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Carbon/Efficiency Labeling & Bio-Blending for Optimising Benefits of Biodiesel & Additive Use

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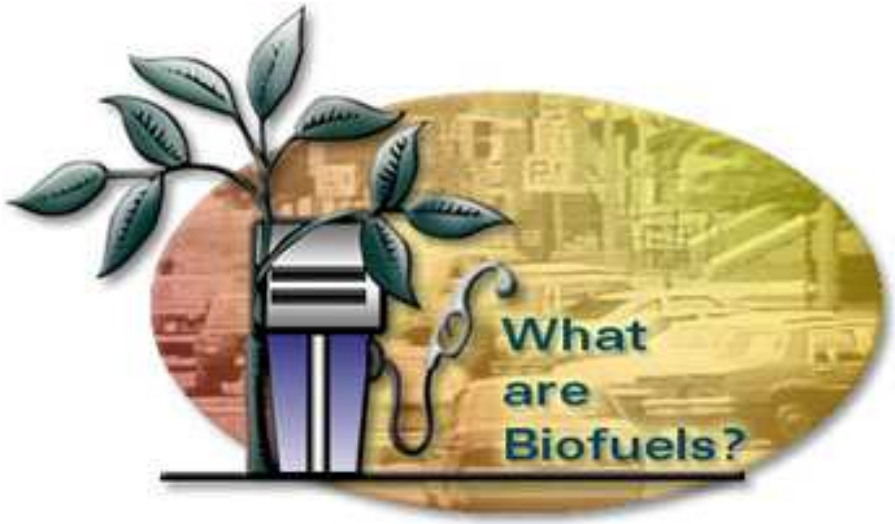
Annex 3-15 Deliverable 13: Biofuels - Informative Brochure (WP6)

Biofuels Informative Brochure



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Carbon/Efficiency Labelling & Bio-Blending for Optimising Benefits of Biodiesel & Additive Use

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This brochure is intended as a guide on the use of biofuels and in particular biodiesel. The Malta Resources Authority does not assume any liability or responsibility for any loss or damage which may occur to any person using the information contained therein.

Contents:

1. Biofuels

1.1 Definition

Biofuel is a generic description given to all type of fuel produced from biomass, that is, material derived from recently living organisms. This is the scientific name given to any plant or animal substance that is combustible, thus releasing off energy which can be then used for a number of purposes, including for producing motion (such as the movement of a piston in an internal combustion engine) and heating liquids (such as water in a boiler).

1.2 Development and interest in biofuels

The development and use of fuels derived from biomass goes back to hundreds of years and their use was mainly for heating and cooking purposes. In the early days of the automobile industry, designers and engineers had considered using liquid biofuels prior to propounding for petroleum derived fuels. In fact, two prominent figures in the development of the automobile industry namely, Nikolaus August Otto and Rudolf Diesel, the inventor of the spark–ignition (petrol) engine and the inventor of the Diesel engine respectively, had both designed their machines to work on biofuels.[1]

When however, abundant supplies of crude oil were discovered and these resources became readily available, petroleum based fuels became inexpensive, and soon were widely used. This resulted in industry and the transport sector relying on petroleum derived fuels, such as petrol and diesel to drive their machines, cars and trucks and interest in biofuels eventually started fading away. Nevertheless, prior to World War II, and during the high demand wartime period, biofuels were valued as a strategic alternative to imported oil.

During the peacetime post Second World War period, inexpensive oil from the Middle East contributed in part to the diminished interest in biofuels. Between 1973 and 1979, general conflict in the Middle East caused the Organization of the Petroleum Exporting Countries (OPEC) to cut exports, and net-oil importing nations experienced a very large decrease in their oil supply. This "energy crisis" resulted in severe shortages, and a sharp

increase in high demand petroleum products, especially petrol and diesel. During this period there was also a renewed interest from governments and academics in energy issues which in turn resulted in an increased awareness in the importance of energy security, the need to diversify the energy mix and renewable energy in general.[2]

In recent years, mainly since 2000 onwards a renewed spike in international oil prices (mainly a result of increased consumption in new emerging economies such as those in Asia and a higher demand-supply ratio of petroleum), concerns over greenhouse gas emissions resulting in global warming and climate change, rural development interests, and instability in the Middle East, renewed interest in biofuels has been observed.

