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XP/CRO/03/022
CROATIA

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COUNTRYWIDE FEASIBILITY STUDY FOR A POTENTIAL CROATIAN BIODIESEL INDUSTRY

Final Technical Report

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PREFACE

Croatia is a country in transition in South-East Europe and a candidate country for joining the enlarged European Union. The country experienced a period of significant growth of the economy from the mid 1990's, though it suffered a mild recession in 1998-1999. Revival started from the beginning of 2000 reaching the peak in 2002 with 5,2% growth rate with tourism, banking, and public investments leading the way. Estimated growth rate for 2005 is 3,5%. In 2004, CPI inflation amounted 2,7% and, according to ILO Survey, the unemployment rate was 13,8%. The main challenges facing the country over the medium-term are structural reforms of the state administration and judiciary, the return of refugees and displaced persons, the restructuring of the economy, the full integration of ethnic minorities into society, the adoption of obligations arising from the Stabilisation and Association Agreement with the EU.

Croatia has an economy based on various services and some, mostly light industry. Tourism is a notable source of income. The Gross Domestic Product per capita in purchasing power parity terms for 2004 was USD 11.200 with following composition: agriculture 8,2%, industry 30,1% and services 61,7%. Croatia has an area of 56.538 km^2 and a population of 4,4 million (Census 2001), out of which 45,7% live in rural areas, which are less developed than the urban ones comparing to the EU standards. Among the rural areas a polarization can be seen, with the villages closer to urban industrial centres being far more developed than peripheral areas.

Family farming is the main form of agricultural production. Farms with an average size of 2,8 ha are holding two-thirds of total agricultural land. Because the average farm size is small, there is a strong tendency for farmers to earn their income from more than one source. Approximately 34% of all the private farm owners work off the farm and only periodically on the farm with the family members. The socioeconomic and political status of farmers is low. In addition, there are many farmers' interest groups in Croatia, but they do not yet have synchronised activities or strong impact.

The national strategy of the Government of Croatia recommends the adoption of an integrated approach to development covering different sectors: agriculture, energy, environment, tourism, etc. In the frame of this integrated approach and as part of the BIOEN national energy programme, the efforts to introduce biodiesel production into the Republic of Croatia have started in the year 2000. The objective of introducing biodiesel industry is to reduce Croatian energy dependency, comply with the relevant EC Biofuels Directive, help improve the quality of the environment and diversify production and employment in agriculture and industry. The cultivation of energy/non food crops to produce biofuels should be an area of particular interest under Croatian agricultural policy for creating new economic resources and preserving employment in the rural communities. The production and use of biodiesel to replace fossil fuels in transport also contribute to meeting signed commitment and targets resulting from the Kyoto Protocol to reduce green gas emission, in addition to enhancing the tourism industry by emphasizing environmentally conscious approach.

The Government of Croatia has requested UNIDO to finance and provide technical assistance to achieve the aforementioned objectives. In the frame of a preparatory assistance project phase, UNIDO evaluated the overall feasibility of introducing biodiesel industry in Croatia, provided information and knowledge to enable taking informative decision on the appropriate production chain and economic model to adopt in function of available feedstock, market segments, distribution channels, promotional policies and financial mechanisms, and recommended guidelines for regulatory measures to be put in place to promote biodiesel production and market development.

This report summarizes the work done and results obtained within the frame of UNIDO technical assistance project XP/CRO/03/022 to the Government of Croatia.

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EXECUTIVE SUMMARY

The report summarised the work carried out as a part of technical assistance from UNIDO to the Government of Croatia in order to support efforts in establishing biodiesel industry in Croatia. This should lead to reduction of Croatian energy dependency and help improve the quality of the environment and diversify production and employment in agriculture and industry. The production and use of biodiesel to replace fossil fuels in transport also contribute to meeting signed commitment and targets resulting from EU Biofuels and other Directives and Kyoto Protocol.

The intention of the report is to provide information and knowledge to enable taking decisions on the appropriate production chain and economic model to adopt in function of available and potential feedstock, market segments, distribution channels, promotional policies and financial mechanisms, and to provide guidelines for regulatory measures to be put in place to promote biodiesel production and market development.

Biodiesel and its blends represents an excellent substitute of mineral diesel which offers a variety of benefits, increased employment, development of rural areas, increased security of energy supply and a better overall trade balance. However, biodiesel is still not cost competitive with mineral diesel without subsidies or tax incentives except in cases where petroleum prices are high in the extreme and vegetable oil prices are low.

Feedstock cost is main factor affecting the competitiveness and profitability of biodiesel production.. The current and potential feedstock,in terms of both availability and price, are identified and quantified, as well as, the factors that may impact the identified feedstock use for biodiesel. Consequently, the importance of the Government intervention with appropriate measures was highlighted in order to encourage the production of rapeseed and other oilseed for non-food purpose. The measures will have to ensure, at least, the quantities of feedstock required for the planned production of biodiesel, increase the yield of rapeseed per hectare and regulate market channels for produced rapeseed and include financial incentives and continuous education and expert support for farmers as the most important components.

To decrease the unit production costs it is necessary to use a lower cost feedstock and or to increase the economic performance of production by carefully choosing the location of biodiesel processing plant. The use of waste edible oils as possible complimentary source or imports of cheap vegetable oils from the global market represent an interesting option especially in the initial phase of biodiesel production in Croatia. The selection of biodiesel production location in a harbour for example would provide cheaper access for transportation of feedstock and biodiesel products.

The selection of appropriate process technology and plant production capacity is considered important factors influencing the financial and economic performance of the whole production operation. The selection should take into consideration a variety of factors including feedstock availability and quality, ability to process multi

feedstock, as well as, available market, investor intentions and plans, etc. There are numerous technologies available on the market today. However, the increasing requirements for producing high quality biodiesel according to strict fuel standards has been the driving force for switching to technologies with accurate cleaning steps for the final biodiesel which usually implies large scale production capacity. The results of the financial analysis undertaken show that the larger the scale of production the better the results in terms of all financial and economic indicators.

Having in mind the goal of establishing a sustainable biodiesel production in Croatia and considering present higher costs of production compared to mineral diesel, it is necessary to develop and put in place a stable mechanism of financial incentives.. This would include de-taxation, and, therefore, would result in a direct loss of Government revenue. However, the undertaken input-output analysis of the rapeseed biodiesel production chain has indicated that biodiesel production will contribute directly and indirectly to additional Government revenue, which would compensate for the loss in tax revenues.

Due to its nature, biodiesel production and utilisation involve various sectors, interest groups and market players and like other renewable energy sources, biodiesel needs to be put in the right context and dealt carefully by integrating its socio-economic and environmental added values into the economic model.

1 INTRODUCTION

Croatia is a country with poor fossil fuel resources. Around two third of the consumption has to be imported. Of these petroleum products needs, diesel fuel consumption for the transport sector has increased to around 1,1 million tons during 2004 and more growth is expected in the future.

Like most transition economies, Croatia, has gone through severe changes in the labour market since the 1990s. The unemployment rate in Croatia ranges between 15 to 35% depending on the region. The policies designed to reduce unemployment in Croatia have concentrated so far on the average level in the country, however often a regional/county approach would be more suitable to deal with the specific situation in each region.

The production of biodiesel is seen by the Government of Croatia as one of the promising options to provide an integrated solution to energy, environmental and socio-economic concerns. Biodiesel production was part of the National Energy Programme BIOEN launched by the Croatian Government in February 1997. The objective of the BIOEN programme was that, at least, 15% of Croatia´s energy needs will be derived from biomass and waste by 2030. To this end, a biodiesel production feasibility study has been undertaken and was presented to Ministry of Agriculture and Forestry in 2001. The next steps in the biodiesel implementation should be the adoption of necessary legislation including standards and taxation exemption, forming a clear national targets and strategy and the construction of a demonstration plant, which is expected to provide useful information on the basic part of the production chain (rapeseed, oil and biodiesel), storage and use of biodiesel especially, in relation to economic models.

The Republic of Croatia became a party to the United Nations Framework Convention on Climate Change (UNFCCC) in 1996. Under the Article 22 of the Convention, Croatia undertaken the commitments outlined in Annex I, to maintain its greenhouse gas emissions at 1990 level. In March 1999, Croatia signed the Kyoto Protocol, which globally entered into force on February 16, 2005. Upon its ratification by the Croatian Parliament, Croatia will commit to reduce its emissions of greenhouse gases by 5 percent in relation to the base year, over the commitment period from 2008 to 2012. Considering the very low initial level of emissions in 1990, the Kyoto target will be an extremely difficult task for Croatia. In 1990, Croatia had almost the lowest emission of CO_2 per capita in Europe (4.8 t CO_2 per capita), half the west European average. After four years of negotiations, at 11^{th} Conference of the Parties, held in Montreal 2005, Croatia is allowed a certain degree of flexibility in determining its reference level of greenhouse gas emission .In return, Croatia seriously committed to consider renewable energy sources utilisation.

Croatia’s agricultural development has been strongly affected not only by the structural changes following the break-up of the former Republic of Yugoslavia (50 percent of land was farmed by large heavily subsidized, vertically integrated agricultural holdings), but also by demographic changes after the Homeland War (high rate of absentee land ownership). The three major agro-ecological zones differ largely in crops and access to markets, but all producers in all regions have access to a very high level of direct subsidies. The large number of very small holdings (averaging approx. 2,8 ha) make outreach for technical assistance and economically feasible production difficult. A well equipped extension service attempts to provide specialized assistance also in agro-tourism, and organic and traditional production. The agricultural sector would benefit from the increased oilseed production for biodiesel through an increased usage of the considerable amounts of currently idle acreage, the introduction of rapeseed as the third crop in crop rotation, a guaranteed additional profit for farmers, and better exploitation of farming machinery which would all be summarized in increased profitability of agricultural production. Rapeseed meal being a by-product in the production of biodiesel would contribute to the replacement of animal protein feeds with protein of vegetable origin in the livestock production as a protective measure against encephalopathy that has luckily not occurred in Croatia.

This study has been conducted under the UNIDO project Promotion of Biodiesel Production in Croatia with the main objective to identify the most promising opportunities for biodiesel production in Croatia, analyse barriers and concerns and give recommendations to the Government of Croatia and other relevant stakeholders.

Chapter 2 focuses on health, environmental, employment and other benefits of biodiesel in relation with relevant Croatian national strategies and objectives. It also analyses some legislative and economic circumstances, and the process of EU accession. Chapter 3 is stressing the key factors affecting potential establishing of biodiesel industry in Croatia, notably feedstock (oilseed) supply, present diesel fuel market and future development scenarios.

Chapter 4 gives a general technology overview of biodiesel production processes, biodiesel by-products and analyses some key issues to sustainable biodiesel industry like site selection, process technology, policies and incentives. Chapter 5 gives macroeconomic analysis of future biodiesel production in Croatia and deals with changes in Government revenues. Chapter 6 describes and proposes policies, financial mechanisms and marketing strategy promoting biodiesel production.

In Chapter 7, a number of factors in technology selection and technology company overviews are given. Chapter 8 is on financial analysis of a proposed small and large-scale of biodiesel production and elaborates needs for biodiesel de-taxation. Chapter 9 contains a comprehensive set of recommendations and conclusions from this report.

Appendix 1 contain report of project workshop held on 15th December 2004 including results from a short questionnaire targeting important questions regarding the reasons of the currently inexistent biodiesel production as well as the future actions and implementation measures needed in Croatia which was conducted as a workshop follow-up. As a separate document, there is also Appendix 2 which contains the complete financial analysis prepared by ITPO Italy which summary and main findings are presented in Chapter 8.

2 BIODIESEL BENEFITS AND CROATIAN NATIONAL STRATEGY

2.1 Biodiesel Benefits

From the utilization perspective, biodiesel and its blends represent an excellent substitute of mineral diesel. Thus, biodiesel features should be benchmarked with mineral diesel features in all their aspects. While consumption features of biodiesel results in, generally speaking, homogeneous results, its production features vary according to the source of production. Namely, biodiesel can or could be obtained from various sources such as different vegetable oils, animal fats, recycled edible oil and, even, soapstocks. Consequently, biodiesel production process greatly depends on geographical and climate conditions as well as magnitude and organisation of sectors related to use of edible oils, such as catering and households.

Here, the focus will be placed on biodiesel originated from rapeseed and recycled edible oil and the comparison will be taken from two standpoints: production and consumption in respect to biodiesel benefits.

Generally speaking, basic emissions from biodiesel and its various blends ratios report decrease in emissions of total hydrocarbon, carbon monoxide and dioxide, particulates, sulphur and an increase in nitrogen oxide emission when compared to mineral diesel emissions.

Table 2.1 *Tailpipe emissions of carbon monoxide, particulates, NO_x and SO_2*

Fuel type	CO	PM	NOx	VOCs	SOx
Diesel (no catalyst)	2,05	0,128	4,70	0,31	-
Diesel (catalyst)	1,52	0,077	4,75	0,19	-
Biodiesel 100% (no catalyst)	1,27	0,081	4,90	0,08	-
Biodiesel 100% (catalyst)	0,95	0,040	4,91	0,06	-

Source: C. Sharp, Southwest Research Institute, Texas, USA, 1997

Domestic production of biodiesel improves energy self-sufficiency of the country as well as job creation.

Before starting, it should be emphasised that all biodiesel benefits are closely related and, therefore, this chapter makes a whole rather than separate parts. The overall benefits of biodiesel are proportional to the percentage of biodiesel presence in the blend with mineral diesel.

2.1.1 Health Benefits

Production of biodiesel from recycled edible oil addresses the problem of sewage or other inappropriate disposal of used edible oils. The waste oil serves as food to rodents and, from the experiences from several cities, enhances their uncontrollable multiplication which presents an undeniable health risk.

Biodiesel is a non-toxic fuel with higher flash point than mineral diesel which makes it non-flammable and non-explosive. In that sense, biodiesel represents less health hazard for all parties involved in its handling and distribution.

Consumption of biodiesel in transport brings numerous benefits regarding the population's health. The health benefits increase together with the population density of an area. Therefore, biodiesel is strongly recommended for appliance in public transport in urban areas.

Biodiesel and biodiesel/mineral diesel blends have the ability to reduce emissions from diesel engines for many air pollutant precursors, and lower toxicity of the diesel particulate matter (PM) emissions, resulting in health benefits for the overall population especially related to asthma and other respiratory diseases caused from air pollution.

Decrease in particulate matter, aromatic hydrocarbons, alkenes, aldehides, and ketones in biodiesel and biodiesel/mineral diesel blends exhaust emissions benefits with less mutagenic effects on mammals than mineral diesel exhaust emissions itself. Biodiesel has a straight chain molecule which has no aromatics. This gives great advantage to biodiesel and its blends over mineral diesel regarding toxic and cancer type of illness.

Specifically, the substitution of mineral diesel with biodiesel in city transport would result in increased air quality in densely populated urban areas, which would in turn insure a lower health risk associated with air pollution. The emission reduction of particulates, carbon monoxides and sulphur oxides is especially important because of the prominent role they play in public health risks; especially in urban areas where the acute effects of these pollutants may be greater. It is important to note that most of these reductions occur because of lower emissions at the tailpipe and for busses and vehicles operated in urban areas this translates to an even greater potential benefit.

Since biodiesel has low emissions, it is ideal for use in places like marine areas, national parks and forests, and heavily polluted cities. Smoke (particulate material) and soot (unburned fuel and carbon residues) are of increasing concern to urban air quality problems that are causing a wide range of adverse health effects for their citizens, especially in terms of respiratory impairment and related illnesses. As an oxygenated vegetable hydrocarbon, biodiesel itself burns cleanly, but it also improves the efficiency of combustion in blends with petroleum fuel. As a result of cleaner emissions, there will be reduced air and water pollution from vehicles operated on biodiesel blends.

Between 1998 and 2000, the U.S. National Biodiesel Board has executed emissions testing programs on biodiesel (known as Tier I and II testing) which had included the most stringent emission testing protocols ever required by USEPA[1] for certification of fuels or fuel additives in the U.S. The authors claim that the data gathered through these tests provide as nearly a complete inventory of the environmental and human health effects attributes of biodiesel as current technology will allow. Health effects in Tier I testing were defined to include both animal and human toxicity studies of any duration, via any exposure route, as well as in vitro, metabolic and structure-activity analyses.

The tests for health evaluations were made in the following aspects:

1. General toxicity in terms of body weight and feed consumption, clinical observation, mortality, haematology (cell counts) and clinical chemistry (liver and kidney function);

2. Pathology in terms of gross and histopathology of all organs;

3. Ophthalmology;

4. Neuropathology in terms of histopathology of brain, spinal cord and nerves as well as brain glial fibrillary acidic protein;

5. Reproduction;

6. DNA damage in terms of micronucleus in bone marrow red blood cells and sister chromatid exchange in lymphocytes.

The exposure conditions are shown in the table below.

***Table 2.2** Exposure conditions used for Tier I and II testing*

	High	Medium	Low	Control
NOx, ppm	50,7	25,6	5,2	0,6
CO, ppm	36,5	15,3	2,2	0,5
HC, ppm	0,50	0,3	0,1	0,1
PM, mg/m^3	1,10	0,5	0,1	0,0

[1] United States Environmental Protection Agency

Results showed:

1. No significant exposure – related effects on feed consumption, clinical condition, mortality, ophthalmology, DNA (micro-nucleus, sister chromatid), neural parameters, reproduction (fertility, teratology).

2. Minor exposure effect deemed not biologically significant on body and organ weights (lower liver weight and higher relative weight in lungs and testis in females and in males, respectively) plus clinical chemistry reported decrease in four liver related parameters and increase in glucose.

3. Minor exposure effects are related to lung histopathology were dose-related increase in macrophages containing particulate matter were recorded. However, there was no toxic effect as changes diminished after 28 days of non-exposure.

Conclusions of the tests recorded that the only biologically significant biodiesel exhaust exposure effect was a small effect in lungs at the high exposure level. Thus, no observable adverse effect level was the medium level.

It is important to point out that biodiesel carries indisputable potential benefits, but as most of the other goods, its production should be carried out in controlled conditions by people with proper training and experience and not at home. Biodiesel production involves hazardous chemicals (i.e. sodium hydroxide and methanol) that represent the risk of fire and explosion when handled poorly. On the other hand, already produced biodiesel does not have any negative reactions with skin, inhaling or swallowing.

2.1.2 Environmental Benefits

The utilisation of biodiesel has environmental benefits that represent one of the major driving forces for its greater introduction. Biodiesel and its blends have reduced greenhouse gasses (GHG) emissions compared to those of mineral diesel. Using biodiesel instead of fossil fuels reduces net emissions of carbon dioxide, which are associated with global climate change. To elaborate, although emissions of carbon dioxide are present in biodiesel combustion process, the level of total carbon is not increased since the carbon was not below but above the earth’s surface. Made entirely from vegetable oils, biodiesel does not contain any sulphur, aromatic hydrocarbons, metals or crude oil residues and thus has many advantages over mineral diesel in the environmental aspects such as air, water and soil pollution.

All health benefits described in the previous part can be applied on all mammals which make biodiesel little, if any, threat to the habitat. Furthermore, biodiesel is totally biologically degradable thus making spills and leaks both in water and soil less of a concern.

The absence of sulphur in neat biodiesel leads to a reduction in the formation of acid rain by sulphate emissions which generate sulphuric acid in the atmosphere. The reduced sulphur in the blend will also decrease the levels of corrosive sulphuric acid accumulating in the engine crankcase oil over time.

Only in the emissions of NO_x, biodiesel showed either the same or higher level of emissions than the mineral diesel. Still, those emissions could be lowered down to 25 percent by adjusting fuel injection timing in vehicles running on biodiesel for which catalytic converters and biodiesel sensor software has been already developed.

The overall results of life cycle paths for biodiesel and mineral diesel production give the same positive impression of the biodiesel's environmentally friendly superiority where "each litre of biodiesel saves the equivalent of 2,2 kg greenhouse gases (IFEU, 2003)". Recent EU studies and data published by the Commission estimate the CO_2 emissions from traditional fuels used in transport (i.e. diesel) at 3,2 tons/1.000 l, including the whole cycle of fuel production and use. The replacement of traditional fuels by biofuels is calculated to produce CO_2 saving in the order of 2-2,5 tonnes/1.000 l.

Although based on different assumptions, three studies, ordered chronologically: ETSU[2] (1996 and 1998), ECOTEC (1999) and IFEU[3] (2003) give reasonable guidelines regarding the effect of biodiesel emissions to mineral diesel emissions.

Table 2.3 *Comparison of biodiesel and diesel life cycle emissions*

Biodiesel to Diesel emissions = 100%		
Emission	**Straw***	**Gas****
Greenhouse gases	24%	30%
SOx	20%	30%
NOx	139%	132%
Particulate	106%	106%
VOC	44%	56%
CO	120%	140%

* processing fired by straw residues

**processing fired by gas

Source: ECOTEC, 1999

[2] ETSU stands for Energy Technology Support Unit for the Energy and Environment Research Programme of the UK Department of Trade and Commerce.

[3] IFEU - Institut für Energie- und Umweltforschung Heidelberg GmbH, www.ifeu.de

ECOTEC study complies with the ETSU study in greenhouse gases, NO_x, VOC and CO emissions while strongly disagrees with SO_x and particulates emissions findings. Namely, ECOTEC claims the following ratios regarding biodiesel and diesel life cycle emissions. Values are organised by taking mineral diesel emissions as base of 100.

When looking to details of the life cycle of biodiesel, it becomes clear that it shows both advantages and disadvantages towards mineral diesel production. IFEU has summarized and simplified its findings in the figure below[4]:

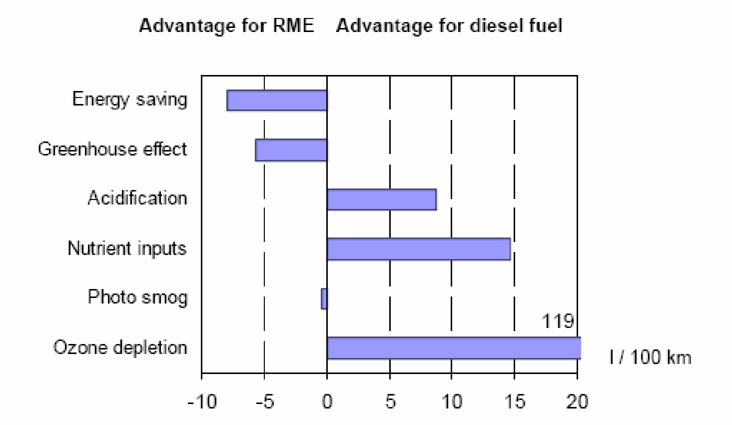

Figure 2.1 *Summarized effects of biodiesel (RME) and mineral diesel production*

Source: IFEU, 2003

To summarise the results of comparison of the life cycle of mineral diesel to the one of biodiesel, IFEU conclusion could be quoted: biodiesel is beneficial with respect to the saving of fossil energy and to the greenhouse effect, but is detrimental regarding acidification, nutrient inputs and ozone depletion.

Thus it is not possible to make a scientific, objective decision for biodiesel or mineral diesel or their mixtures regarding environmental effects. The decision has to have an additional criterion which is, in this case, given by the government of Republic of Croatia, and the EU. The priority for Republic of Croatia is to reduce energy dependency on energy imports and decrease GHG emissions as well as preventing the process of deruralisation and rural population empowerment through increased use of

[4] Example how to interpret the top two bars in the diagram: if biodiesel is used instead of diesel fuel on a distance of 100 km the amount of energy saved equals the amount of energy required to produce 8 litres of diesel fuel and the amount of greenhouse gases saved equals the amount of greenhouse gases emitted due to the production and consumption of 6 litres of diesel fuel. Converted into a different unit approximately 2,2. kg of CO_2 equivalents can be saved for each litre of biodiesel used.

renewable energy sources. Given this additional decision rules, biodiesel production in Croatia seems like a logical choice for the given circumstances.

There are some other impacts on the environment provoked by traditional means of acquiring petroleum, including exploring, drilling and transporting crude oil, that were not assessed in previous figure. More importantly, the use of mineral diesel significantly contributes for many of the environmental problems – greenhouse gases, air pollution, groundwater and soil contamination, and others. Utilisation of biodiesel can play an important role in reducing emissions from transport for many air pollutants, and unlike other 'clean fuels' such as compressed natural gas, biodiesel and other biofuels are produced from renewable materials, like agricultural crops, that assimilate carbon dioxide from the atmosphere to become plants and vegetable oil. Biodiesel has a higher centane rating than mineral diesel, which means more efficient biodiesel combustion.

The lack of heavy petroleum oil residues in the vegetable oil esters that are normally found in diesel fuel means that engines operating with biodiesel will have less smoke, and less soot produced from unburned fuel. In other word, biodiesel utilisation could reduce city smog and improve air quality. Further, since the biodiesel contains oxygen, there is an increased efficiency of combustion even for the petroleum fraction of the blend. The improved combustion efficiency lowers particulate material and unburned fuel emissions especially in older engines with direct fuel injection systems. The lack of toxic and carcinogenic aromatics (benzene, toluene and xylene) in biodiesel results in the fuel mixture combustion gases having a reduced impact the environment.

Introduction of rapeseed as a third crop culture would improve yield and soil recuperation of all cultures (such as maize and wheat) involved via crop rotation. In other words, reduced input of agrochemicals in the sense of pest protection agents and fertilizers would decrease impact of agriculture towards soil pollution and degradation.

Republic of Croatia faces the problem of deruralisation and, consequently, fields are turning into shrub land. Those shrubberies are potential risk of spontaneous fires especially if neighbouring with a forest or populated area.

3.1.1. Employment

The introduction of biodiesel production in Croatia could play a significant role not only from energy point of view, but will also help in regulating the unemployment rate, especially regional unemployment deriving from the structural changes in agriculture to take place. Production of biodiesel from two feedstocks, recycled edible oil and rapeseed methyl ester, is expected to create several new job opportunities in the feedstock supply chain, both in the urban areas due to the required labour for waste oil collection and cleaning, and more importantly in rural areas due to the required labour for rapeseed agricultural production, which will also lessen the urge to abandon land and reduce the ongoing migration into cities.

Studies at EU level have demonstrated that the production of biodiesel requires directly or indirectly 50 times more work-effort than the refining of the same amount of diesel. In addition, the number of job positions that are expected to be created in relation to biodiesel production has been estimated to range between 16-26 per ktoe/year, depending on a number of local parameters.

Increased production of raw materials for biofuels will contribute to the multi-functionality of agriculture and provide a stimulus to the rural economy through the creation of new sources of income and employment, since biofuels are relatively labour-intensive, especially in rural areas during the exploitation phase. Furthermore, in many cases in the agro-food and forestry industry, biofuels could turn problematical waste production into a sustainable product.

Biodiesel production could contribute to agricultural diversification and form part of the job creation policy, which will contribute to putting in place a consistent and lasting framework for guaranteeing the future of the rural community. From the farmer's point of view, rapeseed growing for production of biodiesel could provide better income stability.

Rapeseed growing has a positive externality towards apiculture. Honey production benefits, in all senses, from additional fields of blossoming rapeseed.

3.1.1. Other Benefits

The introduction of biodiesel in Croatia would facilitate the reduction of imported fossil fuels consumption through the utilisation of national energy sources. This will result in diversification concerning energy types and consequently in increase of the security of energy supply in the country.

