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Lessons Learned from SO_2 Allowance Trading

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The most ambitious application yet undertaken of a market-based instrument for environmental protection has been for the control of sulfur dioxide (SO_2) emissions in the context of acid rain reduction under Title IV of the Clean Air Act amendments of 1990. That Act established an allowance trading program to cut SO_2 emissions by 10 million tons from 1980 levels—a 50% reduction. In this article, I identify lessons that can be learned from this grand experiment in economically oriented environmental policy.

The System and Its Performance

In Phase I of the allowance trading program, emissions allowances were assigned to the 263 most SO_2-emissions-intensive generating units at 110 power plants operated by 61 electric utilities, located largely at coal-fired power plants east of the Mississippi River. After January 1, 1995, these utilities could emit SO_2 only if they had adequate allowances to cover their emissions. The US Environmental Protection Agency (EPA) allocated each affected unit, on an annual basis, a specified number of allowances related to its share of heat input during the baseline period (1985-87) plus bonus allowances available under a variety of special provisions. Cost-effectiveness was promoted by permitting allowance holders to transfer their permits among one another and bank them for later use. Under Phase II of the program, which began on January 1, 2000, almost all electric power generating units were brought within the system. Certain units are exempted to compensate for potential restrictions on growth and to reward units that were already unusually clean.

The SO_2 allowance trading program has performed successfully. Targeted emissions reductions have been achieved and exceeded, and total abatement costs have been significantly less than what they would have been in the absence of the trading provisions. Trading volume has increased over the life of the program (Figure 1), and the robust market has resulted in an estimated cost savings of up to $1 billion annually, compared with the cost of command-and-control regulatory alternatives that were considered by Congress in prior years, representing a 30–50% cost savings.

The allowance trading program has had exceptionally positive welfare effects, with estimated benefits being as much as ten times greater than costs. It is notable that the majority of the benefits of the program are due mainly to the positive human health impacts of decreased local SO_2 and particulate concentrations, not to the ecological impacts of reduced long-distance transport of acid deposition. This contrasts with what was assumed at the time of the program's enactment in 1990.

Lessons for Design and Implementation of Tradable Permit Systems

The performance of the SO_2 allowance trading system provides valuable evidence for environmentalists and others who have been resistant to these innovations. It shows that market-based instruments can achieve major cost savings while accomplishing environmental objectives. The system's performance also offers lessons about the importance of flexibility and simplicity, the role of monitoring and enforcement, and the capabilities of the private sector to make markets of this sort work.

In regard to flexibility, tradable permit experience indicates that systems should be designed to allow for a broad set of compliance alternatives, in terms of both timing and technological options. Allowing flexible timing and intertemporal trading of the allowances—that is, "banking" allowances for future use—has played a very important role, much as it did in EPA's lead rights trading program a

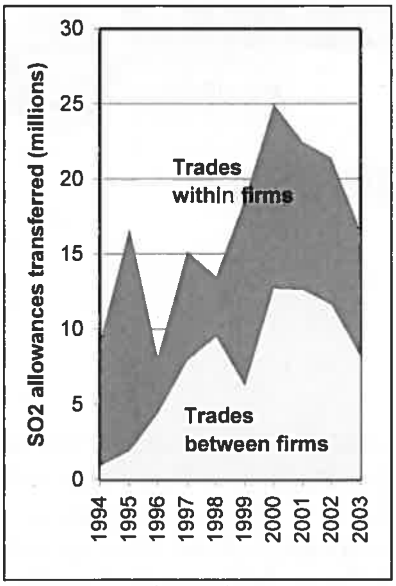

Figure 1. Trading volume in the SO_2 Allowance Trading Program.

Source: Based on data from USEPA "Trading Activity Breakdown" (see http://www.epa.gov/airmarkets/trading/so2market/transtable.html).

decade earlier. The permit system was based on emissions of SO_2 (as opposed to sulfur content of fuels), so that both scrubbing and fuel-switching were feasible options. Moreover, one of the most significant benefits of the trading system was simply that technology standards requiring scrubbing of SO_2 were thereby avoided. This allowed Midwestern utilities to take advantage of lower rail rates (brought about by railroad deregulation) to reduce their SO_2 emissions by increasing their use of low-sulfur coal from Wyoming—an approach that would not have been possible if scrubbers had been required.

In regard to simplicity, simple formulas for allocating permits based upon historical data have proven to be difficult to contest or manipulate. More generally, experience shows trading rules should be clearly defined up front without ambiguity. For example, there should be no requirements for prior government approval of individual trades. Such requirements hampered the EPA's Emissions Trading Program for local air pollutants in the 1970s, while the lack of such requirements was an important factor in the success of lead trading in the 1980s. In the case of SO_2 trading, the absence of requirements for prior approval reduced uncertainty for utilities and administrative costs for government and contributed to low enforcement and other program implementation (transactions) costs.

Considerations of simplicity and the experience of the SO_2 allowance system also argue for using absolute baselines—not relative ones—as the point of departure for tradable permit programs. The difference is that with an absolute baseline (so-called "cap-and-trade"), sources are each allocated some number of permits (the total of which is the "cap"); with a relative baseline, reductions are credited from a hypothetical baseline—what the source would have emitted in the absence of the regulation. A hybrid system—where a cap-and-trade program is combined with voluntary "opt-in provisions"—can also be undesirable because it would create the possibility for "paper trades," where a regulated source is credited for an emissions reduction (by an unregulated source) that would have taken place in any event. Relative baselines would have complicated the program and could have led to an unintentional increase in the total emissions cap.

The SO_2 program has also brought home the importance of monitoring and enforcement provisions. In 1990, environmental advocates insisted on continuous emissions monitoring, which helps build market confidence. The costs of such monitoring, however, are significant. On the enforcement side, the Act's stiff penalties—$2,000 per ton of excess emissions, a value more than 10 times that of marginal abatement costs—have provided sufficient incentive for the very high degree of compliance that has been achieved.

Another lesson involves permit allocation procedures. There are obvious political advantages of allocating permits without charge, as was done for the SO_2 program. But the same characteristic that makes such allocations politically attractive—the conveyance of valuable allowances to the private sector—also makes free allocations problematic. It has been estimated that the costs of SO_2 allowance trading would be 25% lower if permits were auctioned rather than freely allocated, because auctioning yields revenues that can be used to finance cuts in preexisting distortionary taxes. Furthermore, in the presence of some forms of transaction costs, the post-trading distribution of emissions—and hence aggregate abatement costs—are sensitive to the initial permit allocation. For both reasons, a successful attempt to establish a politically viable program through a specific initial permit allocation can result in a program that is significantly more costly than anticipated.

Finally, the SO_2 program's performance demonstrates that once a tradable system is established, the private sector can then step in to make it work. In the SO_2 context, despite claims to the contrary when the program was enacted, entrepreneurs provided brokerage needs, developed price information, matched trading partners, developed electronic bid/ask bulletin boards, and made available allowance price forecasts. The annual EPA auctions may have served the purpose of helping to reveal market valuations of allowances, but bilateral trading has also informed the auctions.

Lessons for Judging Effectiveness of Tradable Permit Systems

When examining the effectiveness of trading programs, economists have typically employed some measure in which gains from trade are estimated for moving from conventional standards to marketable permits. Aggregate cost savings are the yardstick best used for measuring success.

The challenge is to compare realistic versions of both tradable permit systems and likely alternatives, not idealized versions of either. It is not enough to analyze the cost savings in any year. For example, the gains from banking allowances should be considered (unless this is not permitted in practice). It can also be important to allow for the effects on technology innovation and diffusion, especially when permit trading programs impose significant costs over long time horizons.

More generally, it is important to consider the effects of the preexisting regulatory environment. The level of preexisting taxes can affect the total costs of regulation, as emphasized above. Also, because SO_2 is both a transboundary precursor of acid rain and a local air pollutant regulated under a separate part of the Clean Air Act, local environmental regulations have sometimes prevented utilities from acquiring allowances rather than carrying out emissions reductions. Moreover, because electricity generation and distribution have been regulated by state commissions, a prospective analysis of SO_2 trading should consider the incentives these commissions may have to influence the level of allowance trading.

Lessons for Identifying New Permit Trading Applications

Market-based policy instruments are now considered for almost every environmental problem, ranging from endangered species preservation to global climate change. Experiences with SO_2 trading offer some guidance as to when tradable permits are likely to work well and when they may face greater difficulties.

First, permit trading is likely to work best where there are wide differences in the cost of abating emissions. SO_2 trading is such a case. Initially, SO_2 abatement cost heterogeneity was great because of differences in ages of generating equipment and their proximity to sources of low-sulfur coal. When abatement costs are more uniform across sources, the political costs of enacting an allowance trading approach are less likely to be justifiable.

Second, the greater the degree of mixing of pollutants in the receiving airshed or watershed, the more attractive will be a tradable emission permit (or emission tax) system, relative to a conventional uniform standard. This is because taxes or tradable permits can lead to localized "hot spots" with relatively high levels of ambient pollution. This is a significant local or regional issue, and it can become an issue of overall consequence, as well, if damages rise more than proportionally with increases in pollutant concentrations.

Third, economic theory has taught us that the efficiency of a tradable permit system will depend on the pattern of costs and benefits. If uncertainty about marginal abatement costs is significant, and if marginal abatement costs are relatively constant, but the benefits of abatement fall relatively quickly at higher levels of abatement, then a quantity instrument (such as tradable permits) will be more efficient than a price instrument (such as an emission tax). The advantage of tradable permits is reinforced when there is uncertainty about both the marginal costs and the marginal benefits of pollution reductions, and these are positively correlated.

Fourth, tradable permits will work best when marketing and brokerage costs are low, and the SO_2 experiment shows that if properly designed, private markets will tend to render such costs minimal. Finally, considerations of political feasibility point to the wisdom of proposing trading instruments when they can be used to facilitate emissions reductions—as was done with SO_2 allowances and lead rights trading—as opposed to using these instruments only to lower the costs of achieving status quo emissions.

What about Greenhouse Gas Trading?

Many of these issues can be illuminated by considering the current interest in applying tradable permits to the task of cutting greenhouse gas emissions—largely carbon dioxide (CO_2) emissions—to reduce the risk of global climate change (for more on why this might occur, see the Fall 2004 issue of *Choices*). It is obvious that the number and diversity of sources of CO_2 emissions due to fossil fuel combustion are vastly greater than in the case of SO_2 emissions as a precursor of acid rain, where the focus can be placed on a few hundred electrical utility plants.

Any pollution-control program must face the possibility of "emissions leakage" from regulated to unregulated sources. This could be a problem for meeting domestic targets for CO_2 emissions reduction, but it would be a vastly greater problem for an international program, where emissions would tend to increase in nonparticipant countries. This also raises serious concerns with provisions in the Kyoto Protocol for industrialized countries to participate in a CO_2 cap-and-trade program while nonparticipant (developing) nations retain the option of joining the system on a project-by-project basis. As emphasized earlier, provisions in tradable permit programs that allow for unregulated sources to opt in can lower aggregate costs by substituting low-cost for high-cost control but may also have the unintended effect of increasing aggregate emissions beyond what they would otherwise have been. This is because there is an incentive for adverse selection: Sources in developing countries that would reduce their emissions, opt in, and receive excess allowances would tend to be those that would have reduced their emissions in any case.

To the limited degree that any previous trading program can really serve as a model for the case of global climate change, attention should surely be given to the tradable-permit system that accomplished the US phaseout of leaded gasoline in the 1980s. The currency of that system was not lead oxide emissions from motor vehicles, but rather the lead content of gasoline. So, too, in the case of global climate, great savings in monitoring and enforcement costs could be had by adopting input trading linked to the carbon content of fossil fuels. This is reasonable in the climate case, because—unlike in the SO_2 case—CO_2 emissions are roughly proportional to the carbon content of fossil fuels, and scrubbing alternatives are largely unavailable, at least at present. On the other hand, natural sequestration of CO_2 from the atmosphere—such as by expanding forested areas—is available at a reasonable cost (even in the United States), and is explicitly counted toward compliance under the Kyoto Protocol. Hence, it could be important to combine any carbon trading (or carbon tax) program with a carbon sequestration program.

Developing a tradable permit system in the area of global climate change would surely bring forth an entirely new set of economic, political, and institutional challenges, particularly with regard to enforcement problems. But, it is also true that the diversity of sources of CO_2 emissions and the magnitude of likely abatement costs make it equally clear that only a market-based instrument—some form of carbon rights trading or carbon taxes—will be capable of achieving the domestic targets that may eventually be forthcoming from international agreements.

Conclusion

Given that the SO_2 allowance-trading program became fully binding only in 1995, we should be cautious when drawing conclusions about lessons to be learned from the program's performance. But despite the uncertainties, market-based instruments for environmental protection—tradable permit systems in particular — now enjoy proven successes in reducing pollution at low cost.

Market-based instruments have moved to center stage, and policy debates look very different from the time when these ideas were characterized as "licenses to pollute" or dismissed as completely impractical. Of course, no single policy instrument—whether market-based or conventional—will be appropriate for all environmental problems. Which instrument is best in any given situation depends upon characteristics of the specific environmental problem and the social, political, and economic context in which the instrument is to be implemented.

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Advice on the Economic and Environmental Impacts of Government Support for Biodiesel Production from Tallow

E4tech

METROECONOMICA
Economic and Environmental Consultants

MILLER KLEIN

Report to the Department of Transport

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Executive summary

Tallow as a biofuel feedstock

The Government's Renewable Transport Fuel Obligation (RTFO) will come into effect in April 2008. It will require road transport fuel suppliers to ensure that, by 2010/11, 5% of total road transport fuel supply in the UK is made up of renewable fuels, equivalent to around 2.5 billion litres of fuel per year. Approximately 50% of renewable fuels used in 2010/2011 is likely to be made up of biodiesel and 50% bioethanol. Biodiesel can be produced from a variety of feedstocks, including virgin vegetable oils, used cooking oils and tallow (which is a by-product from the meat rendering industry).

Biodiesel made from tallow will qualify for certificates under the RTFO, and it is also a biofuel within the definition in the European Commission's Biofuels Directive.

Tallow is also used in the food, feed, medicinal and non-food sector, and some of the existing uses of tallow include:

- Oleochemicals
- Soap
- Bird Food
- Cooking
- Candles
- Steel Rolling
- Heating fuel
- Flux

Concerns have been expressed regarding the use of tallow as a biodiesel feedstock particularly with regard to its environmental benefits and its potential economic impact on certain sectors including the UK's oleochemical, speciality chemicals and cleaning product industries.

Aims of the project

This project examined these concerns with the objective of:

1. Establishing whether the Renewable Transport Fuel Obligations (RTFO), by supporting the production of biodiesel from tallow, will have adverse effects on the other industries, which use tallow as a feedstock.

2. Enabling the Government to consider whether changes need to, and could, be made to the design of the RTFO as the result of the above.

In order to accomplish these objectives, four specific tasks were developed:

Task 1: An understanding of the UK market for tallow

This task examined the current UK market, including the tallow supply chain in the UK; the major players in the tallow supply chain; and the major users of tallow in the UK. In addition, identification and understanding of the principal alternative feedstocks to tallow in the biodiesel and oleochemical, speciality chemicals and cleaning product industries was also undertaken. This work included discussions with key stakeholders who provided data that was used in the analysis undertaken in the project.

Task 2: An assessment of the impact of use of tallow in biodiesel on tallow price

This task examined the impact of increases in tallow price on other industries which use tallow as a feedstock. This used data collected as part of Task 1. The results from this review informed an analysis of key issues around the impact of the RTFO – the extent to which tallow prices are likely to have been affected by Government support for tallow as a biodiesel feedstock and the likely impact of the RTFO on the future price of UK tallow.

Task 3: An assessment of the impact of the RTFO on the UK oleochemicals, speciality chemicals and cleaning product industries

This analysis assessed the potential wider impacts of the RTFO on the supply of UK tallow, and the impact of the RTFO on the UK oleochemical, speciality chemicals and cleaning product industries. This included an assessment of the likely impact of the RTFO on the supply of UK tallow and an assessment of whether the RTFO is could lead to the diversion of tallow away from existing markets into biofuels.

Task 4: Assessment of whether the diversion of tallow into biodiesel from other industries will have a beneficial or harmful greenhouse gas impact

This analysis examined the wider sustainable development issues of the diversion of tallow from oleochemicals to biodiesel, specifically by examining the overall impact on greenhouse gas emissions. This is relevant in understanding the potential implications for tallow of the minimum GHG saving threshold for biofuels included in the draft Renewable Energy Directive.

Project team

This project was undertaken by a team of experts led by AEA Technology: Richard Miller (Miller-Klein associates), Nick Dale (Metroeconomica) and E4tech.

The Findings

The UK Tallow sector

UK tallow is a limited resource, the size of which is dependent predominantly on UK meat production. The only way to expand this resource is to import tallow from abroad. This is not simple. Imported tallow is expensive compared to UK tallow; in addition, the 'hub' for import of tallow into Europe is in Rotterdam and there is significant additional cost to importing this tallow into the UK. Effectively this limits the tallow available to the UK to around 250,000t/y, with some small additional import/export mainly centred around the import of Irish tallow. This situation is discussed in more detail in Chapter 2.

Currently **all tallow produced is used for some economic purpose**. None is disposed to landfill. (Figure 3 in Chapter 2 provides a breakdown of use). The main uses are dictated by the category of tallow under the Animal By-products Regulations[1]
Category 1 can only be used for burning or fuel production
Category 2 can be used for industrial applications
Category 3 can be used for human contact (e.g. in soaps and cosmetics).

This is a key influence on the current predominant uses: burning of (mainly category 1) tallow in boilers by the rendering industry to raise process heat and the use of category 2 and 3 tallow by the oleochemicals and soap industry. Other, smaller–scale uses involve power generation, biofuels production, animal feed and food.

The UK oleochemicals and soap sectors exist because of the historical supply of cheap tallow in the UK. If this feedstock increases significantly in price (relative to alternative feedstocks available abroad) or the supply of the feedstock diminishes, the sector is unlikely to exist in the UK. This is because export tariffs on alternative feedstocks (most notably palm oil) make production of oleochemicals and soaps from other feedstocks uncompetitive in the UK.

Alternative feedstocks for the key uses for tallow were examined:

- The rendering industry currently substitutes fuel oil (or natural gas) for tallow for generation of process heat and steam, depending on the relative prices of these fuels.
- The oleochemical and soap industry is more complex. For the major products the main alternative feedstock is palm oil, although for some chemicals mineral oils are more appropriate. The oleochemicals industry and the rendering industry provided information on the chemical processing of tallow to its various products and this is presented in Chapter 2.

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[1] See Chapter 2 for an explanation of these terminologies.

Tallow prices

The UK rendering industry and oleochemicals industry comprise relatively few organisations. Trade in tallow is not done on the open market, but as direct contracts between companies. Consequently much information regarding the use of tallow and its price is commercially sensitive and this study was unable to uncover precise data regarding tallow price. This means that the analysis undertaken had to be done on relative trends in prices and on ranges of tallow prices rather than actual prices; and that these figures were provided by the industry because there is no independent source of information on tallow prices.

However, some trends are clear. In the absence of subsidies the price of category 1 tallow is linked to fuel oil prices. As fuel oil prices increase the incentive to the rendering industry to use tallow in their boilers increases. Category 2 and 3 tallow prices reflect the trends in category 1 tallow, plus the additional cost of segregation and processing. The upper price of category 2 and 3 tallow is linked to the lowest equivalent virgin plant oil, minus the transport costs and any import or export tariffs. Price trends in tallow and other oils and fats relative to 2003 were provided by Uniqema. Other information on oils and fats prices was obtained from Oil World[2]. The prices of oils and fats have been climbing steeply recently and there is an indication that the tallow price is linked to these trends and is also rising. However, the nature of this link is not clear.[3] Prices and price trends for tallow are provided in Chapter 3. **If category 1 prices increase sufficiently this acts to disincentivise the production of the category 2 and 3 tallow and their availability decreases**. This situation has a significant effect on the oleochemicals and soap industry, for which alternative feedstocks are not available in the UK and, if this situation is sustained for any period, would result in the closure of a significant part of its production in the UK.

In the absence of clear prices, the analysis in this report (Chapter 4) focused on evaluating the likely effects of assumed price changes on decision making by relevant sectors and on identifying the price thresholds that lead to changes in decisions. In addition the likely impacts of meeting biodiesel blend targets on the feedstock demands of different sectors and the financial impact on the oleochemicals sector, if it had to pay specific prices for feedstock was also modelled.

Results of this work included:

- An examination of the theoretical maximum 'willingness to pay' of biodiesel producers suggests that with the current duty relief the production of biodiesel is already quite competitive with unblended diesel. This is a function of the current high whole sale price of diesel, but the introduction of further measures under the RTFO to incentivise supply of biofuels may have the effect of further increasing the attractiveness of producing biodiesel, including from tallow.

- Assuming the RTFO 5 per cent biofuel target was met through biodiesel analysis of the *least cost* solution (under the assumptions in the economic model) would be that biodiesel producers buy all the available domestic supply of tallow. This is likely to be supplemented by imports from Republic of Ireland and continental Europe. In this scenario, renderers would buy fuel to replace tallow used for energy; and the oleochemical industry would no longer be able to use any domestic tallow. Therefore, under this assumption (that biodiesel sector meets their feedstock demands at least cost and only then do other sectors buy any excess supply available), there is likely to be a significant diversion of tallow away from existing markets. Even if lower percentage targets were met the diversion effect would still be strong.

- In this situation, the increased prices for alternative feedstocks to domestic tallow would have significant effects on the oleochemicals industry.

- It must be remembered that this is a theoretical situation. The tallow-biodiesel refining capacity in the UK is low at present. However, biodiesel plants are not complex refining plants and it is possible to establish new ones relatively quickly, subject to planning. There is currently an application for a 150,000t/y biodiesel plant that would be able to take tallow as a feedstock.

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[2] www.oilworld.biz

[3] It could be related to a number of factors such as the oil price, the current shortage of certain foods and feed which has led to rising prices for agricultural commodities and the substitution of feedstocks in the presence of high prices, but this is speculation without hard evidence.

- The model suggests that at the current price of tallow (£150/t for category 1 assumed in this analysis), profits of renderers would be maximised when over half the production of tallow would be category 1 (which would all be used for in house energy by renderers), the rest being sold as category 3. As tallow prices increase a threshold would be reached above which it becomes more profitable for renderers to switch production to category 1 and away from category 2 and 3. In the model examined in Chapter 4, at or above £186/t for category 1 (after meeting in house energy demands), it becomes more profitable for renderers to sell all remaining tallow as category 1 and none as category 2 and 3, unless the price of Category 3 simultaneously increases to £367/t.
- The overall conclusion is that any price increases to category 1 tallow, which may be brought about by increased demand from the biodiesel sector given RTFO incentives or for other reasons, would result in a switch away from category 3 and towards category 1, all other factors being equal. The model indicated that the threshold where no category 2 or 3 tallow is produced in the UK was an increase of about 25 per cent in the current category 1 tallow price (to £186/t from the assumed current price of £150/t).

Socio-economic impacts

We have been unable to obtain sufficient information about the patterns of employment and value added for the alternative uses for tallow to do an in-depth analysis of socio-economic impacts. However, a crude analysis shows that switching tallow to biodiesel will have a net negative effect on employment, gross value added and the balance of trade.