1.3 Benefits of biofuels

Biofuels are usually attributed with two main benefits, namely **environmental** and **security of supply**.

*1.3.1 Environmental benefit*s

The environmental benefit of biofuels relates to the fact that during their production, they are Carbon Dioxide (CO_2) sinks, that is, they absorb carbon dioxide. Over one complete cycle, that is, from vegetable plant cultivation when they absorb CO_2 to combustion when they emit CO_2 the net production of CO_2 is lower for biofuels compared to petroleum fuels which just release CO_2 during their life cycle. Hence, as shown in Figure 1 replacing petroleum fuels with biofuels helps in reducing the release of CO_2 into the atmosphere and therefore reduces the effect on climate change.

Currently, a vigorous debate is ongoing on the actual savings in CO_2 from biofuels and the sustainability of biofuels, given that uncontrolled cultivation of crops used to produce biofuels may lead to de-forestation of natural habitats, especially in territories such as South-East Asia and Brazil. The EU in this regard is proposing that a certification system is put in place to ensure the sustainability of the raw materials used to produce biofuels and that a minimum threshold of greenhouse gas savings is attached to biofuels produced from different raw materials.

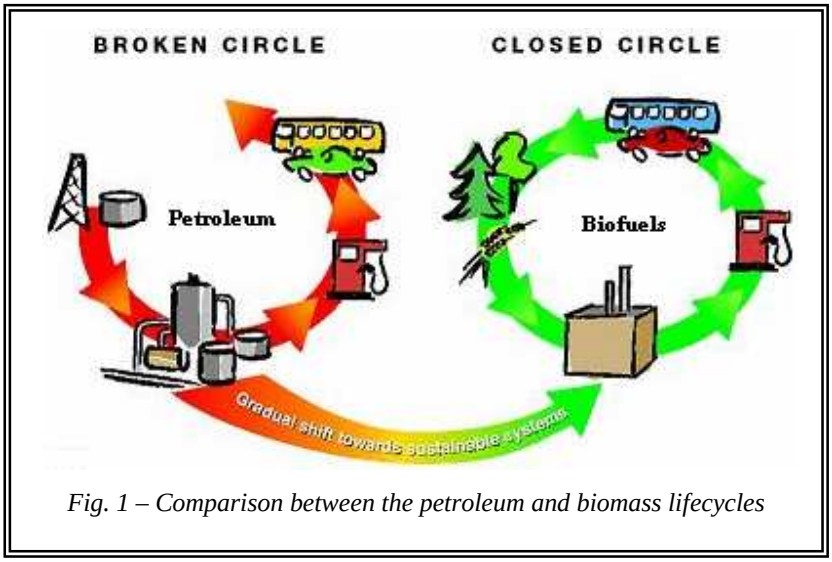

Fig. 1 – Comparison between the petroleum and biomass lifecycles

1.3.2 Security of supply

Relying on just one type of energy source is always dangerous as any disruption in that energy source can create severe repercussions to a country. In countries similar to Malta, which do not have their own indigenous sources of petroleum fuels and which presently rely completely on imported fuels for their energy needs, diversification of the fuel-mix would go a long way in enhancing security of supply and reducing the risks which are associated with the volatile energy market.

1.4 Types of biofuels

Biofuels can range from solid, liquid and gaseous products, and their application is as varied as that of the petroleum products they replace. Biofuels can be used in almost all applications where petroleum products are used. Only in the aviation industry is their used still very limited, almost inexistent, however recent studies and experimental flights might in the future lead to a breakthrough and a wider use similar to that experienced in the road transport sector. The following is a list of the main biofuels available and a brief description of their use.