It is also expected that the development of production and use of biodiesel in Croatia will partly create a mushrooming effect of new innovative technologies and facilitate technology transfer from the EU to the whole Western Balkan region and South-East Europe.

The outcomes of the proposed project offer an opportunity for trade to promote sustainable development, since the need for biodiesel in the EU, and subsequently in other countries, could open a new market for innovative agriculture products which could particularly benefit countries dependent on agriculture. Agricultural activity per capita in Croatia and surrounding countries is considerably higher then in EU countries, therefore there is potential for sustainable farming of biodiesel.

Assuming that biodiesel will not be affected by the possible rise in crude oil prices, its introduction on the market can be expected to have a modest effect in dampening the effect of changes in crude oil prices on prices paid by consumers.

2.2 Croatian National Strategy and Objectives

Within its integration process into the European Union, Croatia will have to adjust the whole concept of the energy sector reform by introducing a legislative as well as an institutional framework in accordance to the EU *acquis communautaire*. Following the European Council's political decision to open negotiations and to convene the bilateral intergovernmental conference on accession, negotiations with Croatia were formally opened on 3 October 2005 at the first session of the intergovernmental conference between EU Member States and the Republic of Croatia. The formal opening of the negotiating process is followed by the analytical overview and evaluation of the degree of harmonisation of national legislation with the *acquis communautaire*, known as screening. The main purpose of the screening process is to determine the existing differences between the national legislation and the *acquis communautaire* for every chapter which the national legislation needs to be harmonised with until the date of accession. On the basis of the conducted analysis, the candidate country is required to state whether it will be able to fully harmonise national legislation with the *acquis communautaire* in individual chapters or if it will require transition periods for complete harmonisation and implementation of the *acquis communautaire*. Screening is conducted for every chapter individually.

The harmonisation and implementation of new legislation will naturally be done within limits of a particular national solution but also considering the fact that each country of the European Union undertook the obligation to change relationships within the energy sector based on common rules determined by the European Union's Directives. Specifically, the two EU directives regarding the production and utilisation of biofuels are the following:

- *Directive 2003/30/EC of the European Parliament and of the Council on the promotion of the use of biofuels or other renewable fuels for transport*, which stipulates that EU member states should ensure that a minimum proportion of biofuels and other renewable fuels is placed on their markets and to that effect set national indicative targets. The Directive also sets reference values for these targets starting from 31 December 2005 and until 31 December 2010;

- *Directive 2003/96/EC of the European Council restructuring the Community framework for the taxation of energy products and electricity*, which allows EU member states to apply a total or partial exemptions or reductions in the level of taxation to biofuels.

The Croatian energy policy today is directed towards increased efficiency, security of supply and diversification, market deregulation, and the use of renewables and environmental protection. In accordance to these goals the production of biodiesel is seen by the Government as one of the important options to provide an integrated solution to energy, environmental and socio-economic concerns. The Croatian Government has launched BIOEN programme that covers biodiesel production and related regulations as a part of the National Energy Programme as early as in February 1997.

The first steps have been made: the Energy Act and the related Regulation regarding renewable energy sources clearly recognises biofuels as a renewable energy source and gives definition and classification of biofuels (including both liquid and gaseous forms) (Energy Act, Official Bulletin (O.B) 68/01). In 2003, the Subcommittee for biofuels was formed within the Technical Department 28 of the Governmental Office for Standardization and Metrology, which defined the Croatian norms for biodiesel. This practically means acceptance of the EU norm EN 14214. The Subcommittee also made a decision to allow the mixing of 5% of biodiesel in the standard mineral diesel fuel without special marking. In 2002, the Croatian Government has, based on the proposal of the Ministry of Environmental Protection and Physical Planning, adopted the *Regulation on Quality Standards for Liquid Oil Fuels*, which was last amended in August 2005. The Ministry has prepared the *Regulation on the Quality of Biofuels* which was delivered in November, 2005 (O.B. 141/05) However, up till now, biodiesel production and legislative framework reinforcement is yet to be unfolded.

In accordance to the requirements stipulated in Directive 2003/30/EC, the Croatian Government in the *Regulation on the Quality of Biofuels* set a national target of 5,75% share of biofuels in total consumption of fuels for transport, up till December 31, 2010, as well as formulate and put in place specific support measures to achieve this target. These should include an overall national plan for the promotion of the use of biofuels for transport, with the aim to establish regulatory environment for biofuels on a fully commercial basis. In order to increase the proportion of biofuel use and promote the blending of biofuels into standard engine fuels, it will be necessary for the Government to approve the refund of the excise duty on biofuels.

The hypothetical amount of biodiesel production considered in this study should fulfil proportions of biofuels and other renewable fuels placed on the national market as recommended in the Directive 2003/30/EC: 2% and 5,75% calculated on the basis of the energy content, of all petrol and diesel for transport purposes placed on national markets by 31st December 2005 and 2010, respectively. However, it is important to note that the Directive 2003/30/EC sets only reference values for the national indicative targets, thus allowing member states to provide derogation from the EU reference values due to a number of reasons (including limited national potential to produce biofuels from biomass, the use of biomass for purposes other than transport, and special technical and climatic characteristics of the fuel market). It is still upon the Croatian government to decide on exercising this right while building the national biofuels strategy.

2.3 Conclusions

From the utilization perspective, biodiesel and its blends represent an excellent substitute of petroleum diesel. Specifically, biodiesel runs in any conventional, unmodified diesel engine, resulting in the fact that no engine modifications are necessary for its use in vehicles no older than 10 years. Furthermore, it can be stored anywhere that petroleum diesel fuel is stored. All mineral diesel fuelling infrastructure including pumps, tanks and transport trucks can thus use biodiesel without modifications.

The replacement of petroleum diesel with biodiesel offers a variety of benefits, including health and environmental benefits, increased employment, development of rural areas, increased security of energy supply, lower import of energy sources and a better overall trade balance and others. Biodiesel and biodiesel/mineral diesel blends have reduced emissions for many air pollutant precursors resulting in health benefits for the overall population. These health benefits increase with the population density of an area, thus it is strongly recommended to use biodiesel for public transport in urban areas. Due to being a non-toxic fuel with higher flash point than petroleum diesel, which makes it non-flammable and non-explosive, biodiesel represents less health hazard for all parties involved in its handling and distribution. Additionally, the production of biodiesel out of recycled edible oil addresses the problem of sewage or other inappropriate disposal of used edible oils. Using biodiesel instead of fossil fuels reduces net emissions of carbon dioxide, which are associated with global climate change. Furthermore, the absence of sulphur in neat biodiesel leads to a reduction in the formation of acid rain by sulphate emissions which generate sulphuric acid in the atmosphere.

The introduction of biodiesel production in Croatia could play a significant role not only from the energy point of view, but would also help in regulating the unemployment rate, especially regional unemployment deriving from the structural changes in agriculture. In that sense, biodiesel production could contribute to agricultural diversification and form part of the job creation policy, which would contribute to putting in place a consistent and lasting framework for guaranteeing the future of the rural community. The production of raw materials for biofuels would contribute to the multi-functionality of agriculture providing a stimulus to the rural economy through the creation of new sources of income and employment. In many cases in the agro-food and forestry industry, biofuels could turn problematical waste production into a sustainable product. The introduction of biodiesel in Croatia would also facilitate the reduction of imported fossil fuels consumption through the utilisation of national energy sources, resulting in diversification concerning energy types and consequently in increase of the security of energy supply in the country.

Within its integration process into the European Union, Croatia will have to adjust its energy sector reform process by introducing a legislative as well as an institutional framework in accordance to the EU *acquis communautaire*.

In order to meet the requirements stipulated in Directive 2003/30/EC, the Croatian Government *in the Regulation on the Quality of Biofuels* set a national target of 5,75% share of biofuels in total consumption of fuels for transport, up till December 31, 2010, as well as formulate and put in place specific support measures to achieve this target. These should include an overall national plan for the promotion of the use of biofuels for transport, with the aim to establish regulatory environment for biofuels on a fully commercial basis. In order to increase the proportion of biofuel use and promote the blending of biofuels into standard engine fuels, it will be necessary for the Government to approve the refund of the excise duty on biofuels as introduced in Directive 2003/96/EC.

3 KEY FACTORS AFFECTING POTENTIAL ESTABLISHING OF BIODIESEL INDUSTRY IN CROATIA

3.1 Feedstock Supply Analysis

3.1.1 National Oilseed Production

The production of oilseed crops in Croatia is exercised at approximate 90 thousand hectares and is focused on 3 plants: soybean, sunflower and rapeseed, with soybean dominating in acreage and yield in the ratio of 55:30:15 ha and 59:29:12 t, respectively as shown in the Table 3.1.

Table 3.1 *Production of oilseeds in Croatia*

Year	1997	1998	1999	2000	2001	2002
Sunflower						
acreage ha	16.946	28.642	41.996	25.715	25.336	26.835
production t	36.138	62.206	72.374	53.956	42.985	62.965
yield t/ha	2,13	2,17	1,72	2,10	1,70	2,35
Rapeseed						
acreage ha	5.356	8.949	15.010	12.886	10.319	13.041
production t	11.181	21.967	36.020	29.436	22.456	25.585
yield t/ha	2,09	2,45	2,40	2,28	2,18	1,96
Soybean						
acreage ha	16.030	34.015	46.336	47.484	41.621	47.897
production t	39.469	77.458	115.853	65.299	91.841	129.470
Yield t/ha	2,46	2,28	2,50	1,38	2,21	2,70
Total oilseed in ha	**38.332**	**71.606**	**77.667**	**86.085**	**77.276**	**87.773**

Source: Central Bureau of Statistics, 2004

Recently, there is an ongoing trend in increasing the acreage and production of oilseed resulting in almost double production in 2002 comparing to 1997. Proportionally, the import of oilseeds has been decreasing ending with positive foreign exchange balance for rapeseed and sunflower in 1999. However, the balance of production and consumption of oilseeds and vegetable oils is still negative with only 52% of self-sufficiency. In addition to that, the protection levies are decreasing both for raw oilseeds and their products jeopardising the fragile bliss of success in the field of oilseed production.

To the difference with other agricultural plants, production of oilseed is specific by being produced mostly on big agricultural areas owned by business companies. Generally speaking, about one half of the production areas and two thirds of production belong to agribusiness while production on family owned farms has been contracted between the farmers and processors.

It is noticeable that the level of rapeseed yield per ha is quite low, ranging from 1,52 t/ha to 2,45 t/ha, comparing to the yields of 3 t/ha and more achieved in the EU. In August 2005, aware of the low yield problem, not only for rapeseed but also in general, Croatian Parliament has adopted the Instruction on Minimal Yield per Hectare Assessment (O.B. 96/05) which defines the minimal yield per hectare for rapeseed of 1,70 t/ha. Briefly, in the sense of that Law, if a farmer fails to achieve the minimum required yield, in the normal cropping circumstances, the farmer loses the right for the subsidies.

On the other hand, the Government is supporting oilseed production by giving the highest amount of subsidies. All oilseeds are encompassed within the national subsidy programme that is based on production areas. The amounts of the subsidies for oilseeds with comparison to those of wheat and maize are shown in the Table 3.2.

***Table 3.2** Agricultural subsidies per cultures for related cultures*

Culture	Subsidy (HRK/ha)
Rapeseed	2.250
Sunflower	2.250
Soybean	1.650
Wheat	1.650
Maize	1.250

Source: Law on Governmental Support for Agriculture, Fishery and Forestry, O.B. 82/04, 9th June 2004

The subsidy for rapeseed is about three quarters higher than those for wheat and maize, due to the fact that there is recognized excess demand for edible plant oil. On the other hand, there is excess supply in wheat production and sufficient supply in maize. However, in order to protect farmers' income, those traditional cultures are still subsidised. Mainly due to this reason, farmers are, at present, reluctant to switch from the traditional cultures to new ones, resulting in low experience and consequently low yield with growing rapeseed. It is expected that only significantly higher margin could motivate farmers to switch. For example, rapeseed producers from Osječko-Baranjska County are claiming that an amount of 2.800 HRK/ha would be sufficient. If the Government recognises rapeseed growing as one of the crops of strategic importance, the solution could be found in downwards cascading support system which will start from, for example 2.800 HRK/ha, as claimed by farmers. This could then gradually decrease over years to the amount 2.250 HRK/ha, as proposed by the Ministry of Agriculture, followed by constant support from the Extension Service regarding cropping techniques improvement. In that sense, more farmers would be willing to convert to rapeseed growing in the initial years and would be able to transfer their knowledge among each other. In the end, farmers' income would stay at the approximate same level: decreased income from the subsidies but increased from the harvested yield.

To understand the whole background of the national oilseed production and agriculture in general, it is important to stress the ongoing trend of decrease in agricultural production and abandoning of the rural areas. The total area of unused agricultural area stays controversial. It varies from 102.422,97 ha (Agriculture Census, 2003) to as much as 377.370 ha (Statistical Yearbook 2003) depending on the methodology. The Agricultural Census was executed according to the recommendation of the EU and statements of the land owners. In this survey, the emphasis was on the "used" areas. With this methodology, the unused agricultural area (it does not specify the type of the unused agricultural area) amounted 7,36%, from total agricultural area of 1.391.621,95 ha. The Statistical Yearbook gives the specific type of land and its use which gives the share of fallow and uncultivated arable land of 35% in total arable area of 1.080.190 ha. Both data come from the official source - Central Bureau of Statistics and represent the same year.

One of the measures to prevent this negative trend, especially in the light of entering the CAP, the Croatian Government has introduced a penalty taxation system in order to motivate the farmers to continue with the cultivation. Agricultural Idle Land Tax is a tax on the land which is defined as an area classified as agricultural land but it is out of use for various reasons over a period of one year. This tax is represents an income for municipality or town to whose administrative territory the idle land belongs. The idle land tax is described by Law on Local and Regional Communities Financing (O.B. 117/93, 33/00,73/00, 59/01, 107/01, 117/01, 150/02 and 147/03) and General Tax Law (O.B. 127/00, 86/01, 150/02). The law penalises the owner or concession holder that is neglecting the agricultural area more than a year. The taxation base is the quantity of the idle land stated in hectares. The maximum annual penalty amounts, depending on the agricultural land classification, from 250 HRK/ha for meadows to 1.000 HRK/ha for orchards, olive yards and vineyards. Arable land annual penalty amounts up to 500 HRK/ha and the actual amount depends on the decision of the local (regional) authority.

According to the National Agriculture and Fishery Strategy, oilseeds industry has enough capacity to process the existing production but it is not prepared for increase due to the technological and technical disuse.

Oil from all three oilseed crops can be used for biodiesel production, although, apart of economic justifiability, rapeseed oil is the most suitable from the technical aspect of biodiesel production. Also, soybean oil is obtained through a series of processing steps, which includes degumming. Degumming is the process of removing phospholipids, such as lecithin which complicates the washing of crude biodiesel produced by transesterification and increases production costs.

3.1.2 Farm Structures by Region

At present, statistics regarding the regional farm structure evaluations apart from the national statistics shown below are not available. However, it is reasonable to assume that the former state farms, which were located in the fertile region of Slavonia, represent the quite large and well organised farms with high productivity, while the small private farms can be found in other regions having quite serious limitations in climatic and soil conditions and therefore rather limited tradition in rapeseed production.

From the figures as shown below it can be seen that approx. 83% of the land is managed by family farms while approx. 17% by legal entities i.e. large farms. Distribution for oilseed cropping shows however approx. a 50/50 split where, in rapeseed cropping, large farms are dominating with a 79% share. Those larger units of the legal entity farms are more suitable to support the advanced cropping methods of rapeseed with higher yield and agro- technological know-how.

Table 3.3 *Distribution of land management (legal entities vs. family farms)*

Year	2000	2001	2002
Total land sawn in ha	1.071.573	1.091.211	1.096.601
Legal entities	187.407	184.951	182.596
Family farms	884.166	906.260	914.005
Total oilseeds in ha	86.919	78.075	89.065
Legal entities	45.143	38.551	42.276
Family farms	41.776	39.524	46.789
Total rapeseed in ha	12.886	10.319	13.041
Legal entities	10.588	8.115	10.309
Family farms	2.298	2.294	2.732

Source: Central Bureau of Statistics, 2004

3.1.3 National Production and Consumption of Food Oils

Coverage of national demand for vegetable oils has varied between 60% in 1991, 83% in 1993 and 71% in 1995. In order to cover the gap oilseeds are imported for crushing in national oil mills.

In 2004 soybeans imports reached 103.109 t and sunflower imports were 4.537 t; other key oil imports in 2004 were sunflower oil, palm oil and rapeseed oil.

Table 3.4 *Production of food oils in Croatia in tons*

	1995	1996	1997	1998	1999
Margarine	10.320	12.374	14.676	15.370	15.370
Rapeseed oil	6.221	3.063	2.731	6.725	11.951
Soy oil	11.700	10.000	16.200	15.600	15.900
Sunflower oil	10.800	14.100	16.500	16.500	16.500
Olive oil	5.447	2.293	1.572	3.150	3.150
Others	509	370	321	435	135
Total	44.997	42.200	52.000	57.780	63.006

Source: FAO, 2002

3.1.4 Production Industry

Currently there are 3 relevant oil mills in place:

1. Sojara in Zadar
2. Zvijezda d.d. in Zagreb, with a refinery
3. Tvornica ulja in Čepin, with a refinery. Oil seed capacity of 182.500 t/y, refining capacity of 36.500 t/yr.

The Agrokor Group represents the major competitor in purchasing, processing and marketing of vegetable oils in Croatia, with the following integrated subsidiaries:

- Sojara Zadar: a mid-sized oil mill for crushing soybeans, oil seed capacity 300.000 t/y, located at a sea harbour for unloading largest cargo ships from e.g. USA, Argentina;
- Zvijezda d.d.: the major producer of edible oils with a market share of 58% and a key role in production and processing of oil seeds into consumer products, located in Zagreb;

- Agrokor Trgovina d.d.: covering approx. 95% of the Croatian market in the segment of soybean and animal feed e.g. soybean meal, as well as sunflower seed and rapeseed.

3.2 Waste Edible Oil as Possible Complimentary Source

Considering the present situation in Croatia, the quantities of rapeseed oil produced annually are at the moment insufficient for starting a larger industrial production of biodiesel and it is highly questionable whether in the near future an increase of rapeseed oil production could be expected. Recycled edible oil could thus serve as an important additional resource especially in the initial phase of biodiesel production in Croatia.

In the times of harmonisation of the national with the EU legislation, it is worth mentioning the changes and trends related to the field of waste treatment and management regulation. According to the Law on Waste (O.B. 178/04) and the Regulation on Categories, Types and Classification of Waste with Waste Catalogue and Hazard Waste List (O.B. 50/05), waste edible oil belongs to the category of non-hazardous communal waste disregarding it's origin (private or legal person) and should be handled by licensed collectors. The waste disposal is organised according to the "polluter pays" principle. Penalty provisions defined by the Article 88 prescribe a substantial fine in the range from 300.000 to 700.000 HRK if, among others, "the legal entity is not collecting and delivering waste with valuable features for recycling". The Law in this particular issue has been started its enforcement by monitoring the biggest producers of waste edible oil such as hotels and restaurant chains and will gradually apply to the smaller waste producers.

The production of biodiesel from recycled edible oil can thus be expected to benefit from a raw material advantage (security) and eventually from improved technology. If significant development of recycled oil to biodiesel production occurs, it will help reduce the overall biodiesel cost.

The utilisation of recycled oil for biodiesel production can also help in eliminating the currently poor practices of wasteful and environmentally harmful, as well as economically disadvantageous, disposal through the sewage system. Experience from several large cities in Croatia has shown that sewage disposal of waste edible oil can also cause problems with uncontrollable multiplication of rodents living in the sewers as the waste oil serves as food, which also presents an undeniable health risk.

Disadvantages of using recycled edible oil as a source for biodiesel production include the difficulties in setting up a collection system large enough to provide substantial quantities of the used oil and the need for filtration and cleaning of the oil, both of which considerably raise the investment costs. Data related to prices and supply and demand of recycled edible oil in Croatia are generally less clear than that available for major commodity oils, making a thorough analysis difficult.

Several small private companies have started collecting waste oil in various parts of the Croatian coast and islands, notably Istria and Dalmatia. However, the major reason for this activity is not the utilisation of the collected oil either for biodiesel or as animal feed, but the resulting environmental problems arising from its disposal. McDonalds restaurant in Zagreb is currently the only known to collect waste oil specifically for biodiesel, however the collected oil is exported to Austria. With the new legislation described before, it is expected to have significant positive changes in the field of collecting.

Biodiesel production from recycled edible oil is especially interesting from this aspect: several studies show that the net CO_2 emissions looking at the whole production-consumption cycle are negative. The main reason for this reduction are the avoided emissions that would normally be generated within the rapeseed production cycle, but also due to the utilisation of resources that would otherwise be dumped in the environment.

3.3 Present Diesel Fuel Market

3.3.1 Supply of Crude Oil, Refining Capacity and Final Diesel Fuel Products by National Production, Import and Export

Local resources of crude mineral oil are covering approx. 40% of the national demand with *INA Industrija nafte d.d.* being the key player in crude and final mineral oil production and distribution. In Croatia, crude oil is produced from 34 oil fields and gas condensation products from 9 gas condensation fields.

By 2003 there were 683 fuel pumps installed and 405 were owned by INA. The INA-Group is furthermore involved in fertiliser production and engineering. The 2 oil refineries (Sisak and Rijeka) have at a capacity of approx. 5 mill t/y each, while the 2 lubricants refineries (Rijeka and Zagreb) have the total capacity of 700.000 t/y. INA, which employs 17.000 people, made a $150 million profit on a turnover of $1,7 billion in 2003. It is worth comparing the business results of INA from 2003 with a loss of $216 million in 1999.

Table 3.5 *Final energy demand overview for diesel in Croatia with emphasis on road and public city transport in 1.000 t/year*

	2000	2001	2002	2003	2004
Final energy demand	**863,7**	**925,3**	**995,6**	**1.145,7**	**1.221,8**
Road transport	533,2	579,0	658,4	785,3	861,5
Public city transport	24,6	25,0	25,2	25,6	26,6
Other transport	53,2	50,9	55,9	57,3	58,5
Other sectors	252,7	270,4	256,1	277,5	275,2

Source: EIHP, 2005

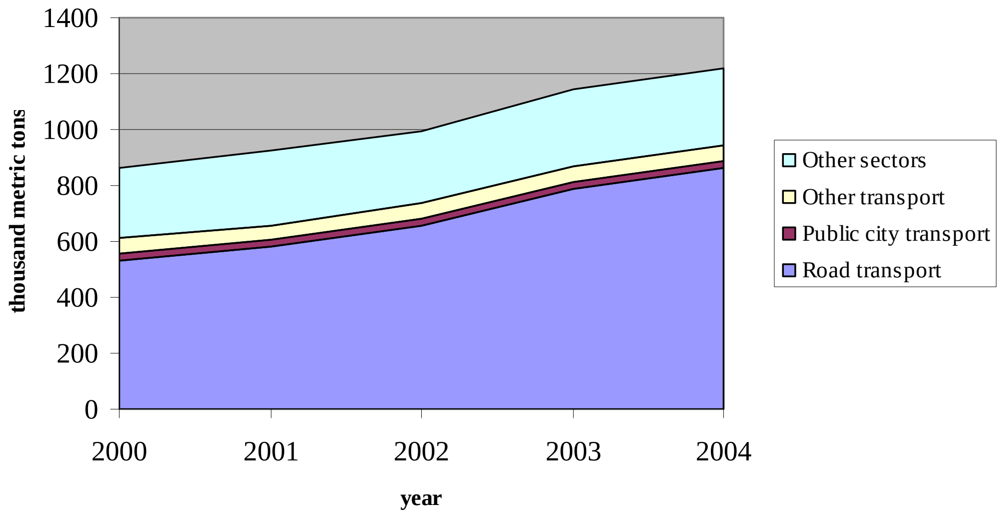

Figure 3.1 *Diesel fuel demand in Croatia with emphasis on road and public city transport*

Source: Annual Energy Report: Energy in Croatia 2004, Ministry of Economy, Labour and Entrepreneurship, Republic of Croatia, 2005

3.4 Scenarios for Future Diesel Consumption and Potential Biodiesel Market Share

According to the Energy sector development strategy of the Republic of Croatia (MoE, 2001), three possible scenarios for the energy sector development up to the year 2030 have been considered:

- S1 – present day technologies without state incentives;
- S2 – new energy technologies with state incentive mechanisms;
- S3 – markedly ecological scenario.

Total diesel fuel consumption for the three scenarios is given in Table 3.6.

Table 3.6 *Total diesel fuel consumption per scenario*

	2000	2005	2010	2015	2020	2025	2030
S1 - Total diesel consumption in 000 t	864	1.066	1.211	1.360	1.544	1.750	1.871
S2 - Total diesel consumption in 000 t	864	1.037	1.150	1.277	1.466	1.639	1.780
S3 - Total diesel consumption in 000 t	864	1.098	1.249	1.316	1.397	1.480	1.484

Considering the recent EU legislation (Directive for the Promotion of the Use of Biofuels) with the objectives to reduce European dependency on energy supply to the transport sector and to reduce greenhouse gas emissions resulting from road traffic, taking S2 (new energy technologies with state incentive mechanisms) as the medium reference scenario in this regard, and assuming the implementation of all European legislation in Croatia when joining the European Union in near future the following potential development for biodiesel demand is outlined.

Table 3.7 *Potential development for biodiesel demand*

Development of the road Diesel / Biodiesel market (based on S2 scenario)	2000	2005	2010 est.
Diesel consumption in 000 t assumed 4% increase p.a.	557,8	678,6	825,7
Biodiesel market shares in % as per EU-Directive	0,0	0%	5,75%
Biodiesel in 000 t	0,0	0,0	44,5

Estimate: Austrian Biodiesel Institute, 2004

The assumption for total fuel growth and in specific diesel fuel growth appears to be however on the conservative side. For the time being, there is no specific biodiesel tax exemption in consideration.

The present quality of mineral diesel sold complies with the European CEN fuel standard EN 590 and fulfils the demand of modern diesel engines with common rail fuel injection equipment. Croatian standardisation committee recently approved European Biodiesel standard (EN 14214) as well as blending of biodiesel with mineral diesel (EN 590) up to 5%.

In late 2005, the Croatian Government delivered *Regulation on the Quality of Biofuels* (O.B. 141/05) that has the aim of placing biofuels at the domestic market as substitutes for diesel and gasoline motor fuels in transport.

3.5 Conclusions

At present, there is no clear strategy or accepted plans how to fulfil Croatian goals to cover the total national biodiesel demand of approx. 45.000 t by the year 2010. Although for this amount only one single mid-size biodiesel production plant would be sufficient there is still a significant difference in perspective and motivation from different stakeholders regarding biodiesel production.

A group of agricultural experts perceives biodiesel as one of the solutions for development of the rural communities through keeping business incentives and job creation at the rural areas. That is why they have a reasonable standing for an ongoing initiative to build several smaller plants which will have more positive impact on the local rural communities. This approach for biodiesel production in Croatia is often referred as 'agricultural model'.

