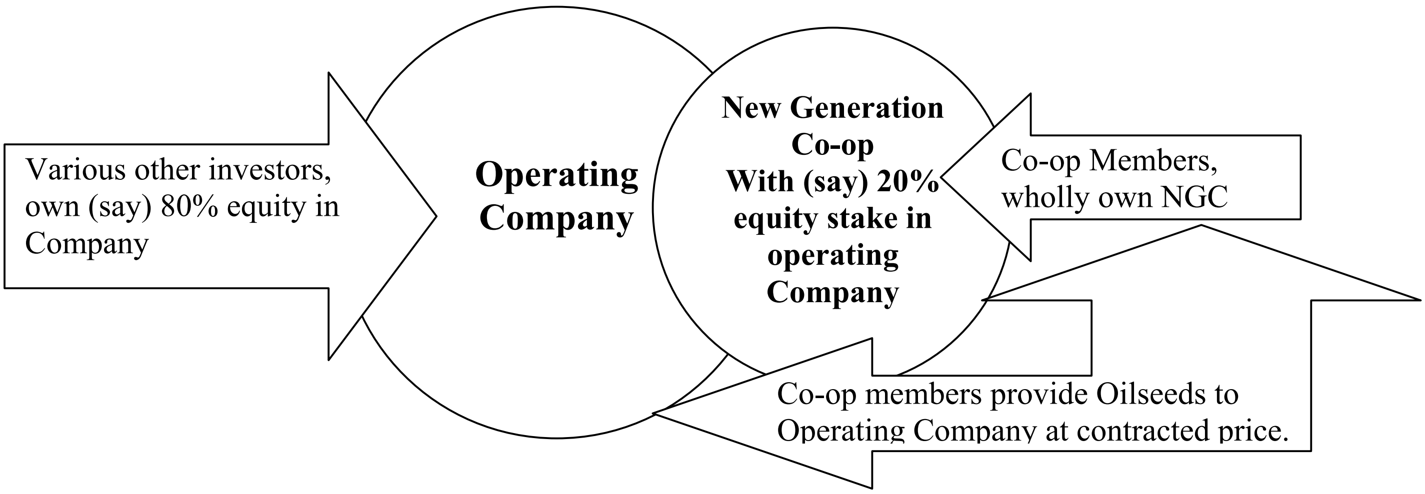
11.3 Description of the New Generation Co-op model

A New Generation Co-operative (NGC) is primarily designed to provide a mechanism for farmers to make a co-operative Joint Venture investment into a processing company. The NGC, as a separate Investment Co-operative, sets out a business plan to buy an equity stake in the processor that guarantees delivery rights for the primary product from farmers, in this case oilseed. Equity is raised from farmers who purchase 'delivery rights' to the processor for their oilseed. Profitability, beyond that available from the commodity market for the primary product, ensures a future value to the rights.

In some respects the process of raising and valuing NGC capital is similar to that of a rights issue in a company. The Co-op members make the judgement as to the value of the investment to their own farm business – the co-operative function: and to the potential future value from the investment in delivery rights – the capital function.

In the case of building an Oilseed Processing business that requires £10m of capital, the NGC might look to take, say, a 33% equity stake in the business. If £7.5m of the total capital were provided by way of various bank loans and grants, the cash cost of a 33% stake would be £838,000 – ie 25% of £2.5m. The cost to the farmer would therefore be £14 per tonne of oilseed delivered.

Figure 11.1 Illustration of a New Generation Co-op with stake in a separate processing company.



In this illustration, the Co-op is an investment vehicle in the Company for and behalf of members, and holds a contract with the company to deliver a specified tonnage of oilseed based on the delivery rights held with its members. Members of the Co-op receive a contracted price for their oilseed delivered to the company that may have bonus based on quality.

Company profits from its operations may provide a dividend both to the NGC and to its other investors. The dividend to the NGC is based on its equity stake. The NGC can decide how to deal with its dividend received, in some cases it may retain its dividends to later purchase a larger stake in the company and allow other equity partners an 'exit' from the company, or, it may simply pay its Members a divided, or patronage, bonus.