1.4.1 Solid biofuels

Examples of solid biofuels are probably the most common to understand as their use has

been present for as long as man has discovered fire. The main examples are **wood** and **charcoal** which are used for everyday use in heating and cooking. Figures 2a and 2b show typical examples of solid biofuels.

Fig. 2a – Charcoal being used in a BBQ

Fig. 2b – Wood being used in a fireplace

1.4.2 Liquid biofuels

The two most common types of liquid biofuels are **biodiesel** and **bioethanol** which are respectively additive/substitutes for petroleum diesel and petrol respectively. Below follows a short description on each.

1.4.2.1 Biodiesel

Biodiesel is the everyday name given to *Fatty Acid Methyl Ester* (FAME), the most commonly used biofuel in Europe. It is produced from oils or fats and is a liquid similar in composition to petroleum diesel. Its production is quite straight forward and consists of mixing oils with sodium hydroxide and methanol. The resulting chemical process produces biodiesel (FAME) and glycerol. A vast range of raw materials, including soybean oil, palm oil, rape-seed oil, waste cooking oil and animal fats can be used as the base material for the production of biodiesel. In the United States, the favoured raw material is soybean oil. This type of raw material alone accounts for about ninety percent of all biofuel stocks in the United States. In Europe the favoured raw material is rape-seed oil.

1.4.2.2 Bioethanol

Ethanol fuel is basically an alcohol fuel produced by the use of enzymes and micro organisms through the process of fermentation of starches and sugar. It can be used as a fuel, mainly as a biofuel alternative to petrol, and is widely used in cars in Brazil, where sugar cane is used as the base material. Ethanol with less than 1% water called **anhydrous ethanol** can be blended with petrol in varying quantities. Currently, all spark-ignited petrol engines can operate with mixtures of up to 5% bioethanol (E5), however certain engine manufacturers do not discourage and actually suggest higher blends of bioethanol to be used.

1.4.3 Gaseous biofuels

Biogas is a renewable fuel, which is produced by the breaking down of organic matter by a process of microbiological activity. Basically this means that rotting municipal waste, food waste or sewage (both human and animal) is turned into gas by means of 'anaerobic conversion' in a digester.[3] Biogas contains methane, which in itself is a fuel and can be recovered from industrial anaerobic digesters, mechanical biological treatment systems and engineered landfills. In engineered landfills, the collected landfill gas can be used to produce electricity and heat as can be shown in the Figure 3 below.

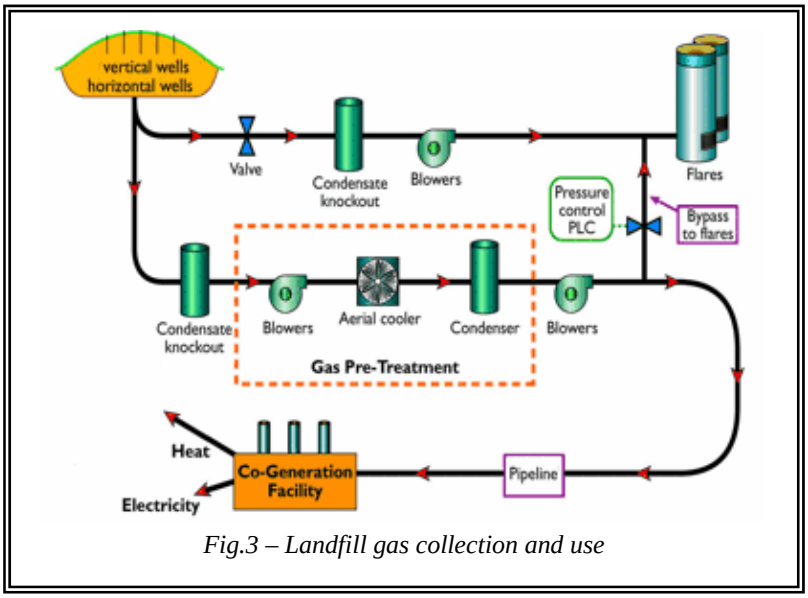

Fig.3 – Landfill gas collection and use

2. Biodiesel

2.1. Production methods

As already described, **biodiesel** is a non-petroleum derived diesel fuel having properties very similar to mineral diesel and is chemically known as fatty acid methyl. It is produced by a process called transesterification.[4] In this process vegetable oils or animal fats are reacted with sodium or potassium hydroxide with methanol as a process catalyst. Figure 4 below shows the different stages in the process leading to the production of biodiesel.