The production of tallow biodiesel is a relatively simple process compared to production of oleochemicals and soap. The oleochemicals industry produces a wider range of products, using a greater variety of chemical transformations, and using a wider range of equipment. In contrast, the essence of a biodiesel plant is minimum complexity and greatest efficiency in producing a single product.

Uniqema estimate that there are over 200 people directly employed in the oleochemical and soap industries (Uniqema 2008). In addition, because of the complexity of their operations there are a large number of contractors and service providers also involved in these sectors. These jobs would be likely to disappear following a major shift of tallow to biodiesel production.

A plant producing about 125kT biodiesel/y would employ about 45-50 people (Argent 2008). There would also be jobs in support and service sectors, but these would probably be no more that the proportion of support and service sector jobs in oleochemicals and soap. Such a plant would use a slightly larger amount of tallow than the current UK oleochemical and soap industries (125kt versus 82kT)

The oleochemical and soap industries have exports of more than £30m p.a. If missing domestic capacity is replaced by imports, the oleochemicals sector has provided figures that indicate the net negative change in the balance of trade is of the order of £100m/y.

For this study we have focused on impacts in the UK and not tried to estimate or compare the net impacts on other economies, particularly Asia.

Overall there are measurable, but not large, socio-economic impacts from the switch of tallow from oleochemicals and soap to biodiesel.

Impact on GHG emissions of the diversion of tallow to biodiesel

The time scale and data available for this analysis restricted the potential for undertaking an in-depth 'cradle to grave' life cycle analysis of the use of tallow for biofuels or oleochemicals within this work. Instead two comparative scenarios were examined in which tallow was either used for biofuels or oleochemicals. These are described in detail in Chapter 5, together with a list of the assumptions inherent in each scenario. Essentially the scenarios were:

1. A scenario in which tallow is used for soap and oleochemicals production, with category 1 tallow being used by the rendering industry for fuel. It was assumed that biodiesel would be produced from palm oil in the UK[4] and palm oil would be transported by tanker to the UK.

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[4] Palm oil is not currently used in any great quantity to produce biodiesel in the UK. However, this scenario was justified on the basis that palm oil is the closest feedstock technically to tallow that could be used to replace tallow in any quantity; and it is the cheapest of the bio-oil feedstocks.

2. A scenario in which all tallow was diverted to biodiesel. It was assumed that soap and oleochemicals would be produced from palm oil in the Far East and transported by boat to the UK[5]. The rendering industry would need to use an alternative energy source and it was assumed that this would be fuel oil.

These scenarios are not strictly representative of what might happen, as is indicated in the footnotes and in Chapter 5. Consequently, they were subjected to a number of sensitivity analyses. These included examination of: the type of boiler fuel which replaces tallow when tallow is used for biodiesel; the type of fuel used by Malaysian soap and oleochemical manufacturers; the energy efficiency and relative mass of soap and oleochemical products transported; the amount of energy and chemicals required for biodiesel production from tallow; the type of process used to produce biodiesel.

The results of this analysis indicated:

- The most important sensitivity in the analysis is the fuel switching at the rendering plant. If displacement of tallow into biodiesel production results in the rendering industry using low sulphur fuel oil instead of tallow for fuel, there will be a significant net increase in GHG emissions (183kT of CO_2e in total, which is equivalent to 974 kg CO_2e/t tallow displaced). However, the overall result is very sensitive to the assumption about the fuel that is used as fuel oil. Some of the rendering industry can use natural gas, which would result in a net increase in GHG emissions, but lower than for fuel oil. If the rendering industry were to use a biomass fuel[6] then the GHG emissions would be much smaller and probably lower than the use of tallow for oleochemicals (depending on the influence of the other key assumptions, such as soap and oleochemical manufacture in South East Asia; international transport; tallow biodiesel production etc.). Before drawing conclusions about the impact of diverting tallow into biodiesel production would have on GHG emissions, it is necessary to gain a better understanding of two factors:
  - whether burning biomass (such as MBM) would be economically attractive for renderers and
  - whether biomass supply in the UK would expand to ensure all existing biomass demand is met.

- Thus there is a need for more data on what is actually happening at the rendering plant in order to ensure the calculation of GHG emissions from production of biodiesel from tallow is an accurate reflection of what is actually happening at the rendering plant. One way to take this into account is to update the default value with the RTFO[7] where the boundary could be expanded to ensure it takes account of any fuel switches which occur (i.e. the scope of the fuel chain could be expanded to take account of the fuel used) at the rendering plant. At the moment data on the fuel switching at the rendering plants is not sufficient to ensure that the reporting is representative of what actually happens at the plant. In the future the RTFO will be linked to carbon savings and this would provide an incentive to the rendering industry to use a low emission fuel at their plants. In order to encourage reporting of actual data (i.e. on the type of fuel used) the default assumption could be that low sulphur fuel oil is used. This would create an incentive on renderers to use another low-carbon fuel instead of tallow, particularly if credits under the RTFO were linked to a biofuel's GHG saving. It would also ensure the Renewable Fuels Agency was aware of what impact the RTFO was having on the market for tallow.

- The other sensitivity analysis undertaken indicated that the other factors examined (i.e. the type of fuel used to provide process heat in soap and oleochemical manufacture, the assumptions made about international transport and the assumption that biodiesel plants require the same energy and chemical inputs regardless of their feedstock) all make a difference to the GHG emissions, but it was concluded that none of these influence the overall conclusion of the main analysis.

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[5] Not all oleochemicals produced from tallow could use palm oil as a replacement feedstock. In some cases mineral oils would be needed. However, palm oil is the closest feedstock to tallow in its chemical properties and a significant proportion of oleochemicals and soaps could be made using palm oil. In addition the oleochemicals sector indicated that in the absence of tallow it is likely that production would shift to palm oil in the Far East.

[6] For example, the rendering industry have indicated an interest in developing MBM as a fuel for their rendering plants. This would take some investment, as the burning of some grades of MBM is strictly controlled. In addition MBM is used as a fuel in other sectors and the substitution of fuels in these sectors would need to be considered. Analysis of this use involves speculation about future possibilities and so it was not examined further in this work.

[7] See: http://www.dft.gov.uk/rfa/reportsandpublications/carbonandsustinabilityguidance.cfm

- A further sensitivity relates to biodiesel production technologies. The analysis assumes that all biodiesel is produced using a conventional trans-esterification process. However, other processes exist which may be able to convert fats and oils to diesel more efficiently. Several companies are, for example, developing hydrotreatment processes which can use tallow (and vegetable oils) to produce a fuel which is very similar to mineral diesel (e.g. Neste's NExBTL process, ConocoPhillips' RenewDiesel process). Analysis undertaken for the companies developing these technologies (e.g. IFEU, 2006) indicates that hydrotreating processes would lead to a biodiesel with higher GHG savings than conventional FAME. However, the analysis carried out above would not be particularly sensitive to the choice of processing technology – since the same technology would have to be used in both scenarios.

Other Environmental impacts

To obtain a balanced understanding of the full environmental impact of switching tallow from oleochemicals to biodiesel it is also important to consider other environmental impacts from the use of tallow in the oleochemicals or biodiesel industry. We were unable to gather clear data on potential environmental impacts from the processing of tallow to oleochemicals or biodiesel to allow comparison between the two routes. Such impacts could arise from additional emissions to air, soil and water from the processing of tallow, the production and disposal of by-products. We do not have clear evidence that these emissions would be significantly higher from the oleochemical or biodiesel use of tallow.

This leaves consideration of their respective roles for recycling or reusing residues and the value of the co-products: do these processes create useful products and does the processing result in co-products that are wastes or have any environmental impact?

The use of tallow both in the oleochemicals and the biodiesel sector represents the production of a new product from a by-product of the rendering industry and both processes represent recovery of value from tallow, as defined in the EC interpretation of the definition of wastes (EC 2007). It could be argued that the use of tallow for oleochemicals represents recycling and the use for biodiesel represents energy recovery. Indeed the oleochemicals industry argues that its products represent processing further up the waste hierarchy, as defined in the UK Waste Strategy (Defra 2007), which is true. This does not represent an argument for better environmental impact *per se*. To do this the whole environmental impact needs to be considered, including all emissions from processing and the disposal or use of by-products. Within the scope of this study it is not possible to do this.

Key questions

There are a number of key questions that also need to be considered:

1. What impact will development of novel technologies and second-generation processing have on biodiesel in the longer term?
2. Does the RTFO unduly encourage one use of tallow over another?
3. If the RTFO were to be modified to create a level playing field for all users of tallow, would the oleochemicals industry be able to survive until this happened?
4. How could the RTFO be modified to avoid these problems, in a manner consistent with the EU and international legislation?
5. To what extent are the problems faced by the oleochemicals industry due to current high tallow prices as opposed to wider, global economic factors?

1. What impact will development of novel technologies and second-generation processing have on biodiesel in the longer term?

The economics of first-generation technology currently used to produce biofuels around the world are heavily dependent on feedstock costs. This means that production costs can only be kept down if feedstock costs are low. As a result there is considerable pressure on the cheapest feedstocks. There are a number of technologies being developed to allow the production of biofuels from lignocellulosic feedstocks. The impetus behind this development is twofold: they allow the use of wastes and feedstocks that currently have little value or use; and they enable more sustainable or more efficient land use. Unfortunately these processing technologies are currently expensive and technological development is still required. However, there are second generation demonstration plants in operation and more demonstration plants are planned.

Many analysts predict this technology will be available within the next five to 15 years. Once the technology is in operation it may supersede first generation technologies in regions such as Europe where feedstock costs are high. Consequently the current methods for producing biodiesel may be phased out in favour of more advanced technology in Europe in the long term.

Marine algae are also being explored as a longer term source of oil for processing into fuel and chemicals. Many of the oil and energy companies have research programmes in this area, as algae are believed to offer the potential for much higher conversion of primary photosynthetic products into oil compared to land crops.

2. Does the RTFO unduly encourage one use of tallow over another?
The analysis in this report demonstrates that the RTFO makes the production of biodiesel from tallow attractive and increases the biodiesel producers' willingness to pay for tallow. This provides an incentive to produce more category 1 tallow and not to produce category 3 tallow unless its price rises substantially, too.

3. If the RTFO were to be modified in the future to create a level playing field for all users of tallow, would the oleochemicals industry in the UK be able to survive until this happened?
There is no cheap alternative feedstock that the oleochemicals industry can use in the UK if tallow is diverted to biodiesel. It is likely that even a relatively short term switch to biodiesel would have a significant impact on the survival of the oleochemicals industry in the UK.

4. How could the RTFO be modified to avoid these problems in a manner consistent with EU and international legislation?
For feedstocks such as tallow that already have existing applications the RTFO should take into account the effect of substitution on the overall sustainability of switching to biofuels production, particularly on GHG emissions. The Govt should consider the implications of this carefully, particularly in the context of the proposed shift to a carbon-linked RTFO

5. To what extent are the problems faced by the oleochemicals industry due to current high tallow prices as opposed to wider, global economic factors?
The oleochemicals industry is facing a number of problems at the moment, including competition from products from the palm oil industry in the Far East. Biofuels are not solely to blame for the problems faced by the oleochemicals industry – they are part of a much bigger picture. However, feedstock costs are a significant proportion of costs for the oleochemicals industry and the industry exists in the UK because historically there has been a supply of cheap tallow. The significance of feedstock costs in the oleochemicals business model means that it is particularly vulnerable to increase in feedstock costs. In addition, it is difficult for the industry to pass these prices onto its customers in the current competitive environment. Consequently, tallow prices are not the only factor affecting the oleochemicals industry but they will have important consequences. At the moment palm oil prices are also high (both in the UK and the Far East) but any price rise for tallow, relative to the price of palm oil, would be difficult for the oleochemicals industry.

Conclusions

- The RTFO is likely to increase the maximum price biodiesel producers are willing to pay for tallow. Depending on prices of alternative feedstocks this may result in diverting supplies from current uses **but the economic analysis suggests that this could result in any case with or without the RTFO.**
- One of the consequences of increased prices for category 1 tallow is likely to be a reduction in availability of category 2 and 3 tallow.
- Tallow is relatively cheap compared to other biodiesel feedstocks. This means that if biodiesel producers only use price to decide which feedstock to use, tallow is very attractive. If the refining capacity was available tallow would be a significant source of biodiesel in the UK.
- Tallow biodiesel refining capacity in the UK is currently met from only one plant, which has a capacity of 45kT/y. According to our figures only 17kT/y are currently used for biodiesel. This situation will change in the future if the proposed Ellesmere Port plant is developed. This plant has a proposed capacity of 150kT/y. This means that although tallow is an attractive feedstock for biodiesel, the refining capacity currently limits the amount of biodiesel that can be produced from tallow. However, developing biodiesel plants is relatively straight-forward and can be done relatively quickly.

- The current high prices for mineral diesel acting together with the RTFO could divert a significant proportion of tallow into biodiesel production (with the caveat that tallow-biodiesel refining capacity is currently limited, as indicated above). Tallow is the major feedstock for the UK oleochemical and soap industry. Diversion of this feedstock to another use would remove tallow as a feedstock for the oleochemicals and soap industry in the UK and could result in a significant shift of UK oleochemical production to the Far East.
- The environmental impact of the shift from the current uses of tallow to biodiesel production is 'negative' in terms of GHG emissions, although this conclusion is dependent on the fuel substituted for heat production at the rendering plant. This is an important consideration in the sustainability of using tallow for biodiesel production.
- All tallow produced in the UK is currently being used. If tallow is switched to biodiesel production, alternative feedstocks are required for the other tallow uses. These feedstocks are likely to be fossil oils or imported vegetable oils. The sustainability of this switch should be considered in more depth.
- The economic impacts of switching tallow from oleochemicals to biodiesel in the UK requires more in depth analysis. From the data we have it appears that there will be a loss of income from oleochemicals exports and a need to import oleochemicals, which are not compensated by the decreased need to import diesel. If this is correct it would result in a negative impact on the balance of trade.
- From the information we have obtained the social cost of the shift of tallow from oleochemicals to biodiesel is a net reduction in jobs.
- If the RTFO is to result in more environmentally sustainable transport fuels it is important that indirect impacts are considered. In the case of wastes that have existing applications the impact of the switch to biofuels on the overall environmental emissions must be considered as part of the calculation of net GHG emission reductions.
- The oleochemicals industry in the UK is facing a number of problems, including increased competition from the Far East. Biofuels are not solely to blame for the problems faced by the oleochemicals industry – they are part of a much bigger picture. However, from the analysis presented in this report, it is clear that demand for tallow for biodiesel could contribute to the problems, although there is not very much direct evidence that this is happening at present.

Recommendations

There are three main recommendations from this report:

1. Our analysis shows that, from a GHG perspective, the use of tallow as a biofuel results in greater emissions. This finding is dependent on the assumptions made in the analysis. A sensitivity analysis of these assumptions indicated that only one of these assumptions would make a significant difference to this outcome, and this is the fuels used as a substitute for tallow in boilers at the rendering plants. If a biomass fuel such as MBM were used for these boilers rather than the fossil fuel used in our analysis a much better GHG balance is achieved. However, this depends on the source of the MBM and how it is used. To take this into account we recommend that **the scope of the RTFO Carbon Reporting methodology could be expanded to ensure it takes account of any fuel switches which occur at the rendering plant**, i.e. the scope of the fuel chain could be expanded to take account of the fuel used at the rendering plant. At the moment data on the fuel switching at the rendering plants is not sufficient to ensure that the reporting is representative of what actually happens at the plant. In the future the RTFO will be linked to carbon savings and this would provide an incentive to the rendering industry to use a low emission fuel at their plants. In order to encourage reporting of actual data (i.e. on the type of fuel used) the default assumption could be that low sulphur fuel oil is used. This would provide a default that reduces the incentive for a renderer to burn fuel oil, particularly when the RTFO is linked to a biofuel's GHG saving. It would also ensure the Renewable Fuels Agency was aware of what impact the RTFO was having on the market for tallow.

2. The revised Renewable Energy Directive proposes that certain more sustainable feedstocks such as wastes will be regarded as more sustainable.[8]

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[8] The text is designed to encourage second generation biofuels and states: 'In order to demonstrate compliance with national renewable energy obligations the contribution made by biofuels from wastes, residues, non food cellulosic material and ligno-cellulosic material shall be considered to be twice that made by other fuels'. This has been interpreted by some stakeholders to mean that tallow-biodiesel will be rated more highly than other biofuels.

The approach makes no provision for displacement impacts or other indirect effects. Our work has shown that it is important that substitution and indirect impacts are included in the environmental sustainability criteria used to assess biofuels. **We recommend that the Government should draw attention to the likely impacts of the proposed double reward for certain types of biofuels including biodiesel produced from tallow.**

3. The UK cannot act unilaterally. **It is important to share the findings of this research with the European Commission and other Member States.**

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Appendices

Acknowledgements

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1 Introduction

1.1 Tallow as a biofuel feedstock

The Government's Renewable Transport Fuel Obligation (RTFO) will come into effect in April 2008. It will require road transport fuel suppliers to ensure that, by 2010/11, 5% of total road transport fuel supply in the UK is made up of renewable fuels, equivalent to around 2.5 billion litres of fuel per year. Approximately 50% of renewable fuels used in 2010/2011 is likely to be made up of biodiesel and 50% bioethanol. Biodiesel can be produced from a variety of feedstocks, including virgin vegetable oils, used cooking oils and tallow; a by-product from the meat rendering industry.

Biodiesel made from tallow will qualify for certificates under the RTFO, and it is also a biofuel for the purpose of the European Commission's Biofuels Directive. The Biofuels Directive is to be superseded by a new Renewable Energy Directive, proposals for which were published in draft on 23 January, 2008. The Directive includes proposed sustainability criteria, which is that Member States must not support biofuels which do not offer at least a 35% saving in GHG emissions relative to fossil fuels. If tallow-based biodiesel were found not to meet this criterion, it might be excluded from incentives even though it met the biodiesel definition. Annex VII of the Directive refers to typical and default GHG savings for waste and animal oil biodiesel (it gives a figure of 83% for the typical value and 77% for the default value).

Tallow is also used in the food, feed, medicinal and non-food sector, and some of the existing uses of tallow include:

- Oleochemicals
- Soap
- Bird Food
- Cooking
- Candles
- Steel Rolling
- Heating fuel
- Flux

Concern has been expressed that using tallow as a biodiesel feedstock offers no net environmental benefits and will have an adverse economic impact on certain sectors for example the UK's oleochemical, speciality chemicals and cleaning product industries.

1.2 Aims of the project

This project examined these concerns with the objective of:

- Establishing whether the Renewable Transport Fuel Obligations (RTFO), by supporting the production of biodiesel from tallow, will have adverse effects on the other industries, which use tallow as a feedstock.

- Enabling the Government to consider whether changes need to, and could, be made to the design of the RTFO as the result of the above.

In order to accomplish these objectives, four specific tasks were developed:

1. **An understanding of the UK market**
   To set the context for the project an understanding of the current UK market was necessary. This included the tallow supply chain in the UK; a summary of the major players in the tallow supply chain and of the major users of tallow in the UK. To further understand the impact of the RTFO on the industries, an identification and understanding of the principal alternative feedstocks to tallow in the biodiesel and oleochemical, speciality chemicals and cleaning product industries was also examined.

2. **An assessment of the impact on use of tallow in biodiesel on tallow price**
   Increases in tallow price could clearly have adverse effect on other industries which use tallow as a feedstock. To examine this, an assessment of the impact of use of tallow in biodiesel on tallow price was conducted. This used data collected as part of the task above.

The results from this review informed an analysis of key issues around the impact of the RTFO – the extent to which tallow prices are likely to have been affected by Government support for tallow as a biodiesel feedstock and the likely impact of the RTFO on the future price of UK tallow.

3. **An assessment of the impact of the RTFO on the UK oleochemical, speciality chemicals and cleaning product industries**
   This assessed the potential wider impacts of the RTFO on the supply of UK tallow, and the impact of the RTFO on the UK oleochemical, speciality chemicals and cleaning product industries. This included an assessment of the likely impact of the RTFO on the supply of UK tallow and an assessment of whether the RTFO is likely to lead to the diversion of tallow away from existing markets into biofuels.

4. **Assessment of whether the diversion of tallow into biodiesel from other industries will have a beneficial or harmful greenhouse gas impact**
   This part of the work examined the wider sustainable development issues of the diversion of tallow from oleochemicals to biodiesel, specifically by examining the overall impact on greenhouse gas emissions. This is particularly relevant in understanding the potential implications to tallow if the future Renewable Energy Directive mandates greenhouse gas emissions from biofuels.

1.3 Project team

This project was undertaken by a team of experts lead by AEA Technology:

- Richard Miller (from Miller-Klein associates) led the data collection and review for Tasks 1, 2 and 3
- Nick Dale from Metroeconomica led the analysis in Task 3.
- E4tech led Task 4.

1.4 Structure of report

The report is structured along the same lines as the tasks described above:

Chapter 2 provides the context for the use of tallow in the UK and includes the data collected in Tasks 1 and 2 of the work.

Chapter 3 examines the evidence for the impact of biodiesel development on the price of tallow

Chapter 4 describes the analysis undertaken in Task 3 to examine the impact of the RTFO on the oleochemical, speciality chemicals and cleaning product industry in the UK

Chapter 5 presents the analysis of the greenhouse gas emissions

Chapter 6 presents the discussion and conclusions

Chapter 7 presents the recommendations.

2 Task 1 - Understanding of the UK Market

2.1 Tallow Definition

Tallow is an animal fat obtained by rendering animal carcases and waste from the food industry. Like vegetable oils, tallow is a triglyceride (Figure 1). A triglyceride consists of a three carbon glycerol head group (shown in red) to which are added three fatty acid chains. All triglycerides have the same basic structure, and the differences in properties and use of commercial triglycerides depends entirely on the length, degree of unsaturation and other chemical modifications to the fatty acid chains.

Figure 1 **Structure of a triglyceride**

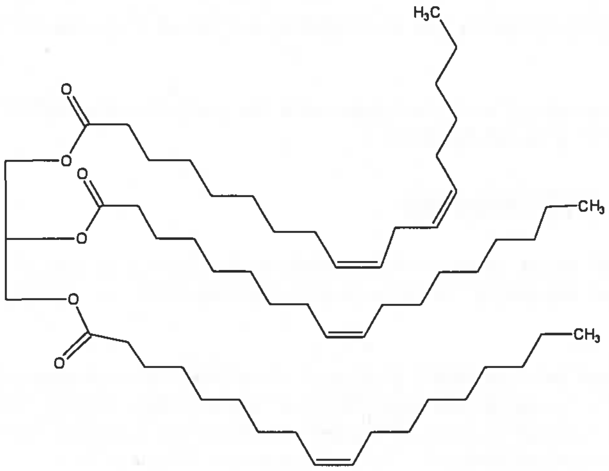


Table 1 **Percentage distribution of fatty acids in commercial oils and fats**

Fatty acid	Beef tallow	Palm	Rape	Soya	Palm Kernel	Coconut
C8					3-4	8
C10					3-4	7
C12					48	48
C14	2-6	0-2	0-2		16	16
C16	24-37	32-45	1-5	12	8	9
C16:1	2-4					
C18	14-29	2-7	0-3	5	2-3	2
C18:1	26-50	38-52	50-66	26	15-16	7
C18:2	1-5	5-11	18-30	50-57	2-3	2
C18:3	0-2		6-14	8		
C20			0-1			
C20:1			0-5			
C22			0-1			
C22:1			0-5			

Table 1 shows the typical percentage fatty acid distribution in several commercial oils and fats. The fatty acids are described in terms of the number of carbon atoms in the chain and the number of double bonds, or the degree of unsaturation, in the chain. C18 represents a fatty acid with 18 carbons and no double bonds. C18:1, 18 carbon atoms and one double bond. These distributions are important because they define the applications for which the oils and fats are most suitable. For example, palm kernel oil and coconut oil are richer in shorter chains and are extensively used to make surfactants, whereas tallow, rape and palm have a good distribution for making diesel.

