An Investigation into the use of Tallow as a Thermal Fuel in Ireland

by

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ABSTRACT

The study investigates the use of tallow as a thermal fuel in Ireland, focusing on its suitability as a fuel in steam raising boilers. The legislative position of such use with regard to the protection of health is discussed under the requirements of the Animal By-Products Regulations. The protection of the environment is discussed in respect of the applicability of waste legislation, the emissions trading scheme and emission of air pollutants.

The quantity of tallow available for use as a thermal fuel is determined and the practical application of the Animal By-Products Regulations at plant level is described. This is further enhanced by a case study of a plant already using tallow as a thermal fuel. The attitude of industry toward fuel usage and particularly tallow is investigated by means of a survey of IPPC licensed facilities in the Food and Drink industry.

Findings show that the Animal By-Product Regulations is competent in providing the protection necessary for health and that the applicability of waste legislation to the combustion of tallow is likely to end because of a review of the Animal By-Products Regulations. Tallow was found to be a cleaner fuel than mineral oils with the exceptions of particulates and carbon monoxide, but these still within the emission limit values of air quality standards.

In conclusion, the study found that tallow is more sustainable than fossil fuel and some renewable fuels. As cost was the primary consideration in fuel choice for the respondents of the survey, the suitability of tallow as a thermal fuel is restricted for economic reasons to those companies using mineral fuel oils and particularly those with Greenhouse Gas permits, due to its zero carbon rating.

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SECTION 1: INTRODUCTION

Animal By-Products, those parts of animals not intended for consumption, constitute almost half the live weight of the animal. In Ireland, 550,000 tonnes of Animal By-Products are produced each year (DAFF, 2008). This material is susceptible to rapid degradation by microbial activity due to its high water content. Rendering reduces the water content and converts ABP into the stable materials: meat and bonemeal and animal fat.

The animal fat, commonly known as tallow, is used for animal feed and in the oleochemical industry. It is also used as a thermal fuel and is similar in viscosity and energy value to heavy fuel oil. Its use as a fuel for steam raising boilers is widespread globally and has been used for this purpose in Ireland since 2000.

Because tallow is derived from Animal By-Products, it falls under the scope of the Animal By-Products legislation (European Parliament and the Council of the European Union, 2002). Under the Animal By-Products Regulations (ABPRs), conditions are laid down for the combustion of tallow as a thermal fuel. These conditions are for the protection of public health. The protection of the environment, with regard to the combustion of tallow, is covered at present by the Waste Framework Directive (European Parliament and the Council of the European Union, 2006) and to a lesser extent, Integrated Pollution Prevention Control legislation, air quality legislation, and the Emissions Trading Scheme (European Parliament and of the Council of the European Union, 2003).

In Ireland, tallow is not classified as a waste by the Department of the Environment, Heritage and Local Government (ECOLAS, 2006) and therefore is used as a thermal fuel without the requirements of the waste legislation, particularly the Waste Incineration Directive (European Parliament and the Council of the European Union, 2000). It is combusted under the conditions of the Animal By-Product Regulations, which are enforced by the Department of Agriculture and Fisheries and Food (DAFF). Currently the Animal By-Product Regulations and the Waste Framework Directive are under review and it seems likely that the combustion of tallow will be removed from the scope of waste legislation.

The practical issues that are the concern of users of this fuel are those of price, availability, and greenhouse gas emissions. With rapidly increasing oil prices and the growth of biofuels, the demand for oils and fats is strengthening. Tallow is no exception and future value and supply are uncertain. In addition, many users are holders of greenhouse gas permits under the EU Emissions Trading Scheme and the use of this biomass fuel (Commission, 2007) is necessary for an economic compliance with this legislation.

The aim of this study is to determine the suitability of using tallow as a fuel in Ireland. This is explored by looking at the legislative position, the quantity available, the attitudes of industry, and the requirements of the Animal By-Product Regulations. The financial aspects of using tallow are considered and finally, a case study is presented which illustrates the practical aspects of using tallow as a thermal fuel.

SECTION 2: LITERATURE REVIEW

2.1 Animal By-Products

When animals are slaughtered, up to 49% of the live weight is not used for human consumption. Table 2.1 below shows the percentage inedible and edible portions of cattle, swine, and poultry.

	Edible	**Inedible**
Cattle	51	49
Swine	56	44
Poultry	63	37

Table 2.1.1 **Edible and Inedible proportions by percentage of live weight of animals (Breitmeyer, Hamilton, and Kirstein, 2006).**

While a small percentage of the inedible portions, such as hides, skins, pet food and some technical products, provide added value to the animal, the majority of Animal By-Products (ABP) is processed, at a cost, by heat treatment, where the fat, protein, and water of the constituent materials are separated. The percentage proportions of fat, protein, and water content of ABPs are presented in Table 2.2 below.

	Protein	**Fat**	**Water**
Blood	10	0	90
Fat Trim	5	55	40
Bones	35	10	55
Offal	15	15	70

Table 2.1.2 **Percentage water, protein and fat content of animal by-products (Breitmeyer et al., 2006).**

The procedure whereby the constituents are separated, known as rendering, produces stable animal fat and meat and bonemeal (MBM) from raw animal by-products. The water is driven off, which causes a volume reduction of greater than 60% and the destruction of bacteria and viruses. The fat portion, known as animal fat or tallow, is separated from the remaining, mostly protein portion. Further processing of the protein portion produces MBM. The animal fat and MBM are stable and capable of being stored for long periods under correct storage conditions (Breitmeyer et al., 2006).

Animal fat quality is graded according to the type of fat used, its production method and free fatty acid (FFA) content. FFA content is a measure of the freshness of the ABP processed. The highest quality is that produced by fat melting of adipose tissue from animals fit for consumption. This is edible fat and must have less than 0.75% FFA, or less than 3% FFA, depending on whether the fat is derived from ruminants, porcine, or other animals. (European Parliament and the Council of the European Union, 2004).
The second grade is high-grade animal fat produced in rendering plants with less than 5% FFA. The third grade is low-grade animal fat produces at rendering plants with greater than 5% FFA (Clearpower, 2003). While strictly, the word tallow refers to the animal fat of bovines the term is widely used to describe all rendered animal fats, as is the case in this text.

2.1.1 The ABP Regulations

Under the ABPR (EC) No 1774/2002, which lays down health rules concerning ABP not intended for human consumption, ABPs are categorised as Category 1, Category 2, or Category 3, depending on the risk they present to animal or public health. Category 1 material includes those by-products thought to cause the most risk, particularly from bovine spongiform encephalopathies (BSE) in cattle. It includes animals infected by the prion and specified risk material (SRM) such as the brain and spinal cord. Category 1 material is prohibited from entering the food chain again and is for disposal only.

Category 2 material includes material that may present risk from disease or residues. It is not for animal consumption but may be used in other regulated areas, such as fertilisers, biogas production, composting, and some industrial uses.

Category 3 material is derived from animals, which have passed both ante mortem and post mortem inspection, and do not contain any disease communicable to man or animal, but is not intended for human consumption.

If categories are mixed, the entire mixture is classified as the category with the higher risk. Rendering plants are approved to process ABP according to its assigned category. Because there is no Category 2 rendering plant in Ireland, Category 2 ABP is treated as Category 1 material by default. Tallow and MBM produced in Ireland are therefore either Category 1 or Category 3. In Europe, all categories are produced due to the existence of all categories of rendering plants.

In Ireland, the Department of Agriculture, Fisheries, and Food (DAFF) is the overall competent authority for the implementation of the ABPRs. The DAFF is particularly responsible for the larger meat plants while smaller abattoirs are the responsibility of the Local Authority Veterinary Service. Marine ABP is controlled by the Sea-Fisheries Protection Authority and the Health Service Executive regulates the retail ABPRs (DAFF, 2008).

The ABPRs were implemented in 2003 to protect human and animal health from risks associated with ABPs, particularly at the time the BSE prion. The incidence of BSE in

Ireland has declined since the peak in 2002 of 333 cases. This is due in part to the early implementation of controls from 1996 onwards. In 2007, just 25 cases were identified (DAFF, 2008).

The incubation period for BSE is approximately 5 years and up to 2003, the incidence of BSE in animals over 6 years had dropped from 40% in 2000 to 0% in 2003 (FSAI, 2004). The increasing age profile of the animals with BSE and the reduction in cases identified indicates that the control measures are effective. A study on the vCJD risk in Ireland showed that there is the possibility of one clinical case to materialise in the future from past exposure to the prion from eating meat from BSE positive bovines (Ghani, Donnelly, Walsh, Walsh, Howley, Brett, and Farrell, 2003).

2.1.2 Processing and Disposal Options for Animal By-Products

Rendering is an established and approved treatment option for processing ABP. However, it is not the only method described in the ABPRs (EC) No 1774/2002 and (EC) No 92/2005 (EC, 2005a).

All categories of ABP material may be disposed of directly in an incineration plant, with or without heat recovery. Tallow and MBM may also be disposed of in this manner and it is still the route for Category 1 MBM. In the absence of an incinerator in Ireland MBM is exported for incineration to Europe at a significant cost to the industry.

Category 2 rendered product, manure, gut content, and Category 3 material may be processed in a biogas plants, and composting plants.

Other options available since the implementation of (EC) No 92/2005 for the treatment of all categories are alkaline hydrolysis, biodiesel production (tallow) and Brooke's gasification process.

2.1.3 Uses of Tallow

The production of tallow is one of the oldest recycling procedures known to man. Frank Burnham, in his 1978 book on rendering 'The Invisible Industry', told of the Roman scholar Pliny Secundas, 'Pliny the Elder', who reported a cleansing compound (early soap?) made from goats tallow and wood ashes. Tallow continued through the ages as a constituent of soap and also was used to make candles. With the advent of electricity and then synthetic soaps, these traditional uses of tallow diminished and were replaced by high-energy animal feed applications for the developing livestock industries. Fatty acid and lubricant functions and the pet food industry also increased demand (Bisplinghoff, 2006).

Table 2.1.3 below, lists many of the industrial uses for fats and fatty acids. These uses are diminishing somewhat due to the availability of suitable petroleum/synthetic-based products (McGlashan, 2006).

Explosives	Makeup	Paints
Saddle soap	Solvents	Industrial oil and lubricants
Margarine and shortening	Chemicals	Rubber products
Crayons	Insecticides	Floor wax
Cosmetics	Paraffin	Herbicides
Ceramics	Dish and hand soap	Medicines
Creams and Lotions	Mink Oil	Antifreeze
Tallow for tanning	Shaving cream	Biodegradable detergents
Hair conditioner	Bone char	Bone china

Table 2.1.3 **Industrial Uses for Fats and Fatty Acids. Source: California Department of Food and Agriculture.**

With the onset of transmissible spongiform encephalopathies in the 1990s and the ensuing ABP in legislation in Europe in 2002, the trade options for tallow and MBM were dependent on the assigned ABP category. Animal feed use was banned for all categories of MBM, as the prion was associated with protein. In contrast, category 3 tallow continues to be used in animal feed so long as it meets legislative requirements. Categories1 and 2 tallow, however, are considered to pose a health risk and are removed from the animal feed trade (European Parliament and the Council of the European Union, 2002).

A survey of tallow use in Europe in 2005 that covered 14 member states and Norway showed that 74% of the Category 1 tallow produced was used by renderers as a fuel for their boilers. The remaining Category 1 tallow was used largely in cement and power plants. Category 2 was used for similar purposes and in the oleochemical industry (49.3%). The major uses of Category 3 tallow were animal feed (49.5%) and the oleochemical industry 41.8%. Total tallow production for the area surveyed amounted to 2,221,356 tonnes for 2005 with a breakdown of 67.24% Category 3, 17.63% Category 1, 9.68% Category 1 and 2 mixed, and 5.46% Category 2 alone as shown in Figure 1. The information presented was considered representative, as the major producers, France, Germany, Spain, and the UK were included in the survey population (ECOLAS, 2006).

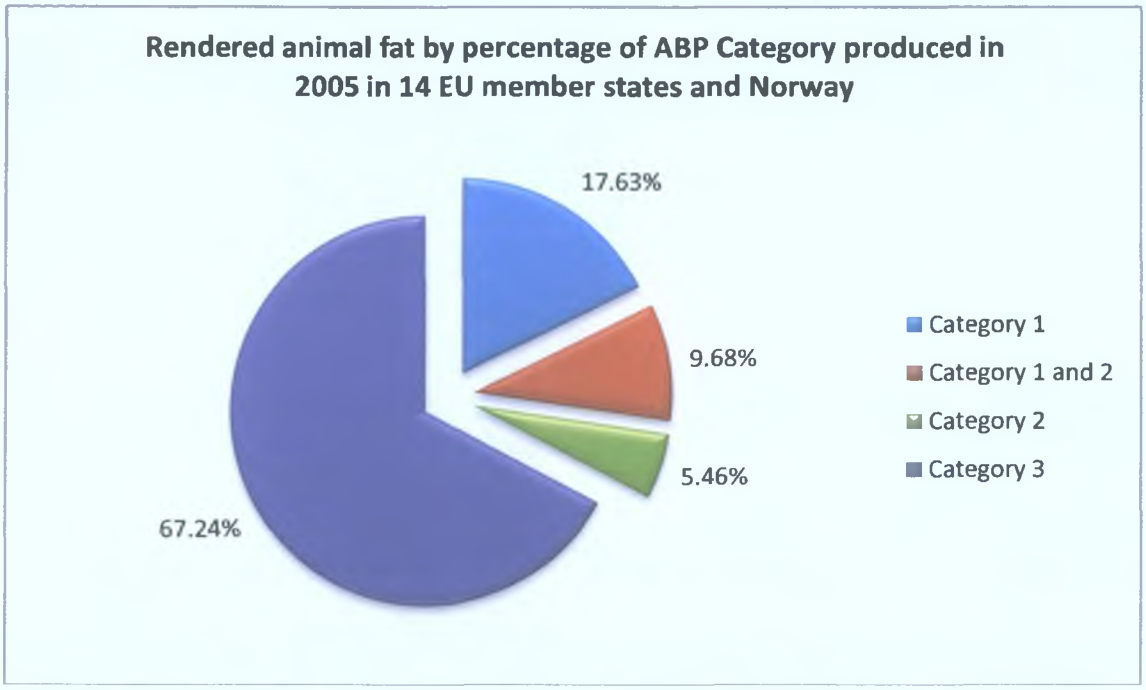

Figure 2.1.1 **Rendered animal fat by percentage of ABP Category produced in 2005 in 14 EU member states and Norway. Adapted from the ECOLAS Report, 2006 (Appendix 2.1)**

2.1.4 Tallow as a fuel

Tallow is comparable to mineral fuel oil with regard to energy content but has the considerable advantage of being categorised as biomass with a zero carbon rating for emissions trading purposes. Although solid at ambient temperatures, once heated, it is readily interchangeable with mineral fuel oil in adapted burners of steam generation boilers. The burners are adapted to run on tallow after initial start up on mineral oil. Once the tallow flow is established through the heated fuel lines, it can replace the fuel oil entirely, and the burner will continue on tallow until it is stopped.

Because of the BSE crisis in the late 1990s, the EU implemented Commission Regulation (EC) No 2777/2000 adopting exceptional support measures for the beef market. Beef animals over 30 months were purchased by the state under the Purchase for Destruction Scheme for destruction/disposal only. This scheme was implemented in Ireland under S.I. No. 48/2001 — European Communities (Slaughter of Bovine Animals Aged over 30 Months) Regulations, 2001, from January to June 2001. Almost 300,000 cattle were slaughtered under the scheme. This created vastly increased amounts of material for rendering. The rendered material had to be destroyed '*by way of incineration or other appropriate means*' according to Article 5.2 of Regulation (EC) No 2777/2000. Within the pool of rendered material due for destruction were Special Risk Material (SRM) and non-SRM MBM and tallow. The non-SRM tallow was allowed for use as a fuel by renderers, which they used in adapted fuel burners. In July 2001 SRM tallow could also be burned in adapted burners under approval of the EPA (DAF, 2004).

2.1.5 Tallow and Waste Legislation

When Category 1 and 2 tallow were legislated as posing a health risk by the ABPRs, the established markets were no longer available.

Combustion as a thermal fuel, as described above provided an economical solution to its disposal. Under the Waste Framework Directive, Council Directive 75/442/EEC newly codified as Directive 2006/12/EC, ABPs, which are derived from discarded material, are by definition 'waste'. This second classification has major implications for the continued use of tallow as a thermal fuel. The Waste Incineration Directive, Directive 2000/76/EC, a daughter directive of the Waste Framework Directive, specifies conditions for the incineration of waste. As tallow (and MBM) are classified as wastes their combustion falls under the requirements of this directive. Article 12.1 of the (EC) No 1774/2002 reiterates the application of this directive in the following sentences

'The incineration and co-incineration of processed products shall take place in accordance with the provisions of Directive 2000/76/EC. The incineration and co-incineration of animal by-products shall take place either in accordance with the provisions of Directive 2000/76/EC or, when that Directive does not apply, in accordance with the provisions of this Regulation.'

There is much debate as to what is meant by the '*when that Directive does not apply*'. Four Member States, Estonia, Ireland, Lithuania, and Denmark perceive this to mean that the WID is not applicable to the combustion of tallow. Other Member States namely Austria, Belgium, Czech Republic, Germany, Spain, Finland, Hungary, Latvia, The Netherlands, Poland, Portugal, Sweden, Republic of Slovenia, Slovak Republic, and the United Kingdom agree that the WID should apply to the combustion of tallow. However, in 2006 only Belgium/Flanders indicated that they were WID compliant (ECOLAS, 2006). The transitional provisions of the WID, detailed in Article 20, are that the provisions of the Directive shall apply to new plants as from 28^{th} December 2002 and to existing plants from 28^{th} December 2005. It would seem therefore that while many Member States agree in theory, in practice the WID is not applied to the combustion of tallow.

2.1.6 Significance

Ireland ratified the Kyoto Protocol (UN Framework Convention on Climate Change) in 2002. The Kyoto Protocol set international reduction targets for greenhouse gas emissions. The EU target, for the period of 2008 to 2012, is 92% of the 1990 emissions level. This 8% reduction is to be shared among all the member states. Ireland, due to the high level of growth during the 1990s was allowed to increase, but limit its emission levels, to 13% above its 1990 level of 55.60 Mt CO_{2eq}. Therefore, its total emission target for the 2008-2012 period is less than 314.18 Mt or less than 62.84 Mt for each year. In 2006 estimated emission levels were 69.76 Mt, some 25.5% above the baseline 1990 level (EPA, 2008).

The Department of Environment, Heritage, and Local Government (DEHLG) published the National Climate Change Strategy 2007-2012 in 2007. The aim of the strategy is to show how Ireland will meet its obligations under the Kyoto Protocol and how we will be in a position to meet our obligations post the 2012 period.

The strategy document shows that for the 2008-2012 period existing measures will reduce GHG emissions by 8.66 Mt CO_{2eq}, additional measures will reduce it by 4.93Mt CO_{2eq}, and the use of flexible mechanisms will reduce it by a further 3.60 Mt CO_{2eq}, to give a total of 17.22 Mt CO_{2eq}. This, according to the document will be more than enough to fulfil our obligations.

The additional measures described in the National Climate Change Strategy cover measures in energy supply, transport, residential, industry, agriculture, waste and the public sector. Biomass, biofuel, and bioheat are mentioned under various headings.

The flexible mechanisms reduction will be achieved by investing in emission reduction programmes outside of Ireland in less developed economies. This facility is enabled because the GHG threat is on a global scale and emission reductions anywhere in the world will be of benefit.

The then Minister for the Environment, commenting on the 2007 budget in December 2006, committed the government to purchase up to 18 million GHG allowances under flexible mechanisms at a cost of €270 million (DEHLG, 2006 a).

Agriculture is the highest contributor to greenhouse gas emissions in Ireland with 27.7% of total emissions in 2006. The greenhouse gases emitted are mainly methane and nitrous oxide, the total effect of which is equivalent to 19.309 Mt CO_2 (EPA, 2008). The methane is released from ruminant livestock and animal manures. Nitrous oxide is released from soil that has been treated with animal manure and other organic and chemical fertiliser (DEHLG, 2006 b).

Tallow emits 2.73 tonnes of CO_2 per tonne when combusted (Source: GHG Permit Application Data, Appendix 4.8). For each 50,000 tonnes of tallow combusted as a thermal fuel 136,500 tonnes of CO_2 are saved. This is because tallow is a biomass fuel and therefore the CO_2 released is rated as zero (Commission , 2007).

2.2. Stakeholder Interest

2.2.1 The Renderers

The rendering industry in the Republic of Ireland processes, each year, 550,000 tonnes of ABP (DAFF, 2008). This provides employment for approximately 400 people and is a vital element of the meat industry. In Ireland, the tallow produced from rendering is used as fuel or sold to the oleochemical industry and animal feed industry. There is concern that if the WID is implemented with regard to the combustion of tallow, there will be major '*direct costs in substituting for fossil fuels plus further additional costs to* *export the Tallow for incineration*' as there is no suitable incineration facility in Ireland. These costs would have a '*serious impact on the economy and particularly the agricultural sector.*' (FIR, 2005).

2.2.2 The Oleochemical Industry

APAG, the European Oleochemicals and Allied Products Group raised their concerns in 2003 about the subsidies available for the production of biodiesel. It recommended that tallow be excluded from the production of biodiesel due the negative impact on supplies for their industry (APAG, 2003).

In 2005, APAG voiced further concerns regarding the continued availability of their feedstocks, vegetable oils, and animal fats. They stated that under the EU Renewable Energy Policy, vegetable oil and animal fat are classified as biomass and subsidised for energy use. They are increasingly used to aid compliance with the emissions trading scheme or for other renewable energy initiatives. The impact of subsidising a limited European supply of vegetable oils and animal fats for energy use, according to APAG, will force the non-energy industries to avail of competitive palm oil in Asia. An increased environmental footprint in Asia and a loss of employment in Europe are likely outcomes of the continuation of this policy. APAG requests that European Commission remove vegetable oil and natural fat from the biomass classification or abolish tax incentives for animal fats when used as bioenergy (APAG, 2005).