'An industrial model' as it is usually referred is represented by *INA Industrija nafte d.d.* that consolidated a team of experts from *Maziva – Zagreb d.o.o.* and from the *INA Sector for strategic development* for the preparation and development of biodiesel production project. The proposed production facility on the location site of Maziva-Zagreb d.o.o. could be realized with considerable savings, because Maziva – Zagreb d.o.o. has possession of the resources necessary for biodiesel production realization (traffic infrastructure, location, premises, energy infrastructure, sewage system, waste water treatment, tank area, pumping stations, laboratories, maintenance and protection control and human resources). In December 2003 Maziva Zagreb d.o.o. issued a letter of intent to Croatian government in which it expressed its readiness to start preparations for the implementation of biodiesel production project as a member of consortia to be formed for the realization of this project.

In 2005, similar letter of intent was issued from *Tvornica ulja* in Čepin (mentioned before) and this intention was widely announced via different media channels. In 2002, this oil factory reported net profit of 1,24 mil HRK which should prove some successful improvements in the structure and management of the company. The company is placed in area related to rapeseed growing. The manager of the company, has stated that Tvornica ulja has prepared the complete project of biodiesel production but the exact time frame is not know as they are waiting for the Government to deliver legal basis for mineral oil excise exemption and subsidies of 2.850 HRK/ha for growing rapeseed variety that is specially designed for biodiesel production. Their plan is to produce 60.000 t/yr of which 30.000 t would be sold for blending, 15.000 t would be used in agriculture, 5.000 t would be sold to special customers as pure biodiesel (B-100) and 10.000 t are predicted for export. There was no clear explanation from where the rapeseed would be purchased but they advocate increase in farmers' subsidies.

More recently, construction works for building a biodiesel processing plant in Ozalj started in 2005, while production in plant of 10.000 t/yr started in May 2006. The plant of a future total capacity of 30.000 t/yr is owned by *Modibit*, local SME and the total estimated investment costs for the plant (first phase) are about €5 mil. The main sales channel for produced biodiesel will export to Austria and Italy. It is interesting that Modibit stated that the current subsidy of 2.250 HRK/ha for rapeseed production is sufficient and also announced possibility of making its own base of raw material from collecting the recycled edible oil.

4 BIODIESEL PRODUCTION AND KEY ISSUES TO SUSTAINABLE INDUSTRY

4.1 Biodiesel Production Processes-General Overview

Biodiesel is made through the chemical reaction of transesterification, during which the mixing of fatty acid triglycerides (vegetable oils, animal fats, recycled edible oils) and methanol result in the production of methyl esters (biodiesel) and glycerin (a valuable by-product which can be sold or used for the production of soaps and other products). The transesterification of triglyceride esters with methanol is a balanced and catalyzed reaction and an excess of methanol is required to obtain a high degree of conversion. Methanol is mixed with catalyst (acid or alkaline) and added to the triglycerides to yield the corresponding methyl esters of fatty acids (FFA) contained in the starting triglyceride and co-product glycerin. The three basic chemical processes used to produce methyl esters from oils and fats, which can be either continuous or batch, are the following:

- Base catalyzed transesterification of the oil with methanol.
- Direct acid catalyzed esterification of the oil with methanol.
- Conversion of the oil to fatty acids, and then to alkyl esters with acid catalysis.

The most common process currently in use, which utilises vegetable oils or animal fats with a low quantity of free fatty acids, is the base catalyzed transesterification of the oil with methanol, as it is the most cost-effective due to several reasons:

1. Low temperature (up to 65^{o}C) and low pressure (atmospheric up to about 1,4 bars) process;
2. High conversion (>98%) with minimal side reactions and reasonable reaction times;
3. Direct conversion to methyl ester with no intermediate steps;
4. Unconventional design materials are not necessary.

However the selection of the specific process and technology to be used for biodiesel production depends upon a variety of factors including the size of the plant, feedstock type and quality, requirements regarding feedstock flexibility, and others.

The main feedstock for the majority of biodiesel produced today is either rapeseed oil, particularly in Europe, or soybean oil particularly in the US. Biodiesel can also be made from other feedstocks such as corn oil, cottonseed oil, palm oil, and animal fats as beef tallow, and recycled sources such as restaurant waste frying oils and industrial waste grease. About half of the biodiesel plants in existence have been designed to use clean, high-quality seed oil and methanol, while the remainder use recycled restaurant oils and some animal fats. The range of acceptable free fatty acids is from less than

4% to as high as 50%. Most technology providers offer technologies that can handle up to 20% free fatty acids. Alternative feedstocks require changes of the production process and in such cases the important parameter to be considered is the free fatty acid level. Crude soybean oil will usually have a free fatty acid level less than 1.0%. If the oil is refined, the free fatty acid level will approach zero. However, recycled restaurant waste oils will have a free fatty acid level from 1% to as high as 20%, with the most frequent range around 10%. The low end of this range corresponds to recently changed oil and the high end is the oil that may have been stored for a considerable time before it is processed. Rendered animal fats will have free fatty acids between 5% and 30%, mostly depending on the time of year. Finally, greases from restaurant grease traps and float grease from sewage or wastewater treatment plants can have free fatty acid levels ranging from 40 to 100%.

High free fatty acid feedstock cannot be processed to biodiesel using the conventional alkaline-catalyzed transesterification because the alkaline catalyst, sodium hydroxide in this case, reacts with the free fatty acids to form soaps, which could create problems in biodiesel production. Thus, free fatty acids have to be removed which this could be done in several ways. Most plants that process high free fatty acid feeds have a two-step approach to processing high free fatty acid feedstock. First, an acid catalyst is used to convert the free fatty acids to esters, and then use an alkaline catalyst to convert the remaining triglycerides to methyl esters. In this way, the maximum efficiency of free fatty acids neutralisation is reached and the transesterification by the use of alkaline catalyst is faster.

The process of biodiesel production can be performed in batch or continuous system. Batch systems require more space for the extra processing vessels. These systems offer the flexibility of a varied feedstock source as each batch can be altered depending on the FFA level of the feedstock, while also offering the flexibility of troubleshooting during the processing stage. Continuous flow systems are highly efficient and quick at processing high quality feedstock with a low level of FFA (less than 0,5%). They are best suited to more centralized, large capacity facilities, producing well over 10 million litres per year where the economies of scale begin to take effect. These systems are highly automated with excellent quality control. There are many new companies that are using hybrid systems that utilize a batch acid esterification pre-process for low to high FFA content feedstock (5-30%). This creates a consistent feedstock that can then be fed into a continuous transesterification system. Another version of a “hybrid” type system involves the use of continuous esterification, followed by batch transesterification reaction, and the resulting ester/glycerine processed continuously in downstream processing equipment. In this instance, only the transesterification reactor is batch, and overall continuous response is achieved via the use of surge tanks ahead of and following the transesterification reactor. Depending on the size of the facility, this approach can be as cost effective as a fully continuous system, for example, plants in the range of 10 million to 30 million litres per year production rates should carefully evaluate this approach from an overall economic comparison standpoint (compared to full continuous). Currently, according to the feasibility study undertaken for British Columbia, the three main methods that are being used commercially to produce biodiesel, ranging from low to high free fatty acids feedstock, are the following:

1. *Straight base catalyzed transesterification.*

   - Simple inexpensive process as no pre-processing is used
   - Low to high yield losses due to the formation of soaps from non-reacted free fatty acids
   - Increased waste costs
   - Difficult quality control issues
   - Limit on amount of allowable free fatty acids in the feed

2. *Free fatty acids removal (caustic washing) followed by straight base catalyzed transesterification:*

   - Purifies feedstock allowing for efficient processing and good quality control
   - An equal amount of clean oil tends to be lost with free fatty acids in the form of soap, resulting in a significant loss in yield (depending on free fatty acids content)
   - Free fatty acids must be sold (can be difficult to find market), or straight acid esterified into methyl esters (additional process equipment) in order to be viable

3. *Acid esterification followed by base transesterification with low or high free fatty acids greases and fats* (see Figure 4.1 for process flow diagram of this processing option):

   - Results in high yields as acid esterification pre-process converts free fatty acids to methyl esters
   - Requires simple additional pre-processing equipment
   - Good quality control
   - Process can be adjusted to suit free fatty acids content
   - Requires high ratios of methanol that must be recovered to be viable
   - Process produces water that must be continuously removed to ensure complete reaction

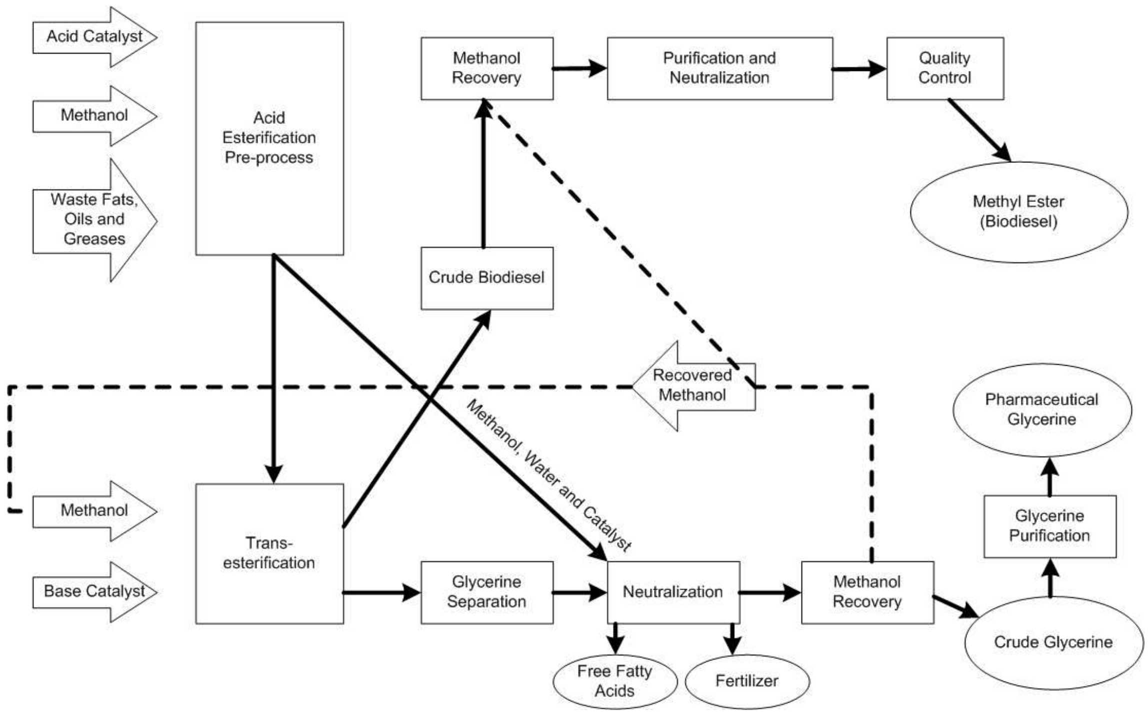

Figure 4.1 *Biodiesel process flow diagram using low-high free fatty acids feedstock*

Considering the reported data regarding the Croatian production of oilseeds, it is evident that the quantities of rapeseeds produced annually are at the moment insufficient for starting a larger industrial production of biodiesel utilising only rapeseed as feedstock. Furthermore, it is questionable whether in the near future a considerable increase of rapeseed oil production could be expected. Recycled edible oil could thus serve as an important additional resource especially in the initial phase of biodiesel production in Croatia. Of the three processes mentioned above, the last one is more adoptable to different feedstock than other two, and as such it can be considered as the most suitable for biodiesel production in Croatia in this phase.

4.2 Biodiesel By-products and Their Contribution to the Cash Flow

Along the biodiesel production chain, apart of main product – biodiesel, there are also several by-products, which include glycerine, seed meal (cake) and potassium sulphate fertiliser (Figure 4.2). These by-products have a significant economic value and contribution to the cash flow of a biodiesel production plant and thus might positively influence the biodiesel market price and its competitiveness (Figure 4.3).

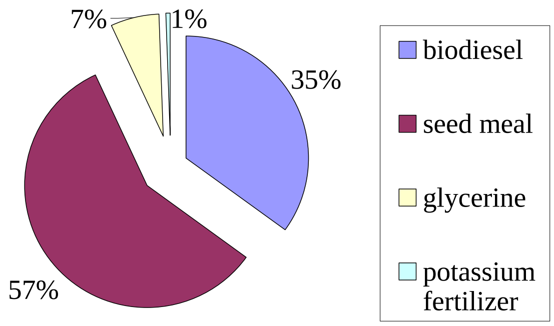

Figure 4.2 *Biodiesel by-products, percentages of produced quantities*

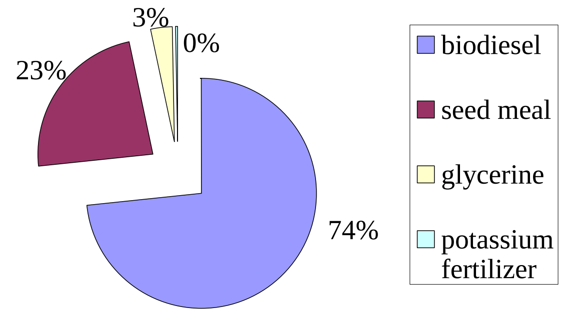

Figure 4.3 *Biodiesel by-products, percentage contribution to the cash-flow*

Source: *Grains and oil seed market*, Nr. 49, Ministry of Agriculture, Forestry and Water Management, 2004

Other products that can be produced from the processed oil could include lubricants and other specialty oils. The amount of refining and marketing of additional products can add complexity and cost, but also increase potential revenue streams to the operation.

4.2.1 Glycerine

Glycerine constitutes up to 10% of the product created in the processing of biodiesel. Generally, glycerine is a by-product in the production of soaps, fatty acids and fatty esters from vegetable oils and animal fats. Depending on the different stages of the same process of rapeseed oil methyl ester production, glycerine of three different purities (low, medium, high) is produced. In a typical biodiesel plant, crude glycerine has some 80 % purity. The most pronounced variations among purities are the concentrations of water, glycerine, phosphorus and methanol. The processing and production of biodiesel hence creates only a crude form of glycerine, and thus the potential market for this material depends in part on the degree of treatment at the biodiesel facility. If the biodiesel investor decides upon some additional investment to covert crude glycerine to pharmaceutical one at 99,5 % purity, the price of this by-product could raise from 500 to 1.030 €/ton. The degree of treatment that is economically feasible is determined to a large extent by the amount of the by-products produced, or in other words by the biodiesel plant size.

Significant sources of crude glycerine are available from other types of processing operations (including fat splitting, soap making, etc.). These sources are well established, with the quality of the glycerine produced in general being superior to that produced in a biodiesel facility. Thus, from the overall desirability point of view, crude glycerine produced from biodiesel processing is at a lower level and will be valued accordingly. Naturally, it is very important to realistically consider this fact when evaluating the economic potential of glycerine resulting from biodiesel processing.

It is also important to note that the market for glycerine is heavily affected by the oleochemical and biodiesel markets. For example, in the case of a poor year of the agricultural sector producing oil crops (rapeseed, canola, soybeans), glycerine prices will increase due to the lower supply. On the other hand, as the recent example from Germany clearly illustrates how glycerine demand is inelastic: in the case of a rapidly growing biodiesel production the glycerine market could be flooded resulting in a sharp decrease in prices. Hence, if the biodiesel market continues to grow (which is to be expected), the supply of glycerine will eventually start to overwhelm demand and glycerine prices will decline (Figure 4.4.). The expected glycerine price drop will affect the profitability of biodiesel production in the sense that it will be profitable to refine it only in the case of large-scale biodiesel production.

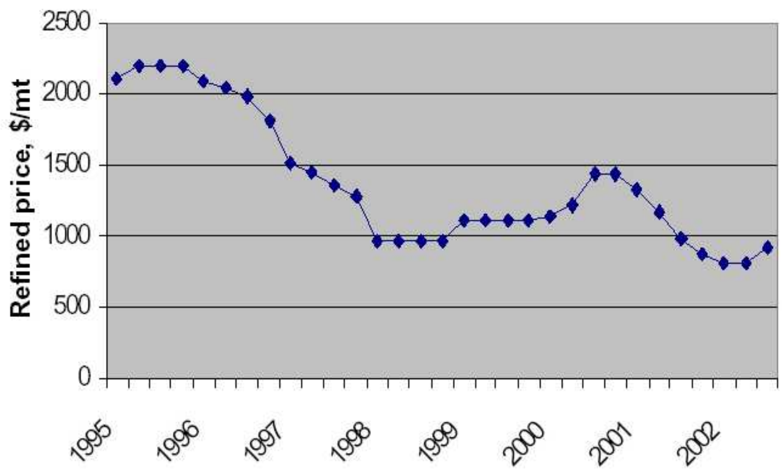

Figure 4.4 *Impact of world biodiesel production on glycerine markets*

Source: Proctor & Gamble, 2003

Presently, all glycerine has been imported to Croatia at average price of 1.000 €/t for use in chemical industry as reported by the Croatian Chamber of Economy.

4.2.2 Seed Meal (Cake)

Seed meal (cake) is the other by-product of the biodiesel production process and it can be used as a valuable livestock feed, depending on the seed type. Soybean meal, due to its higher protein, energy and lower fibre content is ideal for high-energy rations such as broiler, turkey and pig starter feeds. Additionally, the available amino acid levels in soybean meal complements those of corn and other coarse grains in meeting the nutrient requirements of poultry and swine, thus making soybean meal the standard to which all other protein sources are compared.

Rapeseed meal can also used as a livestock feed in varying quantities for cattle, sheep, pigs and poultry, and its present usage is mainly in this area. However, rapeseed meal may have some detrimental effects when fed in large quantities (i.e. fishy tasting eggs if fed in too large a quantity to layers), as reported in the report on oilseed rape and turnip rape produced by the Interactive European Network for Industrial Crops and their Applications.

Other then feedstock, other uses of rapeseed meal can be its direct utilization as fertilizer and combustion material or processing of rapeseed meal for preparation of biodegradable materials.

The main industrial uses of the proteins contained within rapeseed meal are the following:

- Bioplastics
- Adhesives
- Cosmetics
- Encapsulation agents
- Lawn care products

Considering this, the production of protein based products for non-food markets can be based upon extracting protein from existing low value by-products like rapeseed meal. Currently soybean and wheat proteins represent the most important resource for protein production, while vegetable proteins are already used in a number of situations, e.g. plastics and adhesives. Even though their current usage is small, their potential is quite significant.

The meal product portion of the operation is the most important by-product contributing to the profitability of biodiesel production, as shown in Figure 4.3.

In 2004, the production of rapeseed cake amounted 11.250 tons out of which around half was exported which contributed to foreign trade balance with USD 524.690. In the same year, 962 tons of rapeseed cake was imported. Thus, the net contribution of the rapeseed cake at the foreign trade balance was reduced to final USD 353.030, as reported by Croatian Chamber of Economy.

4.2.3 Potassium Fertiliser

Depending on the catalyst used for the biodiesel reaction, using phosphoric acid to separate the co-product results in a catalyst layer that settles to the bottom under the glycerine layer (sodium phosphate if sodium hydroxide catalyst is used, and potassium phosphate if potassium hydroxide catalyst is used), as reported in the material available on the website www.journeytoforever.org.

Large scale biodiesel operations often use potassium hydroxide as the catalyst, because potassium phosphates left after separation can be sold as a fertilizer. The catalyst, either sodium or potassium, can safely be composted. In many ways this is a better option for both catalysts as too much of either sodium or potassium directly applied to the soil can cause soil imbalance that can ruin the soil structure and leave other nutrients unavailable to plants.

However, as and additional point of consideration, the potential amounts of fertilizer production involved, even for a fairly large biodiesel production plant, are very small (Figures 4.2 and 4.3). Another constraint to the value of the fertilizer produced lies in the fact that the material will contain some level of entrained glycerine as moisture. Attempting to upgrade this material in the way to be accepted as a conventional fertilizer typically results in costs that are well in excess of any value that might be received, due purely to economies of scale. Thus from a practical economic standpoint, very little value is generally attributed to this material.

4.3 Key Issues to Sustainable Biodiesel Industry

Considering the fact that currently there is no biodiesel production in Croatia, in order to establish a sustainable national biodiesel industry it is first necessary to identify and analyze the relevant key issues, based on the experience of countries with more advanced and established biodiesel production. The world-wide review of biodiesel production, performed by the Austrian Biofuels Institute for IEA Bioenergy Task 39, provides very valuable information in that regard. The review was performed by approaching targeted active and potential actors in the biodiesel field with a short questionnaire in electronic and hard copy versions, leading to some 280 valid and detailed responses from all over the world. Briefly, the main findings of the review are the following:

1. Legislation: As a required basis for implementation several initiatives for a pace setting legislation were established e.g. by defining market share targets in the European Union (EU), by subsidies to feedstock usage in the USA and by requiring renewable energy usage in Australia, recognising also the importance of reducing greenhouse gas emissions.

2. Feedstock: Rapeseed production on set-aside non-food acreage represented the most important feedstock source in the EU, with recycling oils growing quickly in importance, while soybean was the oilseed of choice in the USA and South America and palm oil is being in consideration in Malaysia.

3. Process technology and engineering companies were striving for continuously improving the required biodiesel quality and for reducing production cost with an increasing number of such companies providing reliable quality at low investment cost.

4. Biodiesel fuel quality reached a level of high quality definition by establishing the European standard EN 14214, the US standard ASTM D-6751-02 and the Australian biodiesel fuel standard, with an effective quality management system in Germany (AGQM).

5. New marketing strategies, which vary by country, as one can observe the pure biodiesel usage, the anonymous blend as well as a “blend & brand” strategy, and

also strategies selling only on a low price, while others are promoting the differential advantages at a higher price.

6. In world-wide production Europe took the lead with more than 1,6 mill t biodiesel produced in 2002 (at capacities of approx. 2,1 mill t), with Germany producing 580.000 t, France 400.000 t, Slovakia 120.000 t (in 2001) and the Czech Republic producing 70.000 t, while the USA were second to Europe with approx. 40.000 t production and Australia being in the phase of establishing 48.000 t production capacity. New initiatives in Brazil, Canada, Malaysia and the United Kingdom may change however this situation quickly."

After analysing the results presented in the world wide biodiesel production review, as well as those presented in the analysis of the best case studies on biodiesel plants in Europe, which presents results relevant to the most important EU biodiesel producers, the following factors were identified as critical in order to establish a sustainable biodiesel production industry in Croatia:

- Feedstock availability and price;
- Site selection;
- Process technology selection;
- Marketing strategy and segment;
- Policies and incentives.

4.3.1 Feedstock Availability and Price

By far the most important input in a biodiesel production plant is the vegetable oils or animal fats used as feedstock. Consequently, feedstock cost is main factor affecting the competitiveness and profitability of biodiesel production, aside from biodiesel final selling price on the market. Considering that, one of the key issues to be examined in detail relative to establishing a sustainable biodiesel industry is the identification and quantification of the current and potential feedstocks (in terms of both availability and price), as well as to summarize factors that may impact the identified feedstocks use for biodiesel fuel.

To decrease the unit production costs it would be necessary to either use a lower cost feedstock or alternately to increase the economic performance of production by carefully choosing location of biodiesel processing plant.

Options to lower the feedstock cost include:

- Utilising recycled edible oils;
- Import of potentially cheaper rapeseed oils from neighbouring countries;
- Import and utilisation of other vegetable oils (e.g. palm oil).

Biodiesel derived from recycled edible oil offers the main advantage in its lower price. Moreover, it has other benefits like the increased security of raw materials supply. Looking specifically at Croatia, the quantities of rapeseed oil produced annually are at the moment insufficient for starting a larger industrial production; hence recycled edible oil could serve as an important additional resource especially in the initial phase of biodiesel production in Croatia. Several small private companies have started collecting waste oil in various parts of the Croatian coast and islands, notably Istria and Dalmatia. However, the major reason for this activity is not the utilisation of the collected oil either for biodiesel or as animal feed, but the resulting environmental problems arising from its disposal. McDonalds restaurant in Zagreb is currently the only known to collect waste oil specifically for biodiesel, however the collected oil is exported to Austria.

In general, it can be noted that rapeseed-oil is by far the leading feedstock for biodiesel production in Europe, and this position has become even stronger in the last two years, when analysing the two leading nations Germany and France. There can be observed, though, a clear trend towards a larger variety and to tailor-made blends of different feedstock sources, such as sunflower-oil, recycling oils and animal fats but also imported soy-oil and palm-oil.

Specific issues related to feedstock availability and price include:

- Level of supply security in feedstock volume (including options of internal or external feedstock supply),
- Level of supply security in chasing cost (including the possibilities to sign a long-term contract with established suppliers in order to insure adequate feedstock),
- Flexibility in processing various feedstock sources,
- Ability to choose cheapest feedstock options,
- Flexibility in storage facility options.

These issues have to be carefully considered in the planning phase of a specific biodiesel production plant.

4.3.2 Site Selection

The selection of the site for biodiesel production could have important implications on both profitability and sustainability of the process. For example, the proximity of the production site to an active freight rail system could ensure the lower transportation costs for both the feedstock delivery and the sale of the produced biodiesel. However, in the case of transportation with a railway, it is also important to consider other questions such as whether the site has a rail siding installed with sufficient length, the system which will be utilised for rail cars loading/unloading and the possible frequency of rail switches. The other possibility to lower transport costs is the placing of the production site in the vicinity of a sea or river harbour, which is especially interesting in the Croatian case considering its geographic placement.

Other issues which have to be carefully considered when planning the site for building the production plant include:

- Existing and possible utility connections:
    - Power supply;
    - Water supply;
    - Sewer connection;
    - Natural gas supply;
- Required legal permits:
    - Building permit;
    - Air quality permits;
    - Permits related to the use of possible hazardous materials;
    - Waste water permits;
- Extent in exploiting synergies of existing industrial areas:
    - Chemical industry park (e.g. methanol supply)
    - Oilseed crushing plant
    - Shared personnel and maintenance

4.3.3 Process Technology Selection

The process used for the production of biodiesel is a well known chemical process that has been used for decades in the soaps and detergents industry. As such, the biodiesel industrial process technology has advanced significantly since the early days of biodiesel production in 1988. Generally it can be observed that in the early phases of starting biodiesel projects in a country experiments with rather simple process technologies with single-step transesterification and only basic purification are tested, which do not achieve the required high quality needed for the modern diesel engine.

The selection of the specific technology which will be utilised depends on a variety of factors (including size, feedstock quality, feedstock flexibility, etc.) and there are quite a few ‘off the shelf’ readily available technologies on the market today. However, the increasing requirements for producing high quality according to strict biodiesel fuel standards has been the driving force for switching from batch processing to continuous process technologies with fast liquid-liquid separation of methyl-ester and glycerine and with accurate cleaning steps for the final biodiesel meeting at least the EU standard EN 14214 or the US standard ASTM D6751, or possibly better than that (e.g. in water content, total contamination). Whatever process or method of operation is chosen, the critical factors in the determination of the quality of the produced biodiesel, insured through the standard for biodiesel, are the following:

- Complete reaction to the mono alkyl esters;
- Removal of the free glycerine;
- Removal of residual catalyst;
- Removal of reactant alcohol;
- Absence of free fatty acids.

The need to meet the quality standard for biodiesel cannot be over-emphasized, especially for the items mentioned above. The experience from the US market shows that of the relatively few problems that have been experienced with biodiesel, most of them can be traced back to biodiesel not meeting ASTM standards. The biodiesel leaving the production plant should also meet moisture, cloud point, pour point, cold filter plug point specifications as well as colour specifications as agreed to with the buyer.