The closest vegetable oil to tallow is palm. Rape and soy have less C16 and a lot more polyunsaturated fatty acids. Fatty acid distribution is important in thinking about substituting vegetable oils for tallow in industrial applications.

2.2 The Rendering Process

Rendering is a straightforward process in which animal carcases and trimmings are crushed and heated. This process drives off the water, sterilises the material and allows it to be separated into the fats (tallow) and meat and bone meal (MBM).

Raw materials are all the unusable parts of a carcass, including bones, internal organs and trimmings. Raw materials are collected for processing from abattoirs and from butchers and food processing sites.

Rendering is an energy intensive process and the industry has traditionally used some of the tallow it produces as fuel.

The industry has undergone substantial consolidation over the years as have abattoirs. The current membership of the UK Renderers Association is given in Appendix 1.

2.3 Tallow Categories and Grades

Following the BSE crisis, three categories of tallow were defined based on the source of the raw materials. These also defined the applications the tallow could be used for (Defra 2001, Animal By-Products Regulations 2005):

Category 1 is very high-risk material and must be completely destroyed. It includes the carcases of animals suspected or confirmed as having a transmissible spongiform encephalopathy (TSE), the carcases of zoo and pet animals, particularly hazardous parts of the animal, known as Specified Risk Material (SRM), and catering waste from international transport. This category can be used for:
- Fuel.

Category 2 is also high-risk material (e.g. diseased animals, animals which die on farm and which do not contain SRM at the point of disposal). This category can be used for:
- fuel;
- production of tallow derivatives for technical use only.

Category 3 Any material which has previously been fit for human consumption, such as catering waste. This category can be used for:
- fuel;
- pet food production;
- production of tallow derivatives.

In addition to the three categories, tallow is graded in terms of quality. The two key grades for the UK market are:
- grade 2 – high quality, low colour, used for demanding applications such as soap;
- grade 6 – low quality, highly coloured, used for technical applications.

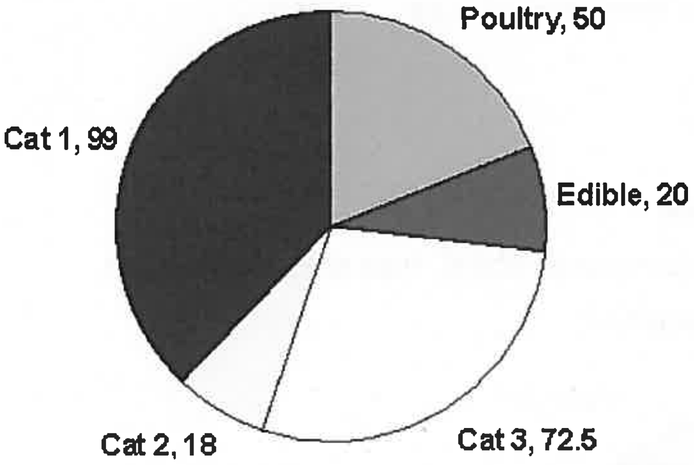
2.4 Tallow Availability

The industry processes the by-products of approximately 2 million cattle, 10 million pigs, 14 million sheep and 800 million chickens annually. Approximately 2 million tonnes of animal by-products are processed.

Estimates of the amount of tallow produced range from 200kT p.a. to 290kT p.a. depending on the definition of what is included and the reference year (Argent Energy, 2008; CIA2008; UKRA 2008; Uniqema 2008). The consensus is that 220 – 240 kT is available in principle for industrial use.

Uniqema (2008) provided the breakdown for tallow production in shown in Figure 2:

Figure 2 **UK Tallow Production**



Category 3 tallow comprises 49.5 kT/y. grade 2 and 23 kT/y. grade 6. All of the category 2 tallow is grade 6.

Other information sources gave different details on the split of production, but these were not substantially different from the above.

Apart from the legal requirements, renderers have some choices about which categories of tallow to produce. Their goal is to maximise the return from the various grades of product they produce. There are costs associated with segregating material into the three categories, and depending on the prevailing market price, renderers may choose to downgrade material that could be category 2 or 3 into category 1.

With increasing value of category 1 tallow as a fuel, there has been a significant fall in the amount of category 2 and 3 tallow being produced (Argent Energy 2008, Uniqema 2008)

Rendering of animal by-products also yields MBM, and currently approximately 400 kT p.a. is produced in the UK.

The amount of tallow produced in the UK has been stable for a number of years. It is governed by the size of the national herds and flocks, and is unlikely to change significantly in the foreseeable future.

Production of tallow in the EU totals approximately 2.5 MT p.a. (Agent Energy 2008). There are estimated to be about 14 MT p.a. of tallow available globally.

2.5 Imports and Exports

Category 3 tallow may be exported. Last year 37 kT were exported; 30 kT to the EU and 7 kT outside the EU. Of that about 17 kT was poultry fat for use in pet food (UKRA 2008). Uniqema estimated that 15 kT of poultry fat was exported for pet food, 23 kT of category 3 for soap and industrial applications, and an additional 5 kT of category 1 for burning (Uniqema 2008). The Chemical Industries Association estimated 30 kT of exports.

About 30 kT of tallow is also imported, from continental Europe (6 kT of Category 2 grade 6) and from Eire (8 kT of Category 3 grade 2 and 17 kT of Category 3 grade 6) ([Uniqema 2008).

Tallow could in principle be imported directly from both North and South America. However, this is not done at present due to costs, and the availability of tallow from other sources.

The flow of imports and exports is governed by mismatches in the supply and demand for the various categories and grades, the market prices both in the UK and in Europe, and the cost of transportation.

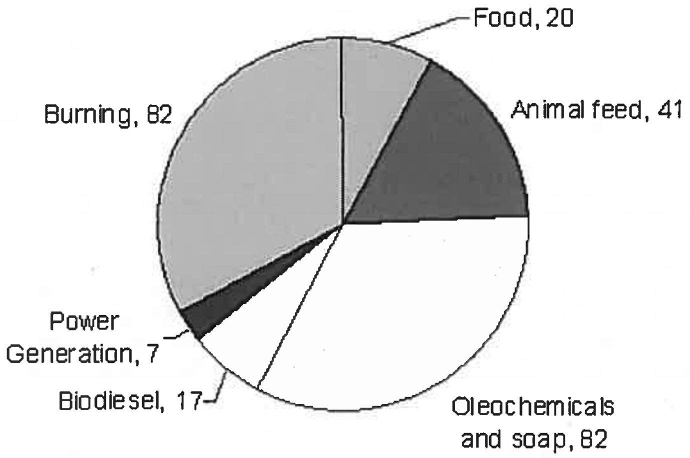
2.6 Tallow Uses

Tallow can be used in a several ways. The key applications are:

- human nutrition
- animal feed
- oleochemicals and soap
- biodiesel
- power generation
- burning for process heat and power

The current UK uses are shown in Figure 3 (Uniqema 2008). These figures exclude exports.

Figure 3 Uses of tallow in the UK (kT p.a.)



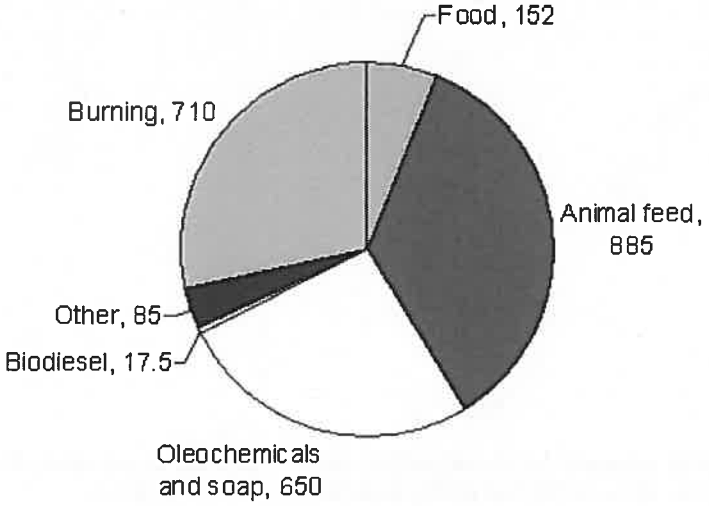
This figure shows that 43% of the tallow is used as a fuel source, and 33 % for industrial applications such as oleochemicals and soaps.

This is a rather different balance than found when considering the EU as a whole where a much greater portion of the available tallow goes into animal feed (Figure 4 (EFPRA 2008)).

Overall, the UK market is currently self-sufficient in tallow use and production. Currently the UK is a net importer of tallow by 3.5 kT p.a. (Uniqema 2008).

Current trends are for more tallow to be used for biodiesel and other fuels. With a fixed amount of tallow available on the market, this can only be obtained by diverting tallow from existing applications such as burning or oleochemical and soap production. Since category 1 tallow can be used for fuel, this trend is part of the pressure on production of category 2 and 3 tallow that can be used for oleochemicals and soaps.

Figure 4 Uses of tallow in the EU (kt p.a. 2005)



2.7 Key Industrial Processes for Tallow Use

If we ignore the use of tallow for in the food and animal feed chain, the key uses of tallow are as a fuel or for oleochemicals and soap. Of the fuel uses, burning for process energy and electricity generation do not require any further significant processing of the tallow. Biodiesel, oleochemicals and soap all require significant processing.

2.7.1 The potential use of tallow as a fuel

The rendering industry currently uses tallow as a fuel to raise heat and steam for its processing. The rendering industry asserts that this use is threatened by the application of the Animal By-products Regulation (ABPR), under which it is required that tallow is disposed of within a Waste Incineration Directive (WID) compliant incinerator. Some of the rendering industry operators are currently appealing against this, i.e. the competent authority's decision to modify their permits to ensure WID compliance, and the results of those appeals are awaited. We understand, however, that there are WID compliant boilers available at the scale required in the rendering industry (Tecgen 2008). Consequently we do not believe that this application is threatened by the outcome of the appeal.

It is interesting to note that under the proposals for the banding of the Renewable Obligation (RO), combined heat and power of biomass fuels will be awarded 2 ROCs per MWh. Tecgen's process is combined heat and power and would qualify for this higher band in the RO. This would provide an incentive for the use of tallow as a fuel for heat and power. We have not studied the economics of this use of tallow as part of this analysis, but it is likely to be of interest to the rendering industry if they have to install WID compliant plant.

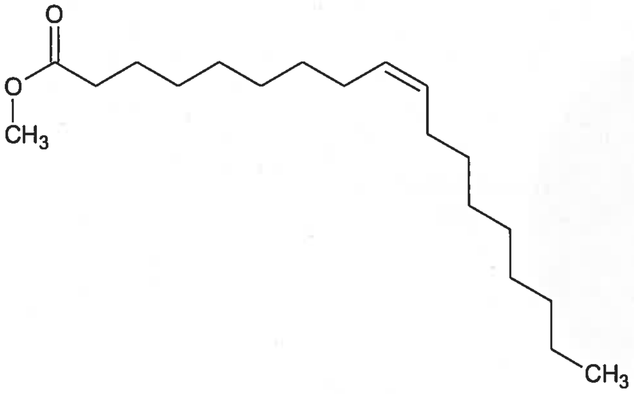
2.7.2 Biodiesel

Diesel road fuel can be produced from tallow in two distinctly different ways.

The most familiar process, which currently dominates the market, is production of fatty acid methyl esters (FAME). The three fatty acid chains are split from the glycerol head group and the acid functionality capped with a methyl group.

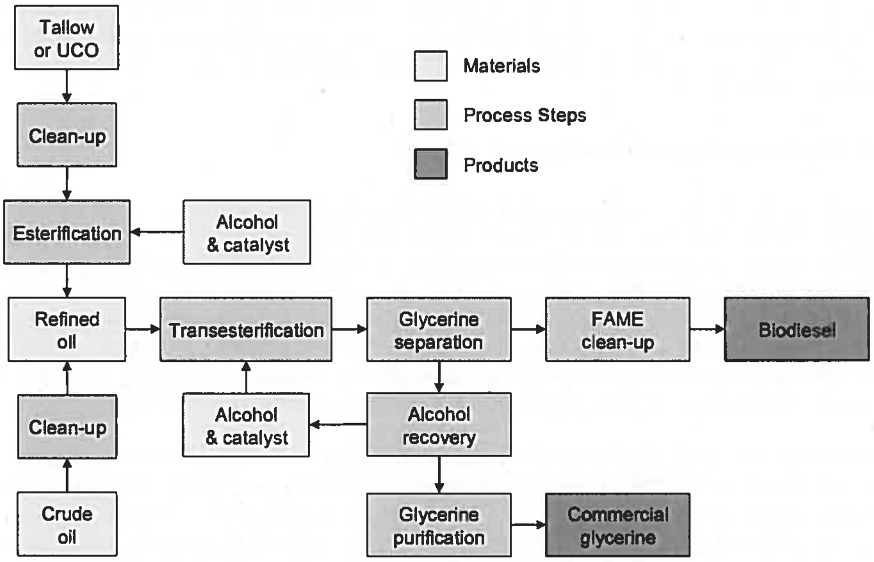
Figure 5 shows a FAME molecule based on the C18:1 fatty acid, oleic acid. This is methyl oleate. Figure 6 provides a flow chart for the production of FAME from oils and fats.

Figure 5 Fatty Acid Methyl Ester (based on the C18:1 fatty acid)



Although structurally rather different to conventional diesel, FAME can be successfully blended with conventional diesel at a variety of dose rates, or used as a pure road fuel in modified engines.

Figure 6 Production of FAME from Oils and Fats



Triglycerides from vegetable oil or animal fats are converted by transesterification with a base catalyst and methanol to fatty acid methyl esters (FAME) and glycerine. The methanol replaces the glycerol which is released for recovery. The FAME is purified for use as biodiesel and the glycerine purified for sale into other markets as a co-product.

The basic process can accommodate virtually any plant oil, as well as animal fat and used cooking oil. However, the technical properties of the biodiesel depend on the fatty acid distribution of the original triglyceride and the level of various contaminants. Tallow and used vegetable oil have a high level of free fatty acids from degraded triglycerides, and these interfere with the transesterification process. They must be separately esterified in a pre-processing step before the main transesterification.

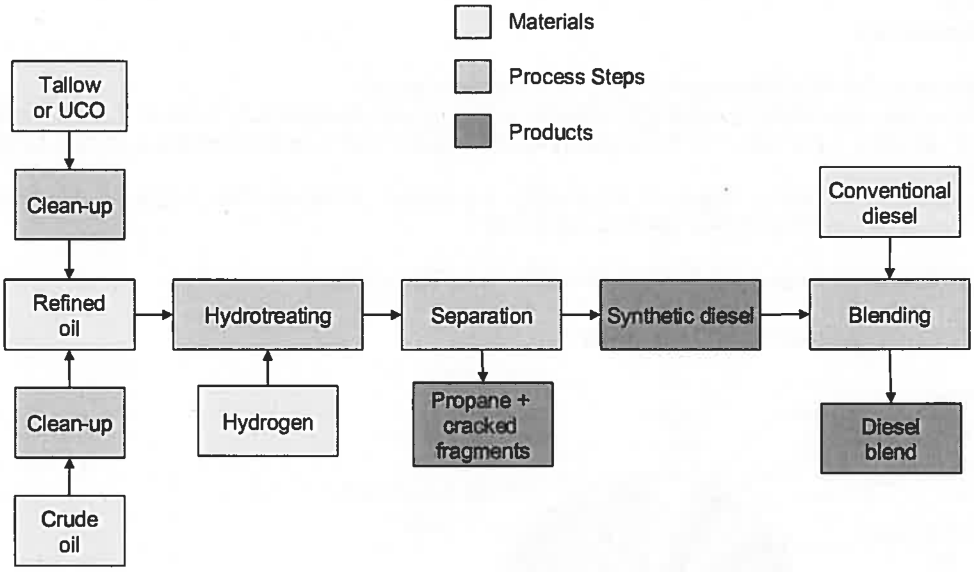
Transesterification of tallow to FAME is currently practised by Argent Energy at their plant in Motherwell. This has a capacity of 45 kT p.a. of feedstock and is supplied with both tallow and used cooking oil. Their Ellesmere Port plant is currently under construction with a capacity of 150 kT of feedstock (Argent Energy 2008)

Tallow as a feedstock has some advantages and some disadvantages. FAME from tallow has a higher cetane number than plant oil biodiesel. This means cleaner and more efficient burning in diesel engines. However, tallow FAME has a higher cloud point because of the high levels of saturated fatty acids. This means that tallow biodiesel tends to crystallise out at low temperatures creating problems in engines. Used neat (100%) tallow FAME would not meet the European standard for biodiesel. However, when blended at 5% into conventional diesel the mixture meets relevant fuel quality standards.

Vegetable oils can easily substitute for tallow in FAME production. The most commonly used oils in the UK for biodiesel are used vegetable oil and oilseed rape. Imported soya and palm are used to a lesser extent, but may be used more in the future.

The second process involves the hydrogenation of oils and fats to produce a synthetic diesel (see Figure 7).

Figure 7 Production of Synthetic Diesel by Hydrotreating of Oils and Fats



The oils and fats are treated with hydrogen in the presence of a catalyst. This breaks the glycerol from the fatty acids, removes all oxygen and removes any double bonds. The glycerol is converted to propane, and together with any fragments created by the hydrogenation process is separated and used within the refinery. The synthetic diesel is a very high quality product that is chemically identical to conventional diesel.

This process is very attractive to petroleum refining companies as it uses technology they already use and are familiar with, is compatible with their supply chain and creates a product that is identical to the rest of their diesel production.

Neste operate a stand-alone process illustrated in Figure 7. They have a 170 kT p.a. output plant in Finland using locally produced tallow, and plans for an 800 kT p.a. plant in Singapore based on vegetable oils. The synthetic diesel can be used directly, or blended with other diesel streams. Neste have no plans to operate the process in the UK, or to use UK sourced tallow (Neste 2008)

Conoco-Phillips operates a similar process, except that they blend the oils and fats into a crude diesel stream before the hydrotreating process. The product of this process is a diesel blend. Conoco-Phillips are currently using approximately 600 kT p.a. of rendered animal fats for this process in the US. In Eire they have demonstrated the process on soya oil. At the moment if they were to use tallow in Europe it would be Irish tallow used in the Whitegates refinery in Eire (Conoco Phillips 2008).

Whilst neither Neste nor Conoco-Phillips currently intend to use UK tallow, it is clear that the widespread adoption of this technology by oil majors could have a major effect on the market for both feedstocks and biofuels. The hydrotreating process can use a wide variety of oils and fats. Feedstocks are selected on availability and price, and in the case of Neste the sustainability of the feedstocks.

2.7.3 Oleochemicals

The oleochemical industry produces a very wide range of chemicals and intermediates that are used in many industries including:

- soap and detergents;
- plastics;
- rubber;
- lubricants;
- paper;
- paints, coatings and inks;
- adhesives;
- food;
- personal care.

The three key chemical commodities made from oils and fats are:

- fatty acids – produced by splitting the glycerine head group from the fatty acids in the triglycerides;
- fatty alcohols – produced by transesterifying the triglycerides to methyl esters and then reducing them;
- glycerine – for every tonne of triglyceride processed, approximately 100kg of glycerine is produced, for which a market needs to be found.

Current markets for these three basic commodities are (Finch 2008):

Figure 8 Global market for fatty acids

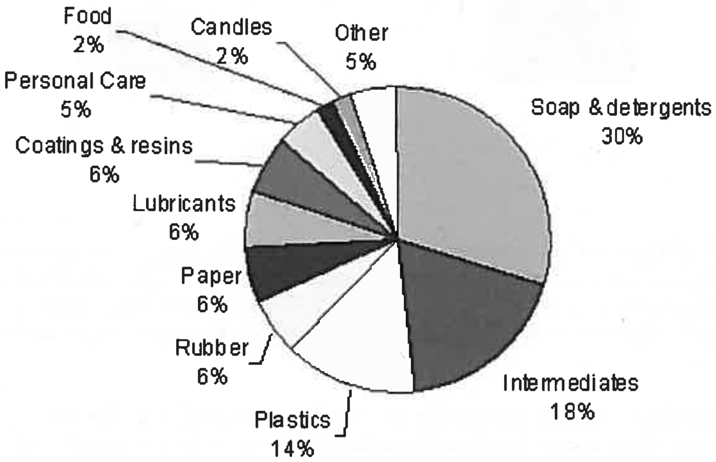


Figure 9 Global markets for fatty alcohols

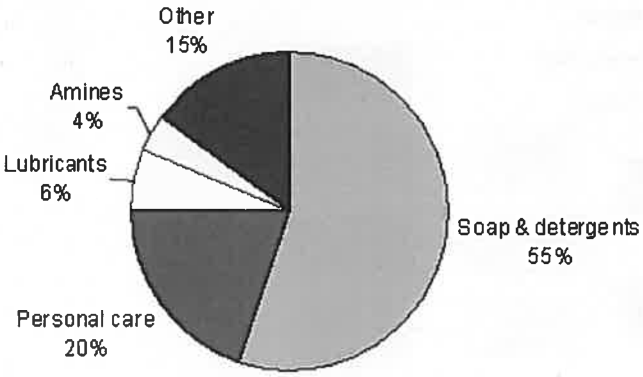
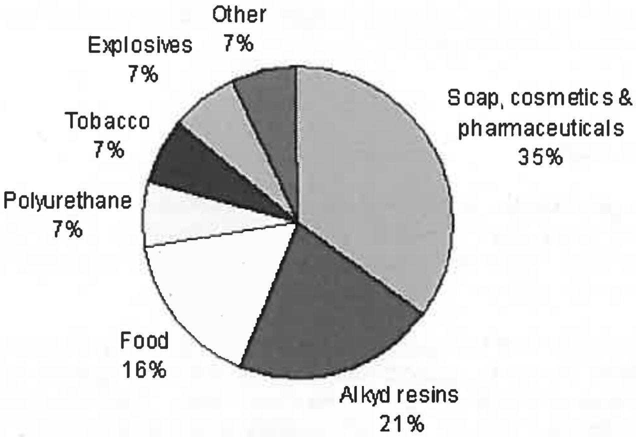


Figure 10 Global market for glycerine



The oleochemical industry in the UK produces a much more restricted range of products. It does not produce fatty alcohols, only acids and their derivatives and glycerine. The key processes are shown in Figure 11 (Uniqema 2008).