2.2.3 Consumers

Technically, it is feasible to use tallow for heating boilers with an adaptation of the burner. Industrial scale burners generally use heavy fuel oil, which in 2003, was cheaper than tallow. Large industry was therefore unlikely to be interested in converting boilers for the use of tallow until heavy fuel oil costs were above those of tallow. Domestic and small use boilers using heating oil could have been profitable if boilers with tallow burners were available economically (SEI, 2003).

Domestic consumers, in Ireland, are encouraged to use renewable energy for home heating. The Greener Homes Scheme operated by Sustainable Energy Ireland provides grant aid for the purchase of wood-fuelled boilers and other renewable energy technologies for residential applications. Because the industry is at its infancy and markets not yet sufficiently established the availability of suitable wood fuel is a concern for those that have taken this initiative. The more expensive bagged pellet is often the source of this fuel, which delivers this type of home heating at 6.69 cent/kWh compared with kerosene at 7.49 cent/kWh (SEI, 2008). Although the wood pellet is still cheaper it comes with it involvedness in supply, quality and ash removal issues, while with kerosene, once the heating tank is full all is generally well.

The majority of European consumers (66%) are reluctant to pay more for renewable energy. However, in Ireland those unwilling to pay more was less at 57% and 24% said they would be willing to pay 5% or more for renewable energy (EC Eurobarometer, 2006).

Sustainable Energy Ireland is an Irish government energy agency set up in 2002 to promote and assist the development of sustainable energy. It commissioned Clearpower Ltd. to complete a resource study on recovered vegetable oils and animal fats. The report, which was published in December 2003, gives an account of supply, demand and the availability of surpluses that could be used as a fuel source. Total tallow produced in Ireland amounted to 78,000 tonnes, which would reduce to 71,000 tonnes in 2010 due to an expected reduction in livestock numbers. Category 1 tallow, used as fuel amounted to 42,000 tonnes. Approximately 7,000 tonnes of Category 3 tallow was also used as a fuel. The remaining Category 3 tallow was sold for animal feed and to the pharmaceutical industry, at prices dictated by the world market but which were greater than the cost of Category 1 tallow. The price of low-grade Category 3 tallow compared well with the price of Light Fuel Oil (LFO) and therefore showed potential for use as a heating fuel. Low-grade Category 3 tallow amounted to 21,900 tonnes in 2003. Barriers to use identified were

> '*The cost associated with installing systems to store/preheat the fuel and widening the injection nozzle of the boiler,*
>
> *A poor public (or employee) perception of using animal fats for heating,*
>
> *Low awareness of the opportunity.*' (Clearpower, 2003).

While these studies show the potential for domestic use and the associated barriers the reality is that legislation as it stands at present does not allow tallow to be used as a fuel outside limited industrial applications and then only in a steam raising boiler.

SEI held Energy Market workshops in August 2007. A presentation on thermal fuel options suggested tallow, among other wastes, under the heading of Waste Derived Fuels. Key points were that approximately 60,000 tonnes per annum are produced and

50% of this is used by the rendering industry for fuel. Heavy fuel oil has a calorific value of 43,100kJ/kg while tallow has approximately 40,000 kJ/kg (Gannon, 2007).

There is therefore, more tallow produced by the rendering industry than is required for the industry's own fuel purposes. The surplus is sold according to ABP category at prices dictated by the relevant market opportunities.

There are growing demands on this industry surplus. Steam raising boilers in non-rendering plants have also been approved for the combustion of tallow. This exerts a steady demand on tallow, particularly the cheaper Category 1 tallow. Category 3 plants have also traditionally burned Category 1 tallow and sold their more valuable Category 3 tallow to the animal feed and Oleochemical markets. Now these plants hold more of their Category 3 for fuel use.

More recently, a new type of consumer has appeared in Ireland, a consumer that does not envisage using tallow as a fuel but as a feedstock for the production of biodiesel. Green Biofuels Ireland Limited has already obtained planning permission from Wexford County Council for a biodiesel manufacturing plant at Marshmeadows, New Ross, Co Wexford (WCC, 2007). The plant, which will have a biodiesel production capacity of 34 million litres per annum, began construction in April 2007 and is expected to be completed in 2008. The feedstocks identified, oil seed rape, recovered vegetable oil and animal fat are to be sourced primarily from company shareholders, which include 4,000 shareholder farmers of Wexford Farmers Co-op. Excise relief on the biodiesel will be provided under the biofuels Mineral Oil Tax Relief Scheme (Fehilly Timoney Ramboll, 2007). Among the company objectives are the production of biodiesel conforming to EN 14214; the use of indigenous feedstocks where possible; and to market the biodiesel to be blended at 5% with fossil diesel according to EN 590. According to information posted on their website, they have already signed supply agreements with their shareholders for 90% of the feedstocks (GBIL, 2008).

Another company, Green Organics Energy Limited has appealed a planning decision, by South Tipperary County Council, to An Bord Pleanala (An Bord Pleanala, 2008) for their proposed biogas and biodiesel plant at Castleblake, Rosegreen, Cashel, Co. Tipperary. The final decision on this enterprise is expected in May 2008. The proposed plant will have the capacity to process 250,000 tonnes of organic material and to generate 50, 000 tonnes of biodiesel per annum. Proposed biodiesel feedstock is tallow, which will be generated on site, and tallow and vegetable oil from other sources. Green Organics Energy Limited is part owned by Dawn Meats who have a combined animal by-product output from their plants of 68,000 tonnes (South Tipperary County Council, 2008).

Each tonne of raw material produces 160kg (16%) tallow (Clearpower, 2003). Therefore, it is likely that 10,880 tonnes of tallow will be removed from the national output and used for biodiesel production if this enterprise comes to fruition. As discussed, a yet unknown amount of tallow will also be used in GBIL. Clearly, the amount of tallow available for combustion in steam raising boilers is increasingly under pressure in this era of bioenergy development.

2.2.4 Department of Agriculture, Fisheries, and Food

The competent authority in Ireland for the enforcement of the ABP regulations is the Department of Agriculture and Food, specifically the Animal By-Products Division.

The ABPR (EC) 92/2005 lays down means for alternative means of disposal of ABP and processed products than those laid down in ABPR (EC) No 1774/2002. An amendment to (EC) No 92/2005 is ABPR (EC) No 2067/2005 (EC, 2005b). This regulation adds Annex VI to the original five annexes of ABPR (EC) No 92/2005. This annex describes the requirements of combusting animal fat in thermal boiler processes.

The first requirement is that the fat is derived from processing method 1 (Annex V, Chapter III, EC No 1774/2002) for Category 1 and 2 materials if combusted in another plant. For fat combusted in the plant of production, any of the processing methods may be used for Category 1 and 2 materials and for Category 3 material.

The second requirement is that the fat and protein have been separated to an extent that less than 0.15% insoluble impurities remain in the fat.

The third requirement is that the fat is vaporised in a steam-raising boiler at a temperature of at least 1,100°C for at least 0.2 seconds.

The regulation also states that Category 1 and 2 fat must be combusted at the plant of production but the competent authority may authorise movement to other plants if approved for combustion and any food or feed production is strictly separated.

Under the regulation, the Department of Agriculture, Fisheries, and Food licences each boiler to burn Category 1 and Category 2 tallow. A submission is made by the applicant with details that include structural, temperature and usage controls, intake and road tanker records, and a HACCP plan. Locations for its use are restricted to rendering plants, fish processing facilities, and slaughter plants. The combustion of Category 3 tallow, by comparison, requires an approval, rather than a licence, for each boiler. The application information is less onerous and the locations permitted for use are more relaxed. Category 3 tallow may also be combusted at food processing and dairy plants (DAFF, 2006).

2.3 The combustion of tallow as a thermal fuel.

2.3.1 America, Australia, and New Zealand

In 1982, at the Nebraska Independence Day Alternative Fuels Classic, a car, powered by animal fat, caused a lot of publicity when it came second in the race. In 1983 an article with the title '*Fat for Fuel, Is This an Idea Whose Time Will Come?*' explored the practicalities of animal fat for fuel. Boiler fuel was identified as one of the possibilities, with use by the renderers themselves as the best option. The feasibility of the idea was recognised as depending on the relative cost compared with fuel oil (FPRF, 1983).

The exploitation of the high-energy properties of animal fats is an established practice in animal feed. However, research into the exploitation of this energy for use in fuel has traditionally taken second place to research into plant sources as alternative fuels. The Fats and Protein Research Foundation addressed this issue by promoting animal fats for use in this area. A summary of progress was published in 2001, in which emissions, energy values, and costs were compared with fuel oil. Tallow, lard and poultry fat showed favourable comparisons with fuel oil for most emission parameters, especially SOx, NOx. Although energy values were somewhat less many plants had already converted to using animal fat and substantial savings had been achieved in energy costs (Pearl, 2001).

A project funded by FPRF and the Poultry Protein and Fat Council of the U.S. Poultry & Egg Association and performed at the University of Georgia demonstrated the use of fat and grease as industrial boiler fuel. The results of this project were put forward as a means of justifying the use of biofuels from a financial perspective and as an aid to obtain air emission permits (Adams, 2002).

The US EPA issued a memorandum on biofuels emissions data and permitting of biofuel burning in March 2003 (Sims, 2003). It concluded that, from information submitted by the National Renderers Association, burning biofuels produced less emissions than No. 6 Fuel Oil but particulate matter could be slighter higher compared with burning No. 2 Fuel Oil. The information gathered was considered, for most cases, adequate for permitting, without the need for further stack testing.

In 2005, a study on the combustion of poultry fat in the University of Georgia and supported by Cagle's Inc., Pine Mountain Valley, Georgia, investigated the utilisation of chicken fat at poultry processing plants (Adams, 2005). The aim of this study was to utilise chicken fat (which was normally sold to renderers) as an onsite fuel thereby offsetting energy costs. It was found that this was possible and economical depending on the juxtaposition of fuel oil cost and the market price of poultry fat. It was noted that as fuel oil costs rise the savings from using the poultry fat as a fuel become more significant.

Meanwhile in Australia, in 2002, Food Science Australia published an article with the title '*Tallow as a Heating Fuel*'. This was based on a New Zealand publication from 1984 and on the experiences of some remote Australian plants using tallow as fuel. The comparative prices of tallow and fuel oil from 1996 to 2002 indicated a sharp rise in fuel oil price since 1999. Tallow compared favourably against fuel oil and electricity in a comparison of energy prices. Figure 2.2.1 sourced from the publication shows the layout of the fuel system.

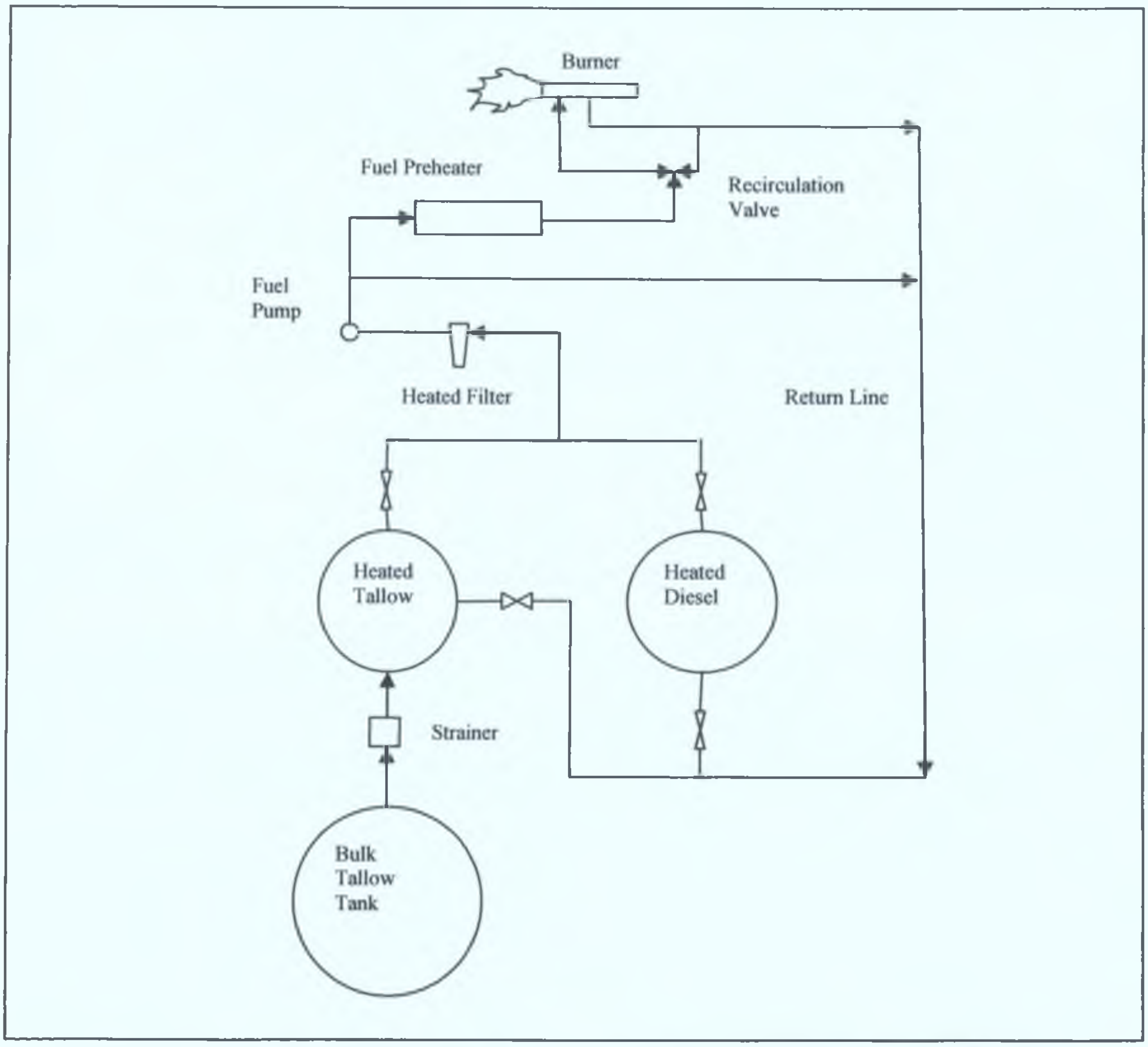

Figure 2.2.1 **Layout of Fuel System. Source: Food Science Australia, 2002.**

With regard to the practical aspects of tallow usage, because of its negligible sulphur content, tallow could be used at lower flue temperatures than fuel oil, which resulted in increased boiler efficiency. Sulphur in fuel oil causes corroding condensation in flues at lower temperatures. Insulated fuel lines helped maintain tallow flow to burners. Clean tallow was recommended in order to prevent deposits in boilers (Food Science Australia, 2002).

In 2004, a report prepared for the Sustainable Energy Authority of Victoria on using tallow for the production of energy, found that in 2004, the price of animal fat was sufficiently high to make its use as a fuel uneconomical. With changing circumstances, its use could be viable in certain situations, particularly in remote areas for abattoirs and in energy production for fat processors that receive poor prices for their refined grease (Joseph, 2004).

2.3.2 Europe and the ABP Regulations

In Europe in 2003, the combustion of tallow in a thermal boiler was compared with its disposal in a waste incinerator. Tallow, which is required to have less than 0.15% of impurities, is considered a much less risk than MBM. This is because the prion is associated with the protein and not the fat.

It was concluded that the combustion of tallow in a thermal boiler has a low uncontrolled emission into air and that it is comparable with the required controlled emission from waste incinerators according to existing EU legislation (Blinksbjerg, 2003).

The European Fat Processors and Rendering Association (EFPRA) commissioned a risk assessment on the combustion of SRM tallow in a thermal boiler. The report which was issued in 2007, focused on the risk of infection with the CJD variant in humans from the combustion of SRM derived tallow. Two thermal boilers, with differing tallow throughputs, were assessed under UK BSE incidence circumstances. The total infectivity of the SRM derived tallow before combustion, the reduction of infectivity after combustion and the infectivity of all operational waste stream pathways were studied. It concluded that the risk was negligible in the main pathways i.e. inhalation of particulates and consumption of water from ground water or surface water supply. This report was prepared for the EU to clarify the CJD variant impact of tallow combustion (Det Norske Veritas, 2007).

2.3.3 The ECOLAS report and the Application of the WID

Unit ENV/C4 – the industrial emissions section of the European Commission commissioned the Belgian environmental consultancy and assistance firm, ECOLAS NV, to prepare an impact assessment on tallow. The report (ECOLAS, 2006) which was completed with the aid of the Belgian environmental law and policy firm Milieu Ltd, was published in December 2006. This report was prepared to address doubts among Member States on the application of the WID to the burning of tallow. The impacts of three main scenarios were investigated.

Scenario 1 – implementation and enforcement of the WID. Scenario 1 was further subdivided into 1a: Stringent interpretation and 1b: Flexible interpretation. The difference between these two subsections related to monitoring of emissions.

Scenario 2 – Exclude the burning of tallow from the scope of the WID. Scenario 2 is again divided into two subsections, Scenario 2a: broad interpretation and Scenario 2b: limited scope of interpretation. The difference here is that in the 'broad interpretation', all tallow would be excluded and in the *'limited scope'*, only tallow burned by renderers would be excluded.

Scenario 3- Specific emission limit values and monitoring for tallow.

Each of these scenarios was investigated against a base scenario of *'business as usual'* i.e. member states continue as they are for the next 20 years. In addition each scenario was evaluated under *'no switching'* i.e. continue burning tallow or '*switching*' to fuel oil as the alternative fuel, or natural gas as the alternative fuel.

It is acknowledged in the report that *'literature and industry sector data on emissions'* show that the combustion of tallow in *'smaller boilers'* generally meets the requirements of the WID, '*with the exception of dust'*. However, combustion in a power plant as a single fuel showed that NO_x and dust were over the emission limit values of the WID.

The conclusion drawn from this report was that the WID should be implemented for the burning of tallow because the *'environmental benefits'* outweighed the costs of implementation. If current users decide to switch to another non *'waste'* fuel to avoid the obligations of the Directive, switching from tallow to oil was considered more expensive and of less benefit to the environment, while a switch to natural gas would yield increased environmental benefit (ECOLAS, 2006).

2.3.4 Biomal Concept

The above literature review relates to the combustion of tallow produced as a result of rendering. An alternative to rendering is the Biomal Concept, *'where ABP are crushed and ground to a renewable fuel.'* This concept was demonstrated in an EU LIFE Environmental project in Sweden where a pilot plant was set up in 2004. The advantages of the concept are operational energy efficiency, elimination of risk from BSE, and renewable fuel production suitable for co-combustion with net heating values of 7-8 MJ/kg. This is similar to the values obtained from biomass such as woodchip at 50% moisture. (Biomal, 2007).

SECTION 3: METHODOLOGY

3.1 Legislative Position with regard to Waste Clsssification

The objective of exploring the EU legislative position of tallow was primarily to ascertain the process by which it became classified as a waste. The waste legislation was explored from its origins with particular emphasis on the definition of waste.

The European Court of Justice rulings gave further insight as to what may be classified as waste on a case by case basis, this being the only method to decide on debated classifications.

Arguments for tallow being designated as a product according to the criteria developed under the EU Court of Justice rulings are presented.

Finally the situation going forward is examined to show how the classification of tallow may change.

3.2 Tallow Quantity Available

The quantity of tallow produced annually is examined so that supplies available for thermal fuel use may be determined. Livestock slaughtering and tallow production data (Appendix 3.1 and 3.2) were obtained from the DAFF and the amount of tallow available for combustion was calculated from production figures and usage patterns.

3.3 Use of Tallow as a Thermal Fuel

A survey of IPPC licensed companies within the Food and Drinks industry provided insight into attitudes towards tallow and thermal fuel usage. Out of a population of 86 companies, 36 responses were received from a survey questionnaire. Company names, addresses and current status of licensing were identified through the EPA website (EPA, 2008). The questionnaire was communicated primarily in hard copy by means of a cover letter (Appendix 3.3) and attached questionnaire (Appendix 3.4) through the post. A stamped self-addressed envelope was included for convenience.

The questionnaire was also communicated electronically using an on-line survey provider (Survey Monkey, 2008). A link to the survey was sent to those companies with a suitable email address. General email addresses were located on company websites while personnel email addresses were obtained by means of communication by telephone. The purpose of the electronic survey was to boost response numbers. However, only one of the 36 responses was received by means of the online questionnaire.

The Animal By-Products Section of the DAFF provided information on the legislative requirements for the combustion of tallow in steam raising boilers (Appendix 3.2).

3.4 Cost of Conversion and Operation

Whether or not it is economically feasible for a company to use tallow depends on the cost of switching from other fuels and on the cost of tallow relative to other fuels. The cost of conversion from HFO and LFO were identified and a cost comparison between tallow and other fuels presented. The situation with regard to the extra incentive that there is to use zero carbon rated fuels for GHG permit holders is also considered.

3.5 Case Study: Slaney Proteins

A case study of a plant already using tallow was undertaken to highlight the practicalities of using tallow as a thermal fuel in steam raising boilers. Slaney Proteins, a Category 3 rendering plant in north Wexford was chosen. This plant has been using tallow and LFO as fuels since 2001.

SECTION 4: FINDINGS

4.1 Legislative Position with regard to Waste Classification

4.1.1 The Origins of the Waste Framework Directive

Article 2 of the consolidated version of the Treaty on European Union (EU) sets objectives for the Union, one of which is achievement of balanced and sustainable development. Article 2 of the consolidated version of the Treaty establishing the European Community (EC) further expands on this objective stating that the community shall have as its task, *inter alia*, the protection and improvement of the quality of the environment. Article 3 of this Treaty establishes the requirement for environmental policy, while Article 6 again reiterates the promotion of sustainable development. Article 174 of the Treaty details the objectives of community policy on the environment and establishes the founding principles of precaution, preventative action, rectification of damage at source, and that the polluter should pay (European Union, 2006).

The Waste Framework Directive 75/442/EEC (now repealed and replaced by Directive 2006/12/EC) was established using Articles 100 and 235 of the then Treaty Establishing the European Economic Community.