Taking into account the requirements mentioned above, it can be concluded that a critical factor for a biodiesel producer is to purchase a well designed plant with adequate automation, as well as with a fully equipped laboratory with a qualified team of chemists that understand the chemistry and unit processes in the plant well enough to troubleshoot feedstock and process issues and give the operations staff the assistance they need to maintain acceptable quality on an ongoing basis. The investment into this additional equipment will naturally be economically feasible only for plants with larger production capacity, and in that regard it is important to note that most of the existing high-tech biodiesel plant manufacturing companies offer plants that are economically feasible for more centralized large-scale production, usually utilising a continuous process.

4.3.4 Market Evaluation and Strategy

A critical factor for establishing a sustainable biodiesel industry is performing a thorough evaluation of the potential biodiesel market, which includes the following:

- Assessment of the potential market size;
- Analysis of market segments;
- Review of distribution options and channels;

- Establishment of market development priorities and related strategies;

The assessment of the current market size as well as the potential development of biodiesel demand and a brief analysis of the market segments (public city transport and road transport) for Croatia is reported in the previous chapters.

Based on the market evaluation it is possible to define market strategies which will be used for the sale of the produced biodiesel. Looking at the countries with a well developed biodiesel industry, quite a variation of different marketing approaches and strategies can be observed, but also each biodiesel producer might have a specific strategy depending on the conditions of the local market. However, in general the market strategies utilised could be divided into two main groups, which can briefly be described as follows, according to the worldwide review on biodiesel production by the Austrian Biofuels Institute:

a) Commodity Strategy:

- Biodiesel is sold as a pure fuel at separate pumps, but without visible product differentiation in comparison to the competitive mineral diesel. In this case, biodiesel is usually sold at lower price than the one of mineral diesel (e.g. Austria). In that case, the consumer preference of biodiesel over mineral diesel is price-driven only.

- Another commodity strategy is to blend biodiesel in refineries into mineral diesel up to 5% and sell it unlabelled at fuel pumps (e.g. France), i.e. with no information to the customer. The main advantage of this approach is that it is the easiest way to put biodiesel on the market as it does not require any new distribution channels like separate pumps.

b) Quality Strategy:

- Quality seal strategy: biodiesel is sold as a 100% pure fuel and is differentiated as a quality product, which is highlighted by a quality seal at the pump (e.g. Germany). The utilisation of the quality seal strategy allows the biodiesel to be immediately identifiable as a high quality product by customers, in which case the consumer preference is not only price driven, but also quality driven.

- Brand Strategy: the fuel (pure or blended between 1 – 20% with mineral diesel) is differentiated by a specific trademark (e.g. United Kingdom: “Bio-Plus”, “GlobalDiesel”). Differential advantages by using the special brand strategy are promoted and linked to a differentiating pricing strategy.

Considering that currently the market for biodiesel in Croatia is about to be developed, the commodity strategy market approach is considered to be the better option for potential biodiesel producers.

4.3.5 Policies and Incentives

The Kyoto Protocol, signed in 1997 and entered into force on February 16, 2005 requires from the European Union a commitment to reduce, by 2008 to 2012, greenhouse gas emissions by 8 percent from the 1990 level. The European Union is now at the cusp of a transition from a stage of experimentation with biofuels to a stage of early implementation. On May 14, 2003, the EU Commission adopted the Directive 2003/30/EC on the promotion of the use of biofuels and other renewable fuels for transport that sets for member states the target that at least 2 percent of petrol and diesel used for motor transport should be from renewable sources. The percentage will increase to reach 5,75 % in 2010. However, it is important to note that the Directive 2003/30/EC on the promotion of biofuels specifies only a reference value for the indicative targets of biofuels used for transport purposes, thus leaving to each country the liberty to set its own indicative target as well as define and set the necessary policies and incentives to reach this target. The EU Commission will monitor the member states, which will have to justify where they may not have met the targets. This directive is for sales and not production, so a country could import biofuels rather than produce their own biofuels to comply with the directive. However, to entice sales, Europeans may find it not to be politically expedient to give tax advantages to imported product rather than developing domestic biofuel industries in their individual EU countries.

The Directive 2003/96/EC of 27 October 2003 restructuring the Community framework for the taxation of energy products and electricity directs that member states are allowed (but not mandated) to give fiscal resources to promote biofuels. According to the Directive, detaxation should be proportional to biofuel content and there should not be overcompensation for biofuels, and support levels should take into consideration the costs of raw materials. With the adoption of Directive 2003/96/EC member countries must follow up with implementing laws for the directives to have there intended effects, while the new taxation system replaces the old system where a number of countries have been allowed special exemption to experiment with reducing motor fuel taxes in order to encourage consumption of renewable fuels.

Another regulated issue regulated is the reduction of risks caused by harmful exhaust emissions, as required by the Directive 2003/17/EC relating to the quality of petrol and diesel fuels, which contains the environmental fuel quality specifications for petrol and diesel fuels in the Community with the main focus on sulphur and for petrol on lead and aromatics, as well as the EURO-emission standards for personal cars and heavy duty vehicles.

Looking at the various EU countries, in France the tax reduction for vegetable oil methyl ester is 35 eurocents per liter. For ethanol, the tax reduction is 38 eurocents per liter. The normal mineral fuel tax in France is 58 eurocents per liter, thus the remaining tax for vegetable oil methyl ester is 23 eurocents per liter and for ethanol it is 20 eurocents per liter. In order to prevent excessively large budget implications, biodiesel production units must agree to production oversight and limitations. The Government of France only allows reduced tax levels to be paid on authorized amounts of biodiesel or ethanol from specified production facilities. Authorized production for 2002 totalled 318.000 tons from five facilities. Biodiesel producers hope to have an official agreement of an additional amount of 70.000 metric tons by the end of 2003. There is no labelling requirement for biodiesel, so motorists in France are normally not aware when they have biodiesel in their vehicle: however, one fuel company recently began selling a biodiesel blend under the brand name of “Ecodiesel” in order to take advantage of concern for the environment. The percentage of biodiesel in blends is normally around 2 or 5 percent, but may increase to 30 percent for captive fleets of approximately 4.000 vehicles (e.g. city buses or highway maintenance vehicles) in 30 communities across the country.

In Italy, the 2001 Financial Law (L388/2000) introduced a 3-year study in excise tax reduction on some products for the purpose of safeguarding the environment. Ethanol and ETBE (ethyl-tertiary-butyl ether) obtained from agricultural sources are given a reduction in excise tax of 29 eurocents per liter. The available budget for this tax reduction is about 15,5 million euros. This law also increased the amount of excise free biodiesel from 125.000 tons to 300.000 tons. The Ministry of Industry is authorized to start a pilot project, to promote the use of pure biodiesel in the motor transport system. The expressed main objectives of Italian bioenergy development programs are the decreasing of fossil fuel imports (greater than 80 % of total primary energy consumption) and fulfilling the commitment, undertaken within the Kyoto Protocol, to reduce CO_2 emissions by a factor of 6,5 % with respect to the 1990 level.

In Germany, the current program of development of the biodiesel industry is not a special exemption from European Union law, but rather is based on a loophole in the law. The motor fuels tax in Germany is based on mineral fuel. Since biofuel is not a mineral fuel, it can be used for motor transport without being taxed. Unlike France and Italy, where biodiesel is blended with mineral diesel, biodiesel sold in Germany is pure, or 100 %, methyl ester. There is no mineral tax on biodiesel in Germany, so when diesel prices were high and vegetable oil prices were low biodiesel becomes very profitable. Germany is expected to have over 1 million tons of production capacity by the end of 2003, exceeding demand at current prices, despite the motor fuel tax exemption. Sales, which had been accelerating rapidly, disappointed proponents in 2002 when new users began experiencing some of the fuels limitations.

In Austria, in accordance with Article 4(1)(7) of the Mineral Oil Tax Law, fuels produced from biogenic substances are exempt from mineral oil tax. The blending of up to 2% biodiesel with diesel is also exempt from tax. There is also tax reduction for the blending of up to 5% biogenic fuels with petrol. The proposal for Article 6a which was amended in the framework of the draft report on the revision of the Fuels Ordinance requires those who are subject to the substitution requirement to place on the market from 1 April 2005 a proportion of 2,5% of biofuels or other renewable fuels calculated on the basis of the total energy content of the petrol and diesel placed on the market in the transport sector each year by those subject to mineral oil tax in Austria. This proportion should increase to 4,3% from 1 April 2007 and to 5,75% from 1 April 2008. Persons subject to the substitution requirement are any taxable persons in accordance with Article 22 of the Mineral Oil Tax Law, who are liable to tax for petrol or diesel in accordance with Article 2(1) and (2) of the Fuels Ordinance.

As the main conclusion after analysing the various EU countries that have already defined the overall framework to promote the use of biofuels in the transport sector, two key measures can be identified:

- Tax exemption, usually in the form of excise duty relief for biofuels;
- Substitution requirement, formulating obligations to place on the market a specified proportion of biofuels.

In general it can be noted that the first measure is more suitable for countries with a relatively poor developed biodiesel production such as in the Croatian case, while the combination of the first and second measure is more suitable for countries with a well developed biodiesel production industry and biodiesel market.

4.4 Conclusions

Chemically, biodiesel is fatty acid methyl ester. The chemical process for producing methyl ester is well known and is considered quite simple. Vegetable oil and methanol are combined in a reaction cylinder in the presence of a catalyst. Currently three basic chemical processes are being used to produce biodiesel:

- Base catalyzed transesterification of the oil with methanol.
- Direct acid catalyzed esterification of the oil with methanol.
- Conversion of the oil to fatty acids, and then to alkyl esters with acid catalysis.

These can be either batch or continuous processes and currently the most common in use, is the base catalyzed transesterification of the oil with methanol, as it is the most cost-effective due to several reasons. However, the process utilising the conversion of the oil to fatty acids and then to alkyl esters is more adoptable to different feedstock than other two. The selection of the specific process and technology to be used for biodiesel production depends upon a variety of factors including the size of the plant, feedstock type and quality, requirements regarding feedstock flexibility, and others.

As part of the process of biodiesel production several by-products are also generated, which include glycerine, seed meal (cake) and potassium sulphate fertiliser. These by-products have a significant economic value and contribution to the cash flow of a biodiesel production plant and thus might positively influence the biodiesel market price and its competitiveness.

One part of glycerine is produced to every 10 parts of methyl ester and in the typical biodiesel plant crude glycerine is produced which is about 80% pure, water being the principal impurity. Glycerine of this quality has a price of approximately €500 per ton. However, with some additional investment, crude glycerine can be converted to pharmaceutical glycerine at 99,5% purity, which carries a price quoted at €1.030 per ton. Lastly, it is important to note that the market for glycerine is heavily affected by the oleochemical and biodiesel markets, as the recent example from Germany clearly illustrates the inelasticity of glycerine demand: in the case of a rapidly growing biodiesel production the glycerine market could be flooded resulting in a sharp decrease in prices.

Seed meal (cake) is the other by-product of the biodiesel production process and it can be used as a valuable livestock feed, depending on the seed type. Rapeseed meal can be used as a livestock feed in varying quantities for cattle, sheep, pigs and poultry, however it may have some detrimental effects when fed in large quantities. Other then feedstock, other uses of rapeseed meal can be its direct utilization as fertilizer and combustion material or processing of rapeseed meal for preparation of biodegradable materials. Industrial uses for proteins contained within the rapeseed meal include bioplastics, adhesives, cosmetics, encapsulation agents and lawn care products.

After analysing the experience of the most important world-wide biodiesel producers with a special focus on leading EU producers, the following factors were identified as critical in for establishing a sustainable biodiesel production industry:

- Feedstock availability and price;
- Site selection;
- Process technology selection;
- Marketing strategy and segment;
- Policies and incentives.

The selection of the site for biodiesel production could have important implications on both profitability and sustainability of the process. Issues which have to be carefully considered when planning the site for building the production plant include:

- Connection to transport routes (river/sea harbour, railway connection, highway connection);
- Existing and possible utility connections (power and water supply, sewer connection);
- Required legal permits (building permit, air quality permit, waste water permit, hazardous materials use permit);
- Extent in exploiting synergies of existing industrial areas (chemical industry park, oilseed crushing plant, shared personnel and maintenance).

An important step in establishing a sustainable biodiesel industry is performing a thorough evaluation of the potential biodiesel market, and based on that evaluation to formulate strategies for the marketing of biodiesel. Looking at present market strategies in countries with a well developed biodiesel industry, quite a variation of different approaches can be observed, but also each biodiesel producer might have a specific strategy depending on the conditions of the local market.

Looking at the various EU countries that have already defined the overall framework to promote the use of biofuels in the transport sector, two key measures can be identified:

- Tax exemption, usually in the form of excise duty relief for biofuels;
- Substitution requirement, formulating obligations to place on the market a specified proportion of biofuels.

5 MACRO ECONOMIC ANALYSIS

5.1 Assumptions and Methodology

The quantification of the macroeconomic effects of biodiesel production can be performed through the input–output analysis. The latest available input–output table for Croatia is the one made in 1997 with the RAS method. Compared to other methodologies, the input-output analysis has the advantage that takes into consideration all indirect effects of the intermediate input links and estimates the multiplier effect achieved due to the new economic activity. This means that not only the additionally stimulated demand for goods and services is quantified, but also the additional tax revenue, to say the least.

Nevertheless, there are some constraints in the analysis itself. Firstly, the input-output analysis does not show the effects of the economy of scale, production coefficients are fixed (production technology is fixed) and do not recognize capacity limitations. Due to mentioned constraints, here it will be assumed that a single factory produces 50.000 tones per year of biodiesel. In that way, by building another factory, the capacity limitation will be reached as economy of scale will be fully exploited plus production coefficients can remain fixed. Lastly, it is important to note that the input–output analysis is a static study and is neither influenced by future market reactions nor could be used as forecasting method.

Keeping the above in mind, there are some general assumptions used in this study:

1. One biodiesel processing plant will have the capacity of 50.000 tones per year;

2. Oil pressing and esterification will be done in the same (annex) factory;

3. Building and storage facilities already exist;

4. Biodiesel will be blended with mineral diesel in the ratio of 5/95%;

5. Biodiesel will be exempted from excise tax and HAC fee (Croatian Highway fee).

In order to assess all direct and indirect effects of production of biodiesel, it is necessary to establish the biodiesel production chain – from rapeseed growing to the wholesale of biodiesel. The biodiesel production chain can be divided into four stages which will be analyzed in detail in the following chapters:

1. Rapeseed growing – production of seed;

2. Seed preparation – storage;

3. Oil pressing and esterification – production of RME plus rape seed cake, glycerol and potassium fertilizer as by-products.

4. Blending and sale – substitution of mineral oil diesel with diesel (EN590).

The production of biodiesel furthermore results in valuable by-products whose impact should be calculated as well. The analysis will take into account the effect of rapeseed growing to the expense of the alternatives such as growing of traditional basic crops like wheat and maize, but also changes in Government revenues structure and amount due to subsidies differences. In this sense, the aim of the analysis is to detect changes in the following macroeconomic categories:

- GDP
- Employment
- Government income
- Subsidies
- Imports
- Private consumption
- Income from employment
- Income from property and entrepreneurship.

Despite the fact that this study does not cover environmental impact assessment, the positive long-term benefits towards nature and human health from replacement of mineral diesel fuel with biodiesel should be kept in mind and assessed separately.

5.2 Agricultural Part of Biodiesel Production Chain

Having in mind one of the main characteristics of agricultural market, notably price instability, the analysis of the biodiesel production chain is based on 3 price scenarios in respect to the main input resource – rapeseed, while the prices of other inputs are held constant. Starting from the first stage, the price scenarios are denominated as low, medium and high price scenarios. Since there is no biodiesel market in Croatia, the biodiesel production chain will be treated as any other profit oriented investment.

For the production of 50.000 tons of biodiesel per year, the necessary quantity of rapeseed as the input resource amounts to approximately 150.000 tons, which takes into account the expected loss due to the harvest and storage of around 10%. The assumed yield of 3 tons or rapeseed per hectare results in the needed planting area of 50.000 hectares. Further, it is assumed that approximately one half of the needed area will be planted on the idle land and the other half will be further distributed between two traditional crops – wheat and maize growing areas. The required planting amount of seeds is estimated as 5 kg/ha, which makes approximately 2.500 tons of planting seed.

The idle land tax is described by Law on Local and Regional Communities Financing (O.B. 117/93, 33/00, 73/00, 59/01, 107/01, 117/01, 150/02 and 147/03) and General Tax Law (O.B. 127/00, 86/01, 150/02). The law penalises the owner or concession holders that are neglecting the agricultural area more than a year. This taxation represents the local authority's income and each local community decides on the amount within the classification and limits recommended by the law. On arable land, the ceiling amount is 500 HRK/ha and it varies from one local community to another. In the analysis the maximum penalty fee was used as a lump sum.

On the remaining cultivated area it is assumed that rapeseed will replace the traditional cultures – wheat and maize in the ratio of 1:1. The subsidy for rapeseed is about three quarters higher than those for wheat and maize and this is the main reason for the highest margin. The reason could be found in the fact that there is excess demand for edible plant oil of about 71% although the percentage was much smaller in the pre-war period. On the other hand, there is excess supply in wheat production and sufficient supply in maize. However, in order to protect the farmers' income, those traditional cultures are still subsidised. Only significantly higher margin could motivate farmers to switch from the traditional cultures to new ones attributable to major reluctance to changes from farmers' side.

Table 5.1 shows the main assumptions made for the analysis of the agricultural production of rapeseed.

Calculating the effect *with and without* the rapeseed production, as expected, increased all total values although there are some negative changes in intermediate consumption (seeds and fertilizer inputs) and loss in taxes due to higher subsidies for rapeseed. However, additional economic activity covered the losses.

It is assumed that the same mechanisation, labour price and fuel amount per hectare are needed for all cultures. Other values are taken from the *Agricultural Input Market* (no. 11, year 2004). Since annual price variations of inputs and outputs have a considerable effect on the outcomes, the results shown here should be taken as static, with stable prices and no time framework.

Rapeseed growing will increase the blossoming area, which will have positive externalities for apiculture as consequence. However, highly uncertain approximations and assumptions on establishing new bee colonies, transport and commercial service plus job creation etc. should be made in order to monetarise the impact of rapeseed production on bee keeping. Thus, to avoid misleading results, apiculture benefits from increased blossoming area will not be taken into account in the calculations.

The value of transportation services from the farm to the seed storage is estimated to be 58.500 HRK for the total amount and of harvested rapeseed, calculated in the difference to transportation services of wheat and maize. Commercial services are transferred and calculated in to the next step of rape sales to the rape oil pressing plant.

Table 5.1 *Assumptions on agricultural production of rapeseed*

Cultivation area for rape	25.004 ha on idle land 24.996 ha on cultivated land	
Marketable rape yields	3 t/ha in total 150.000 t	
Competing production processes	On idle land: taxation penalty of 500 HRK /ha On cultivated land: wheat and maize growing	
Prices and performance of rape:	Wholesale price *low*:	1.830,00 HRK /t
	Wholesale price *medium:*	1.891,00 HRK/t
	Wholesale price *high*:	1.952,00 HRK /t
	Margin *low*:	4.410,33 HRK /ha
	Margin *medium:*	4.593,33 HRK/ha
	Margin *high*:	4.776,33 HRK /ha
Lack of performance on idle land:	Penalty fee of	500,00 HRK /ha
	In total	12,5 millions HRK
Prices and performance of wheat:	Wholesale price *high*:	1.268,80 HRK /t
	Margin *high*:	49,63 HRK /ha
Prices and performance of maize:	Wholesale price *high*:	1.634,80 HRK /t
	Margin *high*:	3.963,82 HRK /ha

5.3 Rapeseed Preparation and Storage

In some studies and macroeconomic analyses the step of seed storage is omitted. However, as existing plant oil facilities are generally inefficient, here an investment in new equipment will be assumed to modernize the storage stage. In that respect, the loss of the stored amount will be decreased to less than 10%. Table 5.2 shows the assumptions used for the analysis of the rapeseed storage stage of biodiesel production.

Table 5.2 *Assumptions and data on seed storage*

Stored amounts		150.000 t
Final amount	Total:	137.250 t (10% loss)
Rapeseed price	Low:	2.062,58 HRK/t
	Medium:	2.129,32 HRK/t
	High:	2.196,05 HRK/t
	Margin low:	282.742,25 HRK
	Margin medium:	292.620,00 HRK
	Margin high:	301.362,50 HRK
Storage costs	Low:	2.060,52 HRK/ton of seeds
	Medium:	2.127,18 HRK/ton of seeds
	High:	2.193,85 HRK/ton of seeds
Total investment in fixed assets		1.685.000 HRK

For the purpose of this analysis, it is assumed existing building and storage capacities and only mid-term fixed asset was included: transporters, ventilations system and active temperature control system. The investment in the fixed asset has the ratio of 58,16:41,84 in favour to import vs. intermediate consumption which represents domestic origin and actually creates the multiplier effect. The price of rapeseed from storage facility to the rapeseed oil processing plant strongly depends on the farmers' price. Therefore, three levels of selling prices are defined based on the calculation where profit equals 0,01% of the total costs. This assumption was made to justify the economic activity from the investor's point of view and to proceed with the macroeconomic analysis.

5.4 Rapeseed Oil Pressing and Esterification

For the analysis of the pressing and esterification stage it is assumed that the investor will make a cost efficient annex plant, hence the oil pressing and esterification will take place in the close area. Depending on the rapeseed prices from the storage facility to the annex plant, the price of RME also varies as it makes around 56% of total costs and 65% of operational costs. Referring to that observation, there are different levels at which the production of pure biodiesel is profitable. Including all by-product sales at current market prices and 0,01% of total costs as profit margin, there are three levels of RME sale prices. This assumption was made to take into account the data uncertainties regarding price changes in both input and output prices by considering all prices of rapeseed and RME exogenous. Table 5.3 shows the assumptions made for the analysis of the oil pressing and esterification stage of biodiesel production. The last assumption is that all by-products of the biodiesel production chain are used in Croatia.

Comparing prices per litre of pure biodiesel and mineral diesel, the outcome complies with actual situation on the biodiesel market: the prices of biodiesel are higher from 11 to 16% than mineral diesel prices per litre, depending on the price scenario. If the lower performance of biodiesel is included, the price difference reaches 18 to 24%.

Table 5.3 *Assumptions and data on oil processing and esterification*

Processing amounts		137.250 t
Oil yield (refined)	App. 38% of the raw material input:	51.820 t
By-products production:	Cake: Glycerol: Potassium sulphate fertilizer:	85.430 t 9.700 t 750 t
By-product prices*	Cake: Glycerol: Potassium sulphate fertilizer:	1.150 HRK/t 1.290 HRK/t 1.371 HRK/t
RME production:	 Density: equals	50.000 t 880 kg/m^3 56,8 million litres
Processing costs:	Low: Medium: High:	10.170,18 HRK/ton of RME 10.353,38 HRK/ton of RME 10.536,55 HRK/ton of RME
RME selling prices:	Low Medium: High:	8.066,30 HRK/t (7,0983 HRK/l) 8.249,92 HRK/t (7,2599 HRK/l) 8.433,54 HRK/t (7,4215 HRK/l)

*Source: *Grains and oil seed market*, Nr. 49, Ministry of Agriculture, Forestry and Water Management, 2004

5.5 Changes in Government Revenues

The replacement of mineral diesel with biodiesel introduces two direct negative impacts on Government revenues:

- Firstly, the Government loses directly 53 million HRK from excise tax, which is about 0,7% of total current Governmental revenue from excise taxes. Taking into account the lower energy value of biodiesel compared to mineral diesel the produced amount biodiesel of 56 millions litres replaces approximately 53 million litres of mineral diesel (the actual amount of not sold mineral diesel and, therefore, not taxed with excise tax and HAC fee is 52.840.990 litres);

- Secondly, additional loss in revenue of public company, Croatian Motorways Ltd.[5], amounts to 21 million HRK due to the HAC fee exemption.

Under the assumption that the retail price of diesel (EN590) will be formed in the same ratio as blending, the prices of biodiesel on the gas stations would be 6,4253; 6,4334 or 6,4416 HRK per litre, depending on the price scenario, which is from 0,03 to 0,05 HRK higher than the price of mineral diesel. The cost structure of diesel (EN590) retail prices is shown in the Table 5.4.

***Table 5.4**. Cost structure of hypothetical of diesel (EN590) retail price*

Price structure (HRK/l)	Mineral diesel (95%)	Biodiesel (5%)			Diesel (EN590)		
		Low	Medium	High	Low	Medium	High
Retail price	6,1559	0,3549	0,3630	0,3711	6,4253	6,4334	6,4416
VAT	1,1101	0,0640	0,0655	0,0669	1,1586	1,1601	1,1616
HAC fee	0,4000	0,0000	0,0000	0,0000	0,3800	0,3800	0,3800
Excise tax	1,0000	0,0000	0,0000	0,0000	0,9500	0,9500	0,9500
Wholesale price	3,6458*	0,2909	0,2975	0,3042	3,9367	3,9433	3,9500

*Import price of oil: 48,73 USD/bbl

There are two strong impacts on the obtained prices of pure biodiesel: (1) feedstock prices and (2) biodiesel processing plant capacity. The initial assumption due to the limitations of the methodology applied was that the whole amount of biodiesel would be produced in one processing plant, and other assumptions regarding the blending of biodiesel with mineral diesel are shown in Table 5.5. The prices of biodiesel calculated here represent the lower boundary for the present technological level and all biodiesel-processing plants with less capacity would have higher prices. On the other hand, the whole biodiesel production chain is based on hypothetical reactions of market forces plus there were no additional Governmental interventions specially

[5] Croatian Motorways, Ltd (Hrvatske autoceste d.o.o., www.hac.hr), a limited liability company for operation, construction and maintenance of motorways, was registered and started its business activity on April 11, 2001, as one of two legal successors of Hrvatske uprave za ceste. The company is 100% owned by the Republic of Croatia.

created to enhance biodiesel production. The only Governmental intervention special to biodiesel appeared at the retail sale level which was mineral tax exemption.

Table 5.5 *Assumptions regarding the blending of biodiesel with mineral diesel*

Blending ratio	Total amount of pure biodiesel: Substitution equivalent of diesel: Total amount of diesel for blending: Total amount of diesel (EN590):	56 million l 52 million l 1.117 million l 1.174 million l
Substitution	Total amount of diesel (EN590): Substitution equivalent to diesel:	1.174 million l 1.170 million l
Retail price of mineral diesel		6,39 HRK/l at gas station
Hypothetical selling prices of pure biodiesel	low medium high	7,09 HRK/l 7,25 HRK/l 7,42 HRK/l
Hypothetical retail prices of diesel (EN590)	low medium high	6,42 HRK/l 6,43 HRK/l 6,44 HRK/l

The total Governmental loss of 73,990 million HRK could be mitigated partially by gains from taxes, such as profit, income and VAT tax, originated from new economic activity, as shown in Table 5.6.

Income from employment and entrepreneurship are actually multiplier effect due to the new or increased economic activity. It depends on the labour intensity of the business activity in question as well as intermediate consumption change due to the investment. Income from employment indicates total change in income caused by a one monetary unit, Croatian Kuna, change in demand. Within the methodology standard for input-output analysis, multiplier effects are solved for the change in the final demand as total income (value added) over direct effects. Biodiesel production, given the assumptions, would generate from 112 to 124 mil HRK from employment along the biodiesel production chain and some 5,7 to 6 mil HRK from entrepreneurship. Unusually high difference between those two incomes is caused by subsidies at the agricultural part of biodiesel production that have inflated income from employment.