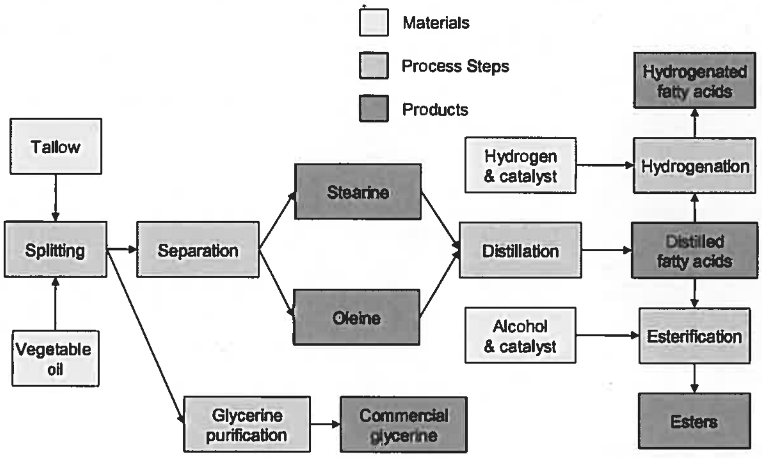
Oils and fats are initially 'split' into glycerine and fatty acids using water at high temperature and pressure to hydrolyse the ester linkages between the fatty acids and the glycerine. The glycerine dissolves in the water and is separated, concentrated by flash evaporation and purified to a commercial grade.

The fatty acids are cooled to a point where the saturated fatty acids crystallise out and can be separated from the unsaturated fatty acids which remain liquid using centrifuges. The solid fraction is called stearine as it contains high levels of C18 stearic acid. The liquid fraction is called oleine as it contains high levels of C18:1 oleic acid. These are commodity products in their own right.

Fatty acids can be further purified by distillation under vacuum to yield a range of distilled fatty acid, usually with a tighter specification on fatty acid composition.

Fatty acids can be hydrogenated to produce saturated fatty acids, or reacted with alcohols to produce a range of esters for applications such as lubricants.

Figure 11 Oleochemical Processes used in UK industry



These products are sold either as intermediates to other chemical companies for onward conversion, or to end users for use in many of the industries listed in Figure 8.

- 90% of the feedstock for the UK industry is tallow.
- Approximately 60% of production is exported.

It is technically possible to substitute plant oils for tallow in the processes described above. Palm oil is the nearest substitute in terms of fatty acid distribution. However, tallow is traditionally a lower cost feedstock than palm oil and the feedstock costs would be increased by the higher price of substitute oil, plus additional transport costs to ship it to the UK from Continental Europe.

In addition, Asian palm oil is subject to an export tariff from producer countries, whereas downstream products are not. These tariffs have been set up to support the development of a downstream industry in oil producing countries so that they can capture more of the value chain. The bulk of the products produced by the oleochemical industry in the UK are commodities that are already being produced in oil producing countries. It is therefore impossible to compete on price from a palm or other tropical oil base.

The UK oleochemical industry currently exists because of access to cheap tallow and transport costs to and from Europe.

2.7.4 Soap

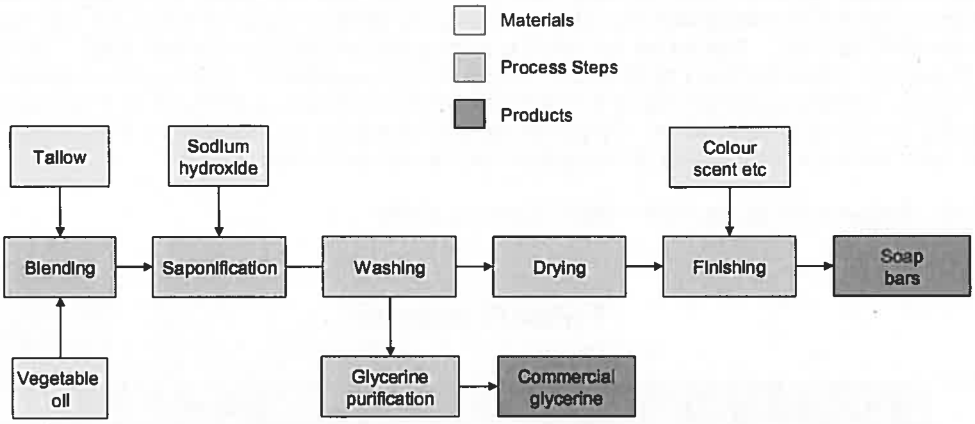
Soap has traditionally been made in large quantities in the UK. However, a reduction in the market for bar soap in the developed world, plus competition from low-cost producers in Asia, has dramatically cut soap production in the UK. All the major soap makers (e.g. Unilever, P&G and Cussons) have either ceased, or are ceasing, production in the UK. The remaining soap makers (see Appendix 2) are SMEs producing specialist soaps for their own brands or on contract to other companies. There are about six companies left producing soap in the UK (UK CPIA 2008).

The basic soap making process for the UK is illustrated in Figure 12 (UKCPIA 2008). A mixture of vegetable oils and tallow is treated with an alkali such as sodium hydroxide. This process is known as direct saponification. It splits the glycerine from the fatty acids and makes sodium soaps of the fatty acids. Other materials such as glycerine and unreacted alkali are washed from the soap and the crude glycerine can be purified for sale. The cleaned soap is then dried to achieve the desired water content, typically under vacuum. Perfume, colour and other ingredients are added to the raw soap and the soap is moulded into bars on a finishing line.

There are several variants to this process. For high volume soap production distilled fatty acids of the desired blend are neutralised with alkali to produce the soap. This avoids the handling of triglycerides and the production of glycerine as a co-product. This is the major process for the large soap producers, but not for the relatively small scale production in the UK.

Many soap-makers stop at the drying stage and produce 'soap-base' in the form of noodles or chips. Smaller companies can then buy the base and add any desired ingredients before moulding the final soap bar. This minimises the equipment they require. All they need is a blender/extruder and a stamping and wrapping line.

Figure 12 Basic soap making process



Pure tallow soap is very hard and does not lather well; so a typical formulation for toilet soap is:

Tallow	60%
Coconut Oil	16% - 20%
Palm Oil	16% - 20%

The vegetable oils improve lather depth and skin-feel (UKCPIA 2008).

Pure vegetable soap can also be made, and is considered by many to be superior in performance. In many markets there is a reluctance to use animal by-products for cosmetic purposes and pure vegetable soaps are preferred.

Soap makers in the UK could easily replace tallow with vegetable oils such as palm. However, palm based vegetable soap is already produced in very large quantities in oil producing countries. There are tariff barriers on the export of the oil, but not on the export of the soap. With the benefit of tariff barriers, large scale and lower production costs, these producers would be significantly cheaper than UK producers if they had to import palm oil.

The soap making industry in the UK now only exists because of access to a cheap source of tallow.

3 Task 2 - Impact of tallow use in biodiesel on tallow price

3.1 Price development for tallow

It has proved difficult to obtain reliable price information on tallow in the UK as there is no open market.

However, Uniqema have provided historical data for UK high and low grade tallow and for tallow compared to a basket of commercial vegetable oils (Uniqema 2008). Figure 13 shows the date for UK tallow from 1999 to 2007. The prices are relative to an index of 100 in December 1999. The time series shows that prices fluctuate continuously, as would be expected for a commodity feedstock in limited supply. However, prices remained fairly stable until the middle of 2005, when they began to rise steadily for both grades of tallow. By the end of 2007 the price had doubled in 30 months. The price increase seems slightly greater for low grade than for high grade tallow.

Figure 13 Tallow Price Index 1999 – 2007 (Uniqema 2008)

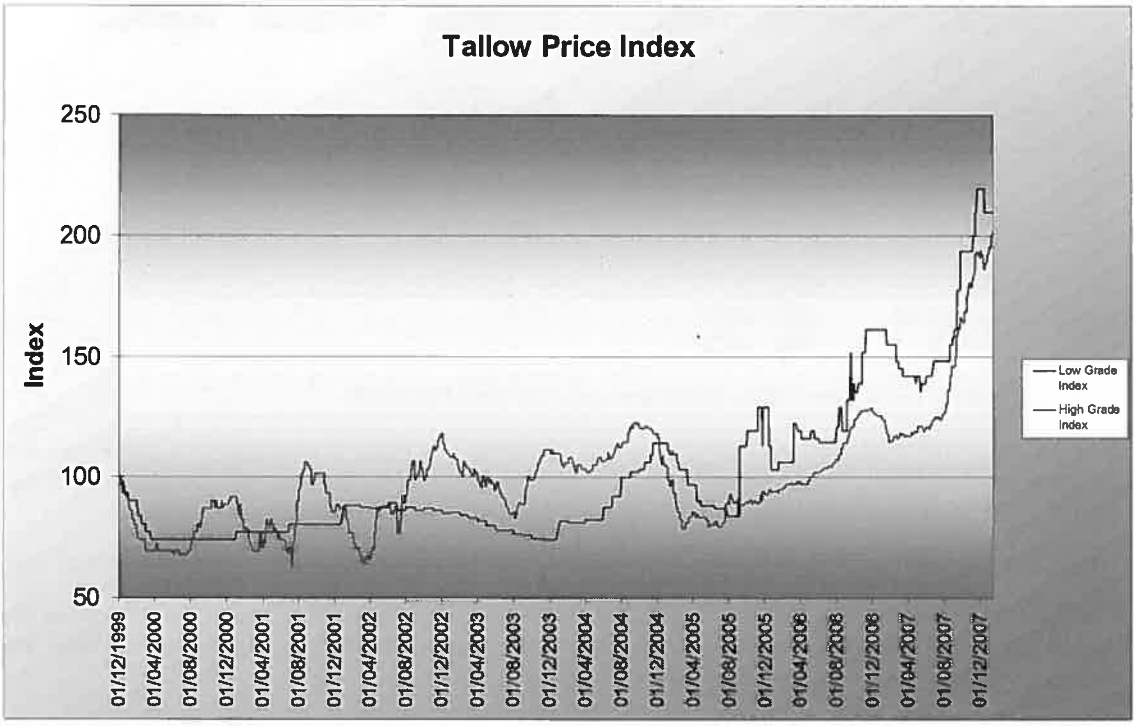


Figure 14 compares the price development of various grades of tallow with other key commercial vegetable oils. Prices are indexed to 100 in October 2003. The oils being compared are:

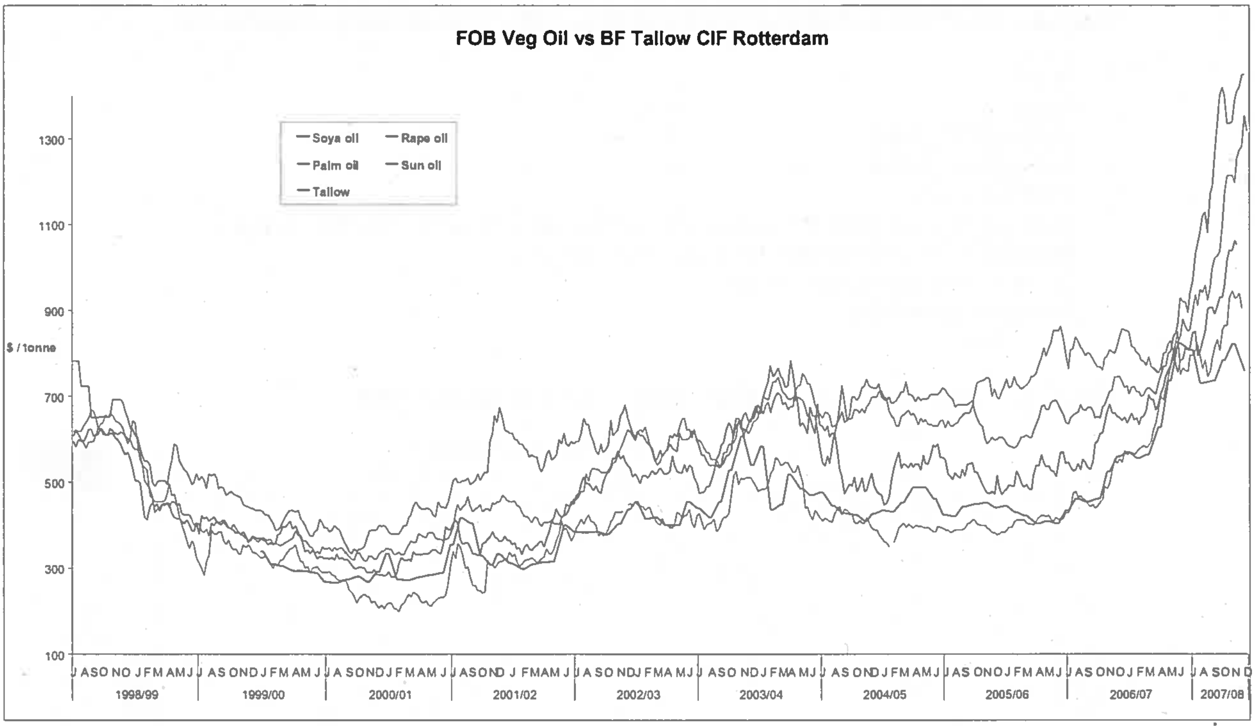
- Soya
- Rape
- Coconut Oil (CNO)
- Palm Kernel (PKO)
- Palm Oil (PO)
- Palm Oil Stearine (POST) Palm oil split and separated into the saturated fraction
- Bleached Fancy Tallow (BFT) imported from the US
- Bonefat (very high grade tallow)
- Technical Beef Tallow
- UK Tallow

Figure 14 Oils and Fats Price Index 2003 – Today (Uniqema 2008)

This data shows the same general price increase from the middle of 2005 for all oils and fats. On this graph UK tallow seems to have risen in price faster than the other oils and fats. However, this apparent difference depends critically on the relative prices in the index month.

Some direct evidence for development of tallow prices is shown in Figure 15 which compares historical prices for Bleached Fancy Tallow, CIF Rotterdam with a basket of oils FOB at their port of origin (Oil World 2008).

Bleached Fancy Tallow (BFT) is imported from the US and is not directly comparable with UK tallow prices. However, it does show some interesting features. The BFT price closely tracks the palm price. In reality, it would trade at a discount to palm in Europe as the palm price does not include transport costs whereas the BFT figure does. Secondly, by comparing the actual cost progression for BFT with the relative movements in Figure 14 it is clear that UK tallow has increased in price faster than BFT over the period 2003 to 2007.



FOB Veg Oil vs BF Tallow CIF Rotterdam

The prediction for future tallow prices is continued upward pressure. This is driven by a combination of high vegetable oil prices driven by demand for human consumption and biodiesel, dragging the higher quality tallow grades up, and high oil prices, dragging the lower quality fuel grades of tallow higher [Argent Energy 2008; CIA 2008; UKRA 2008; Uniqema 2008). The complexity of the market can be seen in the news item from ICIS Chemical Business (Finch 2008), reproduced in its entirety in Appendix 4.

4 Task 3 – RTFO impact on the other sectors

4.1 Introduction

The lack of transparent data on costs and prices and the time limitations in this project prevented in depth economic analysis. Instead two key questions were considered:

Whether the RTFO is likely to lead to the diversion of tallow away from existing markets into biofuels.

The likely impact of the RTFO on the supply of UK tallow (i.e. an assessment of any changes in the relative percentages of category one, two and three tallow produced).

4.2 Economic Analysis

Economic analysis has been undertaken to provide understanding of these issues. This analysis does not attempt to model price changes for tallow and alternative feedstocks brought about by the introduction of the RTFO. Rather it has focused on evaluating the likely effects of assumed price changes on decision making by relevant sectors and to identify price thresholds that lead to changes in decisions. It has also modelled the likely impacts of meeting biodiesel blend targets on the feedstock demands of different sectors and the financial impact on the oleochemicals sector if it had to pay specific prices for feedstock. The analysis of biodiesel blend targets on the feedstock demands has, to some extent, been based on an approach used in a study (Stiefelmeyer *et al.* 2006), which analysed the economic impact of the mandated use of biodiesel blends in Canada, focusing specifically on the oilseed sector and the rendered animal fats industry.

It is stressed that the analysis is based on data provided through stakeholder consultation and sourced literature; however, some assumptions have had to be made were data has been lacking. The analysis does not give firm conclusions, but is intended to contribute to the assessment of likely impacts of the RTFO on use of tallow in the UK. A detailed description of the economic models used and the underlying assumptions is given in Appendix 3. The analysis sought to provide insights to address a number of questions from the point of view of key sectors in the tallow market.

Principal questions

Q1: How might biodiesel producers' maximum willingness to pay (WTP) for tallow change as a function of increasing fuel duty?

Here, assuming that feedstock costs comprise 80% of total net production costs (an average of values reported in Duncan 2003, Nelson 2006 and Schmidt 2004), we sought to identify the maximum feedstock cost biodiesel producers could incur while maintaining pump price parity with unblended diesel, with various rates of duty relief on biodiesel. We then viewed this maximum cost as biodiesel producer's maximum WTP for feedstock; we are not saying that biodiesel producers will pay this amount, but rather they could pay this amount while maintaining pump price parity with diesel.

Given the assumptions in Appendix 3, the results showed that, with no duty relief, biodiesel producers could pay up to £265 per tonne tallow while maintaining pump price parity with unblended diesel. Since the quoted price in consultations for category 1 tallow was about £150/t, this result indicates that the biodiesel producers can afford to pay more for category 1 tallow feedstock than the assumed market price while remaining competitive with unblended diesel, even without the duty relief. With 20 ppl duty relief, biodiesel producers' could pay up to £435/t tallow delivered, while maintaining pump price parity with unblended diesel. Of course they would not pay this price since it is significantly higher than alternative feedstock. The maximum WTP of biodiesel producers for feedstock would be capped at the lowest alternative feedstock price.

We also considered here how the RTFO buy-out price might affect the maximum WTP for feedstock of biodiesel producers while maintaining pump price parity with unblended diesel. When a buy-out price of 15 ppl is paid by fuel suppliers, and if it is assumed that these suppliers will pass on all this additional cost to the pump price for diesel, then there will be a total price differential of 35ppl, including the 20 ppl duty relief on biofuel supply foregone by fuel suppliers paying the buy-out, and biodiesel producers' maximum WTP would increase to about £563 per tonne tallow in this analysis. The signalled intention is that the combined price differential brought about by the duty incentive and buy-out price will fall to 30 ppl in 2010-11, in which case the biodiesel producers' maximum WTP would be about £520 per tonne tallow in this analysis. It is stressed again, however, that these maximum WTP figures are only theoretical because they are significantly higher than real alternative feedstock prices.

There may also be an indirect effect on WTP if the buy-out funds are recycled to all fuel producers which have redeemed certificates under the RTFO. This might further increase the maximum WTP of biodiesel producers while maintaining pump price parity with unblended diesel. However, this effect would depend on the total funds gathered which are determined by total amount of buy-outs in a given year. This is not known in advance although it is the Government's intention that the buy-out price should be sufficiently high to ensure that obligated suppliers do not routinely resort to its use. Therefore, if the RTFO is working as intended total buy-out funds will be low or zero.

Varying the assumed proportion of total net production costs comprising feedstock costs will change the results given above. However, the general conclusion seems quite robust that biodiesel producers could – in principle – offer higher prices for tallow and still remain competitive with unblended diesel; a situation that is only enhanced by the presence of the duty relief and the buy-out option. The results also suggest that, since the diesel wholesale price is relatively high in comparison to historical levels, biodiesel producers appear not currently to need the full duty relief or buy-out price to compete with unblended diesel at the pump – assuming that they can obtain suitable quantities of feedstock at prices below about £265/t.

It should also be pointed out that, while the combination of duty incentive and buy-out price will produce a cost differential between biodiesel and diesel of 35 ppl in 2008, these two elements should be treated as separate instruments with separate effects in analysis. The duty incentive is a reduction in fuel duty paid at the pump (referred to as a subsidy by some consultees although it is technically a reduction in tax due rather than a net subsidy payment by Government) while the buy-out price is a penalty paid by suppliers for producing diesel rather than biodiesel and therefore not redeeming RTFO certificates. The former instrument will make a difference to general tax revenues, while revenues from the latter instrument may be recycled among suppliers with redeemed RTFO certificates (in which case it could be described as a subsidy).

Q2: What will renderers do in terms of producing Category 1, 2, and 3, tallow given different prices for each?

To help address this question, we assume that 250,000 t of tallow in all categories is produced in the UK per annum. Of this total, category 1 tallow will be sold to other sectors or used as a fuel by renderers, depending on a number of assumptions given in Appendix 3 regarding the relative price of alternative oil based energy sources (e.g. HFO, gas oil) vis-à-vis the price offered for category 1 tallow, and historical use of tallow and other oils to meet the energy needs of renderers. If profitable, tallow will be converted to category 2 and 3 and sold to other sectors. While stakeholder consultation noted a significant cost differential for renderers to segregate category 2 and 3 from category 1 tallow we do not have precise figures for this and assumptions for these conversion costs are given in Appendix 3.

Using a simple linear programming model (see Appendix 3 for a description) we look at the tallow production decisions taken by renderers as they maximise profits under a number of tallow price scenarios. Subject to the assumptions presented in Appendix 3, the results are summarised below:

In the 'base case' about 65 per cent of UK tallow production would be category 1, of which all would be used as a fuel by renderers, and the remainder, around 35 per cent, would be sold as category 3. In the stakeholder interview with Uniqema figures for production by category were quoted indicating about 45 per cent category 1 (most used for energy by renderers and the remainder used for biodiesel) and 55 per cent for category 2 and 3.

In the case where the price of category 1 tallow is increased from £150/t to £265/t (recall from above that we assume this price is the estimated maximum WTP of biodiesel producers even without duty relief), renderers will maximise profits by producing only category 1 tallow, still meet all their energy demands from tallow, and sell the surplus category 1 tallow to biodiesel producers. No category 2-3 tallow is produced in the model if the price of category 1 tallow were to increase to this level. Even if the price of category 1 were to rise to only £186/t, it becomes more profitable for renderers to switch all production to category 1, and away from category 3 (which is produced under the base case). At this price, after meeting in-house energy demands, it becomes more profitable for renderers to sell all the remaining tallow as category 1.

If the price of category 1 tallow were to reach £326/t, it becomes more profitable for renderers to sell all tallow produced as category 1, and meet all oil-based in-house energy needs by purchasing oil. Recall from above, that with duty relief equal to 20 ppl, biodiesel producers could – in theory – offer prices in excess of this £326/t, while maintaining pump price parity with unblended diesel. However, whether buyers of category 1 tallow will actually offer this price depends on the price of alternative feedstocks. For instance, vegetable oils are – generally – available at higher prices than this at present. Premiums paid on imported category 2-3 tallow range from +£10 to +100/t, depending on source. The price of used cooking oil is lower – at about £170/t – but has limited availability.
Assuming that the price of category 1 tallow increases to £186/t (the consequences for renderers decision-making is outlined above), category 3 will not be produced unless the price of category 3 subsequently increases to at least £367/t[9], i.e. at £367/t the gross marginal profit on category 3 is greater than the gross marginal profit on category 1 at £186/t, hence it becomes more profitable again to produce category 3 tallow. (Note that this observation from the model is based on conversion cost assumptions given in Appendix 3).

If the price of oil were to drop from £360/t to £185/t, then renderers would maximise profit by selling all tallow as category 3, and purchase oil to meet all oil-based energy demands. Clearly this is an unrealistically low price. The base case price of £360/t of oil – taken from the Uniqema submission on "tallow economics" – is much lower than those found in Quarterly Energy Prices December 2007. We considered higher oil prices in the model, however, prices above £360/t were not found to alter base case decisions by renderers; all renderers oil-based energy needs are still met by using category 1 tallow.