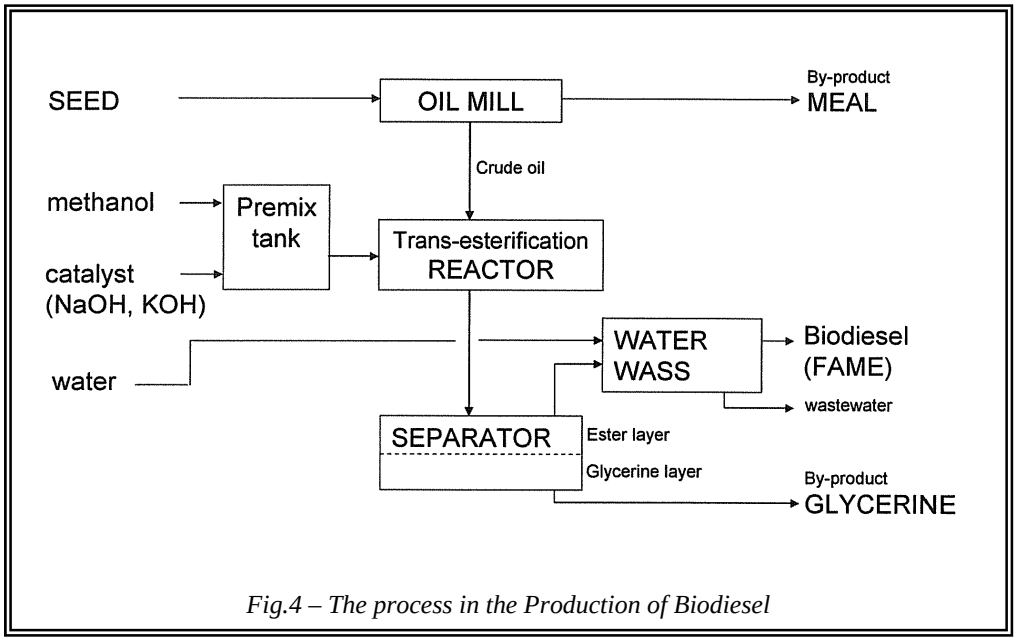

Fig.4 – The process in the Production of Biodiesel

2.2 Characteristics

In its pure form biodiesel is a liquid which can vary in color from golden to dark brown depending on the production feedstock. It is **immiscible with water, has a high boiling point and low vapor pressure**. Typical methyl ester biodiesel has a **flash point** of approximately **150 °C** and its **density** is about **0.88 g/cm^3**.[5]

2.3 Comparison between biodiesel and petroleum diesel

European Standards EN 590[6] and EN 14214[7] set the minimum quality parameters which diesel and Fatty Acid Methyl Ester (Biodiesel) must have in order to be placed on the

market. Currently, EN 590 limits the amount of biodiesel which can be placed in diesel to **5% by volume**. In this regard, Table 1 compares a number of properties of biodiesel (FAME) with those of petroleum derived diesel. Apart from the energy content, all parameters are extracted from the relevant standards specifying the properties of biodiesel and petroleum diesel.