'This was in the absence, prior to the Treaty of Maastricht in 1993, of any more appropriate measure in the Treaty. After the Treaty of Maastricht, the Treaty Establishing the European Economic Community (EEC) was renamed the 'Treaty of Establishing the European Community (EC)'. The European Union (EU) was founded at this time. From then on measures to protect the environment were formally enshrined in the EC Treaty.' (Unfried, 2001).

The subject of Article 100 (now Article 94) was the approximation of laws within the Community. Article 235 (now Article 308) provided a means to attain objectives not provided by the Treaty, where the Council acts unanimously on a proposal by the Commission.

4.1.2 The Definition of Waste in the EU under the Waste Framework Directive

The Waste Framework Directive, 75/442/EEC, defined waste as '*any substance or object which the holder disposes of or is required to dispose pursuant to the provisions of national law in force*'. Disposal was defined as 'the *collection, sorting, transport, and treatment of waste as well as its storage and tipping above or underground*'. Article 1 of the current Directive 2006/12/EC, defines waste as '*any substance or object in the categories set out in Annex I which the holder discards or intends or is required to discard*' and disposal means 'any *of the operations provided for in Annex II A*'. Annex I, referred to in the definition, describing categories of waste, describes under Category Q14 '*Products for which the holder has no further use (e.g. agricultural, household, office, commercial and shop discards, etc)*' and under Q16 '*Any materials, substances or products which are not contained in the above mentioned categories*'.

With regard to the protection of health and the environment Article 4 states that '*Member States shall take the necessary measures to ensure that waste is disposed of without endangering human health and without harming the environment, and in particular without risk to water, air, soil and plants and animals.*'

Article 3 refers to the use of waste as an energy source as an objective to be encouraged within member states. In Annex II A, incineration on land is one of many disposal operations. Annex II B, which describes recovery operations. One such recovery operation is R1 *'Use principally as a fuel or other means to generate energy'*.

It stipulates that in accordance with Article 4, '*waste must be recovered without endangering human health and without the use of processes or methods likely to harm the environment*'.

It should be noted that Article 2.2(c) of 75/442/EEC (WFD); Article 2.1(iii) of 2006/12/EC (newly codified WFD); and Article 2.2. (a) (vii) of 2000/76/EC (WID) all exclude animal carcases from their scope, which are seen as distinct from ABP.

4.1.3 The European Court of Justice Rulings

Clarification on the definition of waste has been provided by the European Court of Justice in numerous case law proceedings.

In the joined cases of C-418/97 and C-419/97 of Arco Chemie, Nederland Ltd on the concept of waste, the Court gave its judgement on the 15th June 2000. In the first case, C-418/97, the Court ruled that it '*may not be inferred from the mere fact that a substance ... undergoes an operation listed in Annex IIB to Council Directive 75/442/EEC ...that that substance has been discarded so as to enable it to be regarded as waste*'. Also in the same case the Court ruled that for the '*purpose of determining whether the use of substance ... as a fuel is to be regarded as constituting discarding, it is irrelevant that the substance may be recovered in an environmentally responsible manner for use as a fuel without substantial treatment.*' It goes on to state '*that the fact that a substance used as a fuel is a residue of the manufacturing process of another substance, that no use for that substance other than disposal can be envisaged .... may be regarded as evidence that the holder has discarded that substance. However, whether it is in fact waste ... must be determined in the light of all the circumstances,* *regard being had to the aim of the directive and the need to ensure that its effectiveness is not undermined.'*

The Court further ruled in the second case C-419/97 that '*the fact that a substance is the result of a recovery operation ... is only one of the factors which must be taken into consideration for the purpose of determining whether that substance is still waste*'. Judgement in the case of Euro and Adino Tombesi (C-304/94) et al, on the 25th June 1997, on, *inter alia,* the control of shipments of waste, ruled that the concept of '*waste'* does not exclude substances '*capable of economic reutilisation'.*

The judgement of the Court on 18th December 1997, in the case of C-129/96 Inter-Environment Wallonie ASBL v Region Walonne, Belgium, was that *inter alia* a '*substance is not excluded from the definition of waste ... merely because it... forms an integral part of an industrial production process'.*

In the case concerning Palin Granit and the Supreme Administrative Court, Finland, Case C-9/00, the Court was asked for guidance as to whether leftover stone resulting from quarrying was to be regarded as waste. The judgement, given on 18th April 2002, ruled that *'the holder of leftover stone... which is stored for an indefinite ... time to await possible use discards or intends to discard that leftover stone, ... is classified as waste'* and that the '*place of storage ... and the fact ... that the stone does not impose any real risk to human health or the environment are not relevant criteria for determining whether the stone is to be regarded as waste'.*

In the case of Verol Recycling and the Netherlands Council of State, Case C-116/01, the Court was asked for a preliminary ruling on the criteria to distinguish between operations for disposal and recovery and on the supervision on the control of shipments of waste. The Court ruled on 3rd April 2003 that '*where a waste treatment process comprises on several distinct stages, it must be classified as a disposal or recovery operation .... taking into account only the first operation the waste is to undergo subsequent to shipment*'. In addition, in this case the Court ruled that '*the calorific value of waste which is to be combusted is not a relevant criterion for the purpose of determining whether that operation constitutes disposal or recovery*'.

Interestingly, in Case C-235/02, Saetti and Frediani, Italy the Court ordered on January 15th 2004 that '*petroleum coke which is produced intentionally or in the course of producing other petroleum fuels... and is certain to be used as fuel ... does not constitute waste within the meaning of Council Directive 75/442/EEC*'.

In case C-457/02 on criminal proceedings against Antonio Niselli on the definition of waste, the Court ruled on November 11th 2004 that the '*definition of waste .... cannot be construed as covering exclusively substances ... intended for, or subjected to, the disposal or recovery operations mentioned in Annexes IIA and IIB*'. It continues that the '*meaning of waste ... is not to be interpreted as excluding all production or consumption residues which can be or are reused .... without harm to the environment, or after undergoing prior treatment without, however, requiring a recovery operation within the meaning of Annex IIB*'.

To summarise, waste is defined according to the definition in the WFD. The interpretation of this definition is decided by case law in the European Court of Justice. The court has ruled that a substance should not be regarded as a waste by the fact that it has been subjected to a recovery operation; that recovery in an environmentally responsible manner is irrelevant to deciding whether a substance has been discarded (C-419/97); the concept of *'waste'* does not exclude substances *'capable of economic reutilisation'* (C-304/94), that form *'an integral part of an industrial production process'* (C-129/96) or that do not *'impose any real risk to human health or the environment'* (Case C-9/00). In addition, the calorific value of waste which is to be combusted is *'not a relevant criterion for the purpose of determining whether that operation constitutes disposal or recovery'.* However, in contrast to many of the rulings, petroleum coke was deemed not to be a waste because, *inter alia*, it was *'intentionally produced'* and *'certain to be used as fuel'* (Case C-235/02).

4.1.3 Current Developments

The European Commission, in its communication *'A Thematic Strategy on the prevention and recycling of waste'* (EC, 2005c), acknowledges that the current situation with regard to waste law *'remains unclear despite Court jurisprudence'* and that this *'may impede necessary investments.'* In Chapter 4 of the document, titled 'Action', an objective of the Thematic Strategy is to, *inter alia*, *'clarify, simplify, and streamline EU waste law'.* Measures to achieve this objective include the amendment of the WFD. The amended directive will include clarification on when waste ceases to be waste and a definition for recycling. In Annex 1 of the Thematic Strategy, on Simplification and Modernisation of Existing Legislation and specifically the definition of waste, the concept of waste becoming a product is addressed. Criteria are to be set for certain waste streams *'on the basis of potential environmental and economic benefit.'* The use of tallow as a fuel is one of the first waste streams to be addressed '*subject to ongoing study on environmental impacts.*

In addition to these developments described in Annex 1, guidelines (EC, 2007) on '*the issue on when by-products should or should not be considered waste'* were published. This communication is to help competent authorities make judgements as to whether a substance is a waste, 'on a case by case' basis and to inform business interests 'on how these decisions should be taken.' The guidelines are based on current waste law and the interpretation of case law of the European Court of Justice. The guidelines will be reviewed in 2010. Annex II of this Communication shows a decision tree, Figure 4.1. below, for '*waste versus by-product decisions*'.

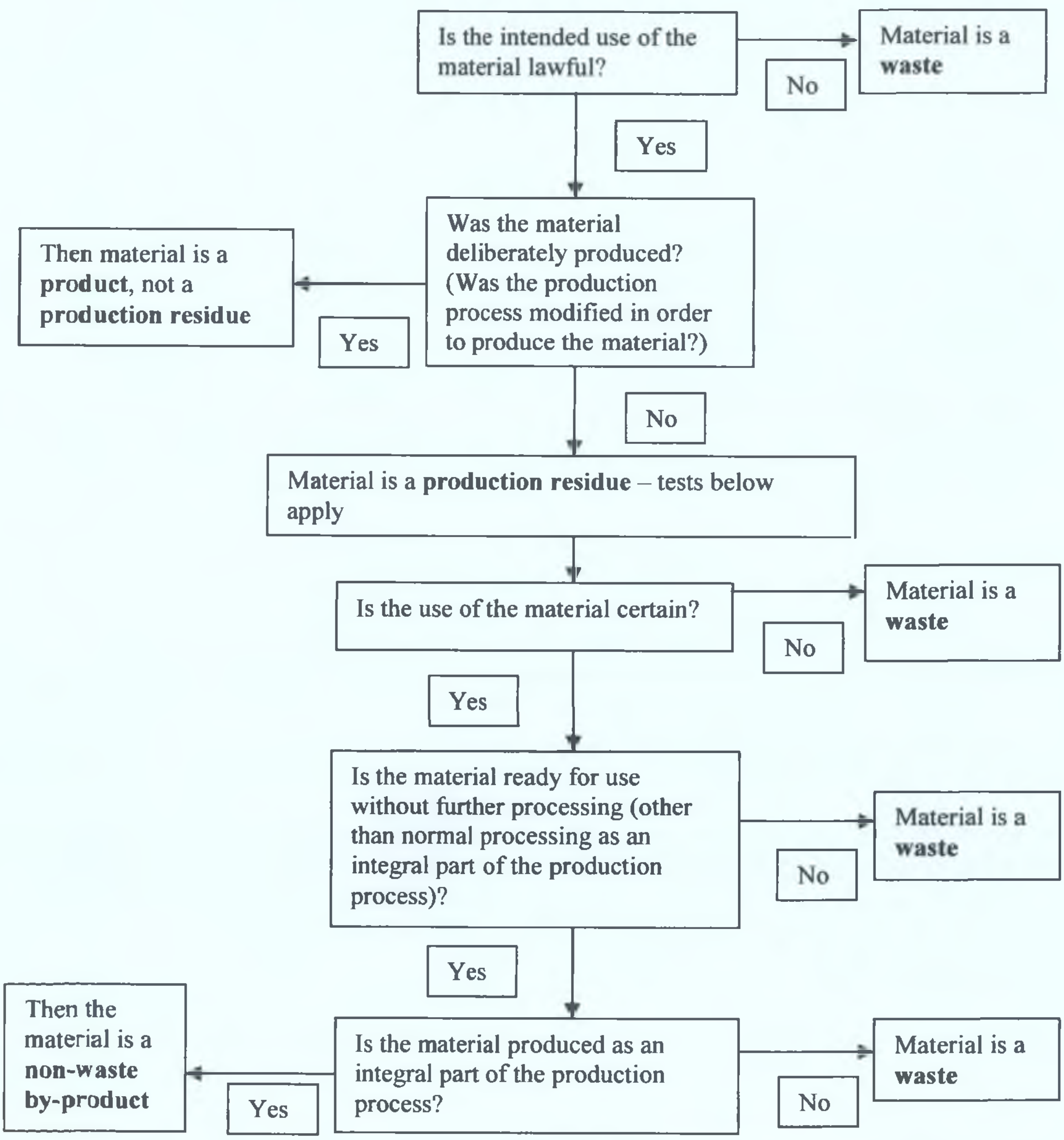

Figure 4.1.1 **Decision tree for waste versus by-product decisions (EC, 2007).**

The Federation of Irish Renderers has presented the following reasons why tallow should be classified as a product and not a waste.

> *'The material is a product the manufacturing process seeks to produce- Tallow is a product produced by the rendering industry, where specific processes are built into the manufacturing process to produce Tallow.*
>
> *The material is the result of a technical choice- Each rendering plant is specifically designed to produce both MBM and tallow.*
>
> *The material can be reused without further processing as part of the production process- The tallow produced is shipped to be used as a fuel, no further processing is required.*
>
> *The reuse of the material is a certainty not a mere possibility – tallow has readily accessible markets and is produced specifically to meet these market requirements.'* (FIR, 2005).

4.1.4 Review of the Animal By-Product Regulations

The ABPRs are currently under review. The Commission published a proposal for a new ABPR in June 2008 (Commission, 2008). The issues for reconsideration identified in the document were

- *'The basic framework of safeguards applicable to all ABP should be maintained.*
- *The scope of the rules on ABP should be adjusted.*
- *The interaction of the rules on ABP with the other Community legislation should be clarified.*
- *A more risk-based approach for the categorisation of ABP, as well as controls, should be introduced.'*

In preparing the proposal technical experts, competent authorities and stakeholders such as ABP producers, renderers, traders, users and consumer organisations, were consulted. An Inter-Service Steering Group analysed the relationships between ABPRs and other EU legislation.

Point 35 of the preamble to the proposed regulation is decisive in its opinion on the combustion of ABP as a fuel.

(35) The use of animal by-products or derived products as a fuel in the combustion process should be authorised and it is not a waste disposal operation. However, such use should take place under conditions which ensure the protection of public and animal health, as well as the appropriate environmental standards.'

Furthermore, Articles 19, 20 and 21 on disposal options for ABP lists '*use as a fuel for combustion*' as an option for each of the three categories.

4.2 Tallow Quantity Available

The quantity of tallow available is directly related to the quantity of raw material rendered. This, in turn is related to the amount of livestock slaughtered and the proportion of that material designated as animal by-products to be rendered.

This equates to approximately 550,000 tonnes of raw ABPs per annum in Ireland (DAFF, 2008).

The yield of tallow from each tonne of rendered product is approximately 160kg or 16% (Clearpower, 2003). Factors that influence the quantity of tallow produced per tonne are the percentage of fat in the raw ABP material, the freshness of the material, absence of biological degradation, and the effectiveness of the separation from the MBM. Using the Clearpower figure of 16% we can expect 88,000 tonnes of tallow from 550,000 tonnes of raw ABP. This simple calculation provides us with a basic background to a more detailed analysis below.

4.2.1 Livestock Slaughtering

Livestock slaughtering in Ireland for years 2004, 2005, 2006 and 2007 are shown in the following table with percentage changes in each sector.

Year	Cattle	% Change	Sheep	% Change	Pigs	% Change	Poultry*	% Change
2004	1,813		3,565		2,735		80,425,684	
2005	1,685	- 7.6%	3,613	+ 1.3%	2,647	- 3.3%	73,346,561	- 9.7%
2006	1,774	+ 5%	3,488	- 3.6 %	2,658	+ 0.4%	75,010,726	+ 2.2%
2007	1,771	- 0.1%	3,267	- 6.7 %	2,616	- 1.6%	73,167,175	- 2.5%

Table 4.2.1 **Livestock slaughtering 2004-2007, Central Statistics Office, 2008, *DAFF, 2008**

The table shows that cattle slaughtering increased in 2006 by 5% after a significant decline in 2005. This increase was maintained in 2007. Figures for sheep show a sharp decline since 2005. Pigs and poultry are also in decline overall since 2004. The figures would indicate a decline in material available for rendering since 2004 and therefore a subsequent reduction in tallow production.

4.2.2 Tallow Production

Inedible Category 3 tallow and Category 1 tallow are produced in Ireland in the following plants.

Approval Number	Name & Address Of Plant	Category Of Material Which Premises Is Approved To Process
R910	Dublin Products Dunlavin Co. Wicklow	Category 1
R911	College Proteins Ltd. Nobber Co. Meath	Category 1
R914	Munster Proteins Cahir Co. Tipperary	Category 3
R915	Premier Proteins Ballinasloe Co. Galway	Category 1
R917	Slaney Proteins Ryland Bunclody Co. Wexford	Category 3
R918	Western Proteins Ballyhaunis Co. Mayo	Category 3
R919	Waterford Proteins Christendom Ferrybank Co. Waterford	Category 1
R921	Farragh Proteins Monery Crossdoney Co. Cavan	Category 3

Table 4.2.2 **List of Rendering Plants, (DAFF, 2008).**

Edible tallow is produced in fat processing plants. This high quality tallow is produced from selected quality fat from the slaughtered animal. It is sold for technical purposes and its value is too great for it to be considered for combustion. Edible tallow is not included in this analysis.

Table 4.2.3 below gives the total inedible tallow produced since the year 2000. Tallow production for 2007 is 87,227 tonnes or 15.86% of 550,000 tonnes of raw ABP available. This is just less than the Clearpower tallow yield figure of 16%/tonne ABP.

Year	Tallow Produced (Tonnes)
2000	77,336.94
2001	109,373.65
2002	79,389.90
2003	70,250.87
2004	75,481.46
2005	88,287.31
2006	89,312.14
2007	87,226.95

Table 4.2.3 **Tallow production in Ireland from 2000 to 2007, (DAFF 2008).**

Since 2004, there has been an overall increase in tallow production of 13.4%. This is contrary to that indicated by the slaughtering figures for livestock. However, there are two explanations for this contradiction in figures. First, the quantity of animal by-product designated for rendering may change according to legislation. Secondly, if the market does not support the sale of certain products the raw material will be redirected for disposal by rendering.

Based on the above figures overall tallow production has not changed significantly in the last three years. It is reasonable to assume that there will be a minimum of 80,000 tonnes /annum produced for the near future.

The following table gives the quantities of each category of tallow produced in the last five years.

Year	Category 1 Tallow Tonnes	Category 3 Tallow Tonnes
2003	21,790.02	48,460.85
2004	38,478.05	37,003.41
2005	42,216.83	46,070.48
2006	50,349.18	38,962.96
2007	46,445.74	40,781.21

Table 4.2.4 **Tonnes of each category of tallow produced in Ireland from 2003 to 2007 (DAFF, 2008).**

Since 2004, Category 1 material has increased by 17% while Category 3 has increased by 9%. A possible explanation is keen competition between rendering plants Category 3 material is sometimes disposed of as Category 1 material.

4.2.3 Tallow Usage

All Category 1 material and some Category 3 material is used as a fuel in thermal boilers in Ireland. The remaining Category 3 tallow is used in animal feed in Ireland and abroad and for technical uses abroad (DAFF, 2008).

In 2005 the breakdown for use of Category 3 tallow usage in Ireland was reported as 35% animal feed, 34 % in the oleochemical industry and 31% as fuel (ECOLAS, 2006). Therefore it may be assumed that approximately 12,000 tonnes of Category 3 tallow and 46,000 tonnes of Category 1 tallow are combusted as a thermal fuel making a total of 57,000 tonnes per annum. The remaining 68% of Category 3 tallow amounts to almost 28,000 tonnes. This tallow is not directed into fuel usage unless market forces make it economically to do so.

Since the implementation of Commission Regulation (EC) No 2067/2005 (the combustion of animal fat in thermal boiler processes) tallow may be used in plants other than rendering plants. The rendering of one tonne of raw ABP requires 85kg of tallow (Clearpower, 2003). Total tallow required for the rendering of the annual 550,000 tonnes of raw material is therefore 47,000 tonnes. The Category 1 plants produce almost this amount.

If Category 1 renderers produce 160kg tallow per tonne (Clearpower, 2003) of raw material rendered and use 85kg to render one tonne they have a surplus of 75kg per tonne rendered. Therefore 47% of their tallow production is surplus to their requirements. In 2007, 46,500 tonnes were produced in the Category 1 rendering plants and with a surplus of 47%, these plants had almost 22,000 tonnes of Category 1 tallow to sell. In practice the surplus is less than 47% as Category 1 ABP produces less than 160kg tallow per tonne, perhaps as little as 120kg tonne (conversation with Mr Brendan Dunne, General Manager, Slaney Proteins), which would give a surplus of 29%. Using the lower figure of 29%, they had just less than 13,500 tonnes to sell. This lower figure reflects the data in Table 2.1.2 'Percentage water, protein and fat content of animal by-products (Breitmeyer et al., 2006)' which shows that offal has a fat content of 15% and bone a fat content of 10% (offal and bone being the main constituents of Category 1 ABP). Using both figures, Category 1 renderers had between 13,500 and 22,000 tonnes of tallow available for sale in 2007.

In 2001 and for some years afterwards only rendering plants were approved to use tallow. The Category 1 surplus was sold to the Category 3 rendering plants for fuel use, being the only market available, at €150/tonne (Clearpower, 2003). Now other plants are also approved and the market has expanded. Those plants with affiliations with Category 1 rendering plants are most successful in obtaining the fuel because of mutual benefit. This development leaves unaffiliated Category 3 plants and any other plants seeking to use tallow at a disadvantage in sourcing Category 1 tallow and therefore the more expensive Category 3 tallow is used.

To summarise, while livestock slaughtering is decreasing, tallow production has remained even over the last three years and a minimum of 80,000 tonnes should be produced annually for the near future. Approximately 57,000 tonnes is combusted in thermal boilers and 28,000 tonnes sold for animal feed and oleochemical uses. Category 1 rendering plants have between 13,500 and 22,000 tonnes of surplus tallow per annum. The demand for this tallow has increased as more plants are approved to combust tallow with the effect that more Category 3 tallow is used for combustion.

4.3 Use of Tallow as a Thermal Fuel

4.3.1 Food and Drink Industry

A survey of companies within the Food and Drink sector was undertaken by means of a questionnaire. The objective of the questionnaire was to reveal attitudes toward fuel choice for steam raising boilers with particular focus on tallow. Companies, that either had, or were applying for, an IPPC licence, were selected as the target group. This group was targeted for three reasons

High proportion with steam raising boilers

DAFF was already the competent authority for the main activities

Finite group

Out of a population of 86 companies, 36 companies replied to the questionnaire. This provided a 42% response rate, which is adequate for the purposes of this survey.