The operating Company has a board of directors as decided by its investors, usually a mix of executive & non-executive directors and would usually include a board representative from the NGC.

The Co-operative has its own board of directors as decided by its members. In the case above, the Co-op may not have an executive function other than that necessary to administer the contracts and any trade in Delivery Rights.

In conclusion, any new oilseed processing business should look carefully at the New Generation Co-operative model as a means to secure a core investment and oilseed feedstock for a Joint Venture operating company.

12.0 Discussion and recommendations

12.1 Fiscal policy and outlook

The Economic and Fiscal Strategy Report (EFSR) accompanying the 2005 budget para 7.41, states that "the Government considers that biofuels can offer significant and cost effective environmental benefits through reduced emissions of greenhouse gases from road transport, local air quality improvement and in the future, potentially contribute to the security of the fuel supply".

The UK has submitted the end of 2005 biofuel target to the EU Commission. It is 0.3% against the directive target of 2%. The Commission has powers to make biofuel use mandatory if a member state fails to take appropriate measures to introduce appropriate amounts of biofuels. The Commission is considering whether the UK has given an adequate reason for the shortfall of 1.7%. The UK government is therefore under pressure to raise biofuel production.

The Renewable Transport Fuel Obligation introduced in the 2004 Energy Act provides Government with the power to obligate transport fuel providers to ensure a proportion of their transport fuel sales are renewable. Consultations have been taking place between Government and the Oil companies over how this might take place. The obligation seems likely to fall on the oil companies and be calculated and enforced at the duty point. Some form of carbon accreditation may also be involved. Government is also examining the potential for fuel duty incentives for input based production as a means of encouraging biomass into conventional fuel production. This could involve the addition and processing of raw vegetable oil at the UK petroleum refinery (so-called hydrogenation) so cutting out the need for esterification. It is unclear how this would affect the validity of vehicle warranties and the performance of modern diesel engines.

Clearly Government is exploring a number of ways of raising the use of biofuels in the UK. The general view is that an announcement will be made this autumn. While the UK has the EU presidency it may wish to make a big announcement on the whole area of renewable energy sources. It is anticipated that any legislation would not come into place until 2007. There are differing opinions on what target the UK would set for renewable fuels. Many expect Government to adopt more realistic targets which would increase over time to the EU's target. While others believe Government will accept the EU's target from the onset – this may be less likely. Either way, by passing legislation, it effectively creates a real demand that has to be met. By taking this action, it effectively means Government passes the additional cost of adopting renewable fuels through the whole chain.

At present the tax break of 20p/l on biofuels is only guaranteed by Government on a rolling 3 year basis. This does cause investors concern as without a tax break biodiesel would not be competitive with mineral diesel. There is a view that the RTFO could be phased over 20 years and the tax break would be retained for the first say 7 years, thereafter reduced and phased out. The reality is, once the RTFO is legislated it forces the market to adopt biofuels therefore creating a real demand. It should be also noted that the inclusion of biodiesel at 5% is likely to only at most 1p/litre to the pump price, which is well within the normal variability. It is likely the biodiesel market will develop over two distinct phases, implementation of the RTFO, followed by a carbon accreditation scheme.

In terms of benefit to any proposed biodiesel plant, implementing the RTFO is better than the 20p/litre tax rebate.

12.2 Assessment of business opportunity

There are two distinct processes involved in biodiesel production from home grown OSR. The crushing process and the esterification plant. Each one could be viewed as an individual component and therefore a separate business opportunity.

Therefore a key question is which one provides the best return and wider benefits – crushing + esterification or a stand-alone esterification plant? Indeed many of the current business models are operating as only an esterification plant using a variety of vegetable feedstock based on comparative cost (e.g. the planned Greenenergy and Biofuel Corporation plants)

The following three pages summarises the pros and cons for the alternative combinations which provides a good overview of many of the key issues .