Table 5.6 Changes in Governmental revenues (in million HRK)

	Low Scenario	Medium scenario	High Scenario
HAC fee	-21	-21	-21
Excise tax	-52	-52	-52
Income from employment	112	118	124
Income from entrepreneurship	5,7	5,9	6
Additional gains of the Government (tax refluxes)	+11 (15,1%)	+13 (17,8%)	+15 (20,5%)
Total loss in taxes	-62	-60	-58

What cannot be expressed in real numbers due to the data unavailability is that the foreign trade balance would be changed in favour to the domestic production, too. After the increased import of specialised equipment necessary for erection of biodiesel processing line in the base year, national imports would decrease for values of glycerin, cake and crude oil related to the biodiesel production.

5.6 Conclusions

The final output of the input-output analysis is a set of multipliers generated due to the changes in the economy. However, one should be aware that multiplier effect might ignore foreign economic effect (import) and, actually create marginal propensity to import. In this macroeconomic analysis, it has been assumed that all raw materials come from domestic origins and only those assets that are not produced domestically would be imported. Even with this strong assumption that neglects cost minimizing attitude, investment prevails in favour to import in all stages of biodiesel production chain but retail sale. It would be wrong to assume that an increase in final aggregate demand, as the case here, would automatically raise the real national output. It might even generate inflation as the money would be needed for import. On the other hand, Croatia has the potentials to meet the increase both in labour, land and production. Theoretical pros and cons could have their ground on their both sides.

Given the assumptions, one single large-scale biodiesel plant of 50.000 t/yr capacity would produce pure biodiesel at price from 7,09 to 7,42 HRK/l. It is reasonable to expect increase in prices per litre at any decrease in capacity as biodiesel production strongly depends on economies of scale and feedstock prices.

When blending pure biodiesel with mineral diesel in ration of 5:95, assuming the same retail price structure for mineral diesel and exise expemption on the biodiesel part, the prices vary from 6,42 to 6,44 HRK/l, depending on the price scenario. In other words, biodiesel blend retail price is 0,55 – 0,80% higher than mineral diesel.

Government would loose directly 53 million HRK from excise tax, which is about 0,7% of total current Governmental revenue from excise taxes plus 21 million HRK due to the fee exemption from the public company, Croatian Motorways Ltd. The Government could mitigate its losses by tax refluxes originated from the newly created economic activity from 11 to 15 million HRK.

6 POLICIES, FINANCIAL MECHANISMS AND MARKETING STRATEGY PROMOTING BIODIESEL PRODUCTION

6.1 Present and Options to Increase Feedstock Supply

EU experiences showed that in the early 1990's, when the biodiesel industry was incurring heavy start-up costs, the contract price for rapeseed used in biodiesel manufacture was much lower than for rapeseed used for food. This was possible because rapeseed for biodiesel was grown on set-aside land where the growing of crops for food and feed are not allowed. Farmers, with no better option, were willing to produce oilseeds (primarily rapeseed) under contract for less than the food use market price. The amount of oilseeds, which can be grown on set-aside land in Europe, is restricted by the Blair House Agreement. For a farmer to raise oilseeds on set-aside they must sign a contract with a buyer who registers the contract with the appropriate national government agency. However, since 1998, contract prices have been similar to cash prices. Contract prices are set prior to planting; so consequently, market prices can move higher or lower than any particular contract price.

Because of the European's commitment under the Blair House Agreement to limit production of oilseeds on set-aside land to one million metric ton soybean meal equivalent, the expanding biodiesel industry has reached the point where it must now use oilseeds from non-set-aside land, imports of oilseeds, or imports of vegetable oil. Some biodiesel producers, when they do not have enough contract rapeseed, purchase rapeseed oil. This minimizes accounting difficulties that would result from trying to keep contract rapeseed separate from non-contract rapeseed.

The reformed EU Common Agricultural Policy adopted in June 2003 sets a carbon credit payment of €45 per hectare for farmers for growing non-food crops. The payments will be for non-set-aside land only. Oilseed growers believe this subsidy will be insufficient to induce the production of industrial crops on a sustained basis, and believe that a €100 per hectare payment for growing non-food crops would be more appropriate.

With the purpose of supporting agricultural and fishery production in the Republic of Croatia state budget funding is secured on the basis of the Law on Financial Incentives and Compensations in Agriculture and Fishery (O.B. 29/99, 105/99, 46/00, 101/00, 12/01, 13/02), the Law on the State Support to Agriculture, Fishery and Forestry (O.B. 87/02, 117/03, 82/04, 12/05), the Law on the Procedure for Eligibility to Receive Financial Incentives and Compensations in Agriculture and Fishery (O.B. 53/00, 98/00, 17/01, 24/01, 71/01, 68/02, 94/02).

The Law on Financial Incentives and Compensations in Agriculture and Fishery regulates the kind and the size of financial incentives and compensations in agriculture and fishery, determines the areas eligible for certain enhanced incentives and identifies the users eligible for receiving financial incentives. According to this law, production of oil crops makes users eligible for financial incentives.

Under article 21, subsection 2 of the Law on Financial Incentives and Compensations in Agriculture and Fishery, the Ministry of Agriculture, Forestry and Water Management is to draw up an Operational Planting Plan determining total production area that is eligible for the system of incentives per hectare of production area, as well as the spread of the determined areas through the counties.

Products and by-products from oil industry used in livestock feed are seed cake, crushed oil seed and seed shells. The Regulations on the Quality of Livestock Feed (O.B. 26/98), as well as the Regulations amendments (O.B. 120/98, 55/99, 76/03), define nutritional features of seed cake, crushed oil seed and seed shells that make them eligible for use in livestock feed. The use of these by-products is regulated by the Law on Food (O.B. 117/03), the Law on Veterinary Practice (O.B. 70/97) and the Regulations on the Conditions of the Facilities for Production and Storing of Animal Feed (O.B. 159/98).

After the break out of Spongiform Encephalopathy, the Decree was issued forbidding the import in to the Republic of Croatia of high-risk tissue, livestock feed of animal origin and ready livestock feed containing components of animal origin (O.B. 11/01), also the Decree forbidding the use of ruminant protein (apart from milk and dairy products) in ruminant feed (O.B.52/91, 26/93) and the Decree on customs tariff (Section IV) (O.B. 184/03) in order to prevent the appearance of this disease in the Republic of Croatia.

The financial incentive for oil crops applicable to rapeseed, soybean and sunflower has recently been increased to 2.250 HRK/ha, which has caused the raising of producers' interest for these crops. However, it can not be expected that this measure alone will lead to the production of enough rapeseed needed for biodiesel production, since the primary use of the produced quantities is within the food industry.

6.2 Present and Options to Improve Competitiveness of Biodiesel

As the various variable parameters can have quite different impacts on the profitability of a biodiesel production plant, and hence on the competitiveness of biodiesel, it is important to know their quantitative influence. The following graph highlights the weight of the single parameters in comparison to others and illustrates the high priority of feedstock cost, of process yield (i.e. to what degree the triglyceride and free fatty acids molecules are processed into the valuable methyl-ester molecules), while the parameters of e.g. energy cost and manpower (operator) cost are of minor importance.

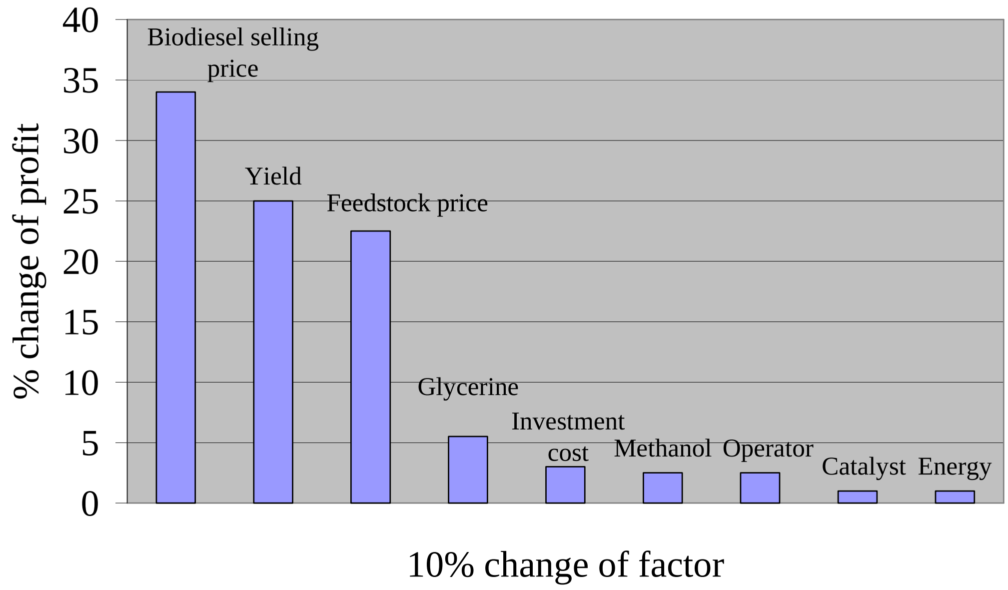

Figure 6.1 *Sensitivity of various input/output factors in influencing profitability*

Source: Austrian Biofuels Institute

Considering the results shown in Figure 6.1, the options to increase the competitiveness of biodiesel production in Croatia include the following:

- A well defined marketing strategy in order to optimise earnings from biodiesel sales, which include defining quality standards in order to gain consumer confidence as well as recommendations from vehicle manufacturers;
- Considering other biodiesel sources other then rapeseed oil which would have a lower price (i.e. recycled edible oil, palm oil, etc.)
- Considering the possibility of importing the feedstock from neighbouring countries (Serbia, Romania);
- Lowering transport cost by placing the biodiesel production plant in a well chosen location (sea or river harbour).

6.3 Market Segments and Distribution Channels

A key element for a successful introduction of biodiesel in Croatia is the identification of the most profitable market niches, followed by promoting biodiesel to customers in those niches. Additionally, environmentally driven regulations can carve out specific market segments in which only biodiesel fulfils the requirements. By decision of the Subcommittee for Biofuels of the Technical Department 28 at the Governmental Office for Standardization and Metrology, it is allowed sell blended biodiesel with standard mineral diesel fuel of 5% without special marking. That decision significantly lowered entry barriers of biodiesel's penetration to the market. By using the same distribution channels, biodiesel blend of 5% could be easily reachable to all consumers without asking any change in consumers' behaviour or huge investments in infrastructure. Pure biodiesel would demand slight changes in distribution as there are not sufficient quantities to cover all diesel market. Its distribution should be carefully targeted not only because of the investment (founding a separate tank for pure biodiesel at a gas station) but also considering the purchasing power and environmental issues of the targeted market.

Considering this fact, the following market segments have been identified as the most promising to be targeted for biodiesel utilisation:

- **Public and commercial road transport of persons and goods.** In this market segment of congested city traffic significant problems are caused by inhalation of harmful exhaust emissions and smog creation. Biodiesel's environmental benefits are needed most in the city and community traffic, and can be exploited and demonstrated ideally in public personal transport as well as in commercial delivery vehicles with positive visibility to citizens, leading to fast product acceptance and to speed up market penetration for biodiesel. Implementation in this niche is the most viable as public transport could be converted to biodiesel by a decree of the authority where this transport has headquarters at, or provides its services. At the introductory phase, it would be recommendable to supply this niche with blended biodiesel as most of the public transport fleets combines different age engines. Gradually, public city transport could completely convert to pure biodiesel use because they use contracted gas-stations. In that way, they will not suffer from low distribution problem of pure biodiesel. The same logic could be applied to commercial delivery vehicles although they generally belong to younger types of diesel engines.

- **Passenger cars.** This niche coincides with elaboration of the public and commercial road transport of persons and goods although is less controllable. It would be recommendable for this segment to use blended biodiesel as it can be used in any diesel engine without any additional adjustments.

- **Use of biodiesel in marine areas like sea or lakes, and especially in protected national parks.** Biodiesel is biodegradable in a relatively short time period and has been shown to be much significantly harmful to fish than petroleum diesel. As a result, the danger to marine life arising from accidental fuel spills from watercraft is minimised. Even the midrange biodiesel blends appear to increase the rate at which spilled petroleum degrades in marine applications. For vehicles employed in protected areas would be ideally to use pure biodiesel for its numerous environmental benefits. However, depending on the age of the fleet and distribution channel development, each protected area management should stream towards pure diesel usage, at least.

- **Agricultural mechanisation.** Looking at countries with a developed biodiesel industry (like Austria, for example), it can be seen that farmers have been among the first to embrace biodiesel, and not only its utilisation but also its production.

Furthermore, producer commodity organisations and cooperatives typically have promoted the use of biodiesel blends in farm trucks and power equipment. In the presence of small biodiesel processing plants, it would be logical for farmers to use biodiesel either in pure of blended form, depending on the price of biodiesel competition – cheaper agricultural “blue” diesel. Nevertheless, farmers do not depend on distribution channels and, thus, are able to decide autonomously on preferred option.

- **Stationary engines used for pumping, emergency power generators and other varied applications** also represent a potential market segment. Cleaner fuels can greatly reduce the particulates and other aspects of air quality in the immediate area where these engines are located. Thus, pure biodiesel would be preferable for this niche. Unlike other niches, they are static and the delivery unit is mobile. That increases viability of pure biodiesel use.

The market segments outlined above cover a broad based group comprising a variety of engine size, power and applications, but a common thread that holds them together is that they all utilise diesel fuel. Because one product fits such a variety of market applications, and the buyers have been conditioned to procure their motor fuels based on economics, it becomes challenging to introduce clean burning fuels like biodiesel even with all its positive attributes. Buyers’ purchasing attitudes and core business philosophies all play a pivotal role in consumers’ fuel purchasing habits relating to diesel fuel and related energy products.

One of the advantages of biodiesel is the fact that it is one of the few energy alternatives that are clean, renewable and do-able today using current engines and distribution channels. Considering that the broad population has developed a habit of using a personal automobile as the most preferable mean of transportation mostly because of the low oil prices, any radical changes in fuel supply or engine technology for road transport would face a number of problems. The utilisation of already existing diesel distribution channels for biodiesel marketing within the road transport sector is therefore seen as the most promising alternative, especially in the case if INA, the Croatian oil company, which expressed its readiness to be involved in biodiesel production. For the three remaining market niches, direct sale of biodiesel by a potential local producer would be possible, although this needs to be investigated for each particular case.

6.4 Quality Control

The most important issue regarding biodiesel quality control involves the removal of alcohol, catalyst, water, soaps, glycerine and non-reacted or partially reacted triglycerides and free fatty acids. Failure to remove or minimize these contaminants draws biodiesel failure to comply with the fuel standards. The standard for biodiesel in Croatia that will be adopted in the near future is essentially the same as the European EN 14214 standard, shown in Table 6.1.

***Table 6.1** Requirements within the EN 14214 biodiesel standard*

		Limits		
Property	Unit	Minimum	Maximum	Test method a
Ester content	% (m/m)	96.5b		prEN 14103
Density at 15 °Cc	kg/m3	860	900	EN ISO 3675 EN ISO 12185
Viscosity at 40 °Cd	mm2/s	3.50	5.00	EN ISO 3104
Flash point	°C	120	–	ISO/DIS 3679e
Sulphur content	mg/kg	–	10.0	prEN ISO 20846 prEN-ISO 20884
Carbon residue (on 10% distillation residue)f	% (m/m)	–	0.30	EN ISO 10370
Cetane number		51.0		EN ISO 5165
Sulphated ash content	% (m/m)	–	0.02	ISO 3987
Water content	mg/kg	–	500	EN ISO 12937
Total contamination	mg/kg	–	24	EN 12662
Copper strip corrosion (3 h at 50 °C)	Rating	Class 1		EN ISO 2160
Oxidation stability, 110°C	Hours	6.0	–	prEN 14112
Acid value	mg KOH/g		0.50	prEN 14104
Iodine value			120	prEN 14111
Linolenic acid methyl ester	% (m/m)		12.0	prEN 14103
Polyunsaturated (≥4 double bonds) methyl esters I Polyunsaturated (≥ 4 double bonds) methyl esters	% (m/m)		1	
Methanol content	% (m/m)		0.20	prEN 14110

Monoglyceride content	% (m/m)	0.80	prEN 14105
Diglyceride content	% (m/m)	0.20	prEN 14105
Triglyceride content	% (m/m)	0.20	prEN 14105
Free glycerol	% (m/m)	0.02	prEN 14105 prEN 14106
Total glycerol	% (m/m)	0.25	prEN 14105
Group I metals (Na+K)k	mg/kg	5.0	prEN 14108
			prEN 14109
II metals (Ca+Mg)l	mg/kg	5.0	prEN 14538
Phosphorus content	mg/kg	10.0	prEN 14107

Generally, large scale processing plants generate biodiesel and its by-products (glycerol and cake) of greater quality. Additionally, it is easier to control the quality at one point of production (large scale) than at several ones (small scale). Small scale processing plants require more intensive system of quality control as there is great possibility that output varies by producers, especially if they use inputs of different qualities and different processing technologies. Usually, quality control laboratory represents a standard feature within the large scale processing plant which is rarely the case for the small scale processing plants.

Independent laboratory for quality control could be established from the Governmental Office for Standardization and Metrology in order to monitor if the biodiesel producers are meeting the required standards.

6.5 Domestic and International Financial Mechanisms and Investment Support

Croatia has significant possibilities for biodiesel production, but there are also certain difficulties and barriers for its development and growth. Looking at the whole biodiesel production cycle, there are two important barriers to its wider scale adoption in Croatia:

- Social barriers (lack of knowledge, understanding and change of behaviour),
- Lack of financing or resources.

The Croatian Government is in the process of formulating a compressive renewable energy policy, which is expected to deal with various policy issues relevant to development and a large-scale diffusion of renewable energy technologies. Financial support is recognized as an important and necessary step in making market penetration possible. Currently the financial mechanism supporting renewable energy projects are:

- Croatian Bank for Reconstruction and Development (Hrvatska banka za obnovu i razvitak – HBOR),
- Environmental Protection and Energy Efficiency Fund.

Nevertheless, a number of other sources of financing, both domestic and international, as described below, could be used to support biodiesel production in Croatia.

6.5.1 HBOR

Croatian Bank for Reconstruction and Development (Hrvatska banka za obnovu i razvitak – HBOR) has, apart of other financial tools for financing investments in infrastructure, Loan Programme for Financing of Projects of Environmental Protection, Energy Efficiency and Renewable Energy Sources[6].

The Programme's main goal is fully in compliance with the properties of biodiesel production in Croatia. Loans are intended for investments in fixed assets and permanent current assets. The Programme is accessible for units of local and regional government, utility companies, commercial companies, craftsmen and other legal and natural entities.

Minimum loan amount is limited to HRK 100.000 while the maximum amount depends on the financing abilities of HBOR, on the investment project, creditworthiness of the final borrower, and the value and the quality of the collateral offered.

In general terms, HBOR is financing up to 80% of the estimated investment value (including VAT) while permanent current assets should not exceed 30% of the total loan amount.

6.5.2 Environmental Protection and Energy Efficiency Fund

The Environmental Protection and Energy Efficiency Fund of the Republic of Croatia (EPEEF) is a structured extra-budgetary fund which finances projects and activities in three basic areas: environmental protection, energy efficiency, and the use of renewable energy sources. It has been established by the Law on the Environmental Protection and Energy Efficiency Fund on July 1st 2003 (O.B. 107/2003).

[6] Detailed description and other updates can be found at http://www.hbor.hr/eng/kre_programi_080.asp

The fund has been established cooperatively by the Ministry of Economy and the Ministry of Environmental Protection and Physical Planning. As a consultant for the Ministry of Economy, the Energy Institute Hrvoje Požar participated and still participates in virtually all activities related to the fund's establishment and operation. The institute's experts played an active role in the processes that led to the fund's establishment. They participate in expert groups for the preparation of secondary legislation and regulations. At present, they are developing framework guidelines for the fund's programme and financial activities in the areas of energy efficiency and the use of renewable energy sources. The guidelines are prepared in study form.

The goals of the study are to: gather existing information on potential areas of financing; prioritise available information in conformity with the Energy Sector Development Strategy, project feasibility within previously defined priority areas etc.; define financial mechanisms at the disposal of the fund (loans, grants, international funding); associate available financial mechanisms with projects; and take into account existing financial support mechanisms for energy efficiency and the use of renewable energy sources in order to adequately supplement the fund and avoid collision with existing programmes.

6.5.3 EU Financing

Sources of financing which have renewable energy sources as a priority line are programmes of the European Union. Those technical assistance programmes that are currently available for Croatia are:

- CARDS (Community Assistance for Reconstruction, Development and Stabilisation) has inherited OBNOVA programme in 2001 and supports the active participation of South-Eastern European countries in the Stabilisation and Association Process by technical and financial assistance.

- INTERREG initiative with the aim of developing cross-border cooperation between adjacent areas on the EU's internal and external frontiers. In this case, non-EU member stated are financing their participation in INTERREG from their own resources and/or, if approved by the EC, from the EU Assistance Programme. There are three streams of INTERREG programme:

    - INTERREG IIIA - The Republic of Croatia may participate in Strand A of the INTERREG initiative through the Programme "Adriatic Cross-border Co-operation"

    - INTERREG IIIB –Croatia belongs to CADSES geographical area (Central European, Adriatic, Danubian, South-Eastern Space)

    - INTERREG IIIC – this interregional co-operation sub-programme divides the entire European territory in four zones where Croatia belongs to the Zone East.

- Other programmes and instruments of the EU open to the Republic of Croatia and related to the biodiesel production are LIFE, and 6th Framework Programme for R&D.

  - LIFE is financial instrument of the EC designed for the issues related to the environmental protection with the focus on development and implementation of the EU environmental policy. LIFE programme in Croatia is coordinated by the Ministry of Environmental Protection and Physical Planning.

  - Sixth Framework Programme for R&D – the 6th Framework Programme for R&D is focused on the promotion of research and technological development by supporting cooperation among universities, research centres and industry. It provides financial assistance to their common projects. The national coordinating body is the Ministry of Science and Technology.

- EU Programmes (Campaign for take-off, Altener II, 6th Framework Programme, Synergy). These programmes are intended for EU member states and countries that are close to accession. The type of project that is supported varies from programme to programme, but few programmes are intended for investment support other than for demonstration plants. Some of the programmes are also, to a limited extent, open to other countries.

- Pre-accession support (PHARE, SAPARD, ISPA), intended for countries that are close to accession. These funds are managed by the Ministries in the recipient countries, and usually do provide investment support for projects that are considered important for certain economic sectors (e.g. agriculture and infrastructure). However, those programmes are currently not open for Croatia but, technically, it is reasonable to take them into the account due to the recent developments and advances in relationship between the EU and the Republic of Croatia.

6.5.4 Global Environmental Facility

Established in 1990, GEF is co-managed by the World Bank, UN Development Programme, and the UN Environmental Programme. To qualify for funding under the GEF, projects must be innovative, demonstrate the effectiveness of a particular technology or approach and fall into one of the four priority areas. GEF funding is possible if the project offers substantial global benefits, but is unlikely to be viable without some concessional funding or if a project is economically viable but requires supplemental finance to bring about global benefits.

GEF projects can either be free-standing, components of World Bank projects, or pass through the IFC to support private sector ventures that have both important demonstration benefits and host government endorsement. Free-standing GEF projects are limited to $10 million, and GEF components of World Bank projects must not exceed $30 million. GEF funds can leverage regular Bank projects by paying the additional cost of incorporating environmentally benign technologies in Bank - supported projects. GEF funds would cover the difference in cost between what the host country is willing to pay and the cost of the benign technology. Use of GEF funds through the IFC can be used if the sponsor/lender could not otherwise underwrite the risk under prevailing market conditions funds cannot be used to avert normal commercial risks.

Member countries of the GEF wish to expand the role of the private sector within its framework. The reason being that the operation of a "leverage effect" makes it exceedingly attractive to undertake investments. In such instances of third-party financing, a specific energy efficiency project is provided with the necessary capital for investment and the technical know-how. Returns on the investment arise from the savings accruing from savings achieved in energy efficiency improvement.

GEF already supported some activities related to the increased use of renewables in Croatia like with ongoing project *Croatia – Removing Barriers to Improving Energy Efficiency of the Residential and Service Sectors*. The project is to remove the key barriers to the implementation of selected economically feasible energy efficiency technologies and measures in the residential and the service sectors in Croatia, thereby reducing their energy consumption and the associated greenhouse gas emissions.

6.5.5 European Bank for Reconstruction and Development

The European Bank for Reconstruction and Development (EBRD) is a multinational institution set up with the specific aim of assisting the countries of Central and Eastern Europe and the CIS develop into market-oriented economies. Its shareholders include countries from these regions and around the world, including the United States, the European Community and the European Investment Bank.

Specifically, the EBRD seeks to promote the development of the private sector within these economies through its investment operations and through the mobilization of foreign and domestic capital. The EBRD’s main advantages, compared with private commercial banks, lie in its willingness and ability to bear risk as a result of its shareholder base allowing EBRD to act at the frontier of commercial possibilities and to be an effective “demonstrator.” It also shares the project risk by acting with private-sector entities such as commercial banks and investment funds, and multilateral lenders and national export credit agencies. The EBRD assists companies that have difficulty in securing financing; as such, it complements the efforts of other lenders.

While its structure is unlike that of a commercial bank, the EBRD has a similar approach to dealing with projects. A project has to be commercially viable to be considered. The EBRD prices its products on a commercial basis. It does not issue guarantees for export credits or provide retail banking services. The Bank offers a wide range of financial instruments and takes a flexible approach in the structuring of its financial products. The EBRD provides loans that are tailored to meet the particular requirements of the project.

6.6 Conclusions

In order to increase the rapeseed production to the amount sufficient for the production of 50.000 t of biodiesel, a comprehensive strategy at the national level has to be developed, coupled with legislative framework and more specifically defined incentive measures. This strategy has to take optimising earnings from biodiesel sales, quality standards, biodiesel sources possibilities (i.e. other oil seeds, recycled edible oil, import etc.) and strategic investment area(s) as its focal points. Regarding the legislation part, until now, the Croatian norms for biodiesel has been defined which are in compliance with the EU norm EN 14214 plus it has been decided that biodiesel blend of 5% can be distributed and sold without special marking. However, up till now, biodiesel production and legislative framework is yet to be unfolded.

There are five market segments identified as target groups regarding biodiesel use. Taking into the account of distribution channels availability and entry barriers, some market segments would be better off if they use pure biodiesel in their vehicle fleet (i.e. all natural protected areas, stationary engines) while passenger diesel engine cars niche would be better off with 5% blend. Some niches such as public and commercial road transport of persons and goods and agricultural mechanisation make viable both pure and blended biodiesel use as they purchasing points are more or less easily controllable where age of the fleet is more important decision factor than distribution issues.

Quality control is easier to establish in large scale processing plant but it would be beneficial if the Governmental Office for Standardization and Metrology establishes an independent quality control laboratory that would monitor if the producer(s) is/are meeting the quality standards.