In the absence of data on the additional cost of producing category 2 tallow relative to category 1 tallow and category 3 tallow relative to category 2 tallow, we assumed that the gross profit margin on category 2 tallow was 50 per cent, and the cost of producing category 3 tallow was 20 per cent more than the cost of producing Category 2 tallow. In other words, the cost of production category 3 tallow is assumed to be an increasing function of the cost of producing category 2 tallow. We tested the sensitivity of the model to these assumptions. The tests found that if gross profit margin on category 2 tallow were to drop below 40 per cent (or the additional cost of separation to increase above approx. £150/t) and the cost of producing category 3 increase accordingly, then the profitability of category 3 would drop below that of category 1 tallow, and the surplus tallow after in-house oil-based energy demands are met, would be sold as category 1 tallow and not converted to category 3 tallow. If the gross profit margin on category 2 tallow was 100 per cent (i.e. costs of separation were zero) this was found not to change the base case decisions of renderers (i.e. no more category 2 or 3 tallow is produced) with renderers still preferring to use category 1 tallow to met oil-based energy needs. Thus we can conclude that conversion cost assumptions would only effect base case decisions by renderers if they are too low, and the conversion cost to category 2 from category 1 exceeds about £150/t. If the conversion costs are actually lower then what we have assumed, base case decisions are unaffected.

Q3. What are likely impacts on purchases of feedstock for key sectors, assuming that specific biodiesel blend targets are met?

The third part of the economic analysis aimed was to model the least cost solutions for meeting feedstock demand by sector subject to meeting biodiesel targets from 1 per cent up to 5 per cent blends (this is equivalent to meeting the UK volume-based target of 5 per cent under the RTFO). Current price data assumptions and assumptions about current quantities of alternative feedstocks used by sector are given in Appendix 3.

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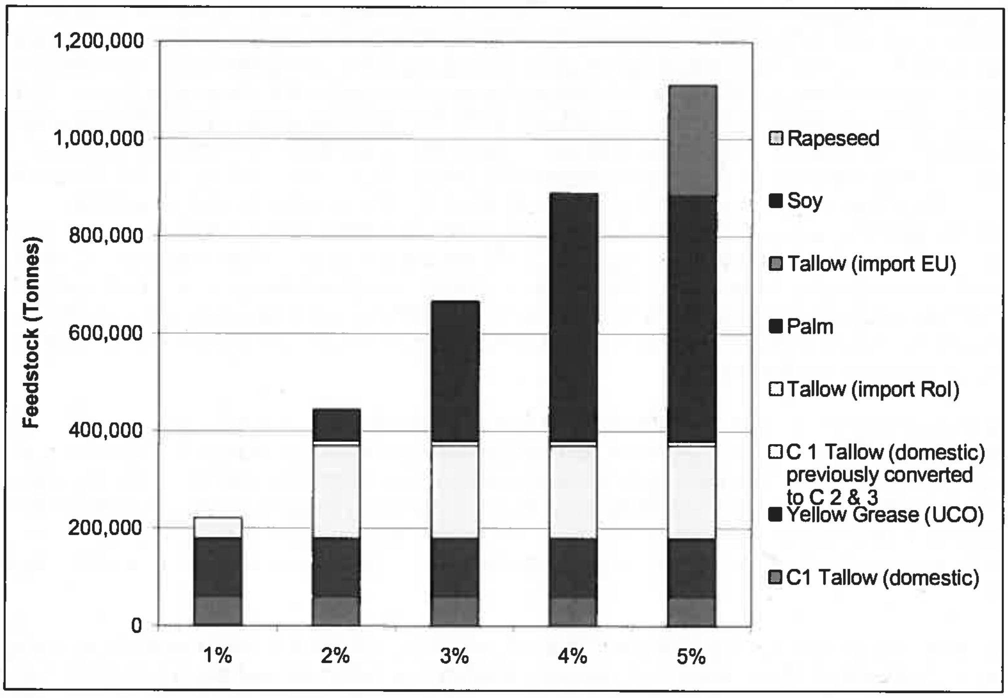
[9] UK price of category 3 is quoted as between £350 and £380 in stakeholder consultation

Figure 16 shows how the biodiesel sector might source feedstocks, subject to decisions on minimising cost, to supply 1 per cent to 5 per cent biodiesel blends. This assumes the biodiesel sector meet their feedstock demands at least cost and only then do other sectors buy any excess supply available. This shows that biodiesel producers will first buy available domestic tallow as well as used cooking oil at 1 per cent blend. At higher blends where all supply of domestic tallow is bought, the sector will look to import tallow from cheapest sources (Republic of Ireland) and to buy palm as the cheapest available vegetable oil alternative. At 4 and 5 per cent blends imports of EU tallow will be bought.

Figure 16 Least Cost Solution for UK Biodiesel Sector to Supply 1% to 5% Target (Tonnes)



Note: The analysis represented in this chart only uses cost for the basis for decisions. This indicates that tallow biodiesel would meet a significant proportion of UK biodiesel. However, it should be noted that the refining capacity for biodiesel does not currently match this potential demand (although new plants would be relatively straight forward to develop). Rape seed and soy do not feature in this analysis, but currently oil seed rape is important in biodiesel production in the UK, whereas very little biodiesel is produced from palm oil. This shows the theoretical nature of the analysis; but it also shows that if cost alone dictated decisions on biodiesel production, very little, if any biodiesel would come from anything other than tallow, used cooking oil (UCO) and palm oil.

The analysis also looked at impacts on the oleochemical industry and other users of feedstocks, given the above assumption that their supply of feedstocks will be the excess remaining after purchases by biodiesel producers. This showed that if the UK biodiesel sector meets a lower 1 per cent blend target, most of the UK produced tallow would be used as fuel by renderers and the oleochemical sector may only be able to purchase about 3 per cent or below of UK produced tallow and would therefore need to start buying higher priced feedstock (e.g. imports from Ireland and other vegetable oil alternatives, primarily palm oil); although we have been informed that it is not economically viable for the UK oleochemical industry to import palm feedstocks due to competition from Asian producers). The consequences for the oleochemical industry of needing to purchase alternative higher priced feedstocks to tallow is illustrated in the analysis of Q 4.

Q 4. What are the potential impacts on profitability of the oleochemical industry?

This part of the analysis simulates the potential impacts on the profitability of the UK oleochemical industry from incurring additional feedstock costs. See Appendix 3 for an explanation of the methodology. It should be noted that the switch to the use of alternative feedstocks by the oleochemical industry assumed in this part of the analysis may be limited by technical considerations.

In the absence of specific data on the proportion of total variable production costs comprised of feedstock costs three scenarios were simulated, for each of 6 possible increases in the price of feedstocks. The results are summarised in Figure 17, Figure 18 and Figure 19 for scenarios were the feedstock costs are assumed to be 60 per cent, 70 per cent and 80 per cent of total variable production costs[10], respectively. Each figure shows the estimated percentage change in gross operating[11] surplus (an indicator of profitability) under six price change scenarios, where it is assumed that alternative feedstocks are bought at a higher price relative to a base case price of £300/t. For each price change scenario the change in gross operating surplus is estimated for varying degrees of cost transfer[12]. Under each price change scenario it is assumed that all feedstock is purchased at the higher price.

As noted in Appendix 3, the underlying financial data is for NACE 24.51[13], which includes other sub-sectors to oleochemicals. The results must therefore be viewed with caution. However, the results do show that if the price the oleochemicals industry had to pay for feedstocks were to increase (as would be necessary if higher prices were to be offered for category 1 tallow, and if other feedstocks were expensive - see conclusions to Q2 above) the oleochemicals sector would face potentially significant declines in gross operating surplus (GOS). For example, under the assumption that feedstock costs comprise 60 per cent of variable production costs, an increase in feedstock costs from £300 to £345/t (approx equivalent to using only imported sources of tallow from the rest of the EU as opposed to UK category 2 tallow) GOS would decline by 50 per cent assuming no cost transfer. At 50 per cent cost transfer, GOS would decline by approx 25 per cent. Under the assumption that feedstock costs comprise 80 per cent of variable production costs, an increase in feedstock costs from £300 to £370/t (approx equivalent to using only imported palm oil as opposed to UK category 2 tallow) GOS would be completely eroded with no cost transfer. The degree to which costs can be transferred to customers depends on how competitive is the market for products from oleochemicals. Feedback in the stakeholder workshop suggested that there is very limited scope for the oleochemical industry due to strong competition in the market. In general, the results from these simulations – as summarised in the figures below – suggest potentially significant risks to the profitability of the oleochemicals sector if they have to pay higher prices for feedstocks.

Figures 17-19 show percentage change in gross operating surplus versus proportion of cost that can be transferred to their customers. Before interpreting the figures, it is worth pointing out that if the raw material price increase leads to a -100% change in the operating surplus (or greater reduction) then the companies are predicted to incur losses from their operation. At the other extreme, if the companies are able to fully transfer any increase in their raw material cost (i.e. a position towards the right hand side of the figure) then virtually no price increase will affect them. The cost transfer value is strongly influenced by the competition faced by the oleochemicals industry, which we know is acute – they find it difficult to pass any cost increase to their customers. As such their current plight is represented by area close to the left hand side (i.e. near to 0% cost transfer according to stakeholder consultation). In Figure 17 (based on the assumption that 60% of the total variable cost is due to tallow price) the increases in tallow price by £95 per tonne (at 0% cost transfer) and £170 per tonne (if there is less than approximately 50% cost transfer) would wipe out any surplus. However, where tallow cost makes up a greater than 60% of the total variable cost, the situation would be more acute (see Figures 18 and 19, based on tallow contributing 70% and 80% of the variable cost, respectively).

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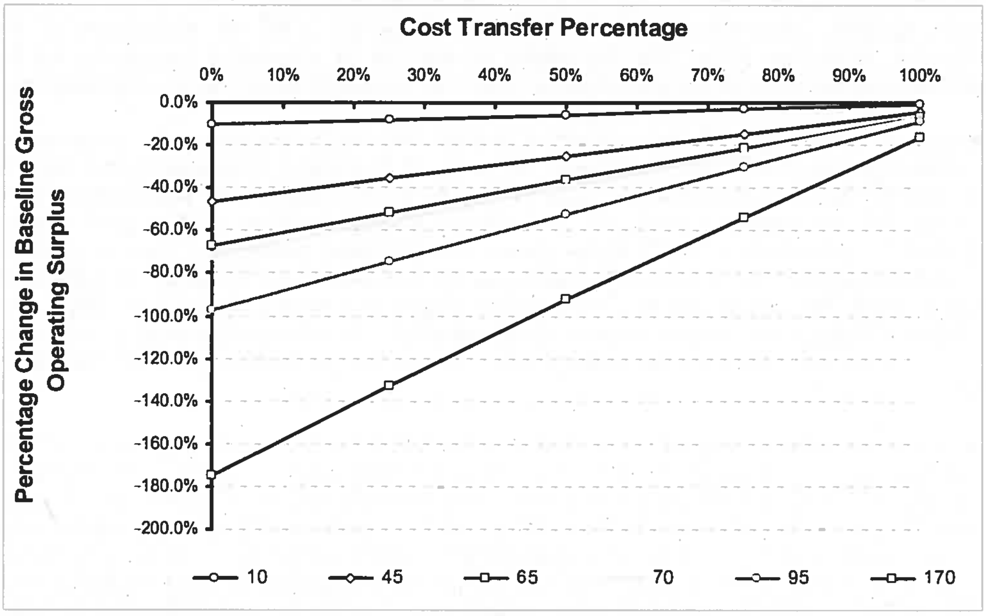
[10] Feedback from the Oleochemical sector states that: " feedstock costs are highly dominant in relation to overall production costs for oleochemicals. In the case of basic fatty acids, the cost of the feedstock is greater than 80% of the variable costs of production".

[11] Gross operating surplus is the surplus generated by operating activities after the labour factor input has been recompensed. It can be calculated from the value added at factor cost less the personnel costs. It is the balance available to the unit which allows it to recompense the providers of own funds and debt, to pay taxes and eventually to finance all or a part of its investment.

[12] Cost transfer refers to the degree to which increased costs for feedstocks paid by oleochemicals industry is transferred to customers by increased prices of oleochemical products.

[13] NACE Code 24.51 refers to 'Manufacture of soap and detergents, cleaning and polishing preparations'.

Figure 17 **Estimated Change in Gross Operating Surplus for Oleochemical Producer when buying Alternative Feedstock (Feedstock 60% of total variable production costs)**



Note: the legend for Figure 17, Figure 18 and Figure 19 is interpreted as follows – e.g. the line labelled "10" indicates what we simulated to happen to GOS if the base case price of feedstock were to increase by £10 per t, under a range of cost transfer percentages. These are based on assumed price increase of alternative feedstocks as given in Appendix 3 (Assumptions for Q4).

Figure 18 **Estimated Change in Gross Operating Surplus for Oleochemical Producers when buying Alternative Feedstock (Feedstock 70% of total variable production costs)**

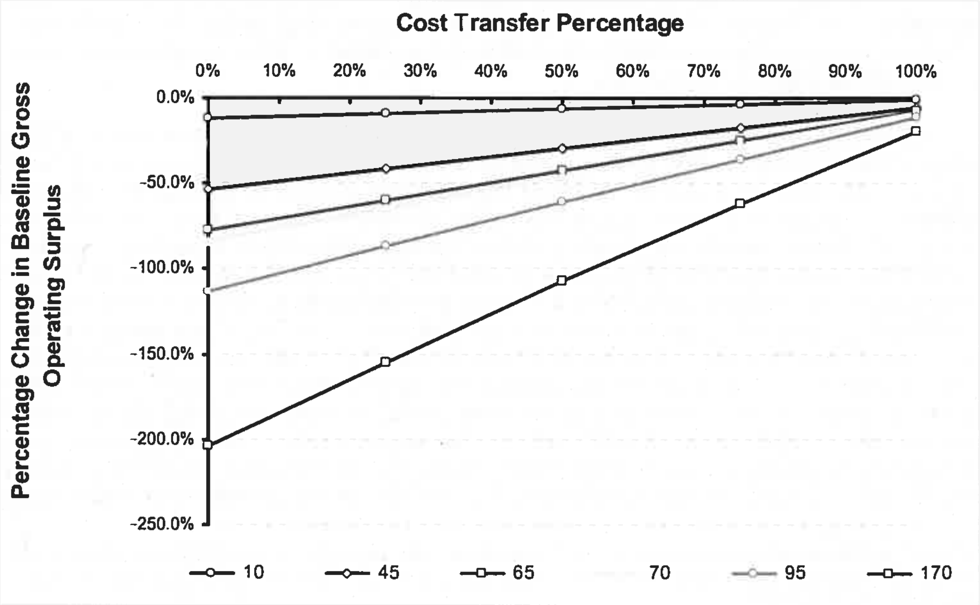
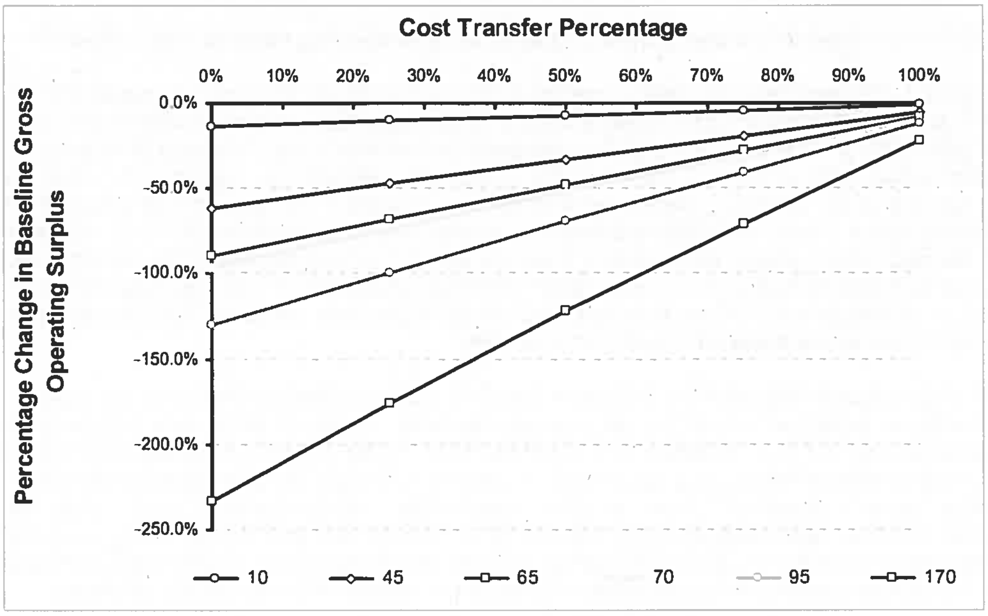


Figure 19 **Estimated Change in Gross Operating Surplus for Oleochemical Producer when buying Alternative Feedstock (Feedstock 80% of total variable production costs)**



4.3 Conclusions from the economic analysis

1. Is RTFO likely to lead to the diversion of tallow away from existing markets into biofuels?

Results from Q1, the analysis of theoretical maximum WTP of biodiesel producers, suggests that with the current duty relief production of biodiesel is already quite competitive with unblended diesel. Since the diesel wholesale price is relatively high in comparison to historical levels, biodiesel producers may remain competitive with unblended diesel at the pump even without the current duty relief and imminent buy-out price, assuming necessary quantities of feedstock are available at prices below about £265 per tonne. Thus, while the introduction of further measures under the RTFO to incentivise transport fuel suppliers to supply biofuels may have the effect of further increasing the attractiveness of producing biodiesel, including from tallow given continued favourable prices with respect to other feedstocks, according to this analysis **even without further incentives under RTFO the production of biodiesel producers is competitive within its market**.

Results from Q3 suggest that were the 5 per cent target for biodiesel blend to be met in the least cost solution, biodiesel producers would buy all available domestic supply of tallow and this would be supplemented by imports from Republic of Ireland and EU. In this scenario, the rendering industry would buy fuel to replace tallow used for energy and the oleochemical industry would no longer use any domestic tallow. Therefore, under the given assumption that the biodiesel sector meet their feedstock demands at least cost and only then do other sectors buy any excess supply available, there is likely to be a significant diversion of tallow away from existing markets if the 5 per cent target were met and even if lower percentage targets were met the diversion effect would still be strong.

Results from Q4 show that the increased prices for buying alternative feedstocks to domestic tallow (as would be necessary under the conclusion to Q3) faced by the oleochemical sector would have significant effects on gross operating surplus. Under the higher assumptions on the proportion of feedstock costs in production (80 per cent of variable production costs), using palm oil as an alternative to tallow – as we simulated would happen even with a 1 per cent blend target being met - would result in a 100 per cent reduction in gross operating surplus, if there was no cost transfer and about 50 per cent reduction in gross operating surplus if there was 50 per cent cost transfer.

2. Likely impact of the RTFO on the supply of UK tallow in categories 1, 2 and 3.

Q2 above addressed the question of what renderers will do to maximise profits in terms of relative production of category 1, 2, and 3 tallow given different prices for tallow. At current price of tallow (£150/t for category 1 assumed in this analysis), to maximise profits of renderers the model suggests that over half the production of tallow would be category 1 which would all be used for in house energy by renderers, the rest being sold as category 3. Raising prices of tallow a threshold would be reached after which it becomes more profitable for renderers to switch production to category 1 and away from category 2 and 3. In the model at £186/t for category 1, after meeting in house energy demands, it becomes more profitable for renderers to sell all remaining tallow as category 1 and none as category 2 and 3 unless the price of category 3 simultaneously increases to £367/t.

The overall conclusion here is that any price increases to category 1 tallow, which may be brought about by increased demand from the biodiesel sector given RTFO incentives or for other reasons, would result in a switch away from category 3 and towards category 1, all other factors being equal. In the model the threshold where no category 2 or 3 tallow is produced in the UK was an increase of about 25 per cent in the current category 1 tallow price.

3. Socio-economic impacts

We have been unable to obtain sufficient information about the patterns of employment and value added for the alternative uses for tallow to provide a reliable assessment. However, a crude analysis shows that switching tallow to biodiesel will have a net negative effect on employment, gross value added and the balance of trade.

The production of tallow biodiesel is a relatively simple process compared to production of oleochemicals and soap. The latter produce a wider range of products, using a greater variety of chemical transformations, and using a wider range of equipment. In contrast, the essence of a biodiesel plant is minimum complexity and greatest efficiency in producing a single product.

Uniqema estimate that there are over 200 people directly employed in the oleochemical and soap industries (Uniqema 2008). In addition, because of the complexity of their operations there are a large number of contractors and service providers also involved in these sectors. These jobs would all disappear following a major shift of tallow to biodiesel production.

A biodiesel plant producing about 125kT/y would employ about 45-50 people (Agent 2008). There would also be jobs in support and service sectors, but not more as a proportion than in oleochemicals and soap. Such a plant is of an economic size, and would use a similar but larger amount of tallow than the oleochemical and soap industries (125kt *versus* 82kT)

The oleochemical and soap industries have exports of more than £30m p.a. If missing domestic capacity is replaced by imports, the net negative change in the balance of trade is of the order of £100m p.a.

For this study we have focused on impacts in the UK and not tried to estimate or compare the net impacts on other economies, particularly in Asia.

Overall there are measurable, but not large, socio-economic impacts from the switch of tallow from oleochemicals and soap to biodiesel.

5 Impact of the diversion of tallow to biodiesel from other uses on GHG emissions

This section of the report discusses the consequences that diverting tallow into biodiesel production will have on greenhouse gas (GHG) emissions. In order to do this, the GHG emissions arising from two hypothetical scenarios are compared. The two scenarios are described in Section 5.1, key assumptions are set out in Section 5.2 and results are given in Section 5.3.

It is important to emphasise that the analysis carried out in this section of the report rests heavily on a number of assumptions. Any conclusions drawn are entirely conditional on the validity of these assumptions. The results section (Section 5.3) includes some brief sensitivity analysis to illustrate the influence of the assumptions.

The time scale and data available for this analysis restricted the potential for undertaking an in-depth cradle to grave life cycle analysis of the use of tallow for biofuels or oleochemicals within this work. Instead we have examined two comparative scenarios in which tallow is either used for biofuels or oleochemicals and sensitivities around these analyses. These scenarios allow comparison of the impact on GHG emissions of switching tallow from oleochemicals and soap production to biodiesel. Section 5.1 describes the basis for the scenario analysis; Section 5.2 provides a description of the assumptions made in the analysis; Section 5.3 presents the results and sensitivity analysis; and Section 5.4 provides the conclusions.

5.1 Description of the two scenarios

The impact of diverting tallow into biodiesel production on GHG emissions is estimated by comparing two scenarios. The first, Scenario 1, represents a policy environment in which biodiesel produced from tallow is ineligible for support under the Renewable Transport Fuel Obligation (RTFO) and fuel duty rebates for biofuels and no tallow is used for biodiesel. Scenario 2 represents the likely scenario in April 2008 – where biodiesel from tallow is eligible for this support. In both Scenarios, it is assumed that no other end use of tallow would be incentivised by the UK government or European policy (e.g. Renewable Electricity Obligation). Figure 21 provides a flow chart of the processes covered in the two scenarios.

On the basis of the economic analysis given in Chapter 2 of this report, it is assumed that:

- In Scenario 1 inedible tallow has three uses: oleochemical manufacture, soap manufacture and as a boiler fuel in rendering plants.
- In Scenario 2 all inedible tallow is used for biodiesel manufacture.

Table 2 summarises the quantities of tallow used in both Scenarios. These figures are taken from the data on tallow use in the UK provided in Chapter 2 of this report.