Property	Unit	Petroleum Diesel		Biodiesel	
		lower limit	upper limit	lower limit	upper limit
Cetane number		51,0	-	51,0	-
Density at 15°C	kg/m³	820	845	860	900
Sulphur content	mg/kg	-	50,0 (and 10,0 as from the 01-01-2009)		10
Flash point	°C	Above 55	-	> 101	-
Ash content	% (m/m)	-	0,01		0.02
Water content	mg/kg	-	200	-	500
Typical energy content by volume[8] (calorific value)	MJ/litre	35.7		32.8	
Total contamination	mg/kg	-	24	-	24
Copper strip corrosion (3 hours at 50 °C)	rating	Class 1		Class 1	
Viscosity at 40 °C	mm^2/s	2,00	4,50	3,5	5,0

Table 1 – Comparison between biodiesel and petroleum derived diesel

Compared to petroleum diesel which has a calorific value of 35.7 MJ/litre, biodiesel has a lower **calorific value of 32.8 MJ/litre**. This difference would in theory bring about less-efficient fuel consumption however, the better lubricity of biodiesel and more complete combustion partially compensates this and therefore in practice and especially at low concentrations **engine performance is not affected**. [9]

In regard to engines, biodiesel has better lubricating properties than petroleum diesel. The reason being that due to the desulphurisation process which the petroleum diesel is subjected to in order to comply with the low sulphur dioxide engine emission limits set

by modern standards, the lubricity is reduced. In fact, certain diesel brands add biodiesel as an additive in order to reduce wear, thus increasing the life of the fuel injection equipment and fuel injectors that rely on the fuel for their lubrication.

2.4 Applications

2.4.1 Use in diesel engines

Biodiesel can be blended with petroleum diesel at different concentrations. The concentration which may best suit a particular type of engine is usually recommended by the car engine manufacturer. Currently, all diesel engines can operate with mixtures of up to 5% biodiesel (B5), however certain engine manufacturers do not discourage and actually suggest higher blends of biodiesel to be used, even up to pure biodiesel (B100), always however provided that this biodiesel complies with the relevant standard for biodiesel.

2.4.2 Use in aviation

Aircraft manufacturers are understandably even more cautious, and only very recently was the first test flight using biofuel conducted. In fact, the world's first biofuel-powered commercial aircraft, a Virgin Atlantic jumbo jet took off from London's Heathrow Airport on the 24th of February 2008 and touched down in Amsterdam on a demonstration flight partially using a fuel derived from a mixture of Brazilian nuts and coconuts. [10]

2.4.3 Use as a heating oil

Biodiesel can be used as a heating fuel in domestic and commercial boilers, with little or no changes to the existing boiler being required.[11]

2.5 Precautions when using biodiesel

Biodiesel is basically comparable to petroleum diesel, thanks to its chemical similarity to the petroleum fuel. Despite this, biodiesel possesses certain features which may necessitate specific requirements when used in a diesel engine.

The following are the main and most common requirements:

- Biodiesel poses different material-related requirements compared with petroleum diesel. All parts coming into contact with biodiesel, for example hoses and seals, must be resistant to biodiesel. In particular biodiesel will degrade natural rubber gaskets and hoses in vehicles (mostly found in vehicles manufactured before 1992), although these tend to wear out naturally and most likely will have already been replaced with fluorinated elastomers, which is non-reactive to biodiesel.

- Biodiesel is very hard to evaporate; therefore, it can accumulate in engine oil especially during idling operation by commercial vehicles. Consequently, all manufacturers of commercial vehicles prescribe shorter oil-change intervals in order to avoid damage by diluted engine oil.

- After extended periods of running on pure petroleum diesel, vehicles converted to biodiesel should undergo a one-time fuel filter replacement after 2-3 tankfuls of biodiesel outside the regular service intervals. This prevents old depositions of petroleum diesel removed by the flow of bio-diesel through the fuel system from blocking the new fuel filter. [12]

Similarly to diesel engines older furnaces may contain rubber parts that would be affected by the biodiesel solvent properties. Nevertheless, old furnaces can burn biodiesel without any conversion required. However initially, varnishes left behind by the petroleum diesel may be released when biodiesel is first used and this can clog the fuel filtering system. Filter replacement is therefore highly recommended. An alternative approach is to initially start using petroleum diesel-biodiesel blends having high petroleum ratios, and decreasing the petroleum portion over time to allow the varnishes to come off more gradually and be less likely to clog. Generally, however thanks to the strong solvent properties of biodiesel, the furnace is cleaned out and becomes more efficient.[13]