Biodiesel production could find its financing sources within domestic (i.e. HBOR) and international (i.e. EU technical assistance programmes, GEF and World Bank, UNDP, UNEP, UNIDO, EBRD) financial mechanisms and investment supports.

7 TECHNOLOGY COMPANY OVERVIEWS

In the last years there have been an increasing number of biodiesel technology companies adopting and improving the production processes. The latest technology of biodiesel plant manufacturing companies usually offers plants that are feasible for larger scale production units, which operate mostly on virgin oils.

Options available from companies include pre-made turn-key plants, custom built turn-key plants to suit specific needs or even engineering services for a locally built custom plant. Naturally, each option has its advantages and disadvantages, and the selection should be made after a careful analysis.

The evaluation and overview of technology companies and factors in the selection of the technology for biodiesel production presented here after is largely based on the overview of the existing literature, available data sheets and Internet sources. In addition, the project team contacted the leading technology companies in Italy and requested information on their technology.

7.1 Factors in Technology Selection

There are a variety of factors that must be taken into account when evaluating and selecting the appropriate technology for biodiesel production. The factors can vary significantly depending on the technologies considered, especially when looking at the flexibility in handling feedstocks of varying quality. A brief summary of the factors affecting technology selection as well as companies supplying the technology is given below:

- Production Capacity - What sizes are offered by the technology supplier?
- Capacity Expansion - How flexible the technology is regarding the changes in production volumes?
- Feedstock Flexibility (percent Free Fatty Acid, FFA) - Can the technology handle various FFA levels?
- Co-product Streams - Quantity and quality of glycerine and other process streams.
- Equipment and Operating Complexity - How complex is the plant and its controls?
- Waste Streams - What is the quantity and quality of waste streams?
- Process Safety Design - What is the safety record for plants using this technology?
- Services Offered - Can one buy a turnkey plant, or just the engineering design?
- Previous Experience - How many plants are in operation or coming on line soon?
- Performance Warranty - Does the company offer performance warranties?

- After Sale Support - Does the company offer technical support and for how long?
- Project Delivery Time - How long will it take once the contract is signed?

7.2 Technology Company Overviews

7.2.1 Axens

The Axens process is primarily designed for use with refined oils containing less than one percent Free Fatty Acid (FFA) and less than 0,1% water. A design was developed for higher FFA feeds, but withdrawn from the market.

Axens, a French company formed from the former IFP, has constructed at least 1 facility in France rated at 70.000 t/year. The facility processes refined oils.

Axens has designs for facilities ranging from 10.000 to about 120.000 t/year. Taking the indicated capital cost for the process and internal factors, an estimation of the cost for a complete facility including periphery systems and typical support systems can be made. The order of magnitude unit capital cost for a larger facility (in the range of 50.000 67.000 t/year) is estimated to be in the €173 to €185 per annual tonne. Thus the estimated cost for a 70.000 t/year plant would be on the order of €12.100.000 to €12.950.000. The estimated construction time is about 15 months.

7.2.2 Ballestra

The Ballestra process has primarily been applied to seed oils with typical feed specification of less than 0,5% FFA and less than 0,05% water. Ballestra, an Italian company with representatives in the U.S., claims that they can process other materials, but each feed would have to be individually checked in their pilot to confirm process applicability. This is a sound move on Ballestra's part.

Ballestra has constructed at least two facilities that process refined oils. The company is large and does have an extensive design and support capability.

The company offers plant designs ranging from about 10.000 to 100.000 t/year, with larger facilities possible. The estimated unit cost for a facility in the range 50.000 67.000 t/year, is in the range of €173 to €196 per annual tonne. The estimated construction time is on the order of 15 to 18 months, depending on the extent of peripheries, etc.

7.2.3 BDI

BDI, a German company of some standing, has been reluctant to share information in a generalized fashion due to their workload and previous negative experiences with the disposition of the information. However, it was possible to make order-of magnitude estimates for various factors based on information it has collected over the years.

The BDI process is capable of handling a range of materials including higher fatty acid feeds. They have commercial experience with the higher fatty acid feeds and have two plants currently under design that will process used oils. They have constructed at least 10 plants for biodiesel production worldwide. From a conservative standpoint, the estimate is that the process should be capable of handling materials such as yellow grease, which has an FFA up to 10%.

BDI offers plants ranging in size from a 1.000 t/year mobile facility to a 100.000 t/year grass roots (i.e. no existing facilities or infrastructure) operation. The estimated cost for a facility in the 50.000 to 67.000 t/year would be on the order of €219 to €254 per annual tonne, and would depend to a large extent on the FFA content of the feed and the extent of process systems required for the specific feed. Obviously, higher fatty acid feeds require more extensive processing thus the expected capital would be higher than that associated with refined oil feedstock. The estimated construction time is on the order from 9 to 14 months depending on the extent of peripheries.

7.2.4 Biodiesel Industries, Inc.

Biodiesel Industries, a U.S. company based in Nevada, indicates that their process can handle feeds with any level of fatty acid content. They currently have constructed two facilities that are processing used cooking oils (with indications that commercial yellow grease has also been treated). The facilities are rated at 10.000 and 33.333 t/year.

The company has an established design for a 10.000 t/year module and for plants in the 20.000 to 30.000 t/year range they would supply multiple modules. Large facilities would be based on a scale-up of the base module design.

The basic process module cost (10.000 t/y) ranges from €385.000 to €1.154.000 depending on various factors. Periphery support systems, e.g. tankage and the like, are extra. From a conservative estimating standpoint, a facility in the 50.000 t/year rate range, is estimated to cost on the order of €196 to €254 per annual tonne depending on the actual feed material and extent of plant peripheries. About three to four months is required for module preparation and shipment to site. From an overall standpoint, the estimate is that the total construction time with this approach would be on the order from 8 to 10 months.

7.2.5 Cimbria-Sket/Bratnev

The Cimbria-Sket process is based on the same technology as the CD Process from Conneman, thus the two are obviously quite similar. Bratney companies represent Cimbria Sket, a Scandinavian company, exclusively in the U.S. The process is based on a refined oil feedstock and the plants constructed to date have used these as feeds. Typical feeds are less than 0,1% FFA and less than 0,05% water. The company has constructed at least 6 plants ranging in size from 5.000 t/year to 120.000 t/year.

The estimated cost for a facility in the 50.000 t/year range is on the order of €231 to €277 per annual tonne. The company offers facilities in the range of 3.333 t/year (skid mounted) to 200.000 t/year production rate. The estimated construction time for a larger facility is in the range from12 to 18 months, depending on project scope.

7.2.6 Connemann

The Connemann CD process, developed in Germany with affiliations from ADM and Westfalia Separator, has primarily been applied to treating refined oils, although the company claims that it can process higher fatty acid oils with the addition of an esterification step. They have not used this step in any of their commercial facilities to date, thus for assessment purposes, the process should be considered as primarily for refined oils. Their process design has been used in four facilities ranging in rate from 40.000 t/year to 140.000 t/year. The company offers standard size plants in the 40.000 to 133.333 t/year range.

The estimated cost for a facility in the 50.000 t/year range is on the order of €231 to €277 per annual tonne. The time to construct a facility is in the range from12 to 15 months.

7.2.7 Renewable Enerqy Group

The Renewable Energy Group is a joint venture between Crown Iron works and West Central Cooperative in the U.S. They offer process design as well as start-up training. Through a relationship with Todd and Sargent, they also offer turn key constructed plants. The process is based primarily on the use of refined oil feeds. The typical feed would have less than 0,3% FFA and less than 0,007% water. The company has constructed at least one facility rated at about 40.000 t/year.

The estimated unit cost for a plant in the range of 50.000 t/year would be about €231 to €254 per annual tonne. The estimated time for construction would range from 12 to 18 months.

7.2.8 EKOIL

Ekoil, a Slovakian company, supplies a process that has mainly been applied to refined oils. Typical feedstock would contain less than 0,1% FFA and less than 0,2% water. The company has supplied process modules for several facilities in the 5.000 to 15.000 t/year production rate range, and offers standard design for this range.

The estimated cost for a complete facility in the range of plants provided by the company (i.e. 15.000 t/year) is on the order of €196 to €208 per annual tonne. The estimated construction time is in the range from 9 to 10 months.

7.2.9 Energea

Energea, an Austrian company, claims that their process can be adapted to handle feeds with any level of fatty acid content. They currently have at least one large (40.000 t/year) facility based on their process technology (and modules) in operation. This plant processes a range of materials including yellow grease. From a "typical" standpoint, the feed would contain 4 to 12% FFA. Water should be less than 0,5%. The company has standard plant module designs ranging from 20.000 to 250.000 t/year production rates.

The estimated capital cost for a facility in the range of 50.000 t/year would be on the order of €185 to €231 per annual tonne. The estimated construction time would be on the order from 9 to 10 months.

7.2.10 Lurgi-PSI

Lurgi-PSI, located in Memphis, U.S.A., with a home office in Germany, has constructed at least seven facilities to produce methyl esters and biodiesel ranging in size from 33.000 to 100.000 t/year. The majority of the plants were designed for refined oil feeds, although Lurgi now claims that it can process feeds with virtually any level of FFA. For oils containing in excess of 20% FFA, modifications to the esterification portion of the process are required.

The estimated unit capital cost for a facility in the 40.000 to 50.000 production rate range using a high i.e. >10% FFA feed, would be on the order of €231 to €265 per annual tonne. For low fatty acid feeds, the unit cost would be on the order of €219 per annual tonne (due to the decreased process needs associated with high FFA feeds). The estimated construction time would range from 12 to 15 months.

7.3 Conclusions

The selection of the specific technology which will be utilised depends on a variety of factors (including size, feedstock quality, feedstock flexibility, etc.) and there are quite a few available technologies on the market today. However, the increasing requirements for producing high quality biodiesel according to strict fuel standards has been the driving force for switching to technologies with accurate cleaning steps for the final biodiesel.

In order to meet the required quality standards, the biodiesel production plant should be well designed with adequate automation, as well as with a fully equipped laboratory with a qualified team of chemists. The investment into this additional equipment is in most cases economically feasible only for plants with larger production capacity.

8 SENSITIVITY AND CASH FLOW ANALYSES

8.1 Assumptions and Methodology

UNIDO ITPO Italy has been requested to perform a project appraisal on two different investment projects providing technical assistance to the UNIDO Headquarter for this project. On the basis of the available set of technical and organisational assumptions coming from the following Croatian working groups:

- Business Innovation Centre of Croatia (BICRO d.o.o.) (large scale production project proposal)
- Faculty of Agriculture University of Zagreb (small scale production project proposal).

However, both scenarios had to be adjusted with different assumptions coming from the INA Oil Company, Croatia National Energy Statistics and the private company Desmet Ballestra, in order to improve the original set of data. As a consequence, the ITPO Italy prepared the current financial appraisal analysing the overall set of industrial projections. The main projected financial schedules and ratios are summarised here, with the complete analysis given in the attached document, providing interested institutions and perspective stakeholders with information pertinent to investment decisions.

The two scenarios analysed in this document are therefore briefly summarised:

a) Small Scale Production Project

The entire production chain was originally included in this scenario: rapeseed cultivation, production of crude oil, production of methyl ester by means of esterification process, and finally, supplying additives to the methyl ester so that it can be used as pure bio diesel fuel. The investor should implement the entire production cycle, and should take advantage of all the available agriculture incentives for rapeseed cultivation; the production capacity of the facilities for such model is estimated between 3.000 t/year to 10.000 t/year.

In the current analysis, only the biodiesel production was introduced, starting from the rapeseed oil processing purchased on the market; the average production facility here analyzed would start with the capacity of 5.000 t/year.

b) Large Scale Production Project

In this scenario a production of rapeseed esters for the out coming capacity of 60.000 ton of esters per year was envisaged. Methyl ester production would proceed in a plant with a daily potential capacity of 200 ton (66.000 ton per year). The basic production feed in this case is rapeseed, and partially also recycled edible oil.

In this improved version, all the agriculture issues are not taken into account: the raw material (rapeseed oil) is assumed to be directly purchased on the international market like the previous scenario, as well as only productive investment was analyzed.

A common sales price of biodiesel was introduced in both the investment projects in order to make possible a comparison between the two scenarios; this sales price was calculated in 5,40869 HRK/l, set as a variable under a calculation aimed at equalizing NPV to zero in the large scale project, under the current investment assumptions[7].

All financial calculations have been carried out using the foreign currency (€, Euro). The results have been reported using € accordingly (the exchange rate with the local Croatian currency, named Kuna, is fixed at 7, 4 HRK/€).

The financial and economic evaluation has been conducted using standard capital budgeting procedures. The future cash flows are forecasted, generated by the project over the estimated planning horizon of 10 years.

In determining the rate of discount to be used, the appropriate cost of funding should be considered, calculating the weighted average cost of capital (WACC) in relation to the foreign currency; in particular, a 10% of discount has been applied[8].

Additionally, two study cases were developed to position both investments from the market side – they were calculated on the basis of the minimum and maximum available current market price obtained by benchmarking with mineral diesel price.

For the methodology recommended in the UNIDO Manual for the Preparation of Industrial Feasibility Studies was used Comfar III package for the financial and economic calculations plus detaxation estimates. By taking into consideration the

[7] A NPV equals to zero means that the investment cost, in discount term, is equal to the sum of the net cash flows estimated in the planning horizon: the investment result can be considered as neutral.

[8] The **discount rate** used for NPV calculation is the **WACC**, where the weights are based on the proportion of the firm's capital structure accounted for by each source of capital. This discount rate takes in account the time value of money, as well as the riskness of the JV's cash flows.

WACC = %D * Rd * (1-t) + %E * Re

where Rd is the cost of debt and Re is the expected rate of return on equities

Re = Rf + Rm

where Rf is the risk free level and Rm is the risk premium over the capital market.

In the present project, no specific assumptions were made regarding the financing aspects of the small scale scenario, therefore a fully capitalized company is assumed; on the opposite, the large scale scenario could be financed 70% through long term loan and 30% equity; in order to make the most comparable analysis between the scenarios, the WACC simply encompasses a generic equity premium rate, here estimated at 10% .

required project input costs and output prices, risks and uncertainty this study is aimed at clarifying the main issues of the projects, calculating:

1. The analysis of the cost estimates for the project, based on the information gathered by the two working groups

2. The financial analysis, including the flow of financial resources and the project financial net benefits

8.2 Financial Analysis

The following assumptions for financial analysis of both scenarios are:

1. All the products are assumed totally sold; the assumption of 100% services performed and sold is applied to the whole project life.

2. The future cash flows are forecasted, generated by the project over the estimated planning horizon of 10 years

3. The national income tax has been assumed at the generic rate of 20%, without any income tax deferral.

4. The presence of a sales tax is not being considered in the present study. The price associated to each unit sold is assumed net of tax, therefore the income to the investor is assumed already free of any further obligation apart from the income tax on the net profit.

5. The base model is assumed without inflation to examine the profitability of the industrial initiative as independent from the general economic context. The calculations have been carried out using € cash flows for product sales and for all payments, and finally discounting all nominal cash flows at the nominal discount rate.

6. Sensitivity analysis was performed on this base case. Different scenarios were enacted to account for testing the costs and prices hypothesis. Prices were forecast to be 5% and 10% percent less than the base case prices. Production costs were forecasted to be 5% and 10% more than the base case. Investment costs were forecasted to be 10% and 20% more than the base case ones. The resulting net present values and internal rate of returns serve to illuminate further the project's value and risks.

8.2.1 Expected Costs and Benefits from the Investment

For the Comfar III calculations, as derived from the data provided by the two working groups, the following sections highlight the input data on the capital structure:

1) **Investment costs** are defined as the sum of fixed assets (fixed investment costs plus pre-production expenditures) and current assets (net working capital). These costs are estimated for the construction phase (the first year of the planning horizon).

For the small scale project, the Faculty of Agriculture University of Zagreb working group designed an investment project encompassing the entire production cycle. In the current financial analysis the three stages are not taken into account in the same way: in order to make a better comparison between the large scale and small scale production stage, only the biodiesel processing stage from rapeseed oil was analysed. The esterification line was estimated at 3.850 Kuna (520,27 €) /Ha[9]. As purchase or construction of the industrial building were not considered as well as any other details on the fixed investment, the total investment for the small scale plant is 2.428.559 €.

The overall fixed investment costs for the large scale project are estimated as 22.030.270 € for fixed investment assets, out of which the "Plant Machinery and Equipment", is valued at 5.610.000[10] €, and “Auxiliary and service plant equipment”, valued at 9.983.784 €. As far as the intangible assets are concerned, no pre-production expenditures has been estimated.

2) **Net Working Capital** requirements have been calculated according to the expected minimum days of coverage (MDC) determined for both the projects.

For the small scale project, no specific assumption can be carried out, given the original available set of data and general purpose of these financial projections: a generic estimation of 30 days for the accounts payable and account receivable was made.

The large scale project had more elaborated assumptions regarding working capital: stock of raw material and other materials for 30 days; stock of final product for 30 days and a payment term of sold products in 30 days; supplying payment terms 30 days, including in advance payment of domestic suppliers and regular import payment.

3) **Total Investment** for the small scale project was composed by the capital expenditures (2.428.559 €) and the required initial net working capital (229.130 €).

It is assumed that the entire initial investment for the large scale project was composed by the capital expenditures (22.030.270 €, including VAT), the capitalized

[9] It’s important to mention that the feasibility study of the Faculty of Agriculture University doesn’t report any specific investment items for the crude oil processing and the methyl ester – biodiesel production, but only the yearly depreciation value (that include other intangible costs like insurance premium). For this reason, the estimation for these items was collected from the other working group, BICRO d.o.o.

[10] this value directly comes from the proforma offer from the company Desmet Balestra, n°OL05108R1, 16th October 2005, for a 60.000 Ton capacity complete processing line.

interests (1.416.610 €) and the required initial net working capital (3.136.608€). The local VAT for fixed capital estimate does not enter in total investment estimate; the original return VAT amount was 4.360.459 €.

4) **Sources of Finance** were differently assumed for the two projects. Namely, no specific assumptions were provided about the financing of small scale project and thus, an automatic equity (2,7 Million €) was introduced.

For the large scale project, it was it was foreseen an overall fixed investment cost amounting to 37.758.108 €, which should be covered by equity and long term loan. The potential investors will contribute with 11.406.757 € for the coverage of the 30% of the total investment. An ensuring of financial needed means by credit is predicted with 195.000.000 HRK or 70%; in this analysis, original financing scheme was kept. Conditions of the long term loan can be summarised as follows: repayment time of 7 years (5+2); grace period of 2 years; interest rate equals 5% with semi-annual instalments.

After establishing the costs of the investment, it is also necessary to detect operational costs such as raw material costs, overhead and labour.

1) **Raw material costs** are crucial for the profitability of any biodiesel investment. Thus, they are given in more elaborated form.

For the small scale project quantities and monetary values (HRK) of raw material are reported in the tables below.

Table 8.1 *Small scale project main raw material (rapeseed oil)*

Year	Quantity	Price	Total
1	417	4.070	1.695.562
2	3.750	4.070	15.262.500
3 onwards	5.000	4.070	20.350.000

Table 8.2 *Small scale project other raw material costs (including utilities)*

	2	3	4	5	6
Raw materials	670.165,71	670.165,71	670.165,71	670.165,71	670.165,71
Methanol	570.731,71	570.731,71	570.731,71	570.731,71	570.731,71
KOH	98.780,49	98.780,49	98.780,00	98.780,00	98.780,00
Wood pulp	315,12	315,12	315,00	315,00	315,00
Water	338,39	338,39	338,00	338,00	338,00
Utilities	34.932,86	34.932,86	34.933,00	34.933,00	34.933,00
Energy	92.602,57	92.603,00	92.603,00	92.603,00	92.603,00
FACTORY COSTS	797.701,14	797.701,14	797.701,14	797.701,14	797.701,14

In calculations of raw materials costs for the large scale project it was supposed the need of 60.000 t of raw material, utilized in a proportion of 5:1; rapeseed oil/recycled edible oil. In the first year raw material and material costs are predicted on the 1/12 level of the full business year due to preparations for production initiation in the first working year and the second year of project economical lifetime.

Table 8.3 *Large scale project raw materials*

Raw materials Consumption	Years		Price (HRK)	€
	2	3 onwards		
Rapeseed oil (t)	37.500	50.000	4.070	550
Recycled edible oil (t)	7.500	10.000	1.480[11]	200
Methanol and other chemicals (HRK/t)	-	-	25,74	3,47
Other material costs (HRK/t)	-	-	1.000,00	135,13

[11] Source: *Biodiesel for Public Transport in the City of Zagreb*, EKONERG and EIHP, 2003.

Table 8.4 *The estimation of the annual raw material cost for the large scale project*

Raw Materials (€)	2	3	4	5
Rapeseed oil	20.625.000	27.500.000	27.500.000	27.500.000
Recycled edible oil	1.500.000	2.000.000	2.000.000	2.000.000
Methanol and other chemicals	156.527	208.703	208.703	208.703
Other material	6.081.081	8.108.108	8.108.108	8.108.108
Total Raw materials	28.362.608	37.816.811	37.816.811	37.816.811

2) In the small scale project case, **the administrative cost** for the other two processing stages was merged under the "administrative overhead costs" item; the total cost of the overhead is therefore calculated in 14.947,56 € per year.

Additional general expenditures, namely marketing, factory rent and administration costs, together with the utility costs and the consumables are taken into account for the large scale under the indirect costs overheads. No particular assumptions had been made in the data provided, and a general estimation of 36 Million HRK per year has been made (27 Million HRK only in the first year).

3) A very simple assumption was provided by the working group for **the labour cost** of small scale project: 3,25€/Ha; the total cost for the workforce was therefore estimated in 15.180,10 € per year while the large scale project where the factory personnel will reach the steady state since the first year of activity.

The large scale plant foresees to employ about 17 workers, in particular 12 qualified workers, 2 engineers for plant management and 3 engineers for laboratory. The total labour cost under these assumptions amount 3.060.000 HRK annually.

After assessing the costs originated from the investment and production, COMFAR III has also detected projects' benefits from production and sales.

The small scale plant will produce biodiesel and glycerol as a byproduct on the esterification process; glycerol sales represent a small portion of the overall company's turnover. The sales programme for biodiesel and glycerol in the small scale project has been assumed equal over the life time of the project. Thus, from 5.000 t of biodiesel, at price of 5.409 HRK/t, small scale would benefit 27,043,494 HRK plus 1.254.714 HRK from 970 t of glycerol at price of 1.293,52 HRK/t. Hence, the total turnover of the project accounts for a value of 3.822.598,97 €.

The production capacity of the large scale production unit is estimated at 60.000 t/yr; where it has been assumed that the production capacity will reach the 100% in the second year, while in the first year a reduced production capacity is scheduled. Given the numbers in the production plan and the total sales estimation amounts 243.391.442 HRK and 21.600.000 HRK from biodiesel and glycerol respectively at the first year. After achieving the full capacity the revenues increase to 353.321.922 HRK (324.521.922 HRK from biodiesel and 28.800.000 HRK from glycerol)

8.2.2 Findings of the Financial Analysis

The financial evaluation has been carried out assuming a basic reference configuration for both the investment project, defined by the cost estimation summarised in the previous paragraphs. This analysis does not include any inflation rate. The main considerations that can be pinpointed are the following:

- Given the general assumptions of both the project, the Net Present Value (NPV), calculated at 10% of discount rate over a 10 years planning horizon, is calculated as equal to 0 for the large scale project, in order to set the related biodiesel sale price (estimated as 5,4087 Kn/l); under this assumption, the small scale project results in a negative NPV (-1.067.572,37 €).

- The internal rate of return IRR is equal to the discount rate (10%) in the large scale project, while it's negative (0,17%) in the small one. In the following graph, a comparison between the NPV resulting from the two scenarios is reported:

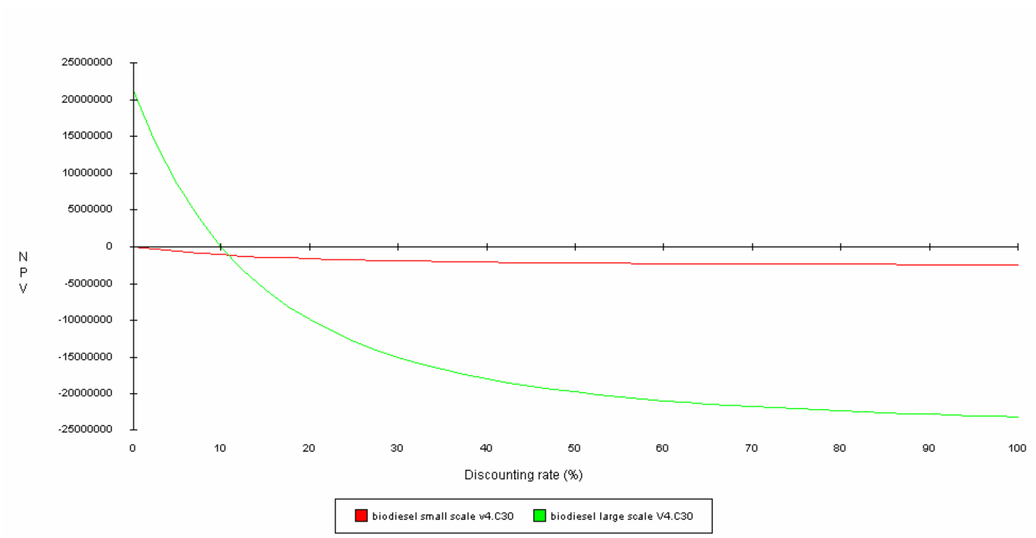

Figure 8.1 *Net present value of total capital invested (€)*

1. **The Net Income Statement** starts to show positive net profit from the first year in the small scale projects, while it becomes positive from the second year in the large scale project; the balance of the Cumulative Cash Flow doesn't requires the additional inflow of a certain level of overdraft for both the projects. The net profit results in positive level of ROE since the beginning of planning horizon (0,1% in the small scale project, about 19% - under the assumption of 30% of equity on

total financial coverage - in the large one). The next table illustrate a comparison between the ROI indicators of the projects:

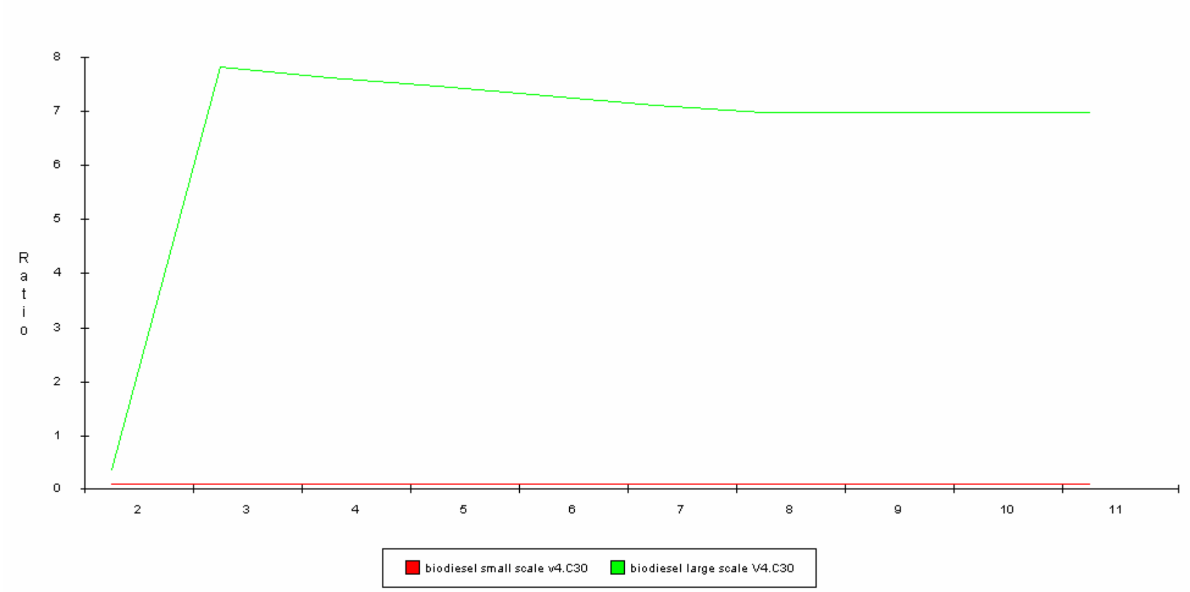

Figure 8.2 *Net profit plus interest to investment (€)*

2. This ratio provides the **return on total investment** (the value of the assets dedicated to the project). It is a measure of the efficacy of profit generation by the committed resources. Values provided for each production period indicate the various stages of profitability. The acceptability of the return on investment is determined by comparison with the opportunity cost of capital or with the return for the other projects; the large scale project (in both the versions) guarantee an higher profitability with respect to the invested capital (ROI calculated at 7% for large scale project versus 0,1% for the small one).