Table 2 Quantities of tallow used in each process

Process	Scenario One	Scenario Two
	(tonnes)	(tonnes)
Soap & oleochemical manufacture	106	0
Boiler fuel (renders)	82	0
Biodiesel production	0	188
Total	188	188

In Scenario 1 it is assumed that the tallow that (under current market and policy conditions) is used for biodiesel manufacture and electricity generation would instead be used for soap and oleochemical manufacture. The rendering industry is assumed to have no need or capacity for additional tallow burning.

In order to construct two scenarios which are directly comparable, it is necessary :o ensure demand for all relevant products is met in each scenario. Scenario 1 must, therefore, include an alternative supply of biodiesel produced from a feedstock other than tallow. Scenario 2 must include an alternative supply of (1) oleochemical products and soap which is produced from a feedstock other than tallow and (2) boiler fuel for UK meat renders.

5.1.1 Alternative supply of biodiesel for scenario One

Under the conditions given for Scenario 1[14], the alternative supply of biodiesel is produced from palm oil, for the following reasons.

- Palm oil is the next cheapest feedstock after tallow (see Figure 27).
- Supply of palm oil is increasing, therefore it is likely to be readily available.
- Biodiesel produced from palm is technically quite similar to biodiesel produced from tallow.

The UK government has announced its intention to move (in April 2010) to an RTFO which rewards biofuels on the basis of the GHG savings they achieve. Such a scheme has the potential to change the relative incentives for biofuels produced from different feedstocks. However, under the current methodology used to assess GHG savings, palm oil biodiesel has a higher GHG saving than many other biodiesel fuel chains (see Figure 20). Therefore, palm oil based biodiesel is still likely to be the alternative supply for Scenario 1 under an RTFO that was linked to GHG savings (provided the current methodology is not changed).

It is assumed that approximately the same amount of biodiesel is produced from 1 tonne of palm oil and 1 tonne of tallow. Therefore, to ensure that the same amount of biodiesel is supplied in both Scenarios, 188 kT of palm oil must be supplied in Scenario 1.

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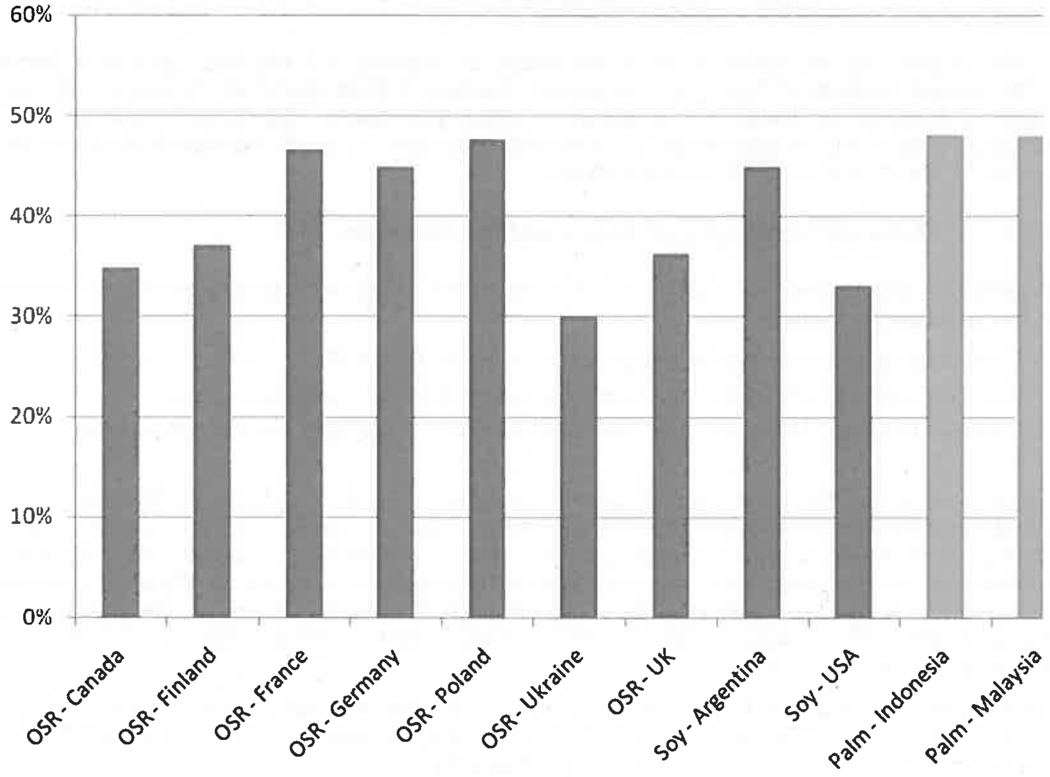
[14] Note: it is assumed that the loophole, which currently allows soy-based biodiesel imported from the USA to receive subsidies in both the USA (a production subsidy) and the UK, will not exist in the near future and, therefore, that this supply chain should not be considered as the alternative supply of biodiesel in Scenario 1.

Figure 20 GHG saving of different biofuel chains, as assessed using the RTFO Carbon Reporting methodology (based on "fuel chain default values" (RFA 2008)



5.1.2 Alternative supply of boiler fuel for scenario Two

The tallow used as a boiler fuel in Scenario 1 will be replaced by the next cheapest boiler fuel which is technically compatible with existing infrastructure. Because the rendering industry currently use tallow as a fuel for boilers any replacement fuel would need to be a liquid. Table 3 shows that the next cheapest liquid boiler fuel would be low sulphur fuel oil.

Table 3 – Prices of liquid fuels in the UK (average 2005 – 07)

Fuel Type	Price (£ / GJ)
Low Sulphur Fuel Oil	£5.69
Light Fuel Oil	£7.95
Automotive Diesel	£22.25

Source: [15]

Another boiler fuel that could be used by renderers is their other product, meat and bone meal. It has not been possible to establish how likely this is, therefore, the assumption made for the main analysis is that light fuel oil is the alternative supply. The implications of this assumption are discussed in the sensitivity analysis.

It is assumed the boilers used by renderers will operate at approximately the same efficiency regardless of whether they are burning tallow or fuel oil.

Therefore, to ensure the same amount of heat and electricity is provided to the renderers in both Scenarios around 75 kT of fuel oil[15] will be used as boiler fuel in Scenario 2.

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[15] Using lower heating values of 37 GJ / tonne for tallow and 40.5 GJ / tonne for heavy fuel oil.

5.1.3 Alternative supply of oleochemicals and soap for Scenario Two

The analysis presented in Chapter 2 of this report implies that, if tallow was not available to the UK oleochemicals and soap industries (as is the case in Scenario 2), this industry would cease to exist and existing demand for these products would be met by supply from South East Asia. In Scenario 2, it is therefore assumed that the alternative supply of soap and oleochemicals comes from South East Asia, where the feedstock used is palm oil. In reality this is a simplifying assumption, since some products (e.g. lubricant esters) are expensive to make from palm oil, and would probably be replaced by petrochemical products (which would have a GHG emissions associated with them). However, these products are thought to be in the minority and have been ignored due to the time and data constraints on this study.

It is assumed that approximately the same amount of oleochemical products and soap is produced from 1 tonne of palm oil and 1 tonne of tallow. Therefore, to ensure that the same quantities of soap and oleochemical products are supplied in both Scenarios, 106 kT of palm oil must be supplied in Scenario 2.

5.1.4 Displacement contacts

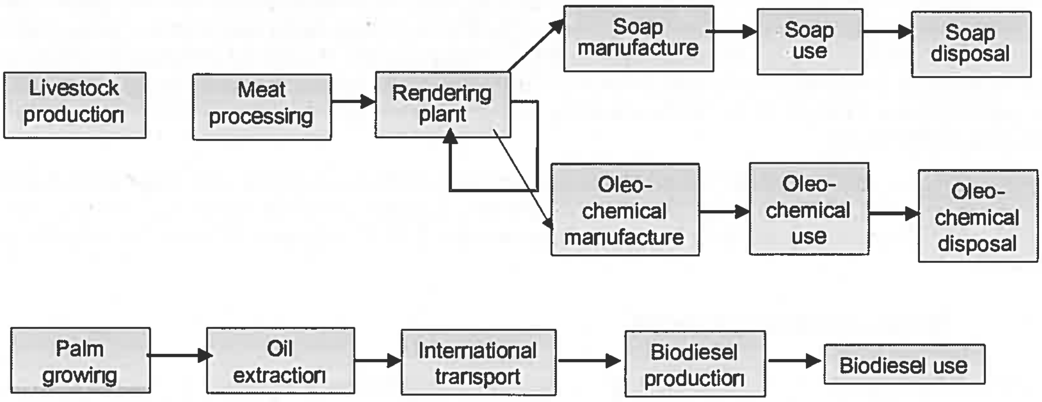
The products produced in Scenario 1 and 2 can have displacement impacts. For example, the biodiesel supplied in both Scenario 1 and 2 will effectively displace some fossil diesel out of the fuel mix. The emissions associated with producing and using this fossil diesel will be avoided and there will be a net reduction in GHG emissions as a result of the displacement.

It is assumed that any displacement impact will be the same in both Scenario 1 and Scenario 2 – e.g. that the same quantity of fossil diesel emissions are avoided in both Scenarios. Therefore, the displacement impacts will not be considered further in this analysis.

Figure 21 provides a graphical summary of the two scenarios which are considered in this analysis.

Figure 21 **Two scenarios compared to estimate impact of diverting tallow into biodiesel manufacture on GHG emissions**

Scenario One: no policy incentives for tallow.



Scenario Two: tallow biodiesel eligible for support under the RTFO and fuel duty rebates.

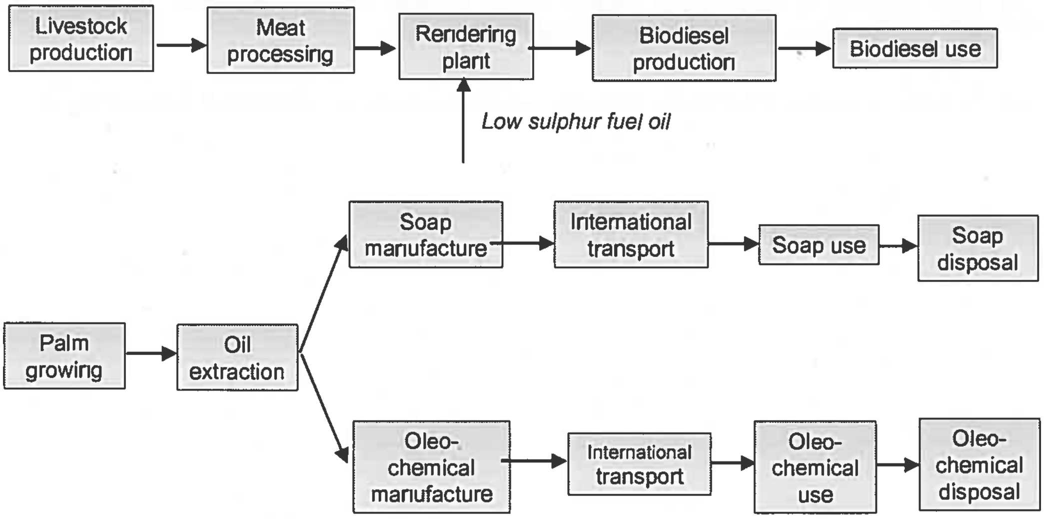


Table 4 summarises the quantities of the different feedstocks used in each Scenario.

Table 4 **Quantities of feedstock used in each process**

	Scenario One			Scenario Two		
Process	Tallow (tonnes)	Palm oil (tonnes)	Fuel oil (tonnes)	Tallow (tonnes)	Palm oil (tonnes)	Fuel oil (tonnes)
Soap & oleochemical manufacture	106	0	0	0	106	0
Boiler fuel (renders)	82	0	0	0	0	75
Biodiesel production	0	188	0	188	0	0
Total	188	188	0	188	106	75

5.2 Key assumptions

Availability of data and timescales mean that it is not possible for this analysis to quantify the full cradle to grave GHG emissions resulting from each supply chain in both scenarios. However, with some careful assumptions it is possible to simplify the analysis and still compare the GHG impact of diverting tallow into biodiesel production.

There are several sources of GHG emissions which can be assumed not to vary between Scenario 1 and Scenario 2:

- All GHG emissions from livestock production and meat processing. Changes in demand for tallow will not have any influence on UK herd sizes, or on the quantity of meat processed, due to its low contribution to overall revenue. Therefore, GHG emissions from these two stages will not differ between Scenario 1 and 2.
- All GHG emissions from use and disposal phases. The end products in each scenario (soap, oleochemical products and biodiesel) are broadly identical regardless of the feedstock used to produce them – therefore, the GHG emissions which occur during use and disposal phases will be identical.

There are five sources of GHG emissions which must be analysed further in order to establish how the GHG emissions they produce vary between scenarios: rendering; soap and oleochemicals manufacture; palm growing and oil extraction; international transport; biodiesel production. Potential differences between the GHG emissions occurring from these processes in Scenario 1 and Scenario 2 are discussed below.

5.2.1 Rendering plants

The main sources of GHG emissions from a rendering plant are from energy inputs (e.g. for process heat, electricity etc) and chemical inputs. There will be no difference in the amount of energy or chemical used between the two Scenarios since:

- exactly the same rendering plants are being used in both Scenarios, and
- the amount of material processed through the rendering plant is the same in both Scenarios.

However, the assumptions made about the type of fuel used to provide energy to the rendering plant will clearly lead to a difference in GHG emissions. In Scenario 1, boiler fuel needs are met by tallow and in Scenario 2, this tallow is replaced by fuel oil. This will lead to an increase in emissions from rendering plants in Scenario 2 as tallow has a carbon intensity of zero (including upstream and combustion emissions) and low sulphur fuel oil has an carbon intensity of 80.6 kg CO_2e / GJ (JEC 2007).

5.2.2 Soap and oleochemical manufacture

The main sources of GHG emissions from a soap and oleochemical manufacturing plant are energy use and chemical use. In Scenario 1, soap and oleochemical manufacture occur in the UK, while in Scenario 2 these processes take place in South East Asia – probably Malaysia.

Malaysian soap and oleochemical plants will be newer and, therefore, more energy efficient than their UK counterparts (Rupilius and Ahmad). However no detailed data comparing the efficiency of manufacturing plants in the two countries is available. Therefore, it is assumed that soap and oleochemical plants will use the same amount of energy and chemicals regardless of whether they are in Malaysia or the UK.

The type of fuel used to supply energy to the manufacturing plants could also influence the GHG emissions from the processing step. Anecdotal evidence and advice from industry suggests that natural gas will be the fuel used by soap and oleochemical plants in the UK. Analysis of industrial energy use statistics in Malaysia suggests that natural gas may also be the preferred fuel for soap and oleochemical plants. In 2000 petroleum products (probably heavy fuel oil) met nearly 50% of Malaysian industrial energy needs, by 2005 this share had fallen to 37%.

Over the same period, the share contributed by natural gas has increased from 20% to 30%. These statistics suggest that natural gas is currently the most attractive fuel for Malaysian soap and oleochemical producers. If both the UK and Malaysian producers are using natural gas, then GHG emissions from this source will be essentially the same in both scenarios. The sensitivity analysis in Section 5.3.1 discusses the implications of this assumption.

5.2.3 Palm growing and oil extraction

The GHG emissions per tonne of oil from palm growing and palm oil extraction are assumed to be the same regardless of whether the oil is being used for biodiesel manufacture or oleochemical and soap manufacture. However, as Table 4 shows, the amount of palm oil required is less in Scenario 2 than in Scenario 1. Therefore, total GHG emissions from palm growing and oil extraction will be lower in Scenario 2.

5.2.4 International Transport

GHG emissions from international transport could be influenced by the total amount of product moved and by the amount of energy used per tonne of product moved. It is difficult to compare the total amount of product being shipped in each scenario because the quantities of oleochemical products and soap produced are not known. However, there will probably be slightly less GHG emissions associated with transporting 1 tonne of palm oil (Scenario 1), than the soap and oleochemical products produced from 1 tonne of palm oil (Scenario 2).

Palm oil would be transported at high volumetric densities in tankers, while soap and oleochemical products will be transported at lower densities due to packaging and handling requirements (in containers or similar). This will mean transport of palm oil is more energy efficient (in terms of energy used per tonne of product shipped) than transport of soap and oleochemical products. Unfortunately, it has not been possible (given the time constraints of the study) to quantity the impact of this difference on GHG emissions from international transport.

An additional influence on international transport GHG emissions is that 1 tonne of palm oil will produce more than 1 tonne of soap and oleochemical products – since mass is gained from water and chemicals in the various reactions which produce these products (e.g. 1 tonne of palm oil will produce roughly 1.05 tonnes of glycerine and fatty acids). It has not been possible to quantify the increase in mass and the resulting impact on GHG emissions.

Because it has not been possible to identify the influence of these two factors it is effectively assumed that transport sector GHG emissions are the same in both Scenarios (except insofar as Scenario 1 requires significantly more palm oil than Scenario 2). The impact of this assumption is discussed in the sensitivity analysis in Section 5.3.1.

5.2.5 Biodiesel manufacture

The main sources of GHG emissions from biodiesel plant are energy inputs, chemical inputs and co-products. Because tallow requires an extra processing step (esterification) prior to entering the standard biodiesel production process it uses more energy and chemicals than are used in producing palm oil based biodiesel. Unfortunately, it has not been possible to collect data which quantifies these additional energy and chemical demands. The analysis is therefore undertaken on the assumption that the type of feedstock used for biodiesel production has no influence on the energy and chemical requirements of the process. The impact of this assumption is discussed in the sensitivity analysis in Section 5.3.1.

An additional influence on the GHG emissions resulting from biodiesel production can be the uses of co-products. Uses for co-products from tallow-based biodiesel production may differ from the uses of co-products from palm oil-based biodiesel production. Both feedstocks produce two co-products in addition to biodiesel: glycerol (approximately 100 kg/tonne biodiesel) and potassium sulphate (approximately 40 kg/tonne biodiesel).

There are two ways in which co-products can be treated within an assessment of a product's GHG emissions. The first involves expanding the system boundaries to identify what happens when the co-product enters the market (i.e. does it displace another product from a different supply chain?) and what impact this has on GHG emissions (i.e. are some GHG emissions avoided because the displaced product is no longer produced?).

The second approach involves allocating emissions between the various products on the basis of a product characteristic such as mass, volume or market value.

The RTFO Carbon Reporting Methodology currently treats co-products from biodiesel production using the approach of allocation by market value.

While system expansion is the preferred approach under this Methodology (E4Tech 2008), the multitude of end uses for glycerol and potassium sulphate and the lack of market data on these end uses meant that a system expansion approach would introduce too much uncertainty into the analysis. A similar approach is used here to understand the impact of co-products.

Each of the co-products from biodiesel production can be have a wide range of end uses; however, for co-products produced from certain categories of tallow some of these uses will be restricted. Discussions with the Environment Agency have confirmed that derivates of tallow are likely to be subject to the same restrictions as the tallow itself (see Chapter 2). This means that glycerol which is produced from Category 1 tallow will have to be burnt.

It is assumed that this glycerol would be used to generate steam for process heat at the biodiesel plant[16] – thereby offsetting some fossil fuel requirements. The impact of this displacement is assessed using the system expansion method.

This displacement also means that there is less glycerol available for non-energy uses in Scenario 2 (all of the glycerol produced from palm oil in Scenario 1 is assumed to be used for non energy uses), implying that an alternative source of glycerol is needed to balance the two scenarios. This alternative source of glycerol would most likely be derived from South East Asian palm oil (if this is the next most expensive source of soap and oleochemicals, it is also likely to be the next most expensive source of glycerol). The GHG emissions from this additional supply of glycerol are taken into account. It should be noted that there is a surplus of glycerol in the world at present. This means that it has little value and some producers are paying for the disposal of glycerol. We think it is likely that glycerol produced from palm oil based oleochemical manufacture in South East Asia would stay in that region (there would be no incentive to transport it to the UK).

Co-products produced from category 2 tallow should be eligible for "technical" uses (i.e. non-food or feed) and Category 3 tallow should be eligible for any use. Further data on the displacement impact of glycerol has not been collected; therefore, category 2 and category 3 tallow will be treated using the market value allocation method. This means that co-products from category 2 or 3 tallow will have the same impact on the GHG emissions attributed to the biodiesel as they do for palm oil-based biodiesel.

5.3 Key results

Based on the assumptions made in Section 5.2, it is possible to calculate the additional GHG emissions which occur in each scenario – full details of these calculations and the data used is available separately. Table 5 summarises the additional emissions which would occur, by process. The net effect of displacing tallow into biodiesel (i.e. Scenario 2) is an increase in GHG emissions of around 183 kT, which is equivalent to 974 kg CO_2e/tonne tallow displaced. The primary reason for this increase in emissions is the displacement of tallow from use as a boiler fuel by renders, which means that a more carbon intensive fuel (low sulphur fuel oil) must be used. This effect is somewhat reduced by the higher demand for palm oil in Scenario 1.

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[16] It is assumed that all Category 1 tallow (99 ktonne) will be used by biodiesel producers who have modified boilers which are capable of burning glycerol.

Table 5 Additional CO_2e emissions by process

Process	Change in GHG emissions (tonnes CO_2e)	
	Scenario 1	Scenario 2
Rendering		+264,868
Soap and oleochemicals manufacture		
Palm growing and oil extraction (including international transport)[17]	+89,872	
Biodiesel production		+8,053
TOTAL	+89,872	+ 272,921
Net impact		+183,049

5.3.1 Sensitivity analysis

As mentioned in the introduction to this section of the report, a number of assumptions have been made in order to analyse the GHG impact of displacing tallow into biodiesel production. It is important to understand the influence of changes in these assumptions before drawing any conclusions from the analysis. Key assumptions include:

1. The type of boiler fuel which replaces tallow in Scenario 2
2. The type of fuel used by Malaysian soap and oleochemical manufacturers in Scenarios 2
3. The energy efficiency and relative mass of soap and oleochemical products transported in Scenario 2
4. The amount of energy and chemicals required for biodiesel production from tallow in Scenario 2
5. The type of process used to produce biodiesel
6. The impact of land use change in the production of palm oil

Each of these assumptions and the impact different assumptions would have on the overall results are discussed below.

1. **The type of boiler fuel which replaces tallow in Scenario 2**

The assumption that heavy fuel oil replaces tallow in Scenario 2 is clearly the most influential assumption in the whole analysis. As mentioned earlier, the rendering industry could switch to burning another product of their process – meat and bone meal (MBM). The consequences of using MBM as a boiler fuel in Scenario 2 are worth exploring:

- Because MBM is a form of biomass, the CO_2 resulting from its combustion would not lead to a net increase in atmospheric GHG emissions – i.e. these emissions would not be counted in the analysis above.
- Burning MBM for heat at the rendering plant would have no impact on upstream GHG emissions (from animal rearing & processing).

These factors suggest there would be no increase in GHG emissions from rendering plants between Scenario 1 and 2. However, it is also necessary to consider how the MBM was being used previously (i.e. in Scenario 1), what will be used to replace it in Scenario 2 and to estimate the consequences for GHG emissions.

Category 1 and 2 MBM must be burnt in order to comply with waste management legislation, currently it is predominantly used to generate electricity and in cement manufacture. Electricity generated from MBM receives Government support under the Renewable Electricity Obligation, and use of MBM in cement manufacture is encouraged by the European Emissions Trading Scheme. Category 3 MBM has similar uses, but may also be used in pet foods.

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[17] Note: it is assumed that this demand for palm oil has not caused any direct or indirect land use change.