2.6 Labelling of biodiesel[14]

Much of the world uses a system known as the **"B" factor** to state the amount of biodiesel in any fuel mix. Biodiesel can be mixed with petroleum diesel in any percentage, from 1 to 99, which is represented by a number following the letter B. For example, B5 is 5 percent biodiesel with 95 percent petroleum, B20 is 20 percent biodiesel with 80 percent petroleum, or B100 is 100 percent biodiesel, with no petroleum diesel added. Figure 5 shows the labelling on a pump selling biofuels.

Fig.5 - Labelling on a pump selling Biofuels

3. Biodiesel in Malta

3.1 Biodiesel in the Maltese market and current production levels

Given the scarce arable land available in Malta and the limited amount of fresh water resources, cultivation of crops for biofuel production is not a feasible or sustainable option. Currently, biodiesel produced from either locally sourced recycled waste cooking oil or imported vegetable oil is the only source of indigenously produced biofuel, and in this regard privately owned companies in Malta have been very active in producing and promoting biodiesel for domestic consumption.[15]

Although still marginal to the overall consumption of transport fuels, the production and consumption level of biodiesel in Malta has been on the increase ever since its introduction in 2003 as can be testified in the chart below (Chart No. 1)

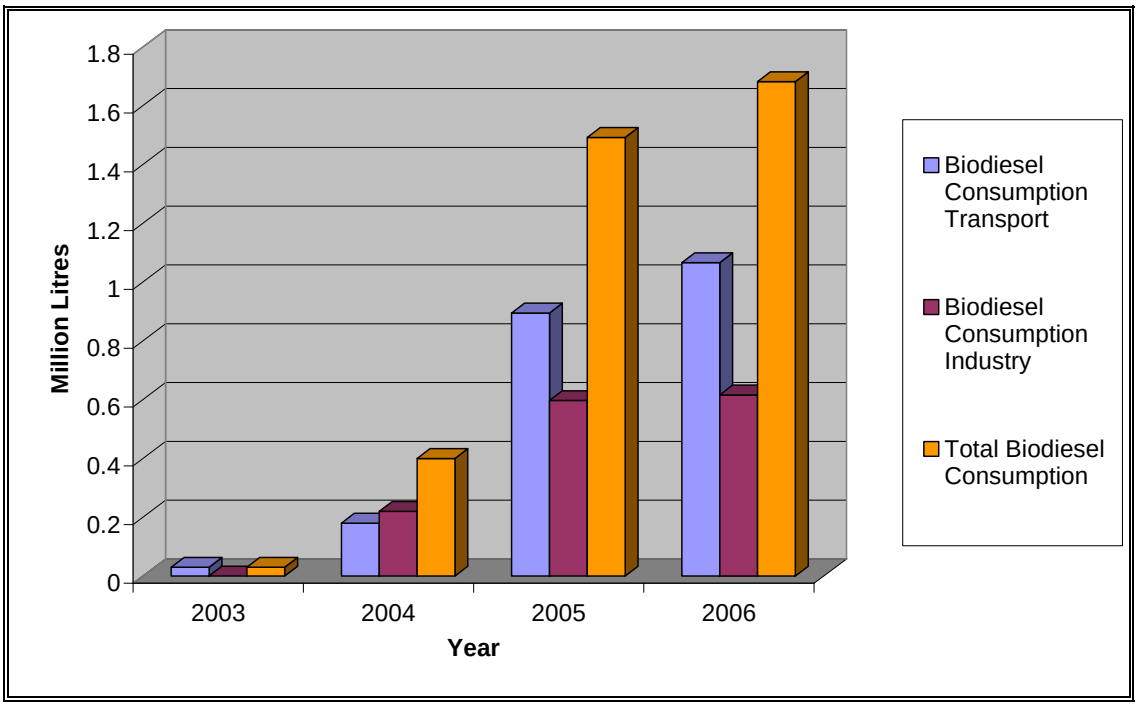

Chart No. 1 – Consumption of biodiesel in Malta between 2003 and 2006

As can be seen the use of biodiesel, particularly in the transport sector has experienced a marked increase, which may be mainly attributed to increased awareness being given to biofuels and increased consumer confidence. Moreover, the fact that biodiesel is now available in almost 40% of the filling stations augurs well for an even larger production and consumption by the public.