The survey findings are presented below.

4.3.1.1 Types of Fuel Used and Considered

Companies used either one or a combination of two types of fuel. The percentage of respondents using each fuel or combinations of fuel is shown in the following pie chart.

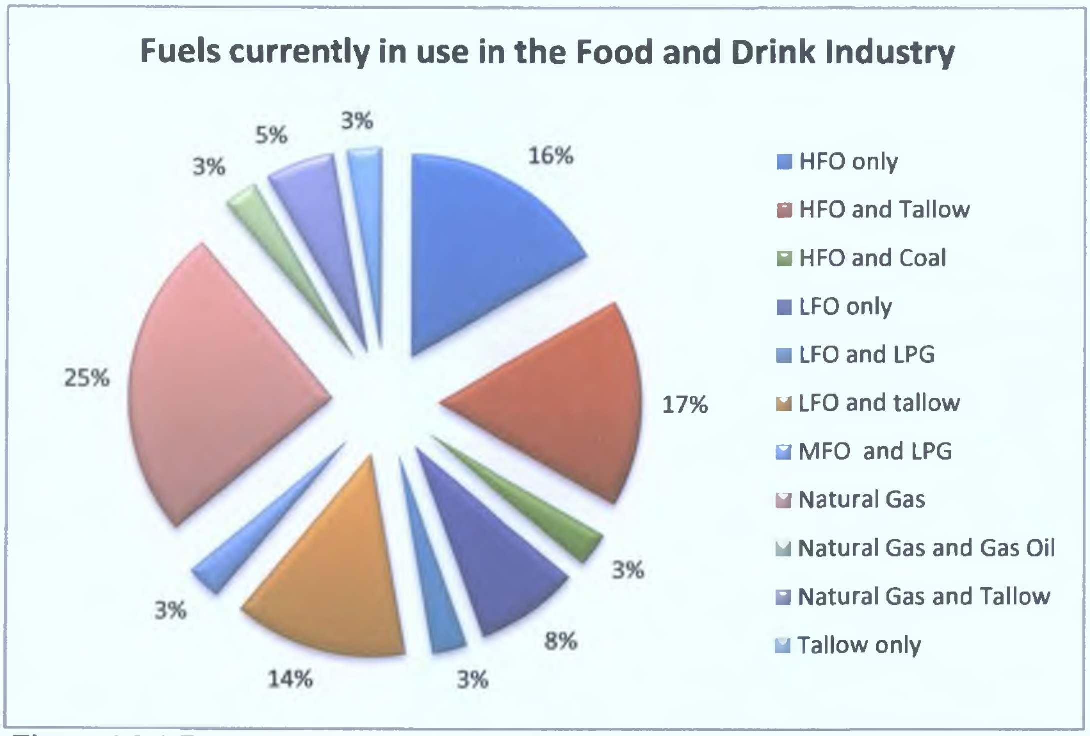

Figure 4.3.1 **Fuels currently in use in the Food and Drink Industry (Questionnaire, Appendix 4.1)**

The predominant fuels used are natural gas only (25%), HFO only (16%), HFO and tallow (17%) and LFO and tallow (14%) and LFO only (8%).

Natural gas supply does not cover the entire country making this option unavailable for some respondents. The counties shaded blue in the map below do not yet have a natural gas supply.

Figure 4.3.2 **Gas Supply Areas Map, Bord Gais Networks 2006, Bord Gais, 2008.**

Many companies had considered switching to alternative fuels (69%) for their boilers. The primary and secondary reasons companies considered switching fuels are graphically illustrated below.

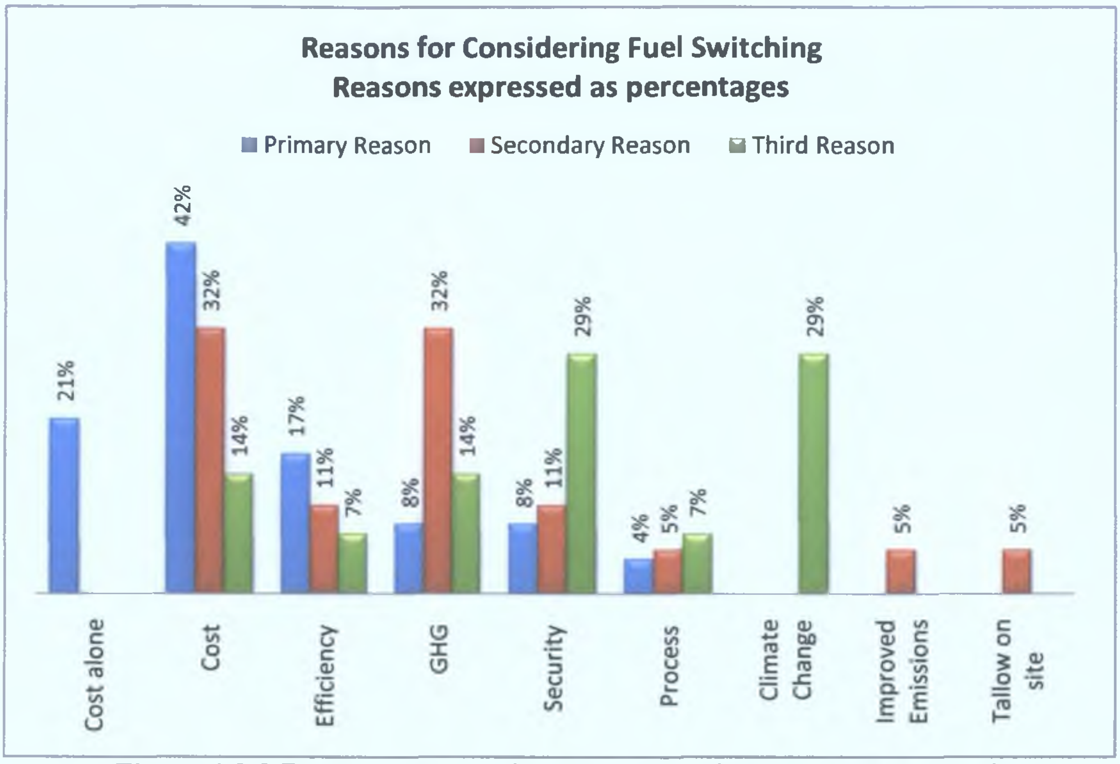

Figure 4.3.3 **Reasons for considering fuel switching (Questionnaire, Appendix 4.2)**

Primary reasons, for those 24 respondents that gave reasons for fuel switching, were cost alone (21%), cost with additional reasons (42%), efficiency (17%), compliance with GHG emissions (8%), security of fuel supply (8%) and finally process requirements (4%).

Secondary reasons for those 19 respondents that gave secondary reasons, were cost (32%), compliance with GHG emissions (32%), and efficiency, and security of supply (11% each). Finally, process requirements, improved emissions, and tallow on site were each 5% for secondary reasons for fuel switching.

Third reasons, for the 14 respondents that gave them, for fuel switching were climate change and security of supply (29%), followed by cost and GHG compliance (each 14%), and finally efficiency and process requirements each at 7%.

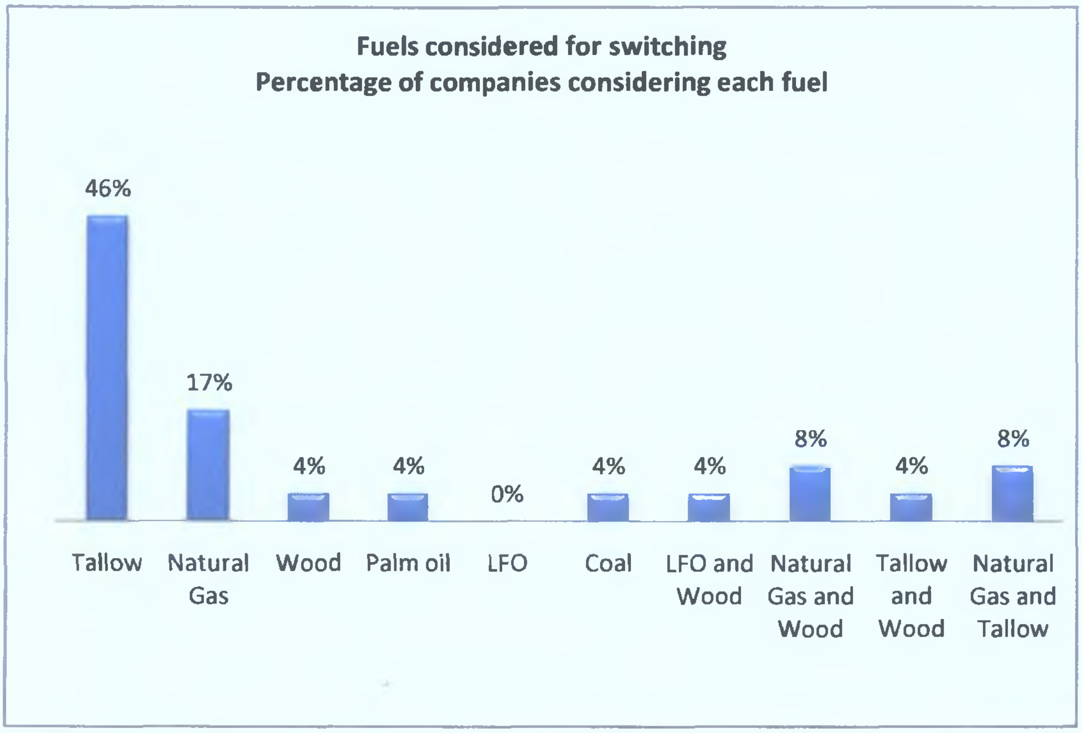

Figure 4.3.4 **Percentage of companies considering each fuel type (Questionnaire, Appendix 4.3)**

Tallow was predominantly the fuel of choice (46%) for fuel switching followed by natural gas (17%). Wood, palm oil, LFO, and coal were also considered.

Figure 4.3.4 above depicts the percentage of companies that considered a particular fuel.

4.3.1.2 Tallow

Awareness that tallow may be used as a boiler fuel under the ABPRs was high (75%). Less than 11% of the respondents were unaware of the use of tallow as a thermal fuel under the ABRs. Figure 4.3.5 below shows the awareness of respondents by percentage.

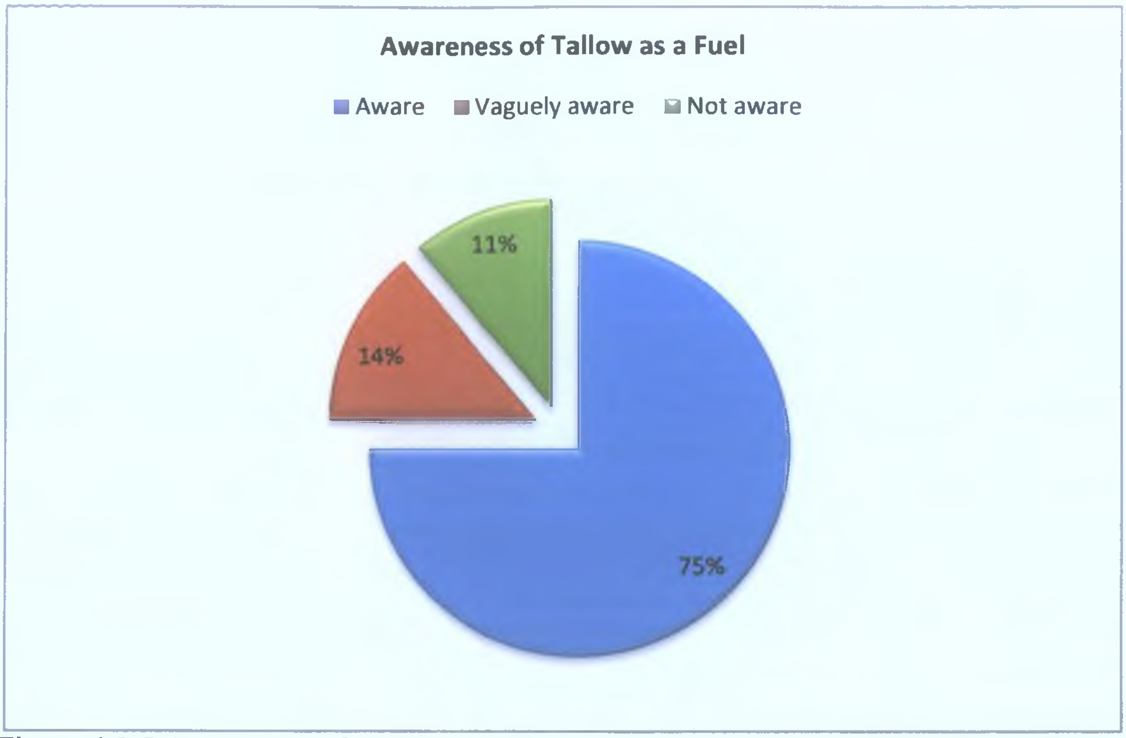

Figure 4.3.5 **Awareness of tallow as a thermal fuel under the ABRs (Questionnaire, Appendix 4.4)**

Figure 4.3.6 below shows the division between choosing Category 1, Category 3 or both categories of tallow. Both categories were chosen by 33% of respondents, while Category 1 and Category 3 alone were chosen by 45% and 22% respectively.

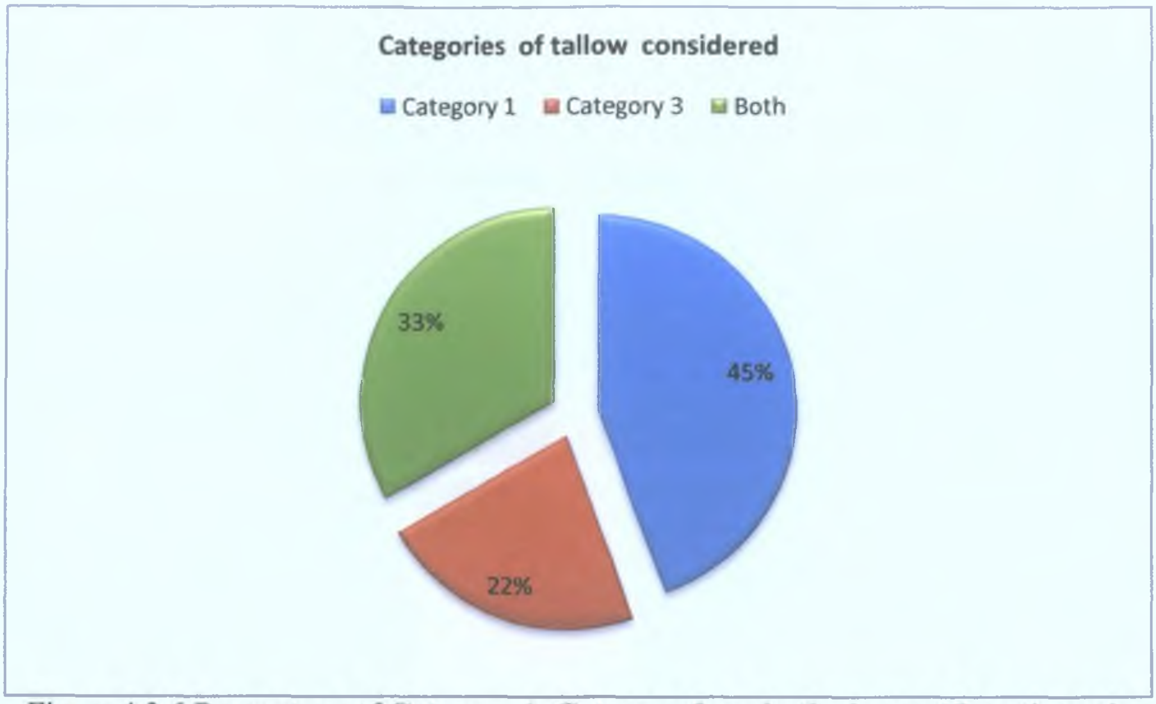

Figure 4.3.6 **Percentage of Category 1, Category 3, or both chosen (Questionnaire, Appendix 4.5)**

The primary reasons cited by the respondents for switching to tallow were that it was an economic fuel (79%), had zero carbon rating (16%) and that it had been observed operating successfully in other plants (5%).

Secondary reasons cited were that it had a zero carbon rating (56%), was an economic fuel (19%), and had been observed operating successfully in other plants (19%) and finally DAFF supervision was already in place for other plant activities (6%).

Some respondents (29%) who considered that DAFF supervision was not onerous as a third reason for choosing tallow. A further 29% cited the observation of successful operation in other plants a third reason. The fact that they already had supervision on site was a third reason cited by 21% of respondents and zero carbon rating was a third reason for choosing tallow by another 21%. This is represented in Figure 4.3.7 below.

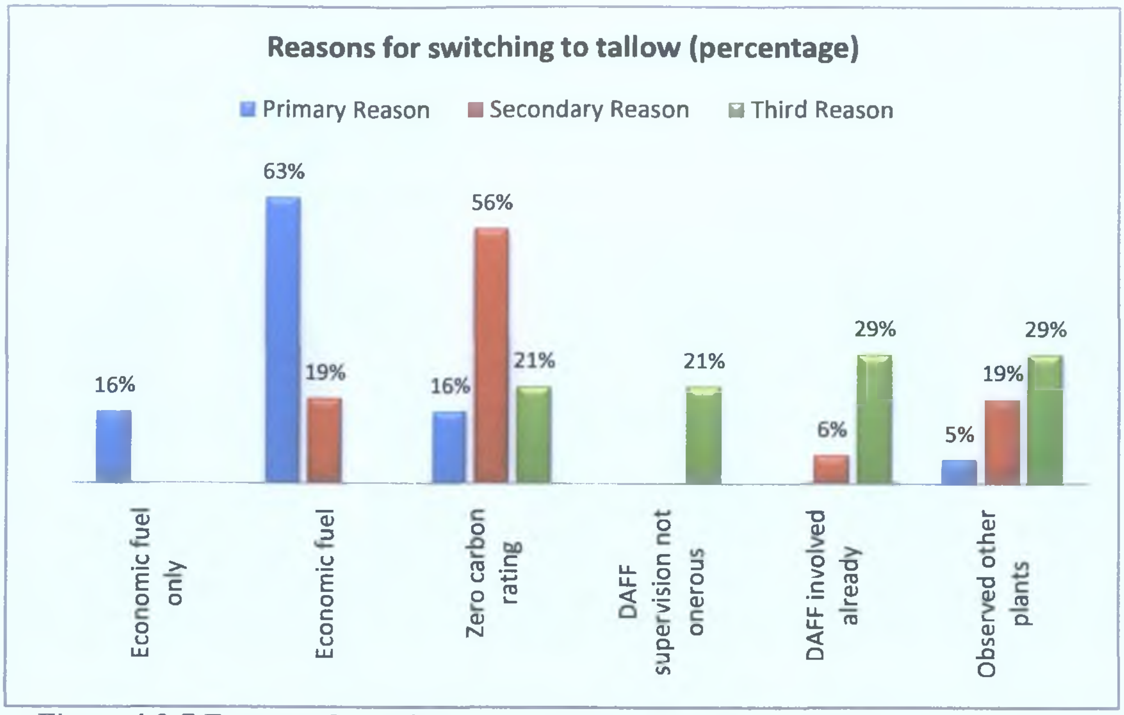

Figure 4.3.7 **Reasons for switching to tallow (Questionnaire, Appendix 4.6)**

4.3.2 Animal By-Products Section of the Department of Agriculture, Fisheries, and Food

The Animal By-Products Section of the DAFF is the competent body for approving the combustion of tallow.

4.3.2.1 Approval and Supervision

To date the Animal By-Products Section has approved ten plants to combust tallow. These plants, which are listed in the following table, include rendering, meat, fish and animal feed plants.

Name & Address Of Combusting Plant	Approval Number	Category Of Material
Kildare Chilling Co Kildare Town Co. Kildare	TB 001	Category 1 & Category 3
Dublin Products Dunlavin Co. Wicklow	TB 002	Category 1
Slaney Proteins Bunclody Co. Wexford	TB 003	Category 1 & Category 3
Western Proteins Hazel Hill Ballyhaunis Co. Mayo	TB 004	Category 1 & Category 3
Munster Proteins Kilcommon Cahir Co. Tipperary	TB 005	Category 1 & Category 3
Connolly's Red Mills Goresbridge Co. Kilkenny	TB 006	Category 1
Waterford Proteins Christendom Ferrybank Waterford	TB 007	Category 1
Charleville Foods Ardnageehy Charleville Co. Cork	TB 008	Category 1 & Category 3
Liffey Meats Ballyjamesduff Co. Cavan	TB 009	Category 1
United Fish Industries Ltd Donegal Road Killybegs Co. Donegal	TB 010	Category 1

Table 4.3.1 **List of plants approved to combust rendered animal fats in accordance with Regulation (EC) No. 1774/2002 (DAFF, 2008).**

A further twenty plants have expressed interest, some of which are at present in the process of obtaining approval. The plants that have expressed interest range from rendering, meat and dairy plants.

Most applications are for the combustion of Category 1 tallow.

The tallow is sourced from within the Republic of Ireland but it is possible to obtain approval to import tallow under Article 8 of the ABPR 1774/2002/EC that allows for the transportation of animal by-products to other Member States (DAFF, 2008).

4.3.2.2 Conditions for Approval

Commission Regulation (EC) No 2067/2005, Annex VI, lays down the requirements necessary for the combustion of animal fat (tallow) in thermal boiler processes.

Companies seeking approval to combust tallow apply to the Animal By-Products Section of DAFF which then provide an application form and guidelines for approval and supervision of combustion. Once the application is submitted with the required information the premises is inspected to ensure compliance with the legislation.

The application form, which is illustrated below is specific for each boiler. In addition to details regarding the company and the Category of tallow to be combusted, it stipulates processing requirements by which the fat is produced and the insoluble impurity requirement of 0.15%.

The person who signs the application on behalf of the company agrees by signing to uphold the above requirements and also that the tallow will be

'(i) vaporised in a steam-raising boiler and combusted at a temperature of at least 1100℃ for at least 0.2 seconds or

(ii) processed using equivalent process parameters authorised by the competent authority.'

as described earlier.