Identifying what would replace MBM in its current end uses is highly uncertain; however, it is considered likely that the replacement product would be some form of biomass or waste. Sufficient quantities of either biomass or waste to replace MBM in energy applications are likely to be available – e.g. recent decreases in the amount of biomass which is allowed to be co-fired to generate electricity under the Renewable Electricity Obligation suggest additional biomass supply should be available; and the significant quantities of waste which are currently being landfilled in the UK suggests additional waste supply should be available.

If the current uses of MBM (i.e. renewable electricity generation and cement manufacture) were to switch to biomass or waste then this could have a significant effect on the GHG emissions in Scenario 2. Biomass would be considered as having no GHG emissions from combustion and some biomass containing wastes would also have very low GHG emissions, which would mean that switching to these alternatives sources of fuel would result in no extra GHG emissions. If the switch was to wastes derived from fossil derivatives there would be an increase in GHG emissions, which would have to be calculated based on the waste composition.

If all of the MBM which was used at the rendering plant was replaced by biomass, there would be no increase in GHG emissions from the rendering plant in Scenario 2.[18] If it were to be replaced by wastes containing fossil derivatives the GHG emissions would need to be examined in more detail.

There is an argument that using MBM at the rendering plant would ultimately lead to the displacement of a fossil fuel somewhere in the market. However, the supply of biomass is not fixed (at least in the medium and long run) and can be expanded in several ways (e.g. recovery of more wood waste from forestry). An important mechanism for expanding the biomass supply curve in the UK is likely to be the growing of more energy crops.

Clearly the overall result of this analysis is very sensitive to the assumption made about the type of fuel which would replace tallow at the rendering plants in Scenario 2.

The relative economics of burning MBM instead of low sulphur fuel oil at the rendering plant need to be explored further before a decisive conclusion about the impacts of using tallow for biodiesel production can be fully understood.

2. The type of fuel used by Malaysian soap and oleochemical manufacturers in Scenarios 2

The assumption in the main analysis above was that natural gas is the fuel most likely to be used to provide process heat for soap and oleochemical manufacture. This is a reasonably certain assumption for UK production; however, it is less certain for Malaysian soap and oleochemical production, where fuel oil may be used instead.

It has not been possible, given the time constraints of the study, to establish the energy requirements of soap and oleochemical production processes – in order to establish the impact using heavy fuel oil in Malaysia would have on GHG emissions. However, it is possible to give a sense of scale:

- Process heat requirements for soap and oleochemical production are likely to be similar to those for biodiesel production since the reactions required are broadly similar.
- Therefore, (based on the RTFO default values), approximately 1.7 GJ of natural gas would be required to provide process heat sufficient for 1 tonne of (say) soap.
- If the same amount of heat was provided using heavy fuel oil, then this would increase GHG emissions per tonne of product by around 40%. If all 106,000 tonnes of palm oil was processed in plants using heavy fuel oil in Scenario 2, this would increase total GHG emissions by approximately 5,000 tonnes.

Clearly the assumption about what type of fuel is used to provide process heat in soap and oleochemical manufacture is important. However, it is unlikely to influence the overall conclusion of the main analysis.

3. The energy efficiency and relative mass of soap and oleochemical transport in Scenario 2

It was assumed that international transport emissions would not differ between scenarios due to a lack of available data. In particular it was assumed that:

- the lower volumetric density of soap and oleochemical products during transport, would have a negligible impact on transport energy efficiency and therefore on resulting GHG emissions.

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[18] There may be some additional GHG emissions as a result of additional transport steps being required, however, these are likely to be relatively small.

- the mass gained when palm oil undergoes various chemical reactions to produce soap and oleochemicals would not lead to significantly higher GHG emissions from international transport.

While in reality these assumptions would clearly be wrong, it is important to understand that their impact is relatively small. Transporting 1 tonne of palm oil from South East Asia to Europe would produce approximately 260 kgCO_2e. If international transport in Scenario 2 was 10% less ene gy efficient (due to the lower volumetric density) and 10% more mass had to be transported, the resulting increase in GHG emissions would still only be of the order of 5,800 tonnes CO_2e.

The assumptions made about international transport are important, however, it is unlikely that they would influence the overall conclusion of the main analysis.

4. The amount of energy and chemicals required for biodiesel production from tallow in Scenario 2

As discussed above, it has not been possible to establish the additional energy and chemical requirements of tallow biodiesel production. Instead it has been assumed that these inputs are the same regardless of the feedstock used. In order to understand the importance of this assumption, the impact of a 10 percent increase in energy inputs (i.e. MJ of natural gas and electricity required to produce a tonne of biodiesel) and chemical inputs (i.e. kg methanol/t of biodiesel) has been explored. For every 10% increase in these inputs, GHG emissions from tallow biodiesel production (Scenario 2) would increase by approximately 9,000 tonnes CO_2e.

The assumption that biodiesel plants require the same energy and chemical inputs regardless of their feedstock is important; however, it is unlikely that they would influence the overall conclusion of the main analysis.

5. The type of process used to produce biodiesel

Another sensitivity relates to biodiesel production technologies. The analysis assumes that all biodiesel is produced using a conventional trans-esterification process; however, other processes exist which may be able to convert fats and oils to diesel more efficiently.

Several companies are, for example, developing hydrotreatment processes which can use tallow (and vegetable oils) to produce a fuel which is very similar to mineral diesel (e.g. Neste's NExBTL process, ConocoPhillips' RenewDiesel process).

Analysis undertaken for the companies developing these technologies (e.g. [18]) indicates that hydrotreating processes would lead to a biodiesel with higher GHG savings than conventional FAME. However, the analysis carried out above would not be particularly sensitive to the choice of processing technology – since the same technology would have to be used in both Scenario 1 and 2.

It is worth noting that hydrotreatment processes require similar quantities of energy for different feedstocks, so, the sensitivity discussed under point 4 above would not be relevant if this was the technology selected.

6. The impact of land use change in the production of biodiesel.

There is currently much concern about the increase in demand for palm oil in the Far East and the impact this will have on deforestation in the region (Casson 2003, UNEP 2007). The increase in demand for palm oil has come about predominantly as a result of its use in food (FAO 2003). However, there are also ambitious targets for biodiesel production in countries such as Thailand, Indonesia, Malaysia, China and India. For the first three of these it is likely that palm oil will be the oil of choice for biodiesel production. If this pressure is added to by increased production of oleochemicals in the Far East, will this result in more land use change? It has been shown that deforestation of tropical rain forest in Indonesia can result in the release of large quantities of carbon from the land (Hooijer *et al.* 2006).

Should we take this into account in the present analysis? This is quite a complex question. Palm oil plantations cannot be blamed alone for deforestation, as logging of valuable tropical timber and slash and burn agriculture have also been blamed (UNEP 2007, Casson 2003). In addition much of the oil used in oleochemicals in the Far East is palm kernel oil, a secondary product after the palm fruit has been processed for palm oil for food. It is clear that there could be some addition impact on GHG emissions from the increased demand for palm oil for oleochemicals in the Far East, should production shift there, but it is not possible to categorically say that all of this production would be met by deforestation of tropical rainforest. Some may be met by the development of plantations on land that has been left uncultivated after logging of rain forest and therefore improve carbon retention in degraded soils. In this work we considered the GHG impacts in the UK.

The effect of global land use change on GHG emissions is complex and controversial and is being examined elsewhere by DfT and the RFA. It is recommended that this topic is examined in a more in depth study once the treatment of carbon release from land use change is clarified.

5.4 Conclusions from GHG analysis

The results given in Table 5 clearly show that if displacement of tallow into biodiesel production results in renderers using low sulphur fuel oil, there will be a significant net increase in GHG emissions.

However, the overall result is very sensitive to this assumption. If, for example, the rendering industry were to replace tallow with MBM instead, then the difference in GHG emissions between scenarios could be much smaller and probably be lower in Scenario 2 (depending on the influence of the other key assumptions discussed in the sensitivity analysis: soap and oleochemical manufacture in South East Asia; international transport; tallow biodiesel production).

Before more definitive conclusions about the impact diverting tallow into biodiesel production would have on GHG emissions can be drawn, it is necessary to gain a better understanding of two factors:

- whether burning MBM would be economically attractive for the rendering industry and
- whether biomass supply in the UK would expand to ensure all existing biomass demand is met.

Finally, the scope of the RTFO Carbon Reporting methodology could be expanded to ensure it takes account of any fuel switches which occur at the rendering plant. In order to encourage reporting of actual data (i.e. on the type of fuel used) the default assumption could be that low sulphur fuel oil is used. This could create an incentive for renderers to seek out low carbon fuels as an alternative source to tallow, particularly if the RTFO were to be linked to a biofuel's GHG saving. It would also ensure the Renewable Fuels Agency was aware of what impact the RTFO was having on the market for tallow.

6 Discussion

This report was commissioned to examine whether the RTFO, by supporting the production of biodiesel from tallow, will have adverse effects on the other industries that use tallow as a feedstock and to enable the Government to consider whether changes need to, and could, be made to the design of the RTFO as the result of the above.

The work was undertaken as a series of four separate, but related, studies, and included consultation with the key stakeholders who have an interest in tallow use in the UK. These four studies provided:

- an overview of the current tallow industry in the UK and the sectors that use tallow as a feedstock
- the position and concerns of the major stakeholders and the relevance of tallow to their business
- the way in which the RTFO might impact on the price of tallow and the subsequent impact this would have on the various stakeholder groups, and
- the effect of switching production of tallow from oleochemicals to biodiesel on GHG emissions.

The time scale of the work and the data available precluded in-depth analysis and modelling, but the work undertaken does provide sufficiently clear evidence to allow conclusions to be drawn. These are listed below, together with a discussion of assumptions and any factors to which they are sensitive.

6.1 The UK Tallow sector

UK tallow is a limited resource, the size of which is dependent predominantly on UK meat production. The only way to expand this resource is to import tallow from abroad. This is not simple. Imported tallow is expensive compared to UK tallow; in addition, the 'hub' for import of tallow into Europe is in Rotterdam and there is significant additional cost to importing this tallow into the UK. Effectively this limits the tallow available to the UK to around 250,000t/y, with some small additional import/export mainly centred around the import of Irish tallow. This situation is discussed in more detail in Chapter 2.

Currently **all tallow produced is used for some economic purpose**. None is disposed to landfill. Figure 3 in Chapter 2 provides a breakdown of use. The main uses are dictated by the category of tallow under the Animal By-products Regulations[19]
Category 1 can only be used for burning or fuel production
Category 2 can be used for industrial applications
Category 3 can be used for human contact products (e.g. in soaps and cosmetics).

This is a key influence on the current predominant uses: burning of (mainly category 1) tallow in boilers by the rendering industry to raise process heat and the use of category 2 and 3 tallow by the oleochemicals and soap industry. Other, smaller–scale uses involve power generation, biofuels production, animal feed and food.

The UK oleochemicals and soap sectors exist because of the historical supply of cheap tallow in the UK. If this feedstock increases significantly in price (relative to alternative feedstocks available abroad) or the supply of the feedstock diminishes, the sector is unlikely to exist in the UK. This is because export tariffs on alternative feedstocks (most notably palm oil) make production of oleochemicals and soaps from other feedstocks uncompetitive in the UK.

- Alternative feedstocks for the key uses of tallow were examined:
  - The rendering industry currently substitutes fuel oil (or natural gas) for tallow for production of process heat and steam, depending on the relative prices of these fuels.
  - The oleochemical and soap industry is more complex. For the major products, a range of vegetable oils can be substituted, although the nearest equivalent in price and performance is palm oil. For some downstream products, mineral oils are more appropriate. The oleochemicals industry and the rendering industry provided information on the chemical processing of tallow to its various products and this is presented in Chapter 2.

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[19] See Chapter 2 for further explanation of these terminologies.

6.2 Tallow prices

The UK rendering industry and oleochemicals industry comprise relatively few organisations. Trade in tallow is not done on the open market, but as direct contracts between companies. Consequently much information regarding the use of tallow and its price is commercial and this study was unable to uncover the data regarding tallow price. This means that the analysis undertaken had to be done on relative trends in prices and on ranges of tallow prices rather than precise figures; and that these figures were provided by the industry because there is no independent source of information on tallow prices available.

However, some trends are clear. In the absence of subsidies the price of category 1 tallow is linked to fuel oil prices. As fuel oil prices increase the incentive to the rendering industry to use tallow in their boilers increases. Category 2 and 3 tallow prices reflect the trends in category 1 tallow, plus the additional cost of segregation and processing. The upper price of category 2 and 3 tallow is linked to the lowest equivalent virgin plant oil, minus the transport costs and any import or export tariffs. Price trends in tallow and other oils and fats relative to 2003 were provided by Uniqema. Other information on oils and fats prices were obtained from Oil World. The prices of oils and fats have been climbing steeply recently and there is an indication that the tallow price is linked in some way and is also rising. However, it is not clear exactly why this should be so.[20] Prices and their trends for tallow are provided in Chapter 3. If **category 1 prices increase sufficiently it acts to disincentivise the production of the category 2 and 3 tallow and their availability decreases**. This situation has a significant effect on the oleochemicals and soap industry, for which alternative feedstocks are not available in the UK and, if it is sustained for any period, would result in the closure of a significant part of its production in the UK.

In the absence of clear prices, the analysis in this report (Chapter 4) focused on evaluating the likely effects of assumed price changes on decision making by relevant sectors and on identifying the price thresholds that lead to changes in decisions. In addition the likely impacts of meeting biodiesel blend targets on the feedstock demands of different sectors and the financial impact on the oleochemicals sector if it had to pay specific prices for feedstock was also modelled.

Results to the work on economic analyses were:

- Even without the RTFO there is still an incentive for tallow to be used to produce biodiesel, given the current high oil price.
- An examination of the theoretical maximum 'willingness to pay' of biodiesel producers suggests that with the current duty relief the production of biodiesel is already quite competitive with unblended diesel. This is a function of the current high whole sale price of diesel, but the introduction of further measures under the RTFO to incentivise supply of biofuels may have the effect of further increasing the attractiveness of producing biodiesel, including from tallow.
- Assuming the RTFO 5 per cent biofuel target was met through biodiesel analysis of the *least cost* solution (under the assumptions in the economic model) would be that biodiesel producers buy all the available domestic supply of tallow. This is likely to be supplemented by imports from Republic of Ireland and continental Europe. In this scenario, renderers would buy fuel to replace tallow used for energy; and the oleochemical industry would no longer be able to use any domestic tallow. Therefore, under this assumption (that biodiesel sector meets their feedstock demands at least cost and only then do other sectors buy any excess supply available), there is likely to be a significant diversion of tallow away from existing markets. Even if lower percentage targets were met the diversion effect would still be strong.
- In this situation, the increased prices for alternative feedstocks to domestic tallow would have significant effects on the oleochemicals industry.

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[20] It could be related to a number of factors such as the oil price, the current shortage of certain foods and feed which has led to rising prices for agricultural commodities and the substitution of feedstocks in the presence of high prices, but this is speculation without hard evidence.

- It must be remembered that this is a theoretical situation. The tallow-biodiesel refining capacity in the UK is low at present. However, biodiesel plants are not complex refining plants and it is possible to establish new ones relatively quickly, subject to planning. There is currently an application for a 150,000t/y biodiesel plant that would be able to take tallow as a feedstock.
- The model suggests that at the current price of tallow (£150/t for category 1 assumed in this analysis), profits of renderers would be maximised when over half the production of tallow would be category 1 (which would all be used for in house energy by renderers), the rest being sold as category 3. As tallow prices increase a threshold would be reached above which it becomes more profitable for renderers to switch production to category 1 and away from category 2 and 3. In the model examined in Chapter 4, at £186/t for category 1, after meeting in house energy demands, it becomes more profitable for renderers to sell all remaining tallow as category 1 and none as category 2 and 3, unless the price of Category 3 simultaneously increases to £367/t.
- The overall conclusion is that any price increases to category 1 tallow, which may be brought about by increased demand from the biodiesel sector given RTFO incentives or for other reasons, would result in a switch away from category 3 and towards category 1, all other factors being equal. The model indicated that the threshold where no category 2 or 3 tallow is produced in the UK was an increase of about 25 per cent in the current category 1 tallow price (to £186/t from the assumed current price of £150/t).

6.3 Socio-economic impacts

We have been unable to obtain sufficient information about the patterns of employment and value added for the alternative uses for tallow to provide a reliable assessment. However, a crude analysis shows that switching tallow to biodiesel will have a net negative effect on employment, gross value added and the balance of trade.

The production of tallow biodiesel is a relatively simple process compared to production of oleochemicals and soap. These produce a wider range of products, using a greater variety of chemical transformations, and using a wider range of equipment. In contrast, the essence of a biodiesel plant is minimum complexity and greatest efficiency in producing a single product.

Uniqema estimate that there are over 200 people directly employed in the oleochemical and soap industries (Uniqema 2008). In addition because of the complexity of their operations there are a large number of contractors and service providers also involved in these sectors. These jobs would all disappear following a major shift of tallow to biodiesel production.

A biodiesel plant producing about 125kT/y a would employ about 45-50 people (Argent 2008). There would also be jobs in support and service sectors, but not more as a proportion than in oleochemicals and soap. Such a plant is of an economic size, and would use a similar but larger amount of tallow than the oleochemical and soap industries (125kt *versus* 82kT).

The oleochemical and soap industries have exports of more than £30m p.a. If missing domestic capacity is replaced by imports, the net negative change in the balance of trade is of the order of £100m p.a.

For this study we have focused on impacts in the UK and not tried to estimate or compare the net impacts on other economies, particularly in Asia.

Overall there are measurable, but not large, socio-economic impacts from the switch of tallow from oleochemicals and soap to biodiesel.

6.4 Impact on GHG emissions of the diversion of tallow to biodiesel

The time scale and data available for this analysis restricted the potential for undertaking an in-depth cradle to grave life cycle analysis of the use of tallow for biofuels or oleochemicals within this work. Instead two comparative scenarios were examined in which tallow was either used for biofuels or oleochemicals. These are described in detail in Chapter 5, together with a list of the assumptions inherent in each scenario.

Essentially the scenarios were:

Scenario 1: in which tallow is used for soap and oleochemicals production, with Category 1 tallow being used by the rendering industry for fuel. In this scenario it was assumed that biodiesel would be produced from palm oil in the UK[21]. Palm oil would be transported by tanker to the UK.

Scenario 2: in which all tallow was diverted to biodiesel. In this scenario it was assumed that soap and oleochemicals would be produced from palm oil in the Far East and transported by boat to the UK[22]. The rendering industry would need to use an alternative energy source and it was assumed that this would be fuel oil.

These scenarios are not strictly representative of what might happen, as is indicated in the footnotes and in Chapter 5. Consequently, they were subjected to a number of sensitivity analyses. These included examination of: the type of boiler fuel which replaces tallow when tallow is used for biodiesel; the type of fuel used by Malaysian soap and oleochemical manufacturers; the energy efficiency and relative mass of soap and oleochemical products transported; the amount of energy and chemicals required for biodiesel production from tallow; the type of process used to produce biodiesel.

The results of this analysis indicated:

- The most important sensitivity in the analysis is the fuel switching at the rendering plant. If displacement of tallow into biodiesel production results in the rendering industry using low sulphur fuel oil instead of tallow for fuel, there will be a significant net increase in GHG emissions (183kT of CO_2e in total, which is equivalent to 974 kg CO_2e/t tallow displaced). However, the overall result is very sensitive to the assumption about the fuel that is used as fuel oil. Some of the rendering industry can use natural gas, which would result in a net increase in GHG emissions, but lower than for fuel oil. If the rendering industry were to use a biomass fuel[23] then the GHG emissions would be much smaller and probably lower than the use of tallow for oleochemicals (depending on the influence of the other key assumptions, such as soap and oleochemical manufacture in South East Asia; international transport; tallow biodiesel production etc.). Before drawing conclusions about the impact of diverting tallow into biodiesel production would have on GHG emissions, it is necessary to gain a better understanding of two factors:
  - whether burning biomass (such as MBM) would be economically attractive for renderers and
  - whether biomass supply in the UK would expand to ensure all existing biomass demand is met.

- Thus there is a need for more data on what is actually happening at the rendering plant in order to ensure the calculation of GHG emissions from production of biodiesel from tallow is an accurate reflection of what is actually happening at the rendering plant. To take this into account the scope of the RTFO Carbon Reporting methodology[24] could be expanded to ensure it takes account of any fuel switches which occur (i.e. the scope of the fuel chain could be expanded to take account of the fuel used) at the rendering plant. At the moment data on the fuel switching at the rendering plants is not sufficient to ensure that the reporting is representative of what actually happens at the plant. In the future the RTFO will be linked to carbon savings and this would provide an incentive to the rendering industry to use a low emission fuel at their plants. In order to encourage reporting of actual data (i.e. on the type of fuel used) the default assumption could be that low sulphur fuel oil is used. This would create an incentive on renderers to use another low-carbon fuel instead of tallow, particularly if credits under the RTFO were linked to a biofuel's GHG saving.

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[21] Palm oil is not currently used in any great quantity to produce biodiesel in the UK. However, this scenario was justified on the basis that palm oil is the closest feedstock technically to tallow that could be used to replace tallow in any quantity; and it is the cheapest of the bio-oil feedstocks.

[22] Not all oleochemicals produced from tallow could use palm oil as a replacement feedstock. In some cases mineral oils would be needed. However, palm oil is the closest feedstock to tallow in its chemical properties and a significant proportion of oleochemicals and soaps could be made using palm oil. In addition the oleochemicals sector indicated that in the absence of tallow it is likely that production would shift to palm oil in the Far East.

[23] For example, the rendering industry have indicated an interest in developing MBM as a fuel for their rendering plants. This would take some investment, as the burning of some grades of MBM is strictly controlled. In addition MBM is used as a fuel in other sectors and the substitution of fuels in these sectors would need to be considered. Analysis of this use involves speculation about future possibilities and so it was not examined further in this work.

[24] See: http://www.dft.gov.uk/rfa/reportsandpublications/carbonandsustinabilityguidance.cfm

It would also ensure the Renewable Fuels Agency was aware of what impact the RTFO was having on the market for tallow.

- The other sensitivity analysis undertaken indicated that the other factors examined (i.e. the type of fuel used to provide process heat in soap and oleochemical manufacture, the assumptions made about international transport and the assumption that biodiesel plants require the same energy and chemical inputs regardless of their feedstock) all make a difference to the GHG emissions, but it was concluded that none of these influence the overall conclusion of the main analysis.

- Another sensitivity relates to biodiesel production technologies. The analysis assumes that all biodiesel is produced using a conventional trans-esterification process. However, other processes exist which may be able to convert fats and oils to diesel more efficiently. Several companies are, for example, developing hydrotreatment processes which can use tallow (and vegetable oils) to produce a fuel which is very similar to mineral diesel (e.g. Neste's NExBTL process, ConocoPhillips' RenewDiesel process). Analysis undertaken for the companies developing these technologies (e.g. IFEU, 2006) indicates that hydrotreating processes would lead to a biodiesel with higher GHG savings than conventional FAME. However, the analysis carried out above would not be particularly sensitive to the choice of processing technology – since the same technology would have to be used in both scenarios.