3.2 Biodiesel tax exemption

In order to promote biofuels individual countries can opt on different financing mechanism. In general however, the following are the favoured mechanisms:

- *Fiscal Incentives,* where a Country decides partially or fully exempt biofuels from the payment on the excise duty normally paid for transport fuels.

- *National Grants,* where a Country decides to give grants for the cultivation of energy crops

- *Substitution obligation,* where a Country may decide that all petroleum market operators who place petrol and diesel on the market for the first time or import these fuels into the country are obliged to market a percentage of biofuels determined by legislation.

Malta opted for the former mode of promotion and in fact currently the biomass content (i.e. the percentage element) in biodiesel is exempted from the payment of excise duty. This makes biodiesel currently cheaper than petroleum diesel retailed in filling stations and therefore a fiscal incentive provides one of the driving forces for the biodiesel sales.

3.3 Biofuel targets for Malta and the EU

Currently, the only piece of legislation regulating the use of biofuels in Malta is an EU **Directive 2003/30/EC** on the promotion of the use of biofuels and other renewable fuels for transport, transposed in Malta by means of Legal Notice 528 of 2004. This legislation

requires Malta, together with the other EU member states to set targets for a percentage of the fuel, based on the total energy content of petrol and diesel used in the transport sector to originate from biofuels. When compared to the results achieved by other countries Malta has had commendable results also in view of the fact that in 2005 as shown in Chart No. 2, Malta ranked 6th for biofuel share in the transport sector amongst the EU member states.

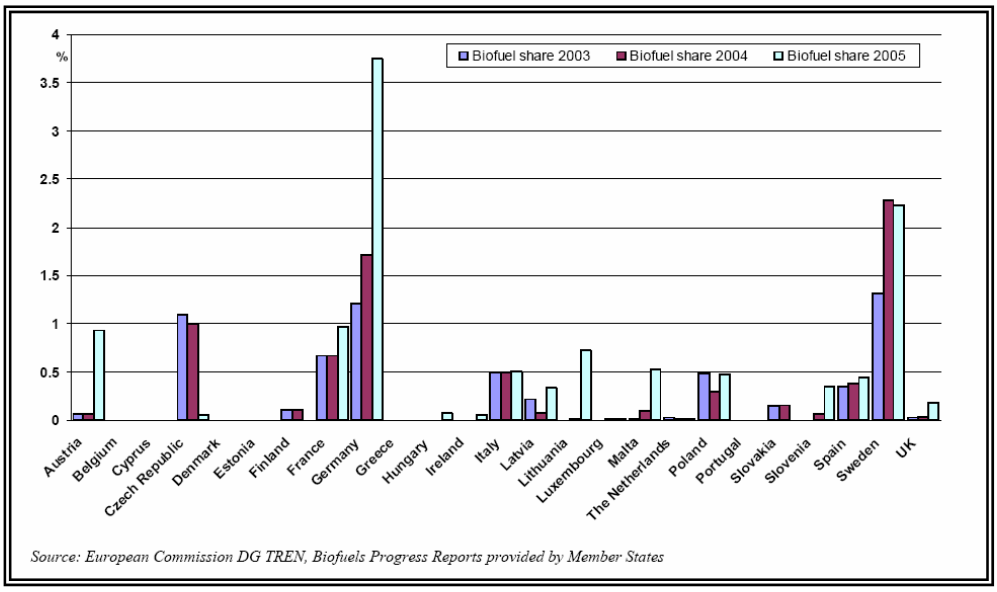

Chart No. 2 – Biofuel share of the EU Member states. Percentage is based on the biofuel share of the EU member states consumption of petrol and diesel consumption based on energy content