Application to the Minister for Agriculture & Food to Combust Animal Fats in a Thermal Boiler under EC Regulation 92/ 2005 as amended by EC Regulation 2067/2005

1. Applicant & Business Details *(Please write in block capitals)*

Name of Company:

Trading name:

Address:

Name of Contact Person

Position in Company (Manager / General Manager etc)

Telephone:

Fax:

Email:

2. Serial Number of Thermal Boiler to which this application refers*

**A separate application is required for each boiler*

3. Category of Tallow to be combusted :

4. In accordance with Annex VI of 2067/2005/EC, I the undersigned agree that :

(a) the fat fraction derived from animal by-products will be first processed using

(i) in the case of fat fraction intended to be combusted in another plant, processing method 1 as referred to in Annex V, Chapter 111, to Regulation (EC) No 1774/2002 for Category 1 and 2 materials ; and

(ii) any of the processing methods 1 to 5 or 7 or, in the case of material derived from fish, processing method 6 as referred to in Annex V, Chapter 111, to Regulation (EC) No 1774/2002 for Category 1 and 2 materials intended for combustion within the same plant and for Category 3 material.

(b) the fat fraction is separated from the protein and insoluble impurities amounting to up to 0.15% by weight are removed.

(c)following the processing the process referred to in (a) and (b)above, the fat is :

(i) vaporised in a steam-raising boiler and combusted at a temperature of at least 1100°C for at least 0.2 seconds; or

(ii) processed using equivalent process parameters authorised by the competent authority.

Signed:...

Position:...

(e.g. Owner, or in the case of a corporate body, the Chief Executive, Managing director or Company Secretary)

Date:..

FOR OFFICIAL USE ONLY

1. This application refers to a NEW or CURRENT operation. *(Delete as appropriate.)*
2. I confirm that the above application is in order.

Signed: .... Date ....

Veterinary Inspector

Date received in HQ

Plate 4.3.1 **Application Form for the Combustion of Animal Fat in a Thermal Boiler, (DAFF, 2008).**

While it is free to apply for approval there is a cost involved in the supervision of the plant. This cost is difficult to evaluate as in most cases there is already a DAFF presence on site for the supervision of other processes (DAFF, 2008).

4.4 Cost of Conversion and Operation

4.4.1 Conversion and Usage Costs

Conversion costs to combust tallow depend on the existing fuel and associated burner fitted to the boiler. The appropriate burner enables efficient and complete combustion by mixing fuel and air in the correct ratio. An atomising burner is appropriate for the combustion of tallow. The fuels used in the target survey group are predominantly HFO, LFO and natural gas. At this time, it is unlikely that plants with access to natural gas will convert to using tallow, as it is already a clean and cost effective fuel. Therefore costs are analysed here for plants already combusting HFO or LFO.

In addition to the initial conversion costs there are also increased maintenance costs, as tallow will erode fittings due to free fatty acids present in the fuel. Damage to equipment may further be compounded by calcite deposits originating from bone in the original raw ABP (personnel communication with Mr Bill Edwards, Saacke Combustion and Energy Systems, 5/3/2008). These complications may be minimised by ensuring that the tallow is of less than 0.15% insoluble impurities (as is required by legislation) and by sourcing tallow of consistent good quality.

Another consideration to address is security of supply. Boiler operators must provide steam when required and down time due to lack of fuel is not conducive to a successful business. The risk of this happening can be overcome by the provision of dual burners, which can be switched from oil to tallow and back again when required.

4.4.1.1 Conversion from HFO to Tallow

Conversion from a HFO fuel system is cheaper than that of an LFO system because of similarities between the viscosity of HFO and tallow. Both systems require the fuel to be preheated before entering the burner. Therefore, it is assumed that a storage tank with heating coils are already available for the HFO system and are not included in the conversion cost.

Conversion Costs From Hfo	Euro Per Boiler
Burner Conversion	1,000
Maintenance Costs	2,000
Total per boiler	**3,000**

Table 4.4.1 **Conversion costs from HFO per boiler (personnel communication with Mr Bill Edwards, Saacke Combustion and Energy Systems, 5/3/2008).**

4.4.1.2 Conversion from LFO to Tallow

LFO is much less viscous than HFO and will readily flow. Therefore preheating of this fuel is not required and it is assumed that plants burning it will not have storage tanks with heating coils. The following table provides an estimate for the conversion of a LFO burner to tallow.

Conversion Costs From LFO	Euro Per Boiler
Burner Conversion	10,000
Tank and Heating Coil	6,000
Metering block to control flow to burner	3,500
Maintenance Costs	2,000
Total per boiler	**21,500**

Table 4.4.2 **Conversion costs from LFO per boiler (personnel communication with Mr Bill Edwards, Saacke Combustion and Energy Systems, 5/3/2008).**

In addition to the above cost of conversion, the cost of monitoring of combustion temperature and time, for the purposes of demonstrating compliance with the ABPRs conditions, must be considered. This involves purchasing and fitting temperature recorders on the burners. As with any monitoring devices, there are additional ongoing costs of maintenance and calibration.

4.4.2 Cost in Comparison to other Fuels

In order to make a decision on whether it would be justified to switch to tallow on economic grounds a comparison must be made between it and other fuels. Figure 4.4.1 below 'Comparison of delivered cost of commercial fuel costs in cent/kWh', produced from data obtained from SEI, shows the relative costs of commercial fuels on a cent/kWh basis on January 1st 2008. Wood chip is the cheapest fuel at 2.68 cent/kWh and Liquid Petroleum Gas the most expensive at 8.17 cent/kWh.

The gross calorific value of tallow is approximately 38MJ/kg or 10.56 kWh/kg. Therefore, if tallow can be delivered, for example, at 0.40 cent/kg it is 4.22 cent/kWh. This would compare favourably with Natural Gas of quantities of less than 73,000 kWh, all mineral oils, L.P.G., and gas oil. Natural Gas, at quantities greater than 73,000 kWh, is cheaper at 2.88 cent/kWh and has advantages with ease of use and low carbon emissions. However, as already illustrated in Figure 4.3.2 'Gas Supply Areas Map, Bord Gais Networks 2006, 2008' it is not available in all parts of the country.

The two main fuel oils used by the companies surveyed are HFO and LFO. Tallow cost is compared against these fuels. Tallow at €500/tonne is 5.28c/kWh, which is less than the cost of HFO. Tallow at €600/tonne is 6.34 c/kWh, which is less than LFO. Therefore, in January 2008, the date of the fuel cost data comparisons (SEI, 2008) shown below in Figure 4.4.1, tallow was a more economical at up to €500/tonne and LFO users €600/tonne.

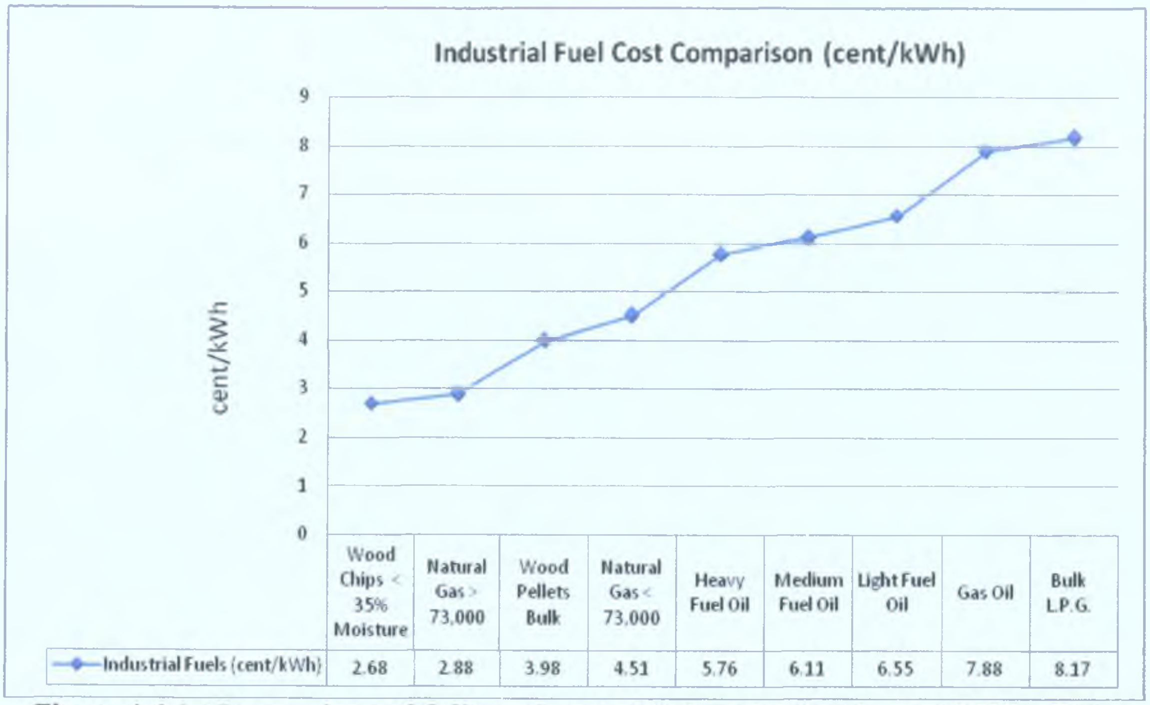

Figure 4.4.1 **Comparison of delivered cost of industrial fuel in cent/kWh. Data sourced from SEI, 2008 (Appendix 4.7)**

The cost of tallow is influenced by five main features (ECOLAS, 2006):

1. Which ABP category it is, with Category 1 the cheapest and Category 3 the most expensive
2. Free Fatty Acid content. Generally, the lower FFA material fetches the higher price
3. Its suitability for its intended use. (e.g., animal feed, combustion etc)
4. The current global and local market prices of vegetable oils and fats
5. If the intended use is combustion, the cost of commercial fuels

The United States Department of Agriculture (USDA) Agricultural Marketing Service reported increases of 63% in 2007 over 2006 prices for inedible bleachable tallow (Swisher, 2008) as demand increases globally. In June 2008, Category 3 tallow in Ireland was available for €550 to €600 /tonne (personal conversation with Mr Brendan Dunne, Slaney Proteins).

4.4.3 GHG Permit Holders

The percentage of GHG permit holders among the respondents of the survey was 47%. Of the 47% that were permit holders 80% considered switching to alternative fuels. The primary reasons for this were fuel cost efficiency and desire to use fuels with a zero carbon rating.

The Emissions Trading Scheme (ETS) has just completed its three year pilot phase which spanned years 2005 to 2007. The objective of the ETS is to cap carbon emissions by allocating a finite number of allowances, known as European Union Allowances (EUAs), to emit carbon. If a company exceeds its EUA allocation, it must purchase more to cover the carbon emissions that are in excess of their allocation. Due to over allocation of EUAs for the pilot phase, the value of each EUA had fallen to 0.2 cent on the final trading day of April 30th 2008. This was against a potential value of €40, which was the penalty to be paid for each EUA missing at the end of each trading year.

The second phase, which covers the five years 2008 to 2012, has a tighter allocation of EUAs and the penalty for not having the required amount to cover a company's annual carbon emissions is €100/EUA. Therefore, the second phase should be more successful because the incentive for companies to reduce their carbon emissions is more significant.

The GHG permit holders surveyed are subject to this incentive as are all permit holders in the EU member states. With a potential penalty of €100 for each missing EUA the need for zero carbon rated fuel is increased. At the beginning of this new trading period, EUAs (second phase) are valued at €26 each (PointCarbon, 2008). This means that zero carbon rated fuels have an extra value of €26 per ton of CO_2 emitted. On average 1 tonne of mineral oil will emit 2.8 tonnes CO_2 while a similar quantity of tallow will emit 2.7 tonnes (Appendix 4.8). This increases the value of tallow by €70 per tonne (€26 per EUA) to companies who expect they will exceed their EUA allowance allocation.

4.5 Case Study: Slaney Proteins, Ryland, Bunclody, Co Wexford.

The following case study on Slaney Proteins illustrates how tallow has been successfully used as a thermal fuel for 7 years. During this relatively short time span many changes have taken place that have had major influence on the economics of fuel usage and on the use of ABPs. Crude oil has increased to $135/barrel (May 2008) and the ABPRs, the WID, the ETS have all been implemented since 2001.

Slaney Proteins is a Category 3 rendering plant in north Wexford. It shares an IPPC licence with a slaughter and cutting plant, Slaney Foods International Ltd., which is located on the same site. Slaney Proteins received its first IPC licence in 1996 and is now under review with Slaney Foods International Ltd. for its third licence, P0047-03. It has used tallow as a thermal fuel since 2001. It is a GHG permit holder as its combined boiler thermal input capacity is over the qualifying 20MW.

4.5.1 Boilers and Burners at Slaney Proteins

The plant had at the time of licensing in 1996, two shell type steam raising boilers, a Ruston Thermax and a Beel fuelled with LFO. The Ruston boiler is fitted with a Saacke VG 593 burner with a thermal input capacity of 6.97 MW. The Beel boiler is also fitted with a Saacke burner and has a thermal input capacity of 6.847MW. With increased production during the Purchase for Destruction Scheme in 2001 a third shell boiler, a

BIB Cochran, was purchased. This is fitted with a Hamworthy burner and has a thermal input capacity of 7.71MW.

Plate 4.5.1 **Cochran boiler with the tallow conversion kit at the base on the left.**

The three burners, which continue in use today, were adapted to use tallow in addition to LFO. The rotary cup type burners were fitted with stainless steel (Type 314) cups that withstand the corrosion caused by the fatty acids in the tallow. An additional task to enable the successful combustion of this fuel was the retro fitting of stainless steel conversion kits to ensure that the tallow is presented to the burners at the correct flow rate and viscosity. The Beel and Ruston boilers were fitted with an Autoflame control for this purpose by A&L Gibson, Industrial Boiler Services, Ballymena, Co. Antrim.

Plate 4.5.2 **Autoflame conversion kit on the Beel boiler**

Plate 4.5.3 **Autoflame Control Panel**

Plate 4.5.4 **Autoflame conversion kit on the Ruston Boiler**

4.5.2 Boiler Operation

A storage tank, with heating coils, dedicated to Category 1 tallow, stores the tallow before it is conveyed via stainless steel piping (to avoid corrosion) to a burn tank which feeds directly to the burners. Category 3 tallow produced on site may also be used and is conveyed from a Category 3 storage tank to the burn tank in a similar fashion.

The burners are started on LFO from cold to heat the tallow. The tallow is heated in the burn tank with heat exchange coils. When the tallow in the burn tank is heated sufficiently (65°C) it is pumped through a circuit of stainless steel pipework to service the boilers. The tallow returns via the circuit to the burn tank in a continuous process that maintains the fuel at sufficient temperature for use. The photograph below shows the pumps, one duty and one standby, and the manifold attached to the burn tank.

Plate 4.5.5 **Pump and manifold used to pump tallow from the burn tank (on the right) around the tallow circuit.**

The operational controls for the burner are switched from LFO to tallow when the tallow has reached the correct temperature. The tallow after leaving the burn tank at 65°C cools somewhat to 60°C. To ensure the correct viscosity it must be at this temperature entering the burner for efficient combustion. The tallow enters the rotary cup and with centrifugal force comes off the inner lip of the cup at an appropriate particle size for combustion. The boiler has already been fired with LFO and the tallow continues the combustion process. Steam is produced in the boiler to a pressure of

10bar. This steam serves to render raw material, and with a heat exchanger, provide hot water for plant purposes and for the adjoining beef plant.

When the boilers are shut down the fuel lines are flushed with LFO to remove the tallow. This prevents the tallow from clogging the fuel lines when it cools. The boilers are then ready for start-up with LFO at the next firing.

4.5.3 DAFF Approval and Supervision

Slaney Proteins is approved by the DAFF for the rendering of Category 3 ABPs under approval number R917. It is approved to combust Category 1 and Category 3 tallow under approval number TB 003. DAFF personnel supervise both operations and the operation of the adjoining beef plant. They are provided with an on-site offices for this purpose.

The DAFF personnel supervise and document all ABP entering and leaving the plant and also supervise the implementation of the rendering HACCP system. As already stated, all tallow used as fuel must be less than 0.15% impurities. The DAFF personnel check this at the plant of production. Samples are taken by the personnel and sent to a laboratory to check that the tallow is as required.

Another CCP is the requirement for combustion at 1100°C for 0.2 seconds. This is demonstrated with the aid of an infra red temperature sensor which logs the temperature achieved on a continual basis in the combustion chamber. The temperature sensor was retro fitted and required drilling a hole in the burner exterior and fitting a pipe to it to house the sensor. The temperature sensors are calibrated annually.

Plate 4.5.6 **Cylindrical housing (on the far right) for the infra red temperature sensor on the Beel Burner.**

The housing for the sensor on the Beel burner, which was detached from the boiler for maintenance, is illustrated in Plate 4.5.6 above. The gas powered electric flame ignition system is shown in the centre of the photograph.

The sensor is in situ in this photograph of the Cochran boiler.

Plate 4.5.7 **Infra-red temperature sensor on the Cochran boiler**


Plate 4.5.8 **Close up of infra-red temperature sensor.**

4.5.4 Emissions

Emissions to atmosphere from fuels are an important issue in the protection of the environment. The issue broadly falls into two categories, firstly, emissions thought to cause global warming, and secondly, emissions that cause pollution of the atmosphere. In relation to this case study, the effect of tallow fuel on emissions thought to cause global warming focuses on emissions of carbon dioxide (CO_2). The emission of pollutants such as particulate matter, nitrogen and sulphur oxides is examined by comparing those emissions from the tallow combustion with those from LFO.

4.5.4.1 GHG Emissions

Since Slaney Proteins started burning tallow in 2001 they have reduced their carbon emissions substantially. The graph below shows the zero rated tallow carbon emissions and the LFO carbon emissions. The LFO emission is from that quantity of fuel used at start-up and shut-down. The combined value of the zero carbon rated emissions from 2001 to 2007 is 37,190 tonnes CO_2.

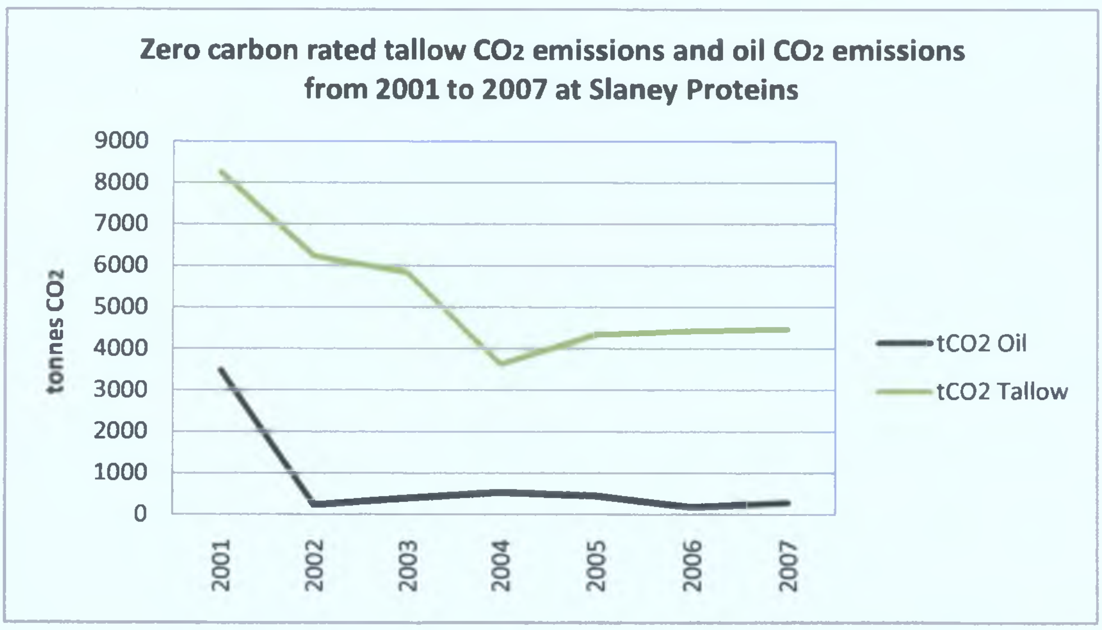

Figure 4.5.1 **Zero carbon rated emissions and carbon emissions from 2001 to 2007 at Slaney Proteins. Source GHG Permit Application Data (Appendix 4.8)**

It can be said that just less than this amount (due to the lower calorific value of tallow compared with LFO) of carbon emissions have been saved.

The graph shows a peak of fuel usage in 2001. This was due to the Purchase for Destruction Scheme and the subsequent Special Purchase Scheme. These schemes were EU support measures for declining beef markets because of the BSE crisis (DAFF, 2005).

4.5.4.2 Pollutant Emissions

In 2008 a screen test of emissions from the two duty boilers, the Beel and Cochran, operating at the same time was completed. The modelling, using the Atmospheric Dispersion Modelling System 4, was performed using tallow and LFO and covered pollutants nitrogen dioxide, nitrogen oxides, carbon monoxide, particulate matter and sulphur dioxide.

Both fuels showed that ground level concentrations were all within the required emission limit values. The tallow, however, as expected, was shown to be superior to the LFO on many parameters. This supports the information gathered during the literature review.

The following tables show the predicted effect on ground level concentrations of the parameters studied compared with the EU limit concentrations laid down in Directive 2000/69/EC (relating to limit values for benzene and carbon monoxide in ambient air) and Directive 1999/30/EC (relating to limit values for sulphur dioxide, nitrogen dioxide and oxides of nitrogen, particulate matter and lead in ambient air).