3. The **operational margin** is positive from the first year, at about 5,64% and 0,1% of sales at the full capacity reference year respectively for the large and small project. The net profit level is respectively about 4,51% and 0,07% out of the total sales in the reference year.

4. A **break-even analysis** was performed on both the projects. Costs were allocated according to their variable and direct cost contribution. The project operation was determined to break-even when it reached about 99,89% of its operating capacity at steady state (mature years) in the small scale project, and 95,33% in the large one.

5. The **sensitivity analysis shows** that small variations of the main parameters (from 5% to 10% in sales price, from 5% to 10% in production costs, about 20% in investment costs) can strongly affect the results of the NPV - IRR criteria for both the projects: the large one seems more reliable in terms of variations of sales

revenues and investment costs, while the small one can seem a bit more flexible on the production cost side.

8.3 Detecting Fiscal Environment via Benchmarking

In addition to the financial outlook, supported with sensitivity analysis, a price benchmarking with mineral diesel has been executed for both small and large scale projects in order to understand better the theoretic effect of a direct (or indirect) total redistribution of the taxation incomes from the Government to the biodiesel investors.

It has been assumed substitution of the original biodiesel price (utilised by the two working groups) with the existing mineral diesel market prices:

- 4,58 Kn/l (3,98 HRK/l as market industrial price of diesel together with the trade margin, estimated at 0,60 HRK/l) (in this document, this assumption will be indicated as “P1”)

- 5,98 Kn/l (this is the end-user price: in this analysis, this price is taken into account as maximum available price under the assumption of taxes and excises revenues per litre is somehow “redirected” to the potential biodiesel producer) (this assumption will be indicated as “P2”)

The two scenarios analysed are slightly changed from the financial analysis in order to bring the comparison on the equal foot. Thus, for the small scale project, the changes are: the processing starts directly from the crude oil (no agricultural activity); the raw material is assumed to be directly purchased on the international market: The large scale uses rapeseed oil only as the production feed. In both cases, the price of rapeseed oil is estimated at 4,07 HRK/l. All other assumptions remain the same as for the financial analysis.

8.3.1 Benchmarking Findings

When calculating discounted cash flows over total investment, the financial evaluation has been carried out assuming the cost-revenues configuration already available for both the investment projects, defined by the cost estimation summarised in the financial analysis. This basic version does not include any inflation rate.

Given the general assumptions of the small scale scenario, the Net Present Value (NPV) over the project is, calculated at 10% of discount rate, negative under the assumption of 4,580 HRK/l (-4.292.014,18 €); the internal rate of return over total investment IRR cannot be calculated. With the assumption of 5,980 HRK /l, the NPV turns to positive values (997.480,38 €), with a positive IRR on total investment (18,07%) representing a 8% spread over the required discount rate; the NPV ratio is 0,33.

As the result of the present analysis, a payback period of 5 years is calculated. The payback periods increases to 7 years when calculated in discounted terms.

Table 8.5 *Main indicators for the both price cases for the small scale project*

IRR	NPV	NPV Ratio	Payback period
not found	-4.292.014,18	-1,43	not found
18,07%	997.480,38	0,33	7

Given the general assumptions of the large scale scenario, the Net Present Value (NPV) over the project, calculated at 10% of discount rate, is negative under the lowest price (-37.474.762 €) but turns to good positive values (22.380.585,99 €) with the highest price; in this latest case the internal rate of return over total investment IRR looks positive too (24,97%), representing a 15% spread over the required discount rate; the NPV ratio is 0,77.

In this scenario, a payback period of 4 years is calculated. The payback periods increases to 5 years when calculated in discounted terms. As for the other scenario, the net cash flow of the last years is the key factor to get a positive NPV.

Table 8.6 *Main indicators for the both price cases for the large scale project*

IRR	NPV	NPV Ratio	Payback period
-24,31%	- 37.474.762	- 1,29	not found
24,97%	22.380.585,99	0,77	5

These calculations are supported by the following indicators:

Net Cash Flow to Total Sales

This ratio measures the 'efficiency' of the annual net cash flow generation. The ratio is useful for the comparison of similar projects, like this case: with a selling price of 4,58 Kn/l, both the projects shows negative cash flows, but the large scale project seems more reliable than the small one; with the selling price of 5,98 HRK /l, both the projects are positive, with a lower difference than in the previous case: it means that small projects is more sensitive to price level than the large one.

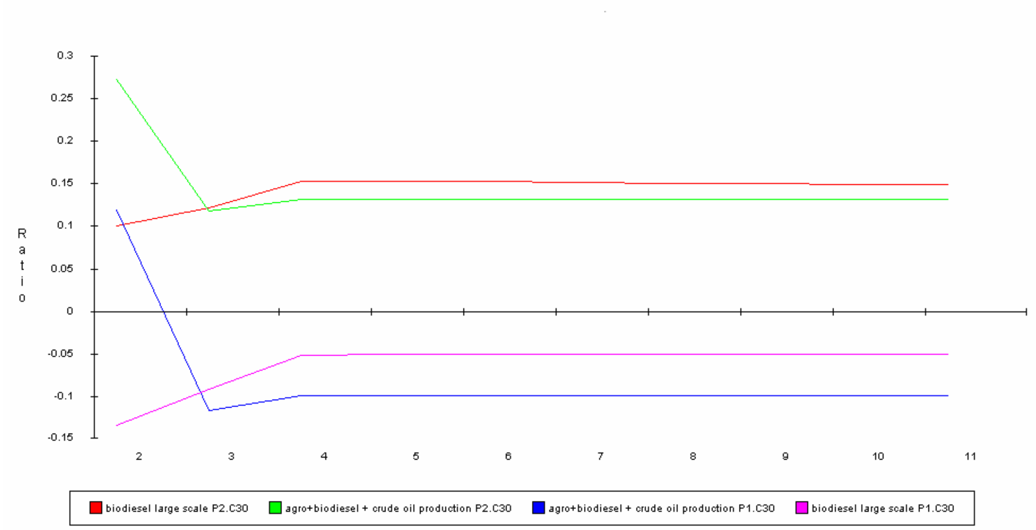

Figure 8.3 *Net cash flow to total sales (€)*

Net Profit to Total Sales

The profit to sales ratios (ROS) is an indicator provided for each production year indicating the various stages of profitability. This ratio reflects the effectiveness of the transformation process from inputs (costs) to outputs (sales). As these ratios are profit-oriented (not cash flow-oriented) they should be of particular interest to shareholders.

The 5,98 HRK/l selling price assumption (the other case is anyway negative), large scale project results the best "profit generator", if compared with the small one. The divergence in the first year depends on the more gradual processing activity planned for this investment project.

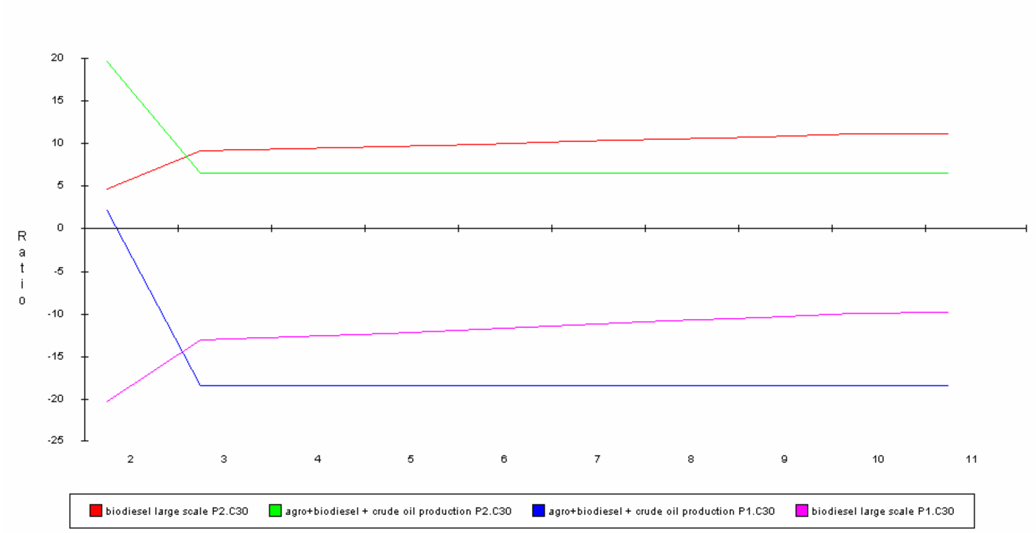

Figure 8.4 *Net profit to total sales (€)*

Net Profit +Interest to Investment

This ratio provides the return on total investment (the value of the assets dedicated to the project, ROI). It is a measure of the efficacy of profit generation by the committed resources. Values provided for each production period indicate the various stages of profitability.

The acceptability of the return on investment can be determined by comparison with the opportunity cost of capital or with the return for similar investment.

It's evident that the ROI estimated for the large scale investment is always higher than the small scale one, so confirming the more profitability of the large scale projects versus the small scale one.

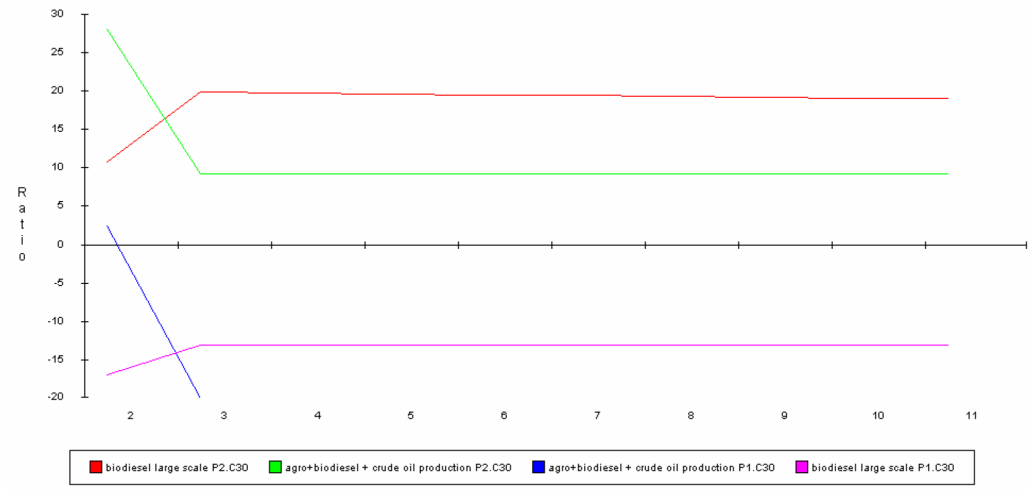

Figure 8.5 *Net profit plus interest to investment*

<u>Break even Ratio</u>

The break-even ratio is the ratio of break-even sales value to planned sales value for the period. It is the percentage of the planned sales value at which the variable margin covers the fixed costs. Risk increases with increasing break-even ratio; a low ratio provides a level of security against unforeseen operational difficulties.

Under the 4,580 HRK/l selling price assumption, the large scale project is closer to 100% that the small one, and under the 5,980 HRK/l selling price assumption the large scale can stay 5 points (86% versus 89,9%) under the small scale one.

Therefore, apart the general risk to be accounted while investing in the biodiesel sector, the large scale one seems more reliable than the small one.

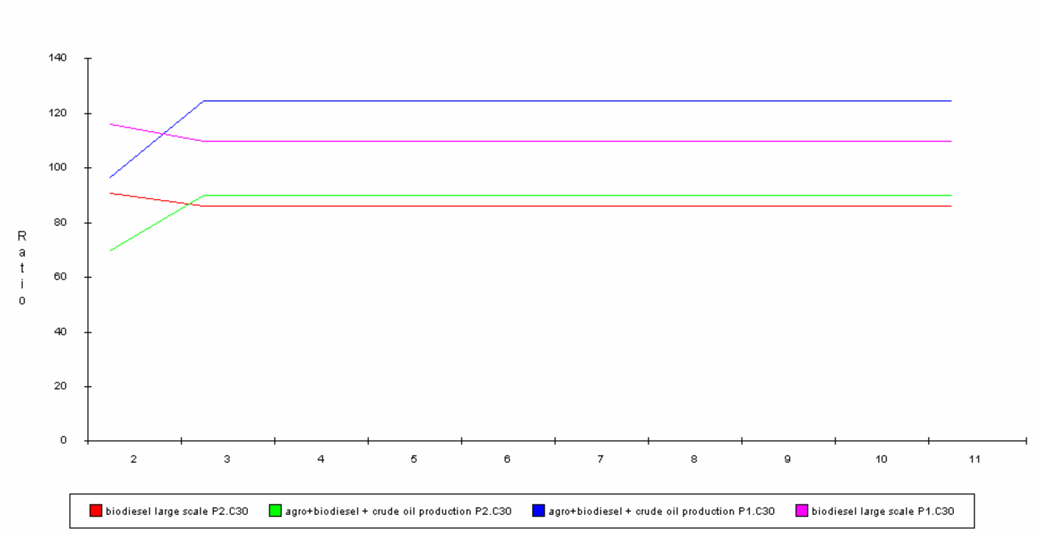

Figure 8.6 *Break even ratio (excluding costs of finance) (€)*

<u>Output to Capital Ratio</u>

This ratio relates annual sales to invested capital. It is a useful yardstick when assessing project at early stages; in this sense, the large scale project is more profitable in each stage of the planning horizon than the small one, independently fro the selling price assumptions selected in the comparison.

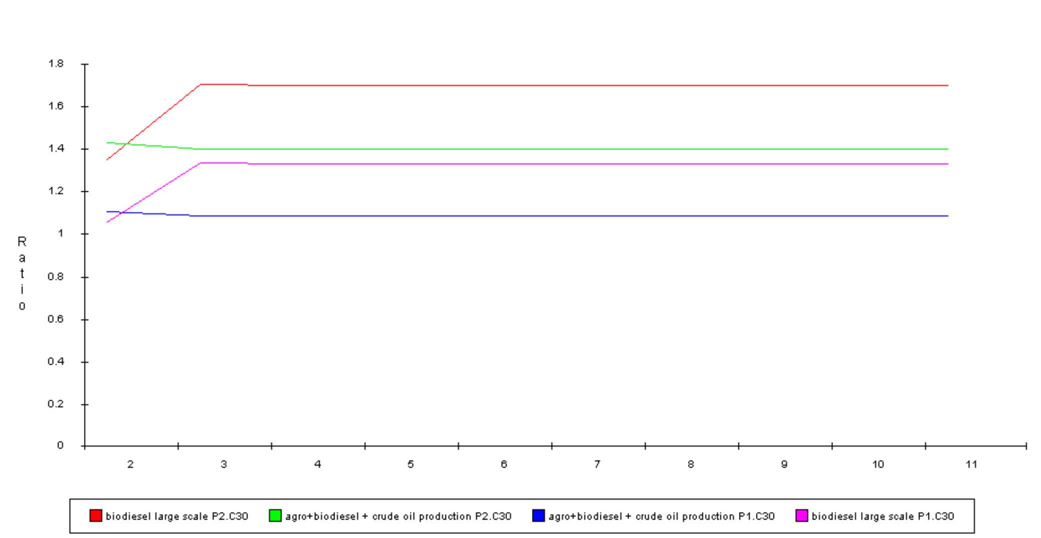

Figure 8.7 *Output to Capital ratio (€)*

Net Present Value on Total Capital Invested

Net benefits (net value of goods and services produced) and costs (the value of the resources committed to the project) are discounted at various rates to determine the net present value of the project. A non-negative net present value at a discount rate equal to opportunity cost of the capital required to finance the project indicates that the project is acceptable from this point of view. A discount rate for which the present values of benefits and costs are equal (i.e., the NPV = 0) is an internal rate of return (IRR), a rate at which the assets dedicated to the project generate net benefits.

As illustrated in the graph, the large scale project is very profitable with respect to the small scale project under the 5,980 HRK/l selling price assumption at a normal discount rate; on the contrary, small scale project can limit the negative returns with respect to the large one under the 4,580 HRK/l selling price assumption; the technical reason is that the small scale project is very close to the x axis in both the scenarios, so the NPV is not very sensitive to the discount rate.

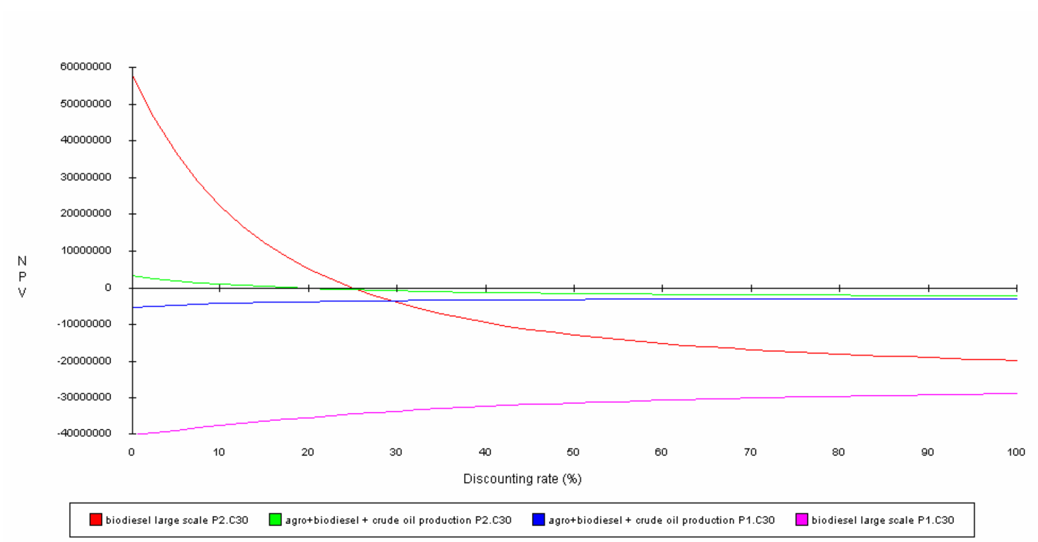

Figure 8.8 *Net present value of total capital invested (€)*

8.4 Conclusions

Given the general assumptions of both the project, the Net Present Value (NPV), calculated at 10% of discount rate over a 10 years planning horizon, is calculated as equal to 0 for the large scale project, in order to set the related biodiesel sale price (estimated as 5,4087 HRK/l); under this assumption, the small scale project results in a negative NPV (-1.067.572,37 €).

Generally speaking, the results of financial analysis showed that large scale project shows better results in terms of all indicators.

Table 8.7 *Comparison of financial indicators obtained for large and small scale projects*

Indicator	Large scale	Small scale
IRR	10%	0,17%
Net profit (ROE)	19%	0,1%
Return on the investment (ROI)	7%	0,1%
Operation margin at the full capacity	5,64%	0,1%
Net profit level (total sales)	4,51%	0,07%
Break even point	95,33%	99,89%

The sensitivity analysis shows that small variations of the main parameters (from 5% to 10% in sales price, from 5% to 10% in production costs, about 20% in investment costs) can strongly affect the results of the NPV - IRR criteria for both the projects: the large one seems more reliable in terms of variations of sales revenues and investment costs, while the small one can seem a bit more flexible on the production cost side.

In the benchmarking with prices of the mineral diesel, two main considerations can be pinpointed:

1. Positive outcome for both the scenarios (997.480,38 € for the small one, 22.380.585,99 € for the large one) under the 5,98 HRK/l selling price assumption ("P2" case); the turning point of the NPV cumulating usually occurs at the last years (in discounted terms) of the projects, mainly in the small one. The internal rate of return IRR looks also positive: 24,97% in the large scale project and 18,07% in the small one.

2. Negative outcome for both the scenarios (-4.292.014,17 € for the small one, -37.474.762,25 € for the large one) under the 4,580 HRK/l selling price assumption ("P1" case); IRR turns strongly negative or not determinate, and the dynamic payback cannot be calculated accordingly.

As a conclusion, fiscal advantages, calculated on the current excises and taxes applied to mineral diesel market can strongly affect the positive outcomes of investment projects in the biodiesel sector, allowing the biodiesel investment to be profitable and attractive in comparison with the mineral diesel market.

9 CONCLUSIONS AND RECOMMENDATIONS

Biodiesel production in Europe is growing, and is becoming important in many aspects. Establishing a national biodiesel industry is a challenging task where at least three separate but related issues should be distinguished – rapeseed (oilseed) production, biodiesel production and biodiesel market or consumption.

The beginning of the large increases in biodiesel production in Europe was 1993. Changes in the European Union's Common Agricultural Policy (CAP) established a set-aside program in 1992 whereby farmers were obligated not to grow food or feed crops on a portion of their arable crop land; however, they were allowed to plant rapeseed, sunflowers, or soybeans for industrial purposes. The production of vegetable oil on set-aside for use in producing biodiesel was clearly an option, and the biodiesel industry has grown rapidly in the last ten years.

Another big boost for biodiesel, especially in Germany, came when vegetable oil prices were relatively low, around US$400 dollars per ton, from early 1999 to mid 2002, and mineral diesel prices varied, but on average were relatively high during this period. With biodiesel exempted from the mineral fuel tax, production began to look very attractive, and a large number of projects were started. The French industry also benefited from low vegetable oil prices, but the amount of biodiesel receiving a reduced motor fuel tax was, and still is, limited according to the rules of the French program.

Currently, the European Union is in a state of stabilising the system of biodiesel production. Many construction projects were approved in 2000, and demand for biodiesel exceeded the available supply. Nevertheless, capacity is expected to continue to rise, albeit at a slower rate. New projects have been announced in the United Kingdom and Portugal. The project in the United Kingdom will lead to the construction of the European Union's largest biodiesel plant with plant capacity of 250.000 tons per year.

This chapter brings a set of recommendations resulting from previous chapters aiming at all three components mentioned before (agriculture, biodiesel production and market or consumption). However, it has to be mentioned that three components are not necessarily connected. Depending on a global market situation different options like national rapeseed production vs. oilseed import or national consumption vs. biodiesel export will always have to be considered.

9.1 Recommendations on Agricultural Policies, Incentives and Support Mechanisms

In order to increase national rapeseed production, it is necessary to expect some intervention from the Croatian government in the agricultural sector regarding rapeseed production. The measures would have to ensure, at least, the quantities of feedstock required for the planned production of biodiesel, increase the yield of rapeseed per hectare and regulate market channels for produced rapeseed. This demands formulation of a comprehensive action plan with synchronised enforcement of existing governmental tools and means of Croatian agriculture policy with some adjustment to the new issues.

It is reasonable to suggest, based on the experience of other countries (i.e. Ireland), establishment of contracting of farmers – rapeseed producers, with or without a mediator between the parties involved in this part of biodiesel production. However, the following recommendations could be pointed out:

- A clear national targets for rapeseed (oilseed) production including timeframe and expected dynamics should be established;
- The incentive for rapeseed and other oilseeds production per hectare should be determined according to the desired quantities of overall production in Croatia. Although the current subsidy for rapeseed is about three quarters higher than those for wheat and maize farmers are still reluctant to switch from the traditional cultures to new ones. This reluctance is also derived by their limited knowledge and experience on rapeseed agricultural practices and inputs which consequently lead to low yield of rapeseed. A solution could be in downwards cascading support system which will start from, 2.800 HRK/ha which is claimed by farmers and gradually decrease over years to the amount 2.250 HRK/ha proposed from the Ministry of Agriculture, constantly supported by Extension Service regarding cropping techniques improvement. In the end, farmers' income would stay at the approximate same level: decreased income from the subsidies but increased from the harvested yield.
- Measures to increase the rapeseed and other oilseeds yield, which is currently below average yields in EU countries, should be formulated and put in place. These include the education of farmers through the already existing Extension services and other similar agencies both governmental and non-governmental, financial and economic measures (detaxation, soft loans and other measures) aimed at the modernisation of the technology used for rapeseed production, including agricultural mechanisation, storage facilities and other;
- Increasing the overall efficiency of agricultural production by implementing measures aimed at better land use (i.e. small farms merging, introducing cooperative organizations and similar);
- Improvement of market position of oilseeds producers through facilitating long-term contracts between farmers and large oil producing companies, as well as better utilisation of by-products resulting from biodiesel production (i.e. rapeseed meal and glycerine).

The agricultural sector would benefit from increased rapeseed production through an increased usage of the considerable amounts of currently idle acreage, the introduction of rape seed as the third crop in crop rotation, a guaranteed additional profit for farmers, a better exploitation of farming machinery, and in this way through an increased profitability of agricultural production. If the biodiesel would be produced in Croatia, rapeseed meal being a by-product would contribute to a replacement of animal protein feeds with protein of vegetable origin in the significant livestock production of the country as a protective measure against encephalopathy.

All these will lead to increase in employment rate and income generation opportunities and contribute to rural and agricultural development

9.2 Recommendations on Competitive Biodiesel Production Industry

9.2.1 Feedstock Costs

The main factor affecting the competitiveness and profitability of biodiesel production are the feedstock cost and the production process efficiency. Clearly, to decrease the unit production costs it would be necessary to either use a lower cost feedstock and/or to increase the effectiveness of production by carefully choosing the location of biodiesel processing plant and to utilise modern technologies and processes with maximum efficiencies.

Options to lower the feedstock cost include:

- Utilising recycled edible oils;
- Import of potentially cheaper rapeseed oils from neighbouring countries;
- Import and utilisation of other vegetable oils (e.g. palm oil).

The key recommendation here would be to establish a biodiesel plant with high flexibility in feedstock processing ability (multi feedstocks), with, at the start, most probably only partial supply from Croatian fields. Within the European Union rapeseed is dominating source for biodiesel, but because of strong demand prices are going up. For example, the biodiesel plant of ADM in the harbour of Hamburg is doubling now its capacity from 120.000 to 240.000 t, and establishing a new 275.000 t biodiesel plant in Mainz at the river Rhine. Because of that high demand for feedstock, palm oil is imported in increasing volumes, (palm oil can be used up to 40 % in summertime), which is an advantage for biodiesel plants located at sea harbours (or at least at big river harbours like river Danube). In rather distant future (5 years time) also non-food oils (e.g. jatropha oil) may reach European harbours from Brazil, India, Egypt or South Africa.