The Directive also sets an indicative reference target of 5.75%, calculated on the basis of energy content, of all petrol and diesel placed on the national market for transport purposes by 31 December, 2010. In this regard Malta has indicated that given the scarcity of arable land and water resources for the production of energy crops used in biofuels production and the existing current conditions the national indicative target for Malta for 2010 is set to 1.25%.[16]

In January 2008 the EU, following the Presidency Conclusions of the Brussels European Council held in March 2007, where the EU had endorsed a 10% binding minimum target

to be achieved by all Member States for the share of biofuels in overall EU transport petrol and diesel consumption by 2020, the Council of the European Union issued a *Proposal for a Directive of the European Parliament and of the Council on the promotion of the use of energy from renewable sources proposal* where it proposed that each Member State should ensure that the share of energy from renewable sources in transport in 2020 is at least 10% of the final consumption of energy in transport in that Member State.

3.4 Availability of biodiesel in Malta

Biodiesel in Malta is retailed either directly from the manufacturers or from a number of petroleum filling stations which retail B100 biodiesel from their pumps. Around 30 petroleum filling stations, equivalent to about 40% of total petroleum filling stations, retail biodiesel.

The following is the full list[17] of petroleum filling stations in Malta retailing biodiesel:

Name of Filling Station	Street Name	Locality
Carmelo Saliba Petrol Station	Main Street c/w St. Sebastian Str	Qormi
St. Joseph Home Service Station	High Street	St. Venera
John Vella & Co. Ltd.	Louis Wettinger Street	Mellieha
Mario Service Station	Zurrieq Road	Safi
Mike Service Station	Main Street	Qormi
Nica Ltd.	Ghajndwieli Road	Paola
Manoel Island Service Station Ltd.	The Strand	Gzira
Pacens C&V	Saqqajja Square	Rabat
Carlo Cini Service Station	Aldo Moro Street	Marsa
F. & A. Magri	Airport Road	Luqa

J.A. Borg & Sons P/S	Mgarr Road	Victoria (Gozo)
Kappara Service Station	Triq Mikiel Anton Vassalli	Gzira
Cassar Service Station	25th November Avenue	Zejtun
St. Rita Service Station	Tarxien By-Pass	Tarxien
Lourdes Service Station	Hompesch Road	Zabbar
Auto Valley Service Station	Valley Road	B'Kara
J.C.C. Ent. Ltd. Service Station	B'Bugia Road	Bir-id-Deheb
JAV Service Station	244, Mdina Road	Qormi
Santa Marija Service Station	Main Street	Mellieha
G. Camilleri Service Station	Valletta Road	Zurrieq
Regional Service Station	Regional Road	Msida
Wembley Service Station	St. Andrews Road	St. Andrews
Falzon Service Station Ltd.	Naxxar Road	B'Kara
G. Darmanin Service Station	Valletta Road	Luqa
Sambro Petrol Station	Eucharistic Congress Rd.	Mosta
MIA Petrol Station	Aviation Avenue	Luqa
Pit Stop Service Station	Mdina Road	Attard
VC Service Station	Naxxar Road	Gharghur
Valletta Service Station Ltd.	City Gate Bus Terminus	Valletta

4. Glossary of terms

Calorific Value means the amount of heat released by combusting a specified quantity (initially at 25 °C or another reference state) and returning the temperature of the combustion products to 150 °C.

Cetane Number means a measurement of the combustion quality of diesel fuel during compression ignition.

Flash Point means the lowest temperature at which a liquid will form an ignitable mixture in air.

Glycerol is a colorless, odorless, viscous liquid widely used in pharmaceutical formulations.

Methanol is a chemical compound with chemical formula CH_3OH known as methyl alcohol, wood alcohol, wood naphtha or wood spirits.

MJ/litre means million joules per litre.

Sodium Hydroxide is a caustic metallic base known as caustic soda.

Viscosity is a measure of the resistance to deformation of a liquid.

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