Parameter	EU Limit Concentration	Exceedance expressed as a %ile	Measured as	Maximum Ground Level Concentration
Nitrogen Dioxide (NO_2)	200$\mu g/m^3$	99.79th	1-hour Mean	40 $\mu g/m^3$
	40 $\mu g/m^3$	-	Annual Mean	3.5 $\mu g/m^3$
Nitrogen Oxides (NO_x)	30 $\mu g/m^3$	-	Annual Mean	3.5 $\mu g/m^3$
Carbon Monoxide (CO)	10 mg/m^3	-	Max Daily running 8 hour mean	0.1 mg/m^3
Particulate Matter (PM10)	50 $\mu g/m^3$	90.4th	24 hour Mean	5 $\mu g/m^3$
	40 $\mu g/m^3$	-	Annual Mean	5 $\mu g/m^3$
Sulphur Dioxide (SO_2)	350 $\mu g/m^3$	99.73th	1-hour Mean	3.0 $\mu g/m^3$
	125 $\mu g/m^3$	99.18th	24 hour Mean	1.6 $\mu g/m^3$

Table 4.5.1 **Predicted effect at ground level of Emissions from Boilers using tallow, Thomas A Keenan, National Environmental Services Agency, 2008**

It can be seen from the data that emissions of carbon monoxide and particulate matter are greater for tallow but well within the EU limit of 10mg/m^3 and 50 $\mu g/m^3$ respectively.

Nitrogen dioxide and nitrogen oxides are doubled for LFO. The LFO emission values for sulphur dioxide are well within the EU limits but over 20 times greater than the tallow emissions.

Parameter	EU Limit Concentration	Exceedance expressed as a %ile	Measured as	Maximum Ground Level Concentration
Nitrogen Dioxide (NO2)	200$\mu g/m^3$	99.79th	1-hour Mean	80 $\mu g/m^3$
	40 $\mu g/m^3$	-	Annual Mean	7 $\mu g/m^3$
Nitrogen Oxides (NOx)	30 $\mu g/m^3$	-	Annual Mean	7 $\mu g/m^3$
Carbon Monoxide (CO)	10 mg/m^3	-	Max Daily running 8 hour mean	0.002 mg/m^3
Particulate Matter (PM10)	50 $\mu g/m^3$	90.41th	24 hour Mean	0.9 $\mu g/m^3$
	40 $\mu g/m^3$	-	Annual Mean	1.8 $\mu g/m^3$
Sulphur Dioxide (SO2)	350 $\mu g/m^3$	99.73th	1-hour Mean	70 $\mu g/m^3$
	125 $\mu g/m^3$	99.18th	24 hour Mean	45 $\mu g/m^3$

Table 4.5.2 **Predicted effect at ground level of Emissions from Boilers using LFO. Thomas A Keenan, National Environmental Services Agency, 2008**

SECTION 5: DISCUSSION

5.1 Legislative Position

The Waste Framework Directive was established in 1975, to provide for *inter alia,* the protection of the human health and the environment with regard to waste. It is newly codified as Directive 2006/12/EC to incorporate the many changes in waste legislation since 1975. Although the definition of waste is improved, it is a subject that causes confusion within the community.

While ultimately what constitutes waste is decided on the precautionary principle as interpreted by the ECJ, it essentially refers to any substance that the holder intends to discard. ABPs, which are derived from discarded material, are then by definition 'waste'.

Member States are required to ensure that waste is disposed of without endangering human health and without harming the environment. The extraction of energy from waste is encouraged with incineration and use as a fuel classified as waste disposal and recovery operations respectively.

There have been many clarifications on what constitutes waste by the ECJ and although these decisions increase the information available, none specially address the combustion of tallow. Decisions are made on a case-by-case basis and as no case specifically addressing the combustion of tallow has come before the court clarification from this source remains outstanding. Yet, because of previous decisions, it can be said that waste includes substances that can be used commercially; are part of a production process; that do not impose risk to health or the environment. Furthermore, the calorific value of a substance is irrelevant in deciding whether it is a waste. Petroleum coke is not a waste because it is intentionally produced and it is certain to be used as a fuel.

One might consider that the same criteria apply to the combustion of tallow. FIR has put similar criteria forward as reasons for the designation tallow as a product and not a waste.

The European Commission are aware of the confusion regarding the definition of waste in spite of the clarifications offered by the ECJ. It fears that this uncertainty is hindering investment. The Commission addresses this issue in the Thematic Strategy, objectives of which are *inter alia* to clarify, simplify, and streamline EU waste law. One of the measures in the attainment of these objectives is the review of the WFD, which is at present taking place.

A new concept presented in the Thematic Strategy is that waste can cease to be a waste based on potential environmental and economic benefit. The use of tallow as a fuel is addressed under this concept and whether it will be designated as a product depends on the outcome of studies on its environmental impact.

A further measure to aid clarification specifically on by-products, are guidelines based on current waste law and the interpretation of case law of the ECJ. On the basis of these guidelines, and in particular with reference to a decision tree therein on deciding whether a material is a waste or a product, one could make the decision that animal by-products such as tallow and MBM are indeed products and not waste. The flow of the decision is as follows:

The answer to the first question '*Is the intended use of the material lawful?*' is yes because the use is described the ABPR.

The second question '*Was the material deliberately produced (Was the production process modified in order to produce the material?)* aids the decision as to whether the material is a product or a production residue If the material was deliberately produced by choice then the answer is in the affirmative and the material is a product. If not deliberately produced the material is a production residue. To answer this question one would have to decide if the production of tallow and MBM from raw ABP was a choice or a consequence of rendering. The degree of separation of the tallow and MBM are deciding factors in their further use so one could say the process is modified by choice to ensure that the separation is sufficient to enable combustion in a steam raising boiler i.e. less than 0.15% insoluble impurities in tallow. The answer then is in the affirmative and the material is a product and more significantly not a waste. If the question is answered in the negative, i.e. that the production of tallow is a consequence of rendering rather than a choice, the material is a production residue and further tests apply before it can be decided if it is a waste.

The first of these tests questions if the use of the material is certain. In the case of tallow it is certain to be used as a fuel, animal feed, or in the oleochemical industry.

The second test *'Is the material ready for use without further processing (other than normal processing as an integral part of the production process?'* can also be answered in the affirmative as tallow is ready for use as a fuel without any further processing. The last test queries if the material is produced as an integral part of the production process. Again, this question can be answered in the affirmative. According to the decision tree, the material is then a non-waste product. In either scenario the material is not a waste.

The ABPRs are currently under review and in June 2008 had reached a stage where the Commission published a final draft of a proposal for a revised ABPR. Significantly, the combustion of ABP or derived products as a fuel is identified as not being a waste operation. There is a stipulation that such use should take place under the appropriate environmental standards. The standards are not defined; however, it is reasonable to assume they are not those of waste legislation. If this proposal is approved by the European Parliament and the Council, it will be implemented fifteen months after the date of entry into force. The proposal was prepared with input from various stakeholders, including renderers.

To summarise, the combustion of tallow is covered by waste legislation and its incineration and use as a fuel are waste operations. Three events can change this situation; a ruling from the ECJ; the application of the concept of 'waste ceasing to be waste'; or its removal from the revised scope of the WFD. In June 2008, in the proposal for a revised ABPR, the latter has happened i.e. the combustion of ABPs and their derived products have been effectively removed from the scope of waste legislation. If this proposed regulation is approved, one of the financial deterrents i.e. the WID, to the use of tallow as a fuel has been eliminated.

5.2 Tallow Quantity Available

The quantity of tallow available in Ireland depends on livestock slaughtering which has shown an overall decrease since 2004. While cattle slaughtering increased significantly in 2006 all livestock groups are below their 2004 figures. Sheep have shown the greatest decline at over 10% since 2006. The production of tallow will decrease with the continuation of this downward trend in livestock slaughtering. Nevertheless, we can expect a minimum of 80,000 tonnes per annum to be produced for the near future.

ABP is processed in eight rendering plants in the Republic of Ireland, four Category 1 plants and four Category 3 plants. Total tallow production from the rendered ABP dropped in 2007 by just over 2,000 tonnes from 2006 to 87, 227 tonnes. Just over 53 % of this was Category 1 tallow, all of which was combusted in steam raising boilers in Ireland in addition to approximately 12,000 tonnes of Category 3 tallow. The remaining Category 3 was used for animal feed and technical purposes.

Category 1 renderers produce a surplus of between 13,500 and 22,000 tonnes of tallow. This quantity is not adequate to supply the market for Category 1 tallow. Although Category 3 tallow has markets in animal feed and the oleochemical industry, some of the Category 3 tallow is used as a fuel to supplement the Category 1 tallow as the market value of Category 3 tallow is less than that of mineral oil price.

To summarise, although livestock numbers are decreasing there will be a minimum of 80,000 tonnes of tallow produced for the near future. Approximately 47,000 tonnes per annum are required for rendering fuel. The surplus Category 1 tallow and some Category 3 tallow are used as fuel. There is increased demand for the cheaper Category 1 surplus and for the Category 3 tallow as both are cheaper than fuel oil. The remaining Category 3 tallow is sold for animal feed and to the oleochemical industry.

5.3 Use of Tallow as a Thermal Fuel

5.3.1 Food and Drink Industry

A survey of attitudes within the Food and Drink industry on fuel usage, and in particular on tallow usage was performed. IPPC licensed facilities were the target group and a 42% response rate was achieved.

The survey revealed that fuel choice for steam raising boilers was primarily made on cost considerations (63%). Efficiency was second (17%), followed by GHG considerations (8%).

Predominant fuels and combinations of fuels used, in decreasing order, were natural gas (25%), HFO (16%), HFO and tallow (17%), LFO and tallow (14%) and LFO alone (8%). Natural gas is not available throughout the entire country making this most popular and economical choice available only to some respondents.

Companies are actively considering alternative fuels (69% of the respondents). Tallow was the fuel of choice for 58% of those considering change, followed by natural gas (33%) and wood (20%). Awareness of tallow as a fuel was high with 75% of the respondents being aware.

Category 1 tallow was chosen by 45% of those choosing tallow. This is likely due to the more reasonable cost. Both categories of tallow were chosen by 33%, with Category 3 alone being considered by 22%, which may have been due to the less onerous supervision and approval by the DAFF. The primary reason tallow was considered was its perception as an economic fuel (79%). This was followed by its zero carbon rating (16%) and its successful operation in other plants (5%).

Significantly, 56% of the respondents cited zero carbon rating as the second reason for switching to tallow. This reflects the interest in zero rated carbon fuels for those companies with GHG permits (42% of the respondents that had considered switching to tallow had GHG permits).

To summarise, the predominant fuels used at present within the IPPC licensed facilities in the Food and Drink industry are natural gas (where available), mineral fuel oils and tallow. A high proportion of companies are considering alternative fuels for their steam raising boilers. Awareness of tallow for this purpose is high. Tallow is the fuel of choice for most companies, with Category 1 tallow preferred. Cost is the main consideration for all companies, with zero carbon rating the second consideration for those companies with GHG permits. Wood and to a lesser extent palm oil are being considered.

5.3.2 Animal By-products Section of DAFF

The Animal By-products Section of the DAFF has approved ten plants to combust tallow. These include rendering, meat, fish, and animal feed plants. A further twenty plants have expressed interest with some plants currently in the process of obtaining approval. All the tallow is from the Republic of Ireland but it is legal to source it from other Member States under the ABPRs. This provision opens up the possibility of supply from Northern Ireland, mainland UK and the continent to augment the limited supply available in Ireland

Each boiler selected to combust tallow is individually approved by the Animal By-Products Section. Category 1 tallow requires each boiler to have a licence while Category 3 requires a less demanding approval due to the reduced risk associated with Category 3 ABP. Supervision of operations and inspection of documentation by personnel from the DAFF is continuous. Requirements for the combustion of tallow in a steam raising boiler are that the tallow must have less than 0.15 % insoluble impurities (to reduce the risk of the TSE prion being present), have been produced by processing method 1 (in the case of Category 1 tallow), and be combusted at a temperature of at least 1100°C for at least 0.2 seconds.

In summary the Animal By-Products Section of the DAFF are the competent body for the approval and supervision of the combustion of tallow as a fuel. They have approved 10 plants to date and are currently processing more applications. The requirements for combusting Category 1 tallow are more restrictive than those of Category 3 tallow. All tallow must be combusted in licensed (Category 1) or approved (Category 3) steam raising boilers and must be less than 0.15% insoluble impurities and combusted at 1100°C for 0.2 seconds.

5.4 Cost of Conversion and Operation

5.4.1 Conversion Costs

Conversion costs from HFO to tallow are much less than from LFO to tallow because much of the system and a storage tank are already in place. This is because the viscosity of HFO requires it to be preheated before use like tallow. Many plants use a combination of mineral fuel oil and tallow for flexibility. In any case, the investment is not excessive being in the region of €20,000, which includes a dedicated storage tank. In addition to the costs of conversion, there are costs associated with the ABPRs compliance for temperature recorders and supervision by the DAFF personnel.

5.4.2 Cost in Comparison to other Fuel

As established in the survey, the cost of the fuel is the most important consideration for the respondents when choosing which fuel to use. Within the range of industrial fuels, wood chip is the cheapest at 2.68c/kWh. Natural gas (quantities greater than 73,000 kWh) is very competitive at 2.88 c/kWh and 4.51 c/kWh (quantities less than 73,000 kWh).

Natural gas has the advantage of being a clean fuel with low carbon emissions and indeed is the fuel recommended for Best Available Technology (BAT) for IPPC licensed activities. Wood has the disadvantages of being bulky, requiring new burners and having poor supply chains. As natural gas is unavailable in some areas and wood is not yet well established as a boiler fuel, tallow prices are essentially competing with those of the mineral fuel oils, HFO and LFO.

HFO is the cheapest at 5.76 c/kWh with LFO more expensive at 6.55 c/kWh. Tallow at 55c/kg is 5.81c/kWh, which is on par with HFO but still cheaper than LFO. To be effective economically those companies using HFO need to source tallow at less than €500/tonne while those companies using LFO can afford to pay €600/tonne and still have a cheaper fuel. Obviously, the smaller the margin, the longer it will take companies to pay back the initial cost of conversion. However, it should be noted that the cost of conversion is small in comparison to the annual fuel bill. For example, if a company used 1000 tonnes of fuel in a year at a cost of €500/tonne, and the cost of conversion for two boilers amounted to €40,000, then the cost of conversion for that company is 4% of their annual fuel bill. The percentage increase in oil prices during 2007 was eight times 4% at over 32% (SEI, 2008). The fuel prices quoted above are from January 2008 and there were significant increases in the cost of mineral fuel oil in the following six months. Therefore the margins in June 2008 were greater and the use of tallow more financially rewarding.

If a company adapts its fuel system to use tallow and oil they gain, for a small percentage of their annual fuel bill, the flexibility to take advantage of tallow when available and the security in having oil on standby when required.

Another factor that improves the cost benefit of tallow is its zero carbon rating for emission trading purposes. This is particularly relevant to those companies with GHG permits which must pay a fine of €100 per tonne of CO_2 emitted without a EUA. At the beginning of the new Emissions Trading Scheme trading period (2008- 2012) EUAs were trading at €26 each (PointCarbon, 2008). One tonne of tallow combusted will save the company 2.7 tonnes of CO_2 while one tonne of LFO will emit 2.8 tonnes of CO_2. Tallow for these companies has an extra potential value of €70/tonne (€26/EUA)

To summarise, because natural gas and wood the most economical fuels, tallow is essentially competing with HFO and LFO as a fuel choice. At January 2008 figures tallow at €500/tonne was competitive against HFO and at €600/tonne competitive against LFO. For GHG permit holders there was a further financial benefit of €70/tonne for CO_2 emission savings.

5.5 Case Study: Slaney Proteins, Ryland, Bunclody, Co Wexford.

Slaney Proteins, a Category 3 rendering plant, and a GHG permit holder, has been using tallow in its steam raising boilers since 2001. The boilers are approved to burn both Category 1 and Category 3 tallow. From 2001 to 2007, the plant has saved 37,190 tonnes of CO_2 emissions by replacing LFO with tallow.

Heating coils in the tanks heat the tallow, which is then pumped to a burn tank. The tallow is pumped via a return circuit from the burn tank to the boilers. The boilers which are started with LFO are switched to tallow as the heated tallow enters the burners. Before the boilers are shut down the fuel lines are flushed with LFO so that they are clear of cold solidfied tallow before the next firing.

The fuel lines and burners are made of stainless steel to mitigate against the corrosive effects of tallow.

DAFF personnel on-site supervise the operation of the rendering plant and the use of tallow in the boilers. The tallow is combusted at a minimum of 1100°C for 0.2 seconds to comply with ABPR. This is verified by an infra red temperature sensor in the combustion chamber of the burner.

A screen test of pollutant emissions of the two duty boilers running at the time showed that ground level concentrations of the pollutants were all within the required emission limit values for both tallow and LFO. Emissions of carbon monoxide and particulate matter were greater for tallow. Nitrogen dioxide and nitrogen oxides were double for LFO than those of tallow while emissions of sulphur dioxide were over twenty times greater.

To summarise, Slaney Proteins has been burning tallow successfully for over seven years. It is approved by the DAFF who supervise the burning of tallow and the rendering process. Since 2001, over 37,190 tonnes of CO_2 emissions have been saved by using tallow as a fuel. Pollutant emissions of nitrogen dioxide, nitrogen oxides and sulphur dioxide are reduced while carbon monoxide and particulate matter are increased with tallow. All emissions are well within the legislative requirements.

5.6 SWOT Analysis on the Suitability of Tallow as a Thermal Fuel in Ireland

The strategic planning tool developed by Albert Humphrey at Stanford University, California, known as SWOT analysis, identifies the strengths, weaknesses, opportunities, and threats of a planned project. It is applied below to the suitability of tallow as a thermal fuel in Ireland.

Strengths	**Weaknesses**	**Opportunities**	**Threats**
Cheaper than mineral fuel oils	Sourcing of supplies difficult	Contributes to reducing national carbon emissions for meeting Kyoto protocol obligation	New bioenergy companies in Ireland will use tallow as a raw material and exhaust supplies
Renewable fuel with calorific value just less than mineral oil	Must have DAFF approval and supervision	GHG permit holders save on purchasing extra EUAs if required for increased CO_2 emissions.	Security of supply going forward not guaranteed due to increased demand for steam raising boilers in other plants
Zero carbon rating for ETS purposes	Cost of conversion not excessive but must be considered	Easy compliance with EU standards for air emissions	Feed and oleochemical industries competing for supply
Globally established and proven fuel	Cost rising quickly due to increased demand of oils	Can purchase from other MS if approval obtained from DAFF	WID implementation, although unlikely, could incur significantly increased costs of abatement and monitoring
Does not compete with food production	Need boiler operation expertise	Environmental friendly use of industry by-product	Alternative means of ABP disposal which does not produce tallow are available
Most compatible renewable fuel with traditional oil burners	Limited supply in Ireland	More sustainable source of renewable fuel than bioenergy crops	Does not compete well with natural gas which may become more widely available
By-product of an existing industry	Not competitive against natural gas or wood	Mitigates against the carbon footprint of livestock rearing	
Clean fuel with negligible sulphur emissions	Decrease in livestock population decreases amount of tallow produced	Locally produced and used reducing transport cost and transport footprint compared with mineral oil	
Produced throughout the world including Ireland	Use subject to increased regulation in the event of new ABP related disease		
Require less storage than wood fuels	Need to install stainless steel fuel lines and equipment to mitigate against corrosive properties		
Expertise in its use throughout Ireland			

Table 5.1 **SWOT analysis of the suitability of tallow as a thermal fuel in Ireland.**

SECTION 6: CONCLUSION

The aim of this study is to determine the suitability of using tallow as a thermal fuel in Ireland. In order to achieve a balanced judgement, suitability is considered from a broad perspective. Aspects in the areas of health, economics, and sustainability are considered in addition to those of an environmental nature.

In the area of health, legislation provides us with protection from the negative aspects of ABPs by laying down rules with regard to the manner in which ABPs are handled. The rules cover the combustion of tallow. It has been decided within the EU that when tallow is combusted according to the legislative requirements the risk to health is low enough to be acceptable. However, it is a fact of life that there are occasions when rules are broken. Is the risk still acceptable in that event? Could the health of the population be compromised if material with the intact prion were released to the environment? To answer this question one looks to the experience gained so far. Tallow has been used in steam raising boilers in Ireland since 2000. Since 2002, and the implementation of the ABPRs the incidence of BSE in Ireland has decreased, with only 25 cases in 2007 compared with 333 in 2002. The fact that the disease has a long incubation period and positive animals are of an increasing age profile indicates that the disease is being eradicated from the bovine population. Therefore, it would seem that the implementation of the ABPRs is effective and provides the protection intended.

Economically it is advantageous to replace LFO with tallow, particularly for those companies with GHG permits, if it can be purchased at less than €600/tonne. The cost benefit in comparison to HFO is less pronounced and there is no economic benefit to those companies with access to natural gas or that have wood-fuelled boilers. For those companies using oil the cost of adapting their fuel system is small in comparison to their annual fuel bill. A dual system is ideal, where both mineral fuel oil and tallow can be used as it provides the flexibility to take advantage of tallow when available and the security in having oil on standby when required.

The survey revealed that cost is the primary consideration in fuel choice for companies. With more companies choosing tallow the amount produced in Ireland is subject to increased demand which has resulted in an increase in value. However, fuel use is not the only use and the cost of tallow as a raw material for the oleochemical industry and animal feed companies is rising. These costs are passed on or more economical alternatives chosen.

This mirrors the global effect of renewable fuels in general: higher animal feed prices and increased demand on cultivated and uncultivated land for the production of food and energy crops. The clearing of natural forestland for cultivation with oil producing plants is one of the great paradoxes of our time; an effort to control global warming by using renewable fuels is contributing to the destruction of the natural carbon sinks of forests. The carbon balance of this phenomenon is important in the analysis of suitability of renewable fuel production and use.

The ultimate stakeholders, in the suitability of any fuel, are the present and future populations of the planet. In this scenario, renewability and the ETS zero carbon biomass ratings are poor yardsticks by which to bestow merit on a particular fuel. Sustainability is more appropriate. The sustainability of fuel production at the expense of food and natural carbon sinks is questionable.

If tallow is subjected to the fuel sustainability test, we can say that it not produced at the expense of food production as it is a by-product of a food-industry. On the other hand, globally livestock production is a threat to uncultivated land. Nevertheless, fuel production is not the primary objective and livestock provide many other benefits. Consequently, it can be argued that tallow is a more sustainable fuel choice than the finite reserves of fossil fuels or renewable fuels produced from the land for solely that purpose.