1. Stand alone crushing plant

2. Oilseed rape crushing plant + esterification plant

3. Stand alone esterification plant

1. **Crushing plant component**

PROS	**CONS**
❑ Major savings in transport costs for growers (£8-£12 /t) ❑ An indigenous plant capitalizes on Scotland's peripherality ❑ Replaces imported proteins for the livestock sector ❑ Two markets for oil → crude oil to RME plants or refined oil to Food industry – both growing demand. ❑ Prices and outlook for rape oil is good ❑ Adds value to primary produce ❑ Technology well developed and understood ❑ Creates rural employment ❑ Cheap protein feed will provide a major boost to Scottish livestock sector	❑ At this scale cannot justify solvent extraction → so higher production costs ❑ Crushing margins fluctuate widely ❑ May need to import OSR for crushing ❑ History against it –experience Arbroath plant ❑ Scottish ports lose business – currently main means of transport (60%)
OPPORTUNITIES	**THREATS**
❑ Could site at an existing grain store to reduce infrastructure costs ❑ Animal feed manufacturer to utilise full value of high oil rapemeal ❑ J-V with Farmer co-op and Animal Feed co ❑ Could invest in a RME plant at later date	❑ Competing & securing OSR supplies – will farmers support? ❑ Response by 2 MN giants – exert huge power in the market ❑ Future crushing margins negative ❑ Operating at full capacity ❑ Cheap imports from developing countries

2. Crushing plant + esterification plant

<table>
<tr><th><u>PROS</u></th><th><u>CONS</u></th></tr>
<tr><td>❑ Major savings in transport costs for OSR growers
❑ Market for biodiesel is growing and could be very large
❑ Scotland has a biodiesel facility – security of supplies
❑ Exploits full value of agricultural primary produce
❑ Technology well developed
❑ Creates rural employment (21+)
❑ Cheap protein feed will provide a major boost to Scottish livestock sector
❑ Replaces imported proteins for the livestock sector
❑ Fits well with SEERAD & SE strategy</td><td>❑ Requires higher level of capital investment
❑ Scale of operation still relatively small → so higher costs
❑ Competitively sourcing enough OSR from Scottish crop
❑ Rebate on fuel duty – 20p/l – is marginal to compete with mineral market in open market
❑ Scottish ports may lose business – currently main means of transport
❑ History against it –experience Arbroath plant
❑ Don't have the skills</td></tr>
<tr><th><u>OPPORTUNITIES</u></th><th><u>THREATS</u></th></tr>
<tr><td>❑ Government's decision on RTFO critical – legislation readily creates massive market
❑ J-V with Farmer co-op + Processor + Animal Feed co + Fuel Distributor
❑ Local Authorities source diesel requirements from plant
❑ Animal feed manufacturer to utilise full value of high oil rapemeal
❑ Local blending of biodiesel with regional fuel distributor
❑ Brand the biodiesel to differentiate
❑ Blend at higher inclusion rates with mineral diesel
❑ Spin-off to wider rural economy</td><td>❑ How oil majors react to RTFO crucial – they could compete with the 'hydrogenation' process
❑ Value of sterling £ - if high would make imports more attractive and exports difficult.
❑ Not operating at full capacity → leads to high unit costs
❑ Imports of biofuel – especially bioethanol
❑ Area of OSR declines in Scotland due to the economics of growing</td></tr>
</table>

3. Esterification plant only

PROS	CONS
❑ Probable provides best economic return to an investor ❑ Can draw on a wide range of potential feedstocks ❑ Market for RME is growing and likely to be massive ❑ Helps Scotland meet biofuel demand – security of supplies ❑ Technology proven ❑ Creates employment (11+) although not rural ❑ Must be located at port → creates business for Scottish port	❑ Unlikely to utilise Scottish produce so no added value ❑ Requires higher level of capital investment ❑ Scale of operation still relatively small → so higher costs ❑ Rebate on fuel duty – 20p/l – is marginal to compete with mineral market in open market ❑ moderate risk – good return ❑ Don't have the skills
OPPORTUNITIES	**THREATS**
❑ Utilises a variety of vegetables oils – inclusion based on cost ❑ Government's decision on RTFO critical – legislation creates massive market ❑ Local blending of biodiesel with regional fuel distributor ❑ J-V with Fuel Distributor ❑ High mineral oil prices make biodiesel more competitive without RTFO ❑ Could backward integrate into establishing own crushing mill	❑ vegetable oil supplies and price ❑ Exchange rates and value of sterling £ very important as likely reliant on imports of feedstock ❑ Competition from imports of cheap biofuels – particularly bioethanol ❑ How oil majors react to RTFO crucial – they could compete with 'hydrogenation' process ❑ Not operating at full capacity