6.5 Other Environmental impacts

To obtain a balanced understanding of the full environmental impact of switching tallow from oleochemicals to biodiesel it is also important to consider other environmental impacts from the use of tallow in the oleochemicals or biodiesel industry. We were unable to gather clear data on potential environmental impacts from the processing of tallow to oleochemicals or biodiesel to allow comparison between the two routes. Such impacts could arise from additional emissions to air, soil and water from the processing of tallow, the production and disposal of by-products. We do not have clear evidence that these emissions would be significantly higher from the oleochemical or biodiesel use of tallow.

This leaves consideration of their respective roles for recycling or reusing residues and the value of the co-products: do these processes create useful products and does the processing result in co-products that are wastes or have any environmental impact?

The use of tallow both in the oleochemicals and the biodiesel sector represents the production of a new product from a by-product of the rendering industry and both processes represent recovery of value from tallow, as defined in the EC interpretation of the definition of wastes (EC 2007). It could be argued that the use of tallow for oleochemicals represents recycling and the use for biodiesel represents energy recovery. Indeed the oleochemicals industry argues that its products represent processing further up the waste hierarchy, as defined in the UK Waste Strategy (Defra 2007), which is true. This does not represent an argument for better environmental impact *per se*. To do this the whole environmental impact needs to be considered, including all emissions from processing and the disposal or use of by-products. Within the scope of this study it is not possible to do this.

6.6 Key questions

There are a number of key questions that also need to be considered:

- What impact will development of novel technologies and second-generation processing have on biodiesel in the longer term?
- Does the RTFO unduly encourage one use of tallow over another?
- If the RTFO were to be modified to create a level playing field for all users of tallow, would the oleochemicals industry be able to survive until this happened?
- How could the RTFO be modified to avoid these problems?

1. What impact will development of novel technologies and second-generation processing have on biodiesel in the longer term?
The economics of first-generation technology currently used to produce biofuels around the world are heavily dependent on feedstock costs. This means that production costs can only be kept down if feedstock costs are low. As a result there is considerable pressure on the cheapest feedstocks. There are a number of technologies being developed to allow the production of biofuels from lignocellulosic feedstocks.

The impetus behind this development is twofold: they allow the use of wastes and feedstocks that currently have little value or use; and they enable more sustainable/efficient land use. Unfortunately these processing technologies are currently expensive and technological development is still required. However, there are second generation demonstration plants in operation and more demonstration plant are planned. Many analysts predict this technology will be available within the next five to 15 years. Once the technology is in operation it may supersede first generation technologies in regions such as Europe where feedstock costs are high. Consequently the current methods for producing biodiesel may be phased out in favour of more advanced technology in Europe in the long term.

Marine algae are also being explored as a longer term source of oil for processing into fuel and chemicals. Many of the oil and energy majors have research programmes in this area as algae are believed to offer the potential for much higher conversion of primary photosynthetic products into oil compared to land crops.

2. Does the RTFO unduly encourage one use of tallow over another?
The analysis in this report demonstrates that the RTFO makes the production of biodiesel from tallow attractive and increases the biodiesel producers' willingness to pay for tallow. This provides an incentive to produce more category 1 tallow and not to produce category 3 tallow unless its price rises substantially, too.

3. **If the RTFO were to be modified in the future to create a level playing field for all users of tallow, would the oleochemicals industry in the UK be able to survive until this happened?**
There is no cheap alternative feedstock that the oleochemicals industry can use in the UK if tallow is diverted to biodiesel. It is likely that even a relatively short term switch to biodiesel would have a significant impact on the survival of the oleochemicals industry in the UK.

4. How could the RTFO be modified to avoid these problems in a manner consistent with EU and international legislation?
For feedstocks such as tallow that already have existing applications the RTFO should take into account the effect of substitution on the overall sustainability of switching to biofuels production, particularly on GHG emissions. The Govt should consider the implications of this carefully, particularly in the context of the proposed shift to a carbon-linked RTFO

5. To what extent are the problems faced by the oleochemicals industry due to current high tallow prices as opposed to wider, global economic factors?
The oleochemicals industry is facing a number of problems at the moment, including competition from products from the palm oil industry in the Far East. Biofuels are not solely to blame for the problems faced by the oleochemicals industry – they are part of a much bigger picture. However, feedstock costs are a significant proportion of costs for the oleochemicals industry and the industry exists in the UK because historically there has been a supply of cheap tallow. The significance of feedstock costs in the oleochemicals business model means that it is particularly vulnerable to increase feedstock costs. In addition, it is difficult for the industry to pass these prices onto its customers in the current competitive environment. Consequently, although tallow prices are not the only factor affecting the oleochemicals industry they will have important consequences. At the moment palm oil prices are also high (both in the UK and the Far East) but any price rise for tallow relative to the price of palm oil would be difficult for the oleochemicals industry.

6.7 Principal Conclusions

- The RTFO is likely to increase the maximum price biodiesel producers are willing to pay for tallow. Depending on prices of alternative feedstocks this may result in diverting supplies from current uses **but the economic analysis suggests that this could result in any case with or without the RTFO.**
- One of the consequences of increased prices for category 1 tallow is likely to be a reduction in availability of category 2 and 3 tallow.
- Tallow is relatively cheap compared to other biodiesel feedstocks. This means that if biodiesel producers only use price to decide which feedstock to use, tallow is very attractive.
- Tallow biodiesel refining capacity in the UK is currently met from only one plant, which has a capacity of 45kT/y. According to our figures only 17kT/y are currently used for biodiesel. This situation will change in the future if the proposed Ellesmere port plant is developed. This plant has a proposed capacity of 150kT/y.

  This means that although tallow is an attractive feedstock for biodiesel the refining capacity currently limits the amount of biodiesel that can be produced from tallow. However, developing biodiesel plants is relatively straight-forward and can be done relatively quickly.
- The current high prices for mineral diesel acting together with the RTFO could divert a significant proportion of tallow into biodiesel production (with the caveat that tallow-biodiesel refining capacity is currently limited, as indicated above). Tallow is the major feedstock for the UK oleochemical and soap industry. Diversion of this feedstock to another use would remove tallow as a feedstock for the oleochemicals and soap industry in the UK and could result in a significant shift of UK oleochemical production to the Far East.
- The environmental impact of the shift from the current uses of tallow to biodiesel production is 'negative' in terms of GHG emissions, although this conclusion is dependent on the fuel substituted for heat production at the rendering plant. This is an important consideration in the sustainability of using tallow for biodiesel production.
- All tallow produced in the UK is currently being used. If tallow is switched to biodiesel production, alternative feedstocks are required for the other tallow uses. These feedstocks are likely to be fossil oils or imported vegetable oils. The sustainability of this switch should be considered in more depth.
- The economic impacts of switching tallow from oleochemicals to biodiesel in the UK requires more in depth analysis. From the data we have it appears that there will be a loss of income from oleochemicals exports and a need to import oleochemicals, which are not compensated by the decreased need to import diesel. If this is correct it would result in a negative impact on the balance of trade.
- From the information we have obtained the social cost of the shift of tallow from oleochemicals to biodiesel is a net reduction in jobs.
- If the RTFO is to result in more environmentally sustainable transport fuels it is important that indirect impacts are considered. In the case of wastes that have existing (disposal outlets or) applications, the impact of the switch to biofuels on the overall environmental emissions must be considered as part of the calculation of net GHG emission reductions.
- The oleochemicals industry in the UK is facing a number of problems, including increased competition from the Far East. Biofuels are not solely to blame for the problems faced by the oleochemicals industry – they are part of a much bigger picture. However, from the analysis presented in this report, it is clear that demand for tallow for biodiesel could contribute to the problems, although there is not very much direct evidence that this is happening at present.

6.8 Recommendations

There are three main recommendations from this report:

1. Our analysis shows that, from a GHG perspective, the use of tallow as a biofuel results in greater emissions. This finding is dependent on the assumptions made in the analysis. A sensitivity analysis of these assumptions indicated that only one of these assumptions would make a significant difference to this outcome, and this is the fuels used as a substitute for tallow in boilers at the rendering plants. If a biomass fuel such as MBM were used for these boilers rather than the fossil fuel used in our analysis a much better GHG balance is achieved. However, this depends on the source of the MBM and how it is used.

To take this into account we recommend that **the scope of the RTFO Carbon Reporting methodology could be expanded to ensure it takes account of any fuel switches which occur at the rendering plant**, i.e. the scope of the fuel chain could be expanded to take account of the fuel used at the rendering plant. At the moment data on the fuel switching at the rendering plants is not sufficient to ensure that the reporting is representative of what actually happens at the plant. In the future the RTFO will be linked to carbon savings and this would provide an incentive to the rendering industry to use a low emission fuel at their plants. In order to encourage reporting of actual data (i.e. on the type of fuel used) the default assumption could be that low sulphur fuel oil is used. This would provide a default that reduces the incentive for a renderer to burn fuel oil, particularly when the RTFO is linked to a biofuel's GHG saving. It would also ensure the Renewable Fuels Agency was aware of what impact the RTFO was having on the market for tallow.

2. The revised Renewable Energy Directive proposes that certain more sustainable feedstocks such as wastes will be regarded as more sustainable.[25]
   The approach makes no provision for displacement impacts or other indirect effects. Our work has shown that it is important that substitution and indirect impacts are included in the environmental sustainability criteria used to assess biofuels. **We recommend that the Government should draw attention to the likely impacts of the proposed double reward for certain types of biofuels including biodiesel produced from tallow.**

3. The UK cannot act unilaterally. **It is important to share the findings of this research with the European Commission and other Member States.**

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[25] The text is designed to encourage second generation biofuels and states: 'In order to demonstrate compliance with national renewable energy obligations the contribution made by biofuels from wastes, residues, non food cellulosic material and ligno-cellulosic material shall be considered to be twice that made by other fuels'. This has been interpreted by some stakeholders to mean that tallow-biodiesel will be rated more highly than other biofuels.

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Appendices

Appendix 1: Participants in the UK Rendering Industry

Appendix 2: Oleochemical and soap manufacturers in the UK

Appendix 3: Task 3 Outline of model and assumptions

Appendix 4: Article from ICIS Chemical Business (Finch 2008)

Appendix 1

Participants in the UK Rendering Industry

[data taken from the UK Renderers Association website www.ukra.co.uk]

Table 6 **Members of the UK Renderers Association:**

- A Hughes and Son Ltd
- Alba Proteins Ltd
- Argent Oils Ltd
- Caledonian Proteins
- Dungannon Proteins Ltd
- Foyle Food Group Ltd
- Harrisons Poultry Ltd
- J G Pears (Newark) Ltd
- John Pointon and Sons Ltd
- Linergy Ltd
- Lisburn Proteins Ltd
- McIntosh-Donald Ltd
- Omega Proteins Ltd
- P Waddington & Co Ltd
- PDM Group
- Peninsular Proteins Ltd
- Sun Valley Foods Ltd
- The Argent Group

Figure 22 **Location of Rendering Plants in the UK**

Appendix 2

Oleochemical and Soap Manufacturers in the UK

The only significant oleochemical company manufacturing in the UK is the Uniqema division of Croda, with a factory in Bromborough on the Wirral (www.uniqema.com).

Soap Producers Listed as Members of the UK Cleaning Products Industry Association
www.ukcpi.org

- Coronation Export / Import Ltd
- Dicom Dalli UK Ltd
- John Drury & Co Ltd
- Kay's (Ramsbottom) Ltd
- PZ Cussons (UK) Ltd
- Sigma Soap Ltd
- Standard Soap Company Ltd

Not all of these are currently manufacturing soap in the UK. Those that are include John Drury & Co, Kays, Sigma Soaps and Standard Soap Company.

Appendix 3

Task 3: Outline of model and assumptions

Assumed decision problem - renderers

It is assumed that renderers will seek to maximise profit when deciding what to do with the tallow they produce. Renderers are assumed to sell tallow at the highest market price. If the relative price offered by biodiesel producers vis-à-vis the price of fossil fuels was right, then renderers would sell tallow for conversion to biodiesel and replace it in their own operations with an equivalent amount of fossil fuel.

Hence, we assume that renderers face the following decision problem with respect to finding outlets for the tallow they produce:

$$\text{Max } \Pi = \sum_{i=1,2,3} \pi_i - q_F \times p_F$$

Where:

Π = Profit from tallow.

$\pi_i^{S,E}$ = Profit from category i tallow, which is either used to meet the energy demands of own operations (*E*) or sold (*S*).

q_F = Quantity of fossil fuel purchased to meet energy demands of own operations.

p_F = Price of delivered fossil fuel (assumed to be HFO).

$\pi_1^S = q_1^S \times p_1$ = Profit from category 1 tallow that is sold.

$\pi_1^E = q_1^E \times (\alpha \times p_F - p_1)$ = Profit from category 1 tallow that is used to meet energy demands of own operations.

$\pi_2^S = q_2^S \times (p_2 - c_2)$ = Profit from category 2 tallow that is sold.

$\pi_2^E = q_2^E \times (\alpha \times p_F - p_2 + c_2)$ = Profit from category 2 tallow that is used to meet energy demands of own operations.

$\pi_3^S = q_3^S \times (p_3 - c_3)$ = Profit from category 2 tallow that is sold.

$\pi_3^E = q_3^E \times (\alpha \times p_F - p_3 + c_3)$ = Profit from category 3 tallow that is used to meet energy demands of own operations.

$q_i^{S,E}$ = Quantity of category i tallow, which is either used to meet the energy demands of own operations (*E*) or sold (*S*).

p_i = Market price for category i tallow.

c_i = Incremental cost of upgrading category 1 tallow to category 2 and 3 tallow.

α = Ratio of the net calorific value of tallow to the net calorific value of fossil fuel (assumed to be HFO).

Subject to the following constraints.

$\sum_i q_i^{S,E}$ $\geq$ Zero.

q_F $\geq$ Zero.

$q_F + \sum_i q_i^E$ $=$ Total energy demands of own operations.

$\sum_i q_i^{S,E}$ $\leq$ Total production of tallow.

Assumed decision problem – biodiesel producers (and other users of oil and fat feedstocks)

It is assumed that the basic decision problem facing biodiesel producers is that of least-cost feedstock procurement, given total capacity and the relative yield of biodiesel from different feedstocks. However, because the purpose of this study is to consider the strategic position of tallow relative to other feedstocks, assuming that specific blend targets (1-5 per cent) for biodiesel production are met, a slightly different approach is taken. As biodiesel producers must compete for feedstocks with other end-users of fats and oils - namely food, animal feed, oleochemicals, and renderers (who use tallow to meet the energy demands of their own operations), the decision problem is set up to minimise the total feedstock cost of producing historical levels of output by each of these sectors. The relevant feedstocks are rapeseed oil, palm oil, soy oil, tallow (separated between UK-produced category 1, UK-produced category 2 plus 3, imports of category 2 plus 3 from the Republic of Ireland, and imports of category 2 plus 3 from the rest of the EU) and yellow grease. Constraints are imposed on the cost model that require it to meet biodiesel blend targets, plus historical demands for fat and oil in foods, animal feed, oleochemicals, and the energy needs of renderers. Hence, we assume that biodiesel producers and other users of oils and fats face the following decision problem with respect to sourcing feedstocks:

$$\text{Min } C = \sum_{i=B,F,A,C} c_i^k$$

Where:

C = Cost of sourcing feedstocks. Available feedstocks include: UK produced category 1 tallow and category 2 + 3 tallow, category 2 + 3 tallow imported from the Republic of Ireland or the rest of the EU, yellow grease, soy oil, palm oil and rapeseed oil.

$c_i^k = \sum_k q_i^k \times p_k$ = Cost to sector i of securing q tonnes of feedstock k at price p_k per tonne. Sectors consuming fats and oils include: UK-based biodiesel producers (B), renderers (R), food (F), animal feed (A) and chemicals (C).

q_i^k = Quantity of feedstock k purchased by sector i.

p_k = Market price of feedstock k.

Subject to the following constraints.

$q_i^k \geq$ Zero.

$\sum_k q_i^k =$ Total feedstock demands of sector i.

$\sum_i q_i^k \leq$ Total supply of feedstock k.

$\sum_k q_B^k =$ Total quantity of feedstocks needed to met the blend target(s).

$q_{\text{F,A,C}}^{\text{UK cat 1 tallow}} =$ Zero.

$q_{\text{F,R,C}}^{\text{Yellow grease}} =$ Zero.

$q_{\text{F}}^{\text{UK cat 2+3, imported cat 2+3 tallow}} =$ Zero.

The model is solved first for biodiesel producers. The excess supply, once biodiesel demand is met, is then made available to the other sectors to meet their feedstock demands.

Assumptions Q1.

- The wholesale price of diesel is 33.60 ppl (from Quarterly Energy Prices (BERR)).
- The profit margin on diesel is 7.50 ppl.
- The duty on diesel is 50.35 ppl.
- The profit margin on biodiesel is 10.00 ppl.
- VAT is levied on both diesel and biodiesel at the standard rate of 17.5%.
- Feedstock costs comprise 80% of the total net production costs of biodiesel.
- CAPEX and fixed OPEX comprise 15% of the total net production costs of biodiesel (this includes capital repayments).
- Variable OPEX comprise 5% of the total net production costs of biodiesel.
- Feedstock yield is 1,067 kg feedstock per 1000 kg biodiesel.
- Biodiesel density is 0.88 grams of biodiesel per l biodiesel.
- Revenue from co-products are not included. At present, the value of biodiesel glycerine is very low as a result of increasing supply on the European market.

Assumptions Q2.

- Total demand for oil to meet the energy demands of operations is 141,659 tonnes per year, of which 140,000 is tallow.
- The price of oil delivered to meet energy demands is £360 per tonne.
- The ratio of the calorific value of tallow to oil is 0.90.
- The baseline price of category 1, 2 and 3 tallow is, respectively, £150 per t, £300 per t and £365 per t.
- The gross profit margin per t of category 2 tallow is assumed = 50% (used to approximate the additional cost of producing category 2 tallow relative to category 1 tallow).
- The mark-up of category 3 tallow production costs relative to category 2 tallow production costs is assumed to be 20% (used to estimate the cost of producing category 3 relative to category 2 tallow).

Assumptions Q3.

- Price data assumptions are as follows (averages for 2007 based on stakeholder consultations and data from Oil World):

(£ per tonne)	End-user 1 Biodiesel	End-user 2 Chemicals	End-user 3 Food	End-user 4 Feed	End-user 5 Renderers
C1 Tallow (domestic)	150	150	150	150	150
Yellow Grease	180	180	180	180	180
C 2 & 3 Tallow (domestic)	335	335	335	335	335
C 2 & 3 Tallow (import RoI)	345	345	345	345	345
Palm	370	370	370	370	370
C 2 & 3 Tallow (import EU)	380	380	380	380	380
Soy	395	395	395	395	395
Rapeseed	470	470	470	470	470

Assumptions are made about which sectors would use which feedstocks. Oleochemical sector would not use category 1 tallow or yellow grease. Food sector would use only vegetable oils and not tallow or yellow grease. category 1 tallow would not be used for feed. Renderers would only use category 1 (*and category 2 and 3??*) tallow.

Oleochemicals sector total demand for feedstocks is 88,890 tonnes pa (based on stakeholder information that Oleochemicals use 80 kt tallow per year, which is about 90% of total feedstocks).

Assumption for Q 4.

Using a simple microeconomic model of a firm, increases in base case variable production costs, turnover and gross operating surplus have been simulated for an average enterprise in NACE 24.51; note that this classification includes oleochemicals, but also detergents, cleaning and polishing preparations. The increase in variable production costs are the result of having to pay more for feedstocks. The base case price of feedstock is assumed to be £300 per t (roughly the price for category 2 tallow). A set of 6 different feedstock prices are simulated:

£310 (approx premium for imports from Eire)
£345 (approx premium for imports from the rest of the EU)
£365 (approx category 3 tallow price)
£370 (palm oil price)
£395 (Soya oil price or imported tallow price from S. America)
£470 (Rapeseed oil)

The simulations consider a range of cost-pass through assumptions from zero % to 100%. The assumed price elasticity of demand for all products from the sector is -0.3.

Appendix 4

Article from ICIS Chemical Business (Finch 2008)

European surfactant and soap manufacturers are in turmoil as competition for renewable energy feedstocks causes shortages and oil prices push up oleochemicals

Heidi Finch/London

EU TARGETS for increasing the use of biofuels, combined with the surge in oil prices, are driving up fatty alcohol and acid prices, and threatening downstream markets. And this is likely to continue in 2008.

Traditionally, the price of palm oil has been independent of crude, but since use of vegetable oil for biofuels began, there has been a correlation between crude movements and those of its vegetable oil counterparts.

In tandem with January's Brent crude high of $96.56/bbl, fourth-quarter (Q4) crude palm oil (CPO) peaked at Malaysian ringgit (M$) 3,000 ($918) ex-works. There was a similar picture in Q1, 2008.

Feedstock competition for vegetable oil and animal fat has also increased with the emergence of the biodiesel market. Fatty alcohol and fatty acid production now compete with biodiesel for vegetable oil feedstock and the fatty acid and biodiesel markets are rivals for tallow.

Market pressure has caused the European Chemical Industry Council (Cefic) to ask for the EU renewables policy - which sets usage targets - to be reconsidered, amid growing concerns about availability for animal and vegetable oil and fat in 2008.

Animal fats were seen to be particularly affected due to tax incentives to burn them for heat, energy and transport fuels.

"It is a waste of good tallow fat raw materials to burn them for energy, and it is causing fundamental feedstock shortages in the oleochemical industry," says Alf Eriksson, business sector manager at AAK/Tefac Oleochemicals.

In the fatty acid market, tallow is used as a substitute raw material for palm oil and as a result, tallow generally follows the price of its vegetable-based competition. However, late in 2007, tallow prices broke with tradition and managed to gain ground on palm oil.

In Q4, tallow contract prices rose by €80-100/tonne, taking values to the low to mid-€500s/tonne FD (free delivered) NWE (Northwest Europe).

In turn, the high feedstock costs pushed up fatty alcohol and fatty acid prices, squeezing downstream margins.

Fatty alcohol and acid find downstream outlets in the soaps and surfactant industries, cosmetics, personal care products and wood preservatives.

Surfactant manufacturers are still suffering

Despite feedstock flexibility, surfactant manufacturers are feeling the high upstream cost pressures. One natural fatty alcohol buyer says that it has struggled to pass on increases into the commodity surfactant sector, and lost some business to its synthetic competition.

Similarly, one tallow fatty acid customer says it is not only difficult to secure business in the commodities sector, but also for specialties, adding that it has been forced to cut back its volume requirements by 15% in Q4.

Industrial applications that had previously benefited from traditionally lower tallow fatty acid prices have also been affected by rising feedstock costs.

Earlier in 2007, tallow prices were considerably lower than its palm oil counterparts.

This triggered a shift in buying patterns where substitution between vegetable and tallow fatty acids was possible. Fatty acid buyers in the surfactant sector were able to take advantage of the attractive price gap.

But this price difference soon eroded during Q4, as tallow and tallow fatty acid prices continued to move up, gaining ground on the high price evolution of its palm oil counterparts.

Looking to Q1 2008, feedstock price pressure is set to continue, according to market participants.

Q1 tallow contract prices are likely to move up by €80-100/tonne, to €600-650/tonne FD NWE. Tallow fatty acid sellers are determined to push for substantial increases of €100-200/tonne on the back of rising raw material costs, supply constraints and strong market fundamentals.

This has led a few fatty acid players to reconsider their quotas to include more vegetable- over tallow -based product, a U-turn in buying patterns from Q3. However, one fatty acid customer says it does not consider this any real solution, taking into account recent palm oil volatility

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