In the European Union (EU), an anomaly exists with regard to the utilisation of fuels for steam raising boilers. Fossil fuels may be employed with minimal emissions abatement, while the more onerous requirements of the Waste Incineration Directive (European Parliament and the Council of the European Union, 2000) are applied to the combustion of tallow, an accepted cleaner fuel. This irregularity arises because, under EU legislation, tallow is classified as a waste and therefore falls under the scope of waste legislation. Fossil fuels are clearly not wastes and therefore are outside the scope of waste legislation.

This anomaly is likely to be eliminated in the near future due to the proposed revision of the ABPRs. In the revised regulation, the combustion of ABP as a fuel is not considered a waste operation. This change removes a major disincentive for the use of this fuel.

From an environmental viewpoint, tallow is recognised as a clean fuel with negligible sulphur emissions and low nitrogen oxide emissions. Particulates and carbon monoxide can be higher than those of fuel oils, but are still within legislative requirements. As already stated it is a zero carbon rated fuel for ETS purposes with the added advantage of being produced as a by-product of the food industry. It is used locally, which further reduces its carbon footprint.

In conclusion, its suitability as a fuel for steam raising boilers in Ireland has been examined from many perspectives. From a health viewpoint, the ABPRs provide the protection necessary from ABPs. It is suitability from an economic viewpoint is limited to those companies using mineral oils, particularly those using LFO with GHG permits. With regard to sustainability it is more sustainable than many other fuels available at present and from an environmental viewpoint it is recognised as a clean fuel.

Its major disadvantage is its limited supply, which is a key factor in deciding its suitability for any company. If a contract for supply at a cost effective price can be arranged with the provider, then it would be difficult to find an alternative that would be more suitable.

SECTION 7: RECCOMENDATIONS

Attitudes toward fuel usage, and particularly tallow, were investigated in this study by a survey of IPPC licensed facilities within the Food and Drink industry, a limited population of 86 companies. A broader more in-depth survey on fuel usage, particularly on sustainable fuels, would have provided a more accurate picture of attitudes toward fuel use.

The case study on Slaney Proteins served to illustrate the practicalities of using tallow as a thermal fuel. Slaney Proteins, a rendering plant, has been using tallow since 2001 and personnel there are experienced in its use. Further insight into the practicalities of using this fuel would have been gained from case studies of newly approved plants in other industries.

This investigation into the suitability of using tallow as a thermal fuel in Ireland brought focus to the legislative position with regard to its classification as waste. The possibility that the use of ABP as a fuel will be removed the scope of waste legislation opens up new possibilities for tallow and more importantly for MBM. The rendering industry has suffered from lost markets for MBM since restrictions were imposed due to the BSE crisis. This has been a significant cost to the industry, particularly in Ireland, as MBM was exported to Europe for incineration. The scope of this study was restricted to the suitability of using tallow as a thermal fuel. In light of these developments, further study might focus of the suitability of MBM as a thermal fuel.

ACRONYMS and ABBREVIATIONS

ABP	Animal By-Product
ABPR	Animal By-Product Regulation
APAG	European Oleochemicals and Allied Products Group
BSE	Bovine Spongiform Encephalopathy
CCP	Critical Control Point
CJD	Creutzfeldt-Jakob Disease
CO_2	Carbon Dioxide
CO_{2eq}	Carbon Dioxide equivalent
ECJ	European Court of Justice
EEC	European Economic Community
EN	Euronorm
EPA	Environmental Protection Agency
EFPRA	European Fat Processors and Rendering Association
ETS	Emissions Trading Scheme
EU	European Union
EUA	European Union Allowance
FFA	Free Fatty Acid
FIR	Federation of Irish Renderers
FPRF	Fats and Proteins Research Foundation
GHG	Greenhouse Gas
HACCP	Hazard Analysis and Critical Control Points
HFO	Heavy Fuel Oil
IPC	Integrated Pollution Control
IPPC	Integrated Pollution Prevention Control

kJ/kg	kilo Joules/kilogram
kWh	kilo Watt hour
LFO	Light Fuel Oil
LPG	Liquid Petroleum Gas
MFO	Medium Fuel Oil
MBM	Meat and Bonemeal
MJ/kg	Mega Joules/kilogram
MS	Member States
Mt	Million tonnes
MW	Mega Watt
NOx	Nitrogen Oxides
SEI	Sustainable Energy Ireland
SOx	Sulphur Oxides
SRM	Specified Risk Material
SWOT	Strengths Weaknesses Opportunities Threats
UN	United Nations
USDA	United States Department of Agriculture
vCJD	variant Creutzfeldt-Jakob Disease
WCC	Wexford County Council
WFD	Waste Framework Directive
WID	Waste Incineration Directive

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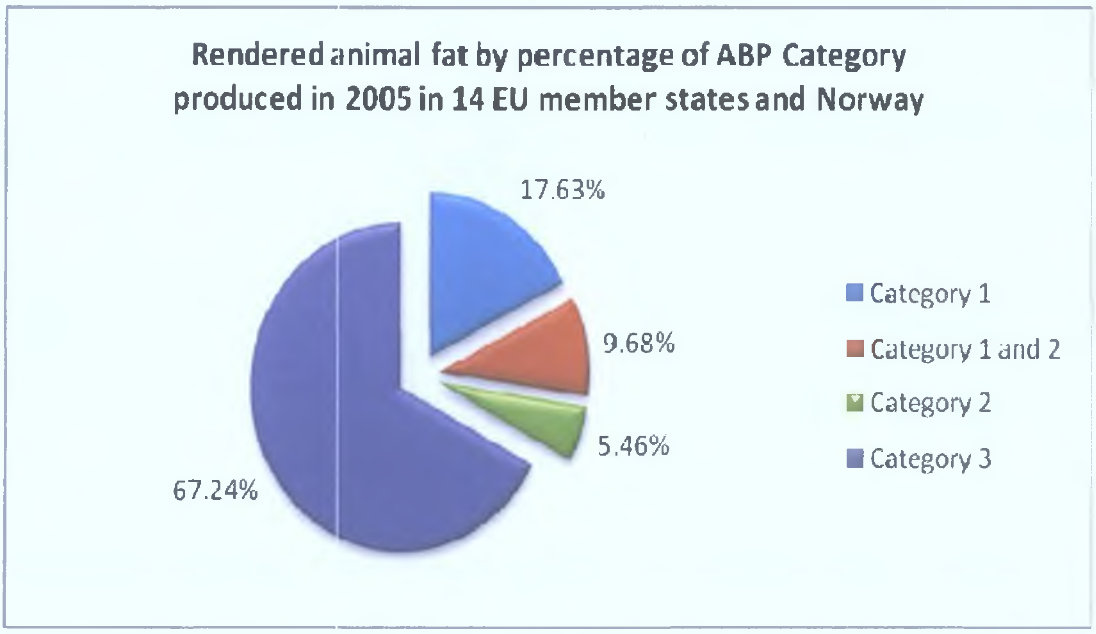
APPENDICES

Appendix 2.1

Figure 2.1.1 **Rendered animal fat by Percentage of ABP Category produced in 2005 in 14 EU member states and Norway. Adapted from the ECOLAS Report, 2006 (Appendix 2.1)**

Tallow Type	tonnes	Percentage
Category 1	391559	17.63%
Category 1 and 2	214925	9.68%
Category 2	121247	5.46%
Category 3	1493625	67.24%
Total	2221356	100.00%



Appendix 3.1

Tallow Production Data from Mr Raymond McEvoy, Animal By-Products Section, DAFF via email correspondence.11/3/2008

Tallow Production (Tonnes)

Year	Category 1	Category 3
2003	21,790.02	48,460.85
2004	38,478.05	37,003.41
2005	42,216.83	46,070.48
2006	50,349.18	38,962.96
2007	46,445.74	40,781.21

Appendix 3.2

General Information on Tallow Combustion from Mr Raymond McEvoy, Animal By-Products Section, DAFF via email correspondence.11/3/2008

1.1 Licensing, approval and supervision costs

There is no fee for making an application for approval to combust tallow in a thermal boiler. The Department of Agriculture, Fisheries and Food (DAFF) has a supervisory presence at all approved plants to ensure full compliance with legislation. However, because the supervisory personnel have other duties, it is impossible to quantify the cost of DAFF supervision of plants combusting tallow.

1.2 Applications and Interest

1. *Can you say how many applications are being processed at the moment?*

As well as the 10 plants that have been approved to combust tallow under Regulation 1774/2002/EC, there have been expressions of interest from a further 20 plants, which includes plants such as rendering plants, meat plants and dairy plants, however not all have submitted an application. The applications that have been submitted are at various stages of the approval process.

2. *Is there an increase in interest in the last few years?*

It is only in the last 2-3 years that plants are being approved to combust tallow so it is difficult to say if there has been an increase in interest.

3. *Which category are most applications for?*

The majority of applications are to combust category 1 tallow. One of the main reasons for this is that there are other uses for category 3 tallow, such as in the oleo-chemical industry.

4. *How many would source tallow from the ROI compared to the UK or elsewhere?*

Currently almost all plants combusting tallow would source their material within the ROI. However, in exceptional cases, plants may be allowed to import tallow. Article 8 of Regulation 1774/2002/EC allows the dispatch of animal by-products and processed products to other Member States subject to certain conditions.

5. *Does the EU stance on the WID deter plants from making a decision to use tallow?*

The Meat and Rendering Industries are strongly opposed to the classification of tallow as a waste and consequently for subjecting the use of tallow as fuel to WID. Perhaps this is a question that should be directed to the plants combusting tallow.

6. *"For official use only"*

When the application form was originally drawn up and plants were to be approved under EC Regulation 92/2005, as amended by EC Regulation 2067/2005, there were some plants already burning tallow in thermal boilers. That is why this question is on the form.

1.3 Miscellaneous

1. *Amount of tallow produced in Ireland*

Tallow Production 2000 – 2007 (Tonnes)

YEAR	TALLOW PRODUCED (Tonnes)
2000	77,336.94
2001	109,373.65
2002	79,389.90
2003	70,250.87
2004	75,481.46
2005	88,287.31
2006	89,312.14
2007	87,226.95

2. *What are the most recurrent problems that arise for applicants in achieving a licence or approval?*

When a plant requests an application form to combust tallow they are also sent the guidelines for the combustion of tallow in thermal boilers and the conditions for the approval and routine supervision of the use of tallow as a fuel in thermal boilers. Therefore, they are aware of what is required of them and when they submit their application and are subsequently inspected by DAFF officials they are, in general, compliant.

3. *Official stance by DAFF with regard to the application of the Waste Incineration Directive.*

DAFF supports the industry's opinion that there is no reason or justification for a requirement that tallow be classified as a waste and consequently for subjecting the use of tallow as fuel to WID.

4. *Number of poultry slaughtered in Ireland since 2004.*

2 Poultry Slaughter figures 2004 – 2007

YEAR	POULTRY SLAUGHTERED
2004	80,425,684
2005	78,346,561
2006	75,010,726
2007	73,167,175

Appendix 3.3

Cover Letter for Questionnaire

Ballyduff

Ballycarney

Enniscorthy

Co Wexford

22nd March 2008

Dear Sir/Madam,

I am completing an MSc in Environmental Protection as a student of the Institute of Technology, Sligo. The subject of my thesis is *The Combustion of Tallow as a Thermal Fuel.* As part of my research I am asking companies within the Food and Drink Industry to complete the attached questionnaire.

I would be most grateful if you would complete and return this short questionnaire so that I can make an assessment on the use and possible future use of tallow within the industry. All information returned is strictly confidential.

If you have any questions I may be contacted at 087 6224409.

Thank you for your time.

Yours faithfully

Dympna Skelton

Questionnaire

Please tick appropriate answers unless otherwise indicated.

Plant Name;____

Site Location____

____

Fuel Usage

1. Do you have on-site boilers with combined thermal input capacities of

0MW→1MW   1MW→20MW   20MW→30MW   30MW→50MW   >50MW

2. What type (s) of fuel do you use in your boilers of greater than 1 MW thermal input capacity?

HFO   LFO   Natural Gas   Tallow   Wood

Other (please specify)

3. What quantity of each fuel is used in your boilers per annum? (combined usage)

Please specify type________________________

0-500   500 -1,000   1,000- 5,000   5,000-10,000   >10,000

tonnes/1000litres

What quantity of each fuel is used?

Please specify type___________________________

0-500 500 -1,000 1,000- 5,000 5,000-10,000 >10,000

tonnes/1000litres

What quantity of each fuel is used?

Please specify type___________________________

0-500 500 -1,000 1,000- 5,000 5,000-10,000 >10,000

tonnes/1000litre

Fuel Switching

1. Have you considered switching to other fuels for running your boilers? Yes

   No

   If 'Yes'

2. Which fuels did you consider switching to:

   HFO LFO Natural Gas Tallow Wood Other (please specify)

3. Was this consideration due to
   a. Increasing energy efficiency
   b. Compliance with GHG emission allocation
   c. Process Requirements
   d. Relative cost of fuels
   e. Security of supply
   f. Climate change
   g. Other (please specify)____

   Please rate numerically (1-7) in order of importance as many as required.

Tallow Usage

Commission Regulation (EC) No 2067/2005, Annex VI, lays down the requirements necessary for the combustion of animal fat (tallow) in thermal boiler processes.

1. Are you aware that tallow may be used as a boiler fuel under this amendment of the Animal By-Products Regulations?

Aware Vaguely aware Not aware

2. If aware, how did you become aware?
    a. Already using tallow as a fuel for boilers.
    b. Exploring the usage of alternative fuels
    c. Awareness of conditions for tallow usage in other plants
    d. Became aware through the Emissions Trading Scheme
    e. General knowledge on bioenergy
    f. Other (please specify)

3. Have you considered the use of tallow as a fuel ? Yes No

    If you answered 'yes' please tick which category you considered.

    Category 1 Category 3 Both

4. If, after consideration, the use of tallow was **rejected**, please choose from the following list the reasons for this decision? Please rate numerically (1-6) in order of importance as many as required.

    Category 1

a. Uncertainty with regard to the application of the Waste Incineration Directive on the future of burning tallow
b. Difficulty in getting approval from the Department of Agriculture for the use of Category 1 tallow
c. The requirement for approval and supervision by the Department of Agriculture complicates the use of this fuel.
d. Difficulty in obtaining a regular supply in sufficient quantities
e. Lack of experience with the use of this fuel could lead to problems with boilers
f. The amount of tallow required for on-site boilers is far greater than what is available on the market and is therefore not a practical consideration

Category 3

a. Uncertainty with regard to the application of the Waste Incineration Directive on the future of burning tallow
b. Difficulty in getting approval from the Department of Agriculture for the use of Category 3 tallow
c. The requirement for approval and supervision by the Department of Agriculture complicates the use of this fuel.
d. Difficulty in obtaining a regular supply in sufficient quantities
e. Category 3 tallow prices are volatile and increased demand due to energy use make future cost difficult to evaluate
f. The price of Category 3 tallow relative to other fuels is not sufficiently low to merit the changeover on fuel price alone

5. If, after consideration, the use of tallow was **accepted**, please choose from the following list the reasons for this decision? Please rate numerically (1-6) in order of importance as many as required.

Please specify which category   Category 1   Category 3   Both

a. Economic fuel
b. Zero carbon rating with regard to emissions
c. Approval and supervision by the Department of Agriculture not considered onerous.
d. Already have Department of Agriculture approval and supervision for other processes
e. Observed successful operation in other plants
f. Other (please specify)

Comments

Thank you for your time in completing this questionnaire. If you have any comments please do so here or on the back of this page.

Appendix 4.1

Figure 4.3.1 **Fuels currently in use in the Food and Drink Industry (Questionnaire, Appendix 4.1)**

Fuels Currently used in the Food and Drink Industry		
Source: Questionnaire	Section: Fuel Usage	Question 2
What type(s) of fuel do you use in your boilers of greater than 1 MW thermal input capacity ? HFO LFO Natural Gas Tallow Wood Other (please specify)		
Fuel Type	**Number of Companies**	**Percentage**
HFO only	6	16.67%
HFO and Tallow	6	16.67%
HFO and Coal	1	2.78%
LFO only	3	8.33%
LFO and LPG	1	2.78%
LFO and tallow	5	13.89%
MFO and LPG	1	2.78%
Natural Gas	9	25.00%
Natural Gas and Gas Oil	1	2.78%
Natural Gas and Tallow	2	5.56%
Tallow only	1	2.78%
Total Respondents	**36**	**100.00%**

Appendix 4.1 continued

Figure 4.3.1 **Fuels currently in use in the Food and Drink Industry (Questionnaire, Appendix 4.1)**

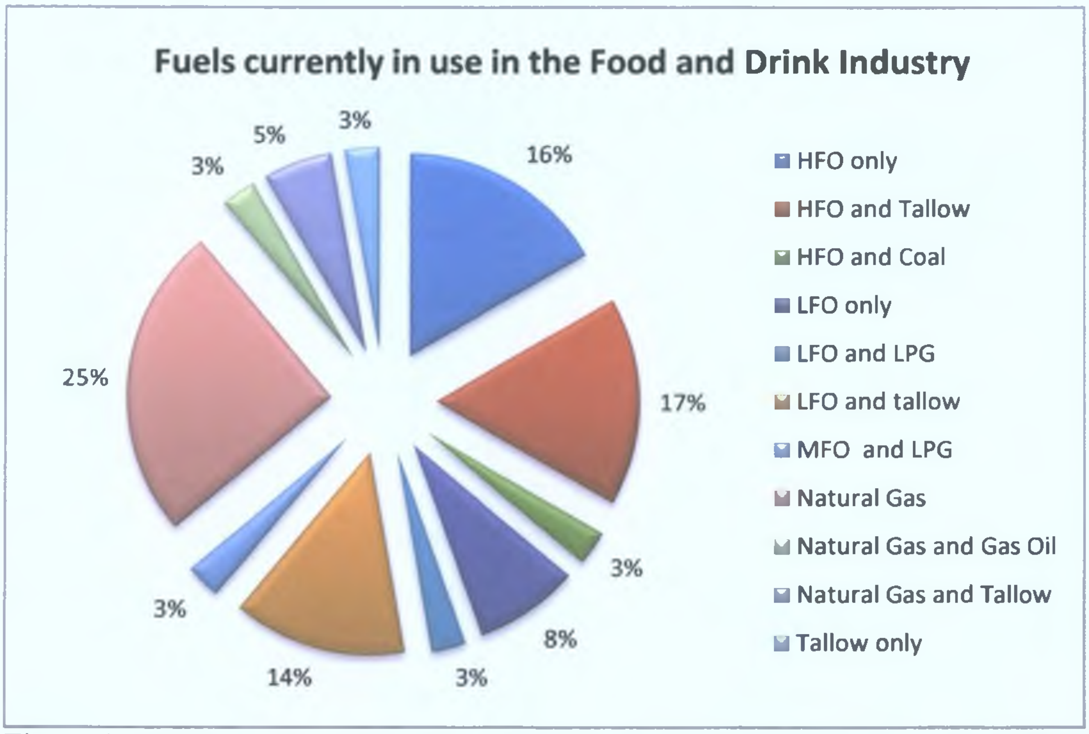


Figure 4.3.1 **Fuels currently in use in the Food and Drink Industry (Appendix 4.1)**

Appendix 4.2

Figure 4.3.3 **Reasons for considering fuel switching (Questionnaire, Appendix 4.2)**

Reasons for Considering Switching Reasons expressed as Percentages			
Source: Questionnaire	Section: Fuel Switching		Question 3
Was this consideration due to a. Increasing Energy Efficiency b. Compliance with GHG emission allocation c. Process Requirements d. Relative Costs of fuels e. Security of supply f. Climate Change g. Other (please specify)			
Reason	**Primary Reason**	**Secondary Reason**	**Third Reason**
Cost alone	21%	0%	0%
Cost	42%	32%	14%
Efficiency	17%	11%	7%
GHG	8%	32%	14%
Security	8%	11%	29%
Process	4%	5%	7%
Climate Change	0%	0%	29%
Improved Emissions	0%	5%	0%
Tallow on site	0%	5%	0%
Total Respondents	100%	100%	100%

Appendix 4.2 continued

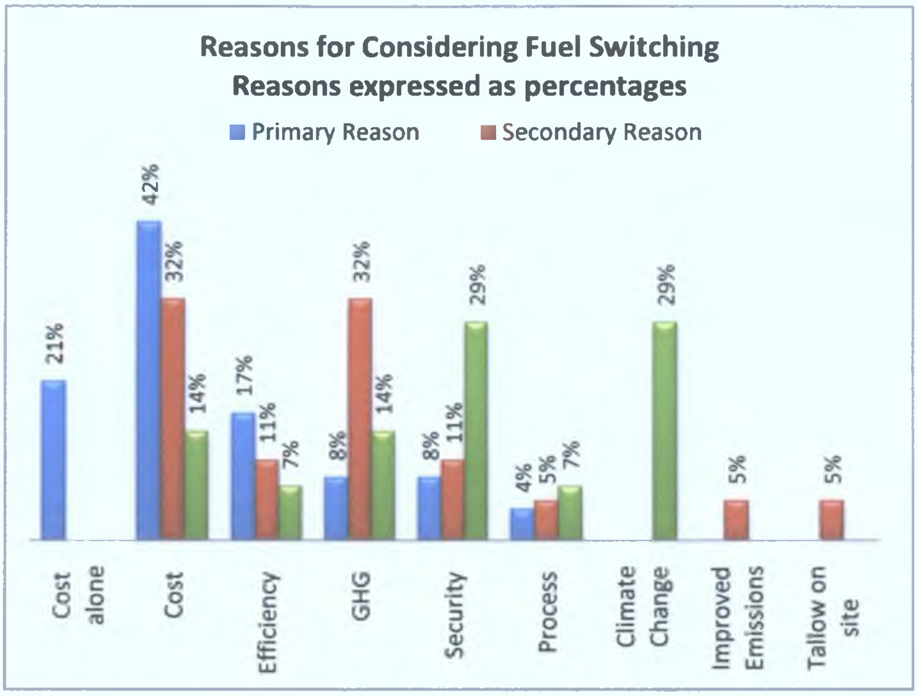
Figure 4.3.3 **Reasons for considering fuel switching.(Questionnaire, Appendix 4.2)**