Ranking the commercial opportunity for these three different businesses:

No detailed costings were carried out to evaluate these different businesses. Experience from the market suggest that OSR crushing is a volatile business being heavily dependent on the rapeseed price and rape oil value. This is an industry where large scale plants providing low unit costs to maximise returns is the norm. It is also an industry which is dominated by the large multinational players (eg Cargill, ADM).

At present, investment in the UK is taking place with esterification only plants (eg Northeast Biofuels & Greenenergy Fuels plants). This model relies on sourcing cheap vegetable oil on the world market. Rape oil is important to the food industry and has a relatively high value so unlikely to be used at high levels in esterification plant for biodiesel production.

Of the three alternative business models, a commercial investor would likely select the esterification option, however, this does not provide any direct benefit to farmers. Considering the wider objectives, a better option is a 'Hybrid' of crushing plus esterification (providing the return is acceptable). This establishes a medium scale OSR crushing mill (60,000t), however, the benefits of economies of scale and access to lower cost vegetable oils are achieved through having a larger capacity esterification plant – option 4. This plant structure fits in with the Scottish conditions and is nearer realisation.

Value of carbon accreditation

As part of the climate change agreement the Government have made a commitment for energy to be supplied from renewable sources. This ensures that the energy produced is from sustainable sources and deliver carbon savings. At present no carbon accreditation scheme operates for biofuels in the UK, but as the industry develops Government are expected to implement a scheme.

In the future a scheme as that applied to the generating electricity industry in the UK will be introduced. Generators of electricity have to comply with the Renewable Obligation and associated Renewable (Scotland) Obligation which came into force in April 2002 as part of the Utilities Act (2000). The obligation requires electricity companies to source 3% (in 2003) increasing to 10% by 2010, of their supply from renewable sources. Companies unable or unwilling to source their required amount of renewable energy have the option of buying in 'renewable obligation certificates' (ROC's) to meet their obligation. ROC's are therefore traded on the market with a value normally ranging in the £40 - £48 /ROC range.

Work carried out in Europe and the United States (source: Austrian Biofuel Institute, US National Renewable Energy) show that for every tonne of biodiesel made from virgin oil (OSR) a saving of 3 tonnes of carbon dioxode will result. Therefore the planned medium scale plant producing 29,300t of biodiesel would displace 87,900 t of carbon dioxide. It is likely that this saving in carbon would have a value in the future, and therefore provide an additional source of income to a biodiesel plant. At present the consultants are unable to estimate the potential value form carbon accreditation to the planned plant.

Could small farm-scale production ever be competitive?

There is considerable interest from Scottish farmers in small scale biodiesel production. In Ireland this scale of operation is currently being practised which begs the question could small scale operation ever be viable in Scotland? The earlier analysis clearly showed that production cost from small scale plants was not competitive. A number of strategies, however, could be adopted in attempt to close the gap and make small scale biodiesel production viable.

In a effort to illustrate the potential, production costs were re-calculated for option 1B – farm scale using 355t of OSR. Under previous assumptions the production cost of biodiesel for this option was 61.3p/litre. The following assumptions were changed as follows:

- FBDS grant of 50% reduced overall capital cost from £30,400 to £15,200.
- Repayment of capital would then reduce to £3,815
- Cost of OSR feedstock reduced by £10/t to £145/t to reflect own use
- Labour cost halved to £5,000
- Value of rapemeal increase by £10 to £100/t to reflect high oil content

Under these conditions the production cost would reduced by 15.5p to 45.8p/litre. At this cost the biodiesel would still not compete with red diesel (price reached peak of 38p/litre in 2005) but could be competitive with mineral diesel. If the biodiesel was for own use and therefore not incurring VAT, then the on-road price would be 72.9p/litre (see table below). Compared to the current mineral diesel price of 90-93p/litre (1st Oct 2005) this is a very attractive option. This scenario illustrates that under certain conditions small scale biodiesel is attractive, however, it must be stressed this is unproven and there is a need for further work to test these figures.

There would also be additional storage costs and administration involved. A farmer producing biodiesel would have to inform HM Customs & Excise and complete a registration form. Following successful registration, the producer would receive a monthly return to complete declaring production and use. HM Customs & Excise would then invoice the producer on a monthly basis to recover the fuel duty due.

	Value (p/l)
Production cost	45.80
Excise duty	27.10
Sub-total	72.90
VAT @17.5%	0
Price	**72.9**

Financing

Capital is required to establish a new OSR processing and biodiesel plant. This will have to cover plant, equipment, storage tanks infrastructure and to provide working capital. Investment in high risk businesses such as this, lenders are normally look for 50% equity with the balance from some form of debt finance. With appropriate strategies to reduce risk such as a sound business plan, firm contracts, NGC, turn-key construction costs and professional management, the equity proportion of the total financing package could be reduced. Securing appropriate grant assistance could further reduce this. In this case, the following funding has been proposed:

Table 12.1 Potential project financing mix

Type	%	Value
Equity	25	£2.55M
Grant	15	£1.55M
Debt	60	£6.10M
Total	**100**	**£10.2M**

It is important to secure access to sufficient working capital to allow the plant to operate effectively particularly in the first year. This would normally be arranged through a bank overdraft.

Term loans for new plant and equipment are generally repaid over 10 years. In this case an earlier repayment is considered desirable given the risks involved.

Size of Scottish market for biodiesel

Using the latest figures (2004) for UK transport fuel provided by the DfT and assuming Scotland would contribute 10% of the market, then petrol and diesel consumption in Scotland was estimated as follows:

Table 12.2 Estimated Annual Transport Fuel Demand in Scotland

Fuel Type	Annual use (t)
Petrol	1,906,000
Diesel	1,893,000

With the introduction of a compulsory RTFO, the demand for biodiesel at a range of targets is as follows:

Table 12.3 Scottish biodiesel demand at different RTFO levels

RTFO %	Biodiesel Demand (t)	% provided by plant
2	37,900	77.4%
3	56,800	51.6%
4	75,720	38.7%
5	94,650	31.0%
5.75	108,850	27.0%

The table shows that a medium scale plant producing 29,300 tonnes of biodiesel would satisify 27% of the Scottish market if the RTFO was applied at 5.75%. It should be noted that in theory, demand could be supplied from some other source of biofuel, for example imported bioethanol. The Argent plant at Motherwell will produce 44,000t when at full-capacity.

Potential demand from the six Local Authorities.

The following table shows the estimated annual demand for diesel from the six partner Local Authorities in the study. The estimate is provided both in terms of litres and tonnes.

Table 12.4 Estimated annual diesel use by Local Authority

Local Authority	Annual Diesel use (litres)	Equivalent in tonnes
Aberdeenshire	2,500,000	2,200
Angus	2,000,000	1,760
Fife	4,500,000	3,960
Highland	5,000,000	4,401
Moray	2,000,000	1,760
Perth & Kinross	3,500,000	3,081
Total	**19,500,000**	**17,162**

It shows the combined annual diesel use by the six Local Authorities is estimated at 19.5M litres or 17,162 tonnes. Using a 5% blend this would require 858 tonnes of biodiesel, or 1,716 tonnes from a 10% blend. If a 10% blend was used, this would take 6% of the production from the medium scale plant (produces 29,300t biodiesel).

12.3 RECOMMENDATIONS

The study makes a number of recommendations with action required on 2 principal fronts, namely;

- Support for the development of a medium scale plant in Scotland
- Support for pilot studies into small scale biodiesel schemes.