Raw Data		
Reasons for Considering Switching **Reasons expressed as Percentages**		
Source: Questionnaire	Section: Fuel Switching	Question 3
Was this consideration due to a. Increasing Energy Efficiency b. Compliance with GHG emission allocation c. Process Requirements d. Relative Costs of fuels e. Security of supply f. Climate Change g. Other (please specify)		

	Number of Companies		
Reason	Primary Reason	Secondary Reason	Third Reason
Cost alone	5	0	0
Cost	10	6	2
Efficiency	4	2	1
GHG	2	6	2
Security	2	2	4
Process	1	1	1
Climate Change	0	0	4
Improved Emissions	0	1	0
Tallow on site	0	1	0
Total Respondents	24	19	14
No data	0	5	10
Total Respondents	24	24	24

Appendix 4.2 continued

Figure 4.3.3 **Reasons for considering fuel switching (Questionnaire, Appendix 4.2)**



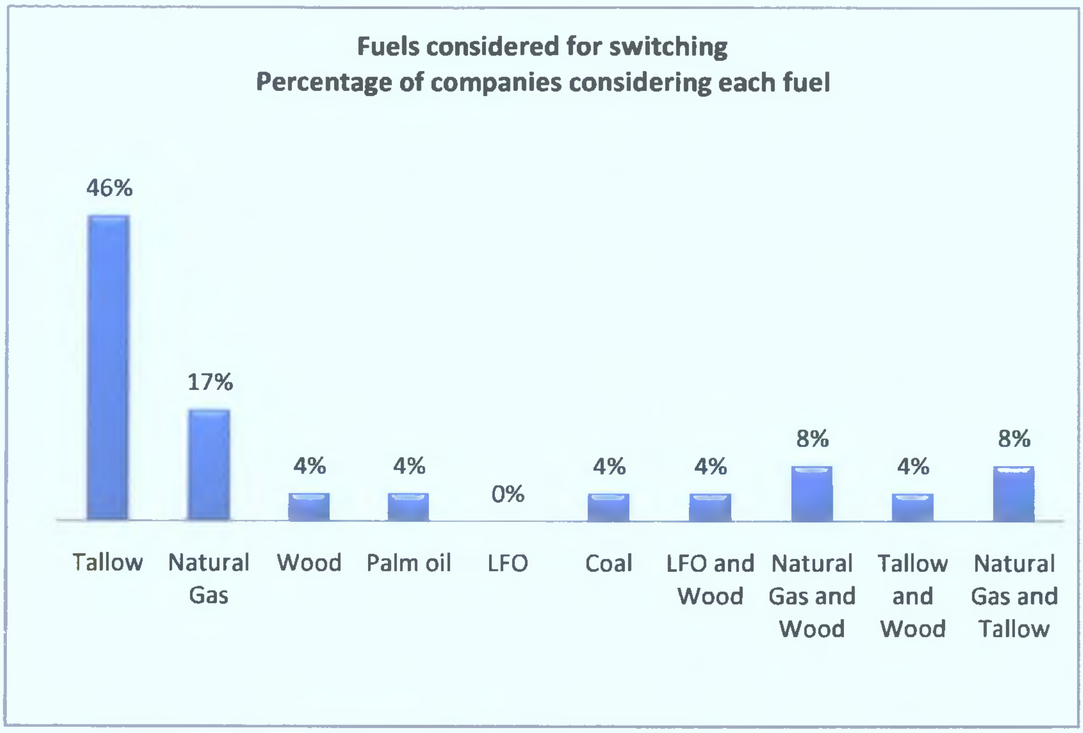
Appendix 4.3

Figure 4.3.4 **Percentage of companies considering each fuel type (Questionnaire, Appendix 4.3)**

Fuels considered for switching Percentage of companies considering each fuel		
Source: Questionnaire	**Section: Fuel Switching**	**Question 2**
Which fuels did you consider switching to HFO LFO Natural Gas Tallow Wood Other (please specify)		
Fuel	**Number of Companies**	**Percentage**
Tallow	11	46%
Natural Gas	4	17%
Wood	1	4%
Palm oil	1	4%
LFO	0	0%
Coal	1	4%
LFO and Wood	1	4%
Natural Gas and Wood	2	8%
Tallow and Wood	1	4%
Natural Gas and Tallow	2	8%
Total Respondents	24	100%

Appendix 4.3 continured

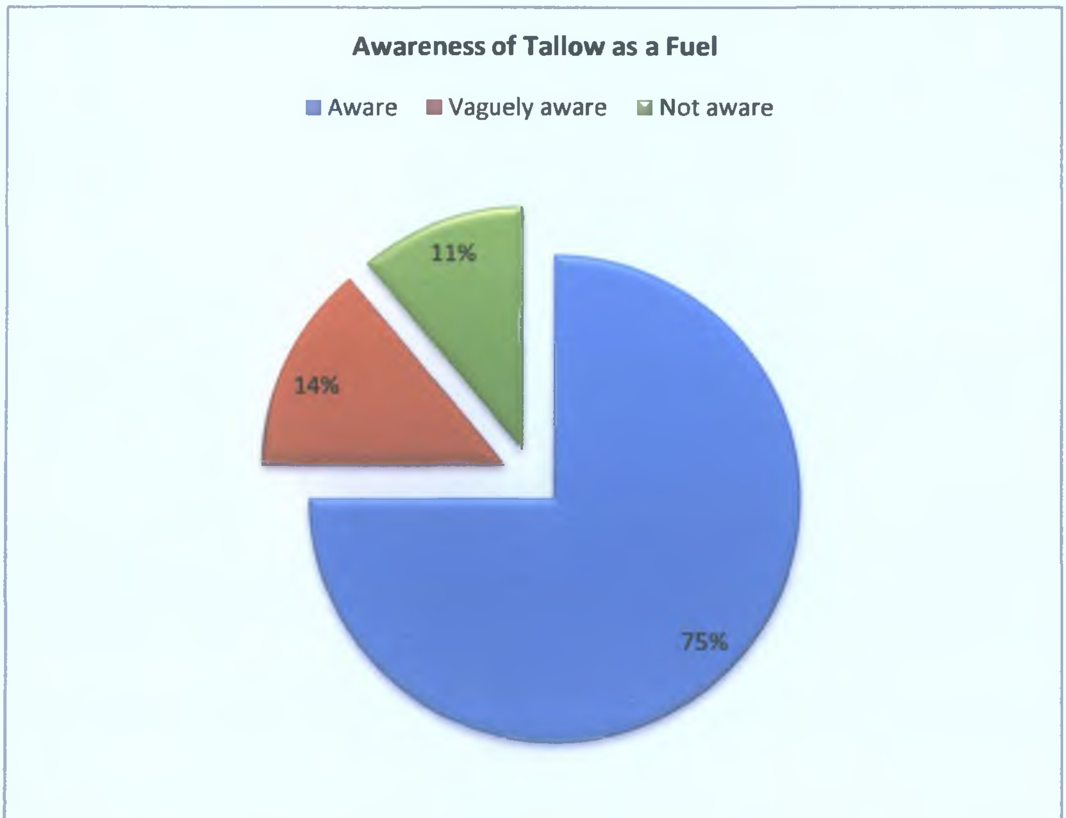
Figure 4.3.4 **Percentage of companies considering each fuel type (Questionnaire, Appendix 4.3)**



Appendix 4.4

Figure 4.3.5 **Awareness of tallow as a thermal fuel under the ABRs (Questionnaire, Appendix 4.4)**

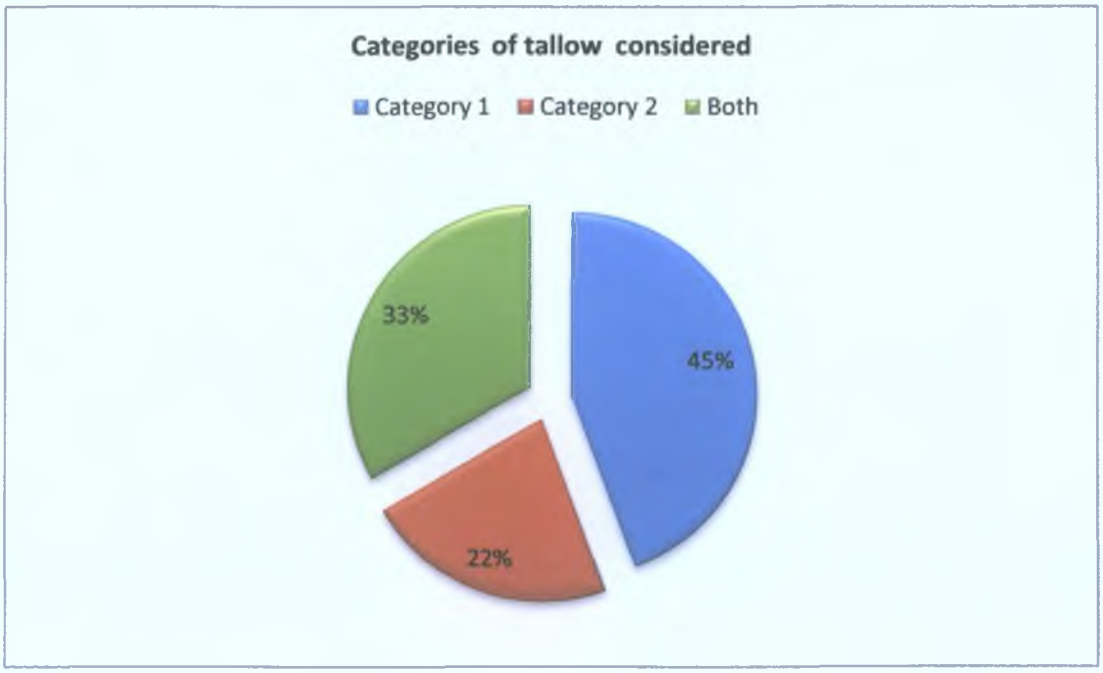
Awareness of Tallow as a fuel		
Source: Questionnaire	**Section: Tallow Usage**	**Question 1**
Are you aware that tallow may be used as a boiler fuel under this amendment of the Animal By-Product Regulations? Aware Vaguely aware Not aware		
Tallow Awareness	**Number of Companies**	**Percentage**
Aware	27	75%
Vaguely aware	5	14%
Not aware	4	11%
Total Respondents	**36**	**100%**



Appendix 4.5

Figure 4.3.6 **Percentage of Category 1, Category 3, or both chosen (Questionnaire, Appendix 4.5)**

Categories of tallow considered		
Source: Questionnaire	**Section: Tallow Usage**	**Question 3**
Have you considered the use of tallow as a fuel ? Yes No If you answered 'yes' please tick which category you considered. Category 1 Category 3 Both		
Choice of Category	Number of Companies	Percentage
Category 1	8	44%
Category 2	4	22%
Both	6	33%
Total Respondents	18	100%



Appendix 4.6

Figure 4.3.7 **Reasons for switching to tallow (Questionnaire, Appendix 4.6)**

Reasons for switching to tallow (Percentage)			
Source: Questionnaire	Section: Tallow Usage		Question 5
If after consideration the use of tallow was accepted, please choose from the following list the reasons for this decision. Please rate numerically in order of importance as required. a. Economic fuel b. Zero carbon rating with regard to emissions c. Approval and supervision by the Department of Agriculture not considered onerous. d. Already have Department of Agriculture approval and supervision for other processes. e. Observed successful operation in other plants. f. Other (please specify)			
Reason	**Primary Reason**	**Secondary Reason**	**Third Reason**
Economic fuel only	16%	0%	0%
Economic fuel	63%	19%	0%
Zero carbon rating	16%	56%	21%
DAFF supervision not onerous	0%	0%	21%
DAFF involved already	0%	6%	29%
Observed other plants	5%	19%	29%
Other	0%	0%	0%
	100%	100%	100%

Appendix 4.6 continued

Figure 4.3.7 **Reasons for switching to tallow (Questionnaire, Appendix 4.6)**

Raw Data Reasons for switching to tallow (Percentage)			
Source: Questionnaire	Section: Tallow Usage		Question 5
If after consideration the use of tallow was accepted, please choose from the following list the reasons for this decision. Please rate numerically in order of importance as required. a. Economic fuel b. Zero carbon rating with regard to emissions c. Approval and supervision by the Department of Agriculture not considered onerous. d. Already have Department of Agriculture approval and supervision for other processes. e. Observed successful operation in other plants. f. Other (please specify)			
	Number of Companies		
Reason	Primary Reason	Secondary Reason	Third Reason
Economic fuel only	3	0	0
Economic fuel	12	3	0
Zero carbon rating	3	9	3
DAFF supervision not onerous	0	0	3
DAFF involved already	0	1	4
Observed other plants	1	3	4
Other	0	0	0
Total Respondents	19	16	14
No data	0	3	5
Total Respondents	19	19	19

Appendix 4.6 continued

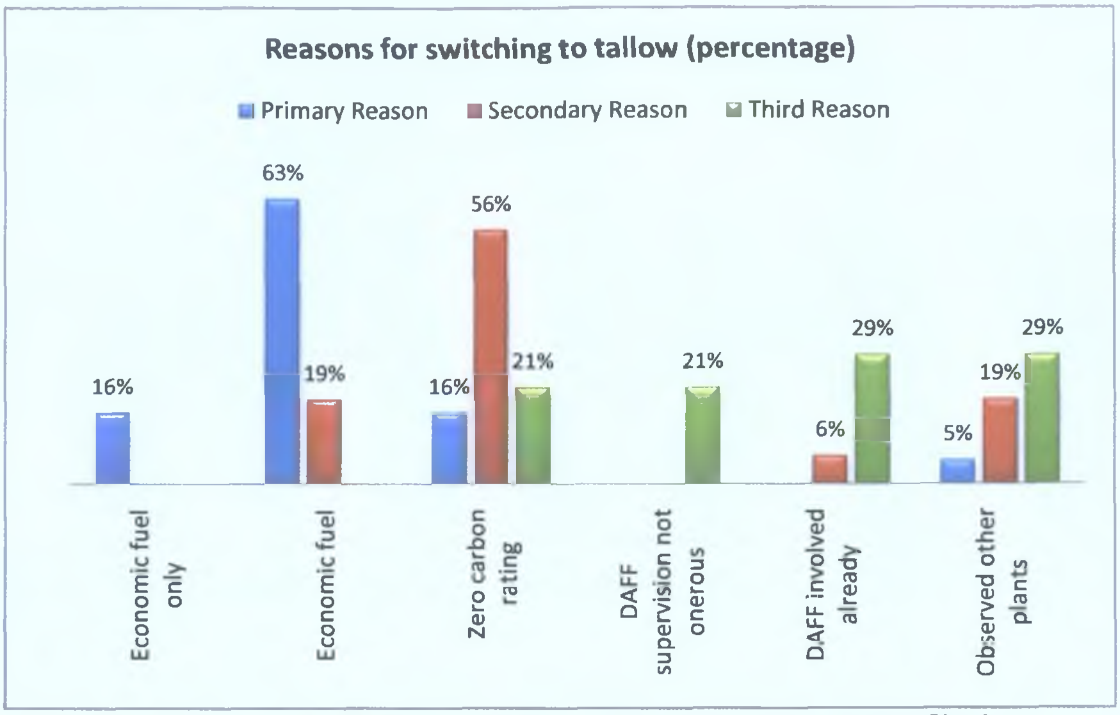


Figure 4.3.7 **Reasons for switching to tallow (Questionnaire, Appendix 4.6**

Appendix 4.7

Figure 4.4.1 **Comparison of delivered cost of industrial fuel in cent/kWh. Data sourced from SEI, 2008 (Appendix 4.7)**

industrial Fuels	Notes	Unit	Average Price Per Unit €	Gross Calorific Value kWh/unit	Delivered Cost cent/kWh	Percentage Change since January 1,2007
Gas Oil	Note 1	Litre	0.831	10.55	7.88	+ 27
Light Fuel Oil	Note 1	Litre	0.734	11.21	6.55	+ 33
Medium Fuel Oil	Note 1	Litre	0.692	11.32	6.11	+ 35.7
Heavy Fuel Oil	Note 1	Litre	0.66	11.45	5.76	+ 38.1
Bulk L.P.G.	3.1 -40 tonnes	Litre	0.579	7.09	8.17	+ 10
Natural Gas	< 73,000 Note 2	kWh	0.0451	1	4.51	Not available
Natural Gas	> 73,000 Note 2	kWh	0.0288	1	2.88	Not available
Wood Chips	Max 35% Moisture Note 3 See Note 3	kg/wet	0.1	3.7	2.68	+ 5.9
Wood Pellets Bulk	See Note 3	kg/wet	0.19	4.8	3.98	+ 0.2

Table 9. Comparison of Industrial Fuel Cost. SEI 1st January 2008

Note 1. Prices used are an average of wholesale schedule prices, exclusive of any rebates that may apply.

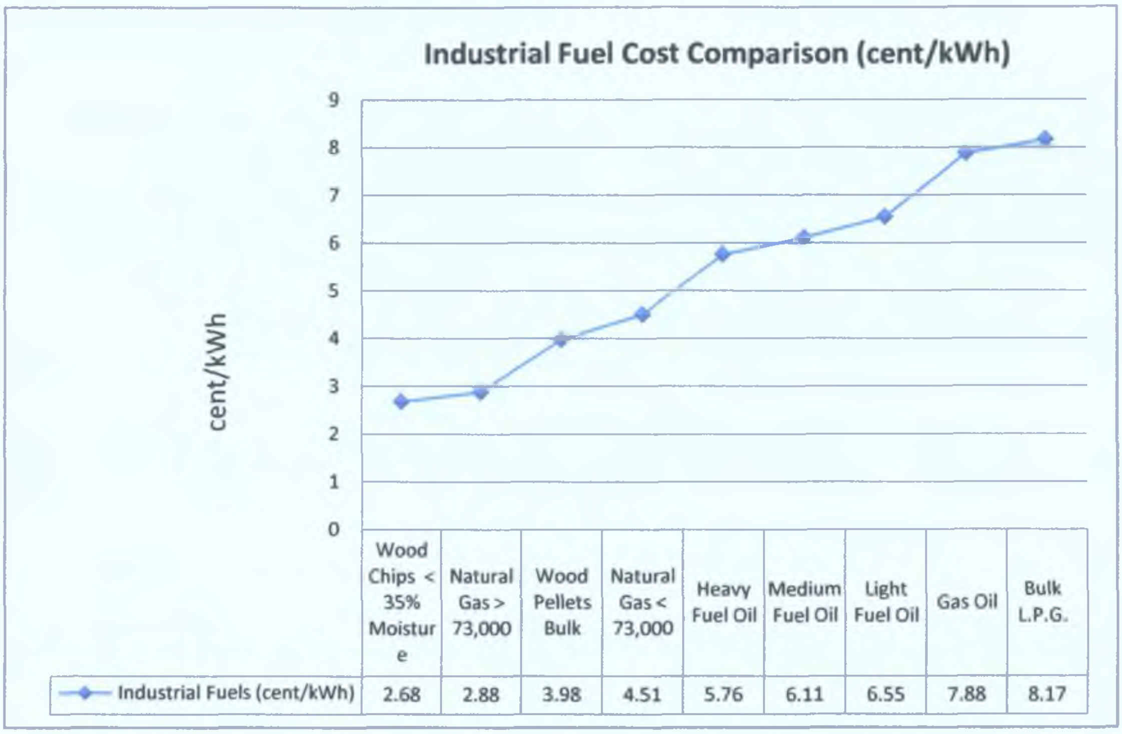
Rebate may reduce fuel cost in the region of 20-25% depending on various market conditions.

Note 2. Includes monthly standing charge assuming > 37,500kWh year.

Note 3. Wood fuel prices may vary considerably from the average, given the fragmented supplier network at present 10 min delivery conditions may apply, discounts may apply for larger quantities.

Appendix 4.7 continued

Figure 4.4.1 **Comparison of delivered cost of industrial fuel in cent/kWh. Data sourced from SEI, 2008 (Appendix 4.7)**



Appendix 4.8

Figure 4.5.1 **Zero carbon rated emissions and carbon emissions from 2001 to 2007 at Slaney Proteins. Source GHG Permit Application Data (Appendix 4.8)**

	Fuel Consumed	NCV	Energy Content	Fuel Factor	CO_2 emitted	Oxidation Factor	CO_2 Tallow
Tallow	tonnes	Tj/t	Tj	tCO2/Tj	tonnes		tonnes
2001	3055.60	0.04	110.00	75.4	8294.12	0.995	8253
2002	2307.92	0.04	83.09	75.4	6264.62	0.995	6233
2003	2160.28	0.04	77.77	75.4	5863.86	0.995	5835
2004	1344.05	0.04	48.39	75.4	3648.29	0.995	3630
2005	1566.38	0.04	57.85	75.4	4362.08	0.995	4340
2006	1557.56	0.04	59.02	75.4	4449.80	0.995	4428
2007	1632.44	0.04	59.60	75.4	4493.86	0.995	4471
Total	13624.22						37190

	Fuel Consumed	NCV	Energy Content	Fuel Factor	CO_2 emitted	Oxidation Factor	CO_2 Oil
Oil	tonnes	Tj/t	Tj	tCO2/Tj	tonnes		tonnes
2001	1107.84	0.04	45.69	76.38	3489.60	0.995	3472
2002	74.88	0.04	3.09	76.38	235.87	0.995	235
2003	124.80	0.04	5.15	76.38	393.11	0.995	391
2004	168.88	0.04	6.96	76.38	531.96	0.995	529
2005	142.16	0.04	5.86	76.38	447.79	0.995	446
2006	56.48	0.04	2.33	76.38	177.91	0.995	177
2007	91.10	0.04	3.76	76.38	286.96	0.995	286
Total	1766.14						5535

Appendix 4.8 continued

Figure 4.5.1 **Zero carbon rated emissions and carbon emissions from 2001 to 2007 at Slaney Proteins. Source GHG Permit Application Data (Appendix 4.8)**