Medium-scale plant support

1. Raise awareness of business opportunity

The study shows there are benefits to farmers and the wider Scottish economy if an OSR processing and biodiesel plant was established in Scotland. The economic appraisal demonstrates there is a business opportunity which is commercially viable.

Local Authorities and Development Agencies need to raise the awareness of this opportunity amongst farmers and the wider business community. Effort needs to be taken to bring interested parties together. This is a role that the Partner Councils in the study should play.

2. Facilitate businesses to form a joint-venture company

There are significant risks involved for a medium scale plant however these could be considerably reduced through the formation of a joint-venture company. Ideally partners should be drawn representing different sectors in the chain. These could be:

- farmers co-operative - to ensure supplies
- processing business – to operate the crushing and esterification plant
- regional fuel distributor - to handle the blending and distribution
- animal feed compounder – to allow rapemeal to be utilised in Scotland

It is recognised it will be a considerable challenge to bring potential partners together to form a joint-venture company. Any action the Study Partners could take to facilitate this would be desirable.

3. Enlist support of SAOS and NFUS to gain farmer commitment

Securing farmers involvement and commitment will be a major step in levering other companies to invest in the project. SAOS and NFUS could play a key role in convincing farmers of the benefits of the project. The New Generation Co-operative (NGC) model provides a good mechanism to get farmers involved. There are many good examples in the United States, Canada and New Zealand to show the benefits for farmers. Whilst a medium scale plant requires feedstock of 60,000 tonnes of OSR, it is not imperative all this tonnage is provided from a NGC. If a NGC could provide a core, of say 10,000 – 20,000 tonnes, the balance could be sourced on the open market through the trade. Whilst offering considerable support to a Scottish industry, this approach allows the benefits of optimising cost efficiency by allowing some procurement on the open market.

4. Provide firm commitment to source biodiesel from plant

The attractiveness of the project would be greatly enhanced if all the Local Authorities involved in the study were able to underwrite a firm commitment to source their diesel requirements from an established biodiesel plant. They would not be expected to pay a premium over market rates but simply guarantee a core demand.

5. The biodiesel produced should be branded.

It would be desirable to differentiate the biodiesel produced by branding it and also blending it at a higher inclusion level (above the market norm of 5%). Both these actions have the advantage of providing something unique to help protect markets from competition. It would also contribute more to the 'green' credentials of the product through lower emissions. If Local Authorities sourced a 10% blend, it has the added advantage of doubling sales and would also provide Local Authorities with a real opportunity to promote their efforts towards improving the environment. One potential obstacle for a 10% blend would be securing vehicle manufacturers acceptance, to ensure engine warranty. This is not believed to be a major obstacle and is already happening in many cases.

6. Approach existing OSR and biodiesel processors

Many regional fuel distributors showed interest in the project and it clearly had a lot to attract this sector. It is not anticipated that it would be difficult to secure a partner to a joint-venture company from fuel distributors. Potentially the most difficult area will be to recruit a partner for the processing side of the business. There are few companies who have experience in this sector. Approaches should be made to existing OSR and biodiesel processors to gauge their level of interest.

Pilot studies into small-scale production.

7. Pilot studies of small scale biodiesel production

It is recognised that the development of a medium scale biodiesel plant will take time, establishment of a new business and considerable capital investment. In the meantime several, it is suggested possibly up to 6, small-scale plants could be supported through a series of pilot studies. Pilot plants could be situated at a number of points within the major growing areas of oilseed rape, possibly at existing farmer co-ops and in different Council regions. This would provide huge benefits to the development of biodiesel production in Scotland. It would also provide confidence to potential investors. There is a real need to gain experience and develop a better understanding of the technology, relationships and cost structures in this whole area.

Engineering aspects of running a biodiesel plant will be assessed. To develop confidence in the fuel produced and enable expansion of the market it will be essential that biodiesel produced is of a sufficient quality. A programme to monitor quality of the biodiesel produced from these micro plants will be implemented. These studies could be for a 2-3 year period with lessons learned through a series of regular reports and visits made available. It would be an advantage to involve an equipment manufacturer in the pilot study.

APPENDIX 1

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