9.2.2 Site Selection

Potentially interesting feedstock supply chain which could contribute to the competitiveness of the produced biodiesel is the import of rapeseed, but also other vegetable oils which could be used for biodiesel production from neighbouring countries. In order to lower the transport and overall costs of this alternative, it would be necessary to place the biodiesel production facility on a river or sea harbour.

Another important location decision feature is existence of Free Trade Zones and Areas of Special Governmental Care in Republic of Croatia. Free Trade Zones are established on sea ports, airports, river ports or next to international transport routes. They are established as an incentive for investment, employment, introduction of new technologies and equipment, modernisation and improving business and industrial networking. A zone user is entitled to the following benefits, apart of the location advantage:

- Profit tax is 50% less than the prescribed rate
- Those zone users that participate in the construction of infrastructure utilities in the zone to a value exceeding 1 mil. HRK are exempt from tax on profit originated from the business activities in the zone in the first five years of business.
- Goods are stored in the zone free-of-charge
- For the good stored, used or consumed in the free-trade zone, there are neither tariffs nor VAT payable.
- If the good produced in the free-trade zone is to be imported to Republic of Croatia, tariffs and VAT are paid for the built-in components of the imported material, and not according to the value and tariff rate for the finished product.

In addition to that, there are Areas of Special Governmental Care, created in the areas that suffered severely from the war, that enjoy additional investment and business incentives in the area of custom duties, taxation, obligatory compensations to the employees as well as favourable conditions at HBOR. In this sense, the town of Vukovar seems as a very favourable location for the processing plant as it is located at the river Danube, with easy access to the rail, road and air transport facilities and brings benefits from both as Free Zone and Area of Special Governmental Care.

9.2.3 Production Costs and Overall Plant Feasibility

Looking at the technologies and processes for biodiesel production, the increasing requirements for producing high quality biodiesel has been the driving force for switching from batch processing to continuous process technologies with fast liquid-liquid separation of methyl-ester and glycerine and with accurate cleaning steps for the final product. High yielding process technologies have obtained preferential attention because their impact onto profitability. Important factors influencing the selection of the process technology to be utilised include the following:

- Level of yields obtained during the reaction
- Flexibility to handle multi-feedstock oils and fats
- Reliability in quality assurance

Key recommendation regarding the financial evaluation of biodiesel production is that large scale (production capacity of 50.000 tons and above) shows better results than small scale projects (production capacity up to 10.000 tons) in terms of all indicators.

The sensitivity analysis shows that small variations of the main parameters (from 5% to 10% in biodiesel sale price, from 5% to 10% in production costs, about 20% in investment costs) can strongly affect the results of the NPV - IRR criteria for both the projects. However, the large one seems more reliable in terms of variations of sales revenues and investment costs, while the small one can seem a bit more flexible on the production cost side.

9.3 Recommendations on Biodiesel De-taxation

Biodiesel competes in the market with petroleum diesel. Prices are volatile, sometimes favouring biodiesel industry expansion, but biodiesel is still not cost competitive with petroleum diesel without subsidies or tax incentives except in cases where petroleum prices are high in the extreme and vegetable oil prices are low. Biodiesel has a major advantage over petroleum diesel in that it is derived from renewable sources; thus, on a net basis, fewer greenhouse gases such as carbon dioxide are emitted into the atmosphere. The political support for the production and consumption of biodiesel and renewable fuels appears to be present to expand the biodiesel industry.

On May 8, 2003, the European Parliament and the Council of the European Union adopted Directive 2003/30EC, on the promotion of the use of biofuels or other renewable fuels for transport. Directive sets for member states the target what percentage of petrol and diesel used for transport purposes should be from renewable sources. The percentage will increase to reach 5,75 percent in 2010. The EU Commission will monitor the member states, which will have to justify where they may not have met the targets. This directive is for sales and not production, so a country could import biofuels rather than produce their own biofuels to comply with the directive. However, to entice sales, Croatia may find it not to be politically expedient to give tax advantages to imported product rather than developing domestic biofuel industry. The De-taxation Directive directs that member states will be allowed (but not mandated) to give fiscal resources to promote biofuels. According to the Directive, de-taxation should be proportional to biofuel content. There should not be overcompensation for biofuels, and support levels should take into consideration the costs of raw materials.

Having in mind the goal to establish a sustainable biodiesel production in Croatia, it will be necessary to develop and put in place a stable mechanism of financial incentives, considering its higher costs compared to mineral diesel. This would include de-taxation, which is also elaborated in this study and is in line with the described EU legislation. The current cost structure of mineral diesel in Croatia includes VAT (of 22%) as well as excise duty tax in the amount of 0,14 €/l (1,00 HRK/l) and Croatian Motorways (HAC) fee in the amount of 0,055 €/l (0,40 HRK/l). As shown in the results in chapter 5, the exemption of biodiesel from these taxes would result in a direct loss of 73 million HRK (approximately 10 million euro) to the Government. However, the economic output of the rapeseed biodiesel production chain, together with the necessary investments in production capacities and logistics, contributes directly and indirectly to additional Government revenue. Depending on the price scenario considered, this additional revenue amounts to 11, 13 and 15 million HRK respectively, which means that the relative tax refluxes amount to 15,1%, 17,8% and 20,5% respectively.

Additionally, the positive environmental socio-economic effects of the biodiesel production chain cannot be disregarded: lower emissions of carbon dioxide, lower local harmful emissions and increased air quality, employment creation, rural development, lower dependence on imports of fossil oil, and others. Even though these benefits were not monetarised within this analysis, they nevertheless should be taken into account when making the decision regarding the support of biodiesel production and utilisation.

9.4 National Partners and Stakeholders

A major challenge in introducing biodiesel blends to the country is how to mobilise and organise different stakeholder groups. Due to its nature, biodiesel production and utilisation involve various sectors, interest groups and market players. The stakeholders and their respective roles relevant to the production of biodiesel in Croatia identified in this study include the following:

- Farmers and farmer associations as well as farmers' support institutions – efficient and feasible oilseed production, introduction of state-of-the-art agricultural practices and technologies, participation in decision making processes related to agricultural policy and state biofuels production strategy;
- Industrial producers of biofuels – application of modern biodiesel production technologies with high process yields, forming partnerships with international companies which should serve as a catalyst to the sustainability dimension and will form an integral part of their Corporate Social Responsibility, contribute to agricultural sector development through establishment of a new market for oilseed producers, namely small farmers;
- Oil companies which will blend the biodiesel – enable sufficient biodiesel market penetration through existing distribution channels, application of EU adopted fuel standards;
- Vehicle retailers and maintenance services – issue necessary warranties and certificates regarding biodiesel utilisation in new and used vehicles, perform drivers informational campaigns, use of appropriate standardised engine parts and equipment;
- Municipalities which could introduce biodiesel in the municipal vehicle fleets – organise and perform educational and promotional activities for local population, city bus and other vehicles drivers and maintenance staff; organise logistics and infrastructure for recycled edible oil collection and utilisation, gradual introduction of biodiesel fuelled vehicles;
- Consumer organisations – perform activities targeted at consumer confidence building, facilitate participatory process in creating a stimulating framework and environment for biodiesel utilisation;
- Government/ministries - formulate overall legal framework, launch a comprehensive campaign with the aim to increase oilseed production, introduce and put in place financial incentives including de-taxation mechanisms.

9.5 Final Conclusions

Biodiesel, being a renewable energy carrier, can provide a clean source of energy while contributing to a securer energy supply. However, like other renewable energy sources, biodiesel needs to be put in the right context and dealt carefully by integrating its socio-economic and environmental added values into the economic model.

In general, a successful biodiesel production needs to be promoted by conceiving mechanisms to ensure that certain key criteria are present mainly the availability of raw materials at a reasonable price and to create market conditions enabling biodiesel to compete with mineral diesel. Other issues and criteria, such as the efficiency of the trans-esterification process and the capital and operational costs associated with it, are also important but to a lesser extent.

Production and utilization of biodiesel meets most of the demands and targets outlined in the national strategy of Croatia which recommends adopting an integrated approach to the development in the different sectors - agriculture, energy and environment. Furthermore, within its integration process into the EU, Croatia will have to comply with the EU regulations related to the security in energy supply, promotion of biofuels utilization, as well as to the reductions of greenhouse gas emissions. As the results of this study indicate, further efforts in promotion of biodiesel production in Croatia could be an effective step in that direction.

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11 APPENDIX 1 - REPORT OF PROJECT WORKSHOP HELD ON DECEMBER 15, 2004

As part of the project 'Promotion of Biodiesel Production in Croatia', a workshop at the Energy Institute Hrvoje Pozar was organised on December 15, 2004. Participants of the workshop included the project working group (Coordinator, National Experts, UNIDO representative and International consultants) but also all stakeholders relevant for biodiesel production in Croatia, Table 1.

The workshop agenda included the following topics:

1. Brief introduction by Dr Fatim Ali Mohamed, UNIDO representative, and Ms Sandra Krmpotić, representative of the Ministry of Environmental Protection, Physical Planning and Construction

2. Project status information by Dr Julije Domac, Project Coordinator

3. Preliminary results of the small scale biodiesel production scenario by Prof Tajana Krička, National Expert

4. Preliminary results of the large scale biodiesel production scenario by Prof Branko Tripalo, National Expert

5. Discussion

Table 1 *Workshop participants*

	Name	Institution/Company
1	Fatin Ali Mohamed	UNIDO
2	Julije Domac	EIHP
3	Velimir Segon	EIHP
4	Branka Jelavic	EIHP
5	Werner Koerbitz	ABI
6	Sandra Balent	UNDP
7	Igor Raguzin	MINGORP
8	Vladimir Puvaca	BELJE
9	Renato Vilenica	Chromos Agro d.d.
10	Ante Orabovac	Zvijezda d.d.
11	Ranko Dubenik	INA Maziva Zagreb
12	Miljenko Podkrajsek	INA Maziva Zagreb
13	Stevo Kolundzic	INA d.d.
14	Josipa Zmijarevic	INA d.d.
15	Ante Radnic	MZOS
16	Marijan Andrasec	DZNM
17	Sandra Krmpotic	MZOPUG
18	Ivana Halle	MGRP
19	Alen Jankovic	Panon Uljarice d.d.
20	Petar Blazincic	Agromedjimurje d.d.
21	Zeljka Gudelj-Velaga	MPS
22	Mladenka Galic	MPS

23	Josip Belosevic	Ratarstvo Bjelovar
24	Vlatka Mrkic	Faculty of Food Technology and Biotechnology
25	Marko Ukrainczyk	Faculty of Food Technology and Biotechnology
26	Ivan Danjek	Croatian Department for Agricultural Consulting
27	Neven Voca	Faculty of Agriculture, Zagreb
28	Tajana Kricka	Faculty of Agriculture, Zagreb
29	Siniša Bogdanic	BIOTEH Projekt d.d.
30	Zeljko Jukic	Faculty of Agriculture, Zagreb
31	Savo Pejak	Astra Internacional, Zagreb
32	Stjepan Komar	IPK Tvornica Ulja Cepin
33	Mirko Ervacic	Osatina – Semeljci
34	Hrvoje Prpic	BICRO d.o.o.

As one of the conclusions and outcomes of the workshop, it was decided that the project team will develop a short questionnaire targeting important questions regarding the reasons of the currently inexistent biodiesel production as well as the future actions and implementation measures needed. The questionnaire was sent to all workshop participants, but also to other important stakeholders that were identified. In total, the questionnaire was sent to more then 70 relevant stakeholder addresses. The results are shown and analyzed in the following chapter.

Questionnaire results

The questionnaire included the following five questions:

1. Who should make the first step in implementing biodiesel production in Croatia (Government, Expert institutions, agricultural producers, other)?

2. What is the main reason for insufficient production of rapeseed in Croatia?

3. Who should produce biodiesel in Croatia?

4. What should be done to start the production of biodiesel by the:

   a) Government

   b) Expert institutions

   c) Agricultural producers

5. Which biodiesel production model would be the most appropriate for Croatia?

Answers to each question are shown separately for each stakeholder group (Government, INA, Oil processing companies, experts/researchers and SMEs).

Table 2 *Who should make the first step in implementing biodiesel production in Croatia – answers sorted by stakeholder groups*

	Government	Government with Expert institutions	Expert institutions
Government	100%	-	-
INA	100%	-	-
Oil processing companies	100%	-	-
Expert/researcher	19%	60%	21%
SMEs	100%	-	-

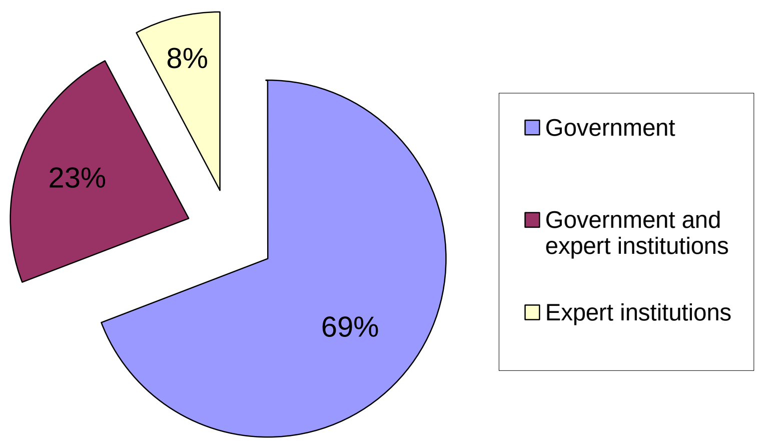

Figure 1 *Who should make the first step in implementing biodiesel production in Croatia – answers in percentages*

Answers to the first question indicate that the majority of stakeholders believe that the first step in implementing biodiesel production should be made by the Government, Table 2 and Figure 1, by forming a stabile long term legislative framework and defining obligations and incentives for producers. However, looking at the answers received from various Croatian experts, the majority of experts believe that actions of the Government should be supplemented with expert advice/consulting.

***Table 3** What is the main reason for insufficient production of rapeseed in Croatia - answers sorted by stakeholder groups*

	Inappropriate/insufficient subsidies	Poor practice/knowledge/organisation of agricultural producers	Lack of market for rapeseed oil	Lack of comprehensive/general strategy
Government		100%		
INA		100%		
Oil processing companies		100%		
Expert/ researcher	35%	25%		40%
SMEs	67%		33%	

When looking at the answers to the question about the main reason for insufficient production of rapeseed in Croatia, Table 3 and Figure 2, a discrepancy can be seen between opinions received from governmental officials, INA and large oil processing companies representatives, all of whom are stating as the main reason the poor practice/knowledge/organization of agricultural producers, and representatives of various small and medium enterprises (both agricultural producers and potential biodiesel producers), who believe that the main reason for insufficient production is inappropriate and insufficient subsidies coupled with a lack of market for rapeseed oil. Answers received from experts and researchers are more varied, with the lack of a general and comprehensive strategy for biodiesel production being the most frequently received.

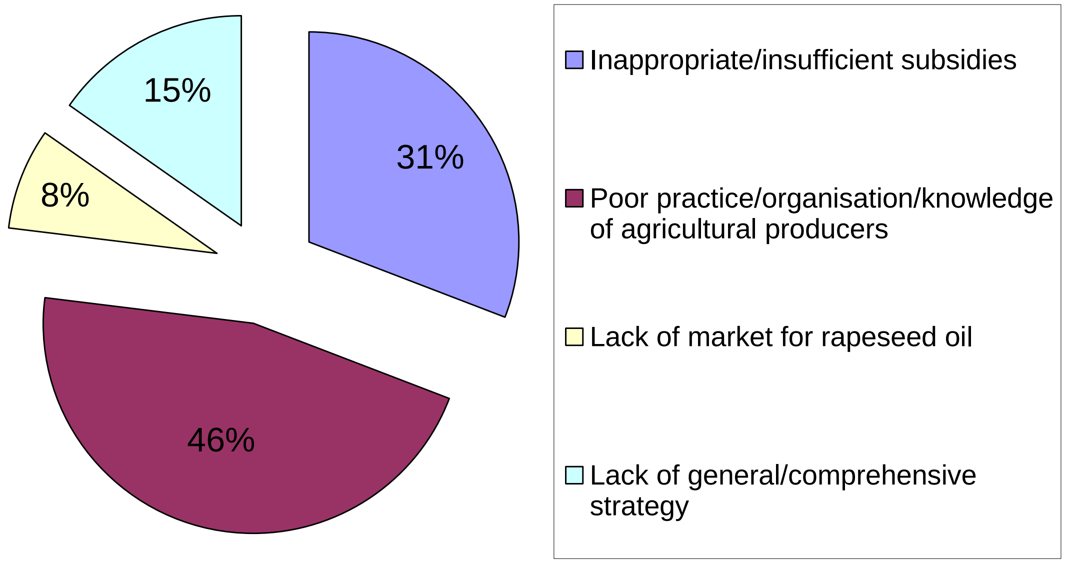

Figure 2 *What is the main reason for insufficient production of rapeseed in Croatia – answers in percentages*

The received answers to the question about who should product biodiesel in Croatia are more varied then to the previous two questions, Table 4 and Figure 3. Governmental officials, probably wanting to keep a neutral position, have uniformly stated that both large and small producers should be involved in biodiesel production in Croatia. In contrast, INA and oil processing companies clearly state large producers as the predominant answer, thus indicating that they expect to play a major role in this sector. Answers received from experts/researchers and SMEs are not uniform. However, looking at all received answers, 50% of the respondents believe that large companies should produce the major part of biodiesel.

The fourth question aimed at getting opinions regarding what should be done to start the production of biodiesel, specifically by the Government, by expert institutions and by agricultural producers. As expected, the most frequent answer regarding the necessary actions by the Government specifies the setting up of a comprehensive legislative framework covering the whole biodiesel production chain (including incentives, standardization, quality control and other issues), complemented with a general biodiesel production strategy. However, looking at oil processing companies and SMEs, it can be concluded that entrepreneurs believe that covering only the economic non-competitiveness of rapeseed production for biodiesel – its higher price – through subsidies and fiscal measures is enough to effectively start the production. Regarding the envisaged necessary actions by various expert institutions the needs to provide expert advice to the Government, to form a multidisciplinary team to lead the project of biodiesel production and to perform educational and promotional activities are given almost equal importance. The answers regarding what should agricultural producers do to start the production of biodiesel are the most obvious ones, indicating the need for better organization of the agricultural sector, as well as the need to implement expert advice and experience of EU countries regarding technology and production methods.

Table 4 *Who should produce biodiesel in Croatia - answers sorted by stakeholder groups*

	Large producers	SMEs	Oil processing companies	Both large and small producers
Government				100%
INA	100%			
Oil processing companies	50%		50%	
Expert/researcher	60%	20%	20%	
SMEs	20%	40%	40%	

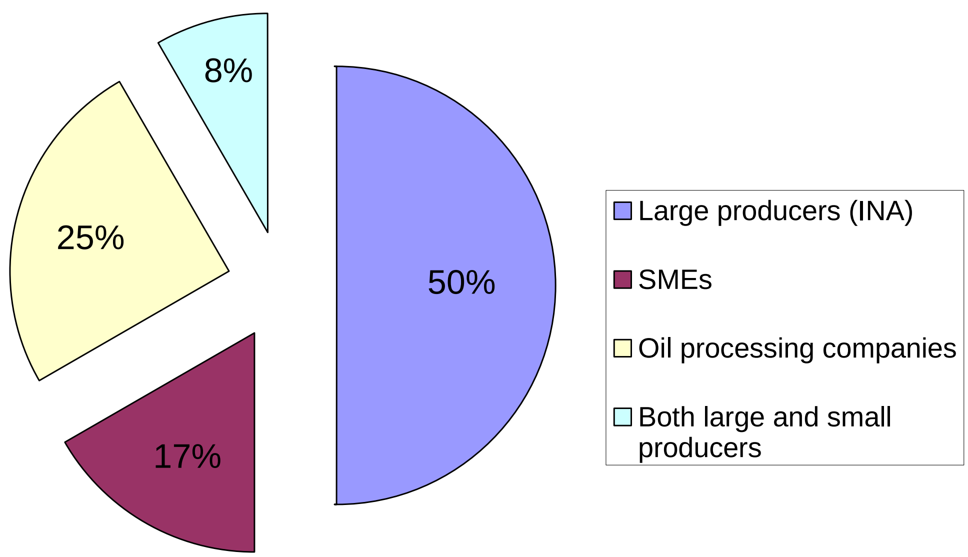

Figure 3 *Who should produce biodiesel in Croatia – answers in percentages*

Table 5 ***What should be done to start the production of biodiesel by the Government – answers sorted by stakeholder groups***

	Comprehensive legislative framework (incentives, standardisation, quality control) and biodiesel production strategy	Fiscal measures (free biodiesel from taxes)	Better subsidies for rapeseed producers
Government	100%		
INA	100%		
Oil processing companies		50%	50%
Expert/researcher	80%	20%	
SMEs		67%	33%

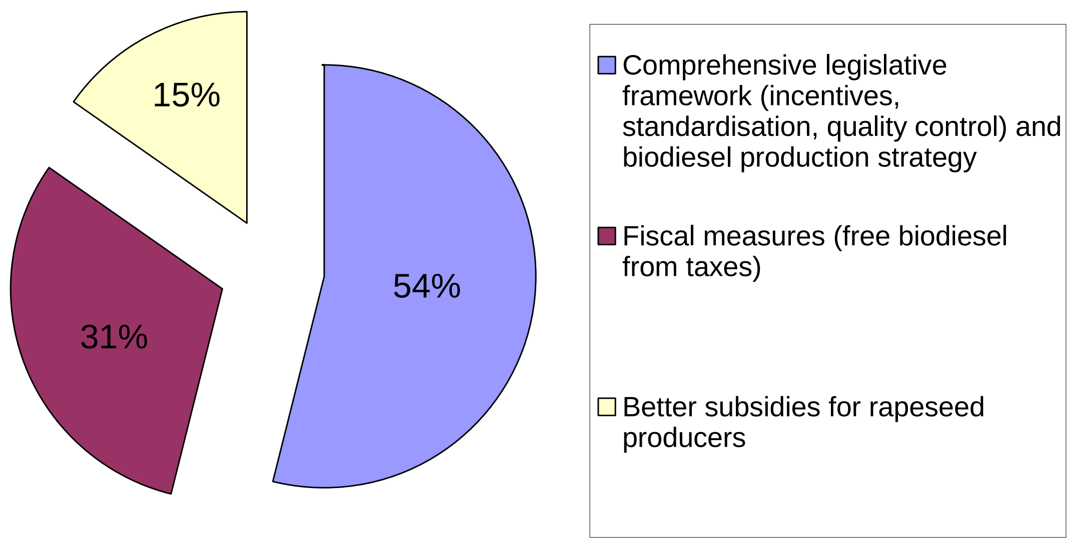

Figure 4 *What should be done to start the production of biodiesel by the Government answers in percentages*

Table 6 *What should be done to start the production of biodiesel by expert institutions – answers sorted by stakeholder groups*

	Provide expert support to Government and rapeseed producers	Educational and promotional activities targeting rapeseed producers	Form a multidisciplinary team to lead the project of biodiesel production
Government	100%		
INA	50%		50%
Oil processing companies	50%		50%
Expert/researcher	58%	22%	20%
SMEs		50%	50%

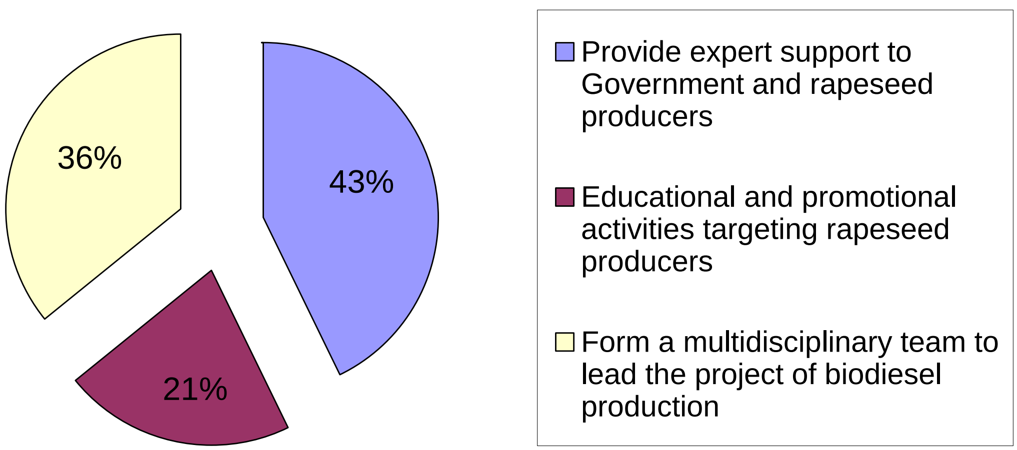

Figure 5 *What should be done to start the production of biodiesel by expert institutions – answers in percentages*

Table 7 *What should be done to start the production of biodiesel by agricultural producers – answers sorted by stakeholder groups*

	Efficient organisation of rapeseed production (small farmers joining forces)	Implement expert advice and experience of EU countries regarding technology and production methods
Government	100%	
INA		100%
Oil processing companies	100%	
Expert/researcher	40%	60%
SMEs	70%	30%

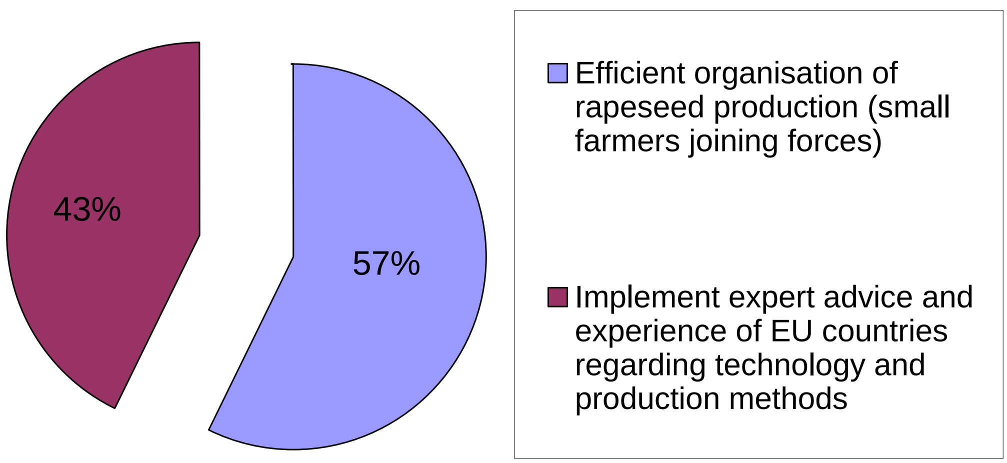

Figure 6 *What should be done to start the production of biodiesel by agricultural producers – answers in percentages*

The final question was aimed to investigate the opinions regarding which model of biodiesel production would be the most appropriate for Croatia. A clear polarization of received answers can be seen when looking at the results in Table 8 and Figure 7, indicating that all relevant stakeholders except SMEs believe that biodiesel production in one or two large facilities would be more appropriate and efficient then production in a larger number of small facilities.

Table 8 *Which biodiesel production model would be the most appropriate for Croatia – answers sorted by stakeholder groups*

	Large production	Small production
Government	100%	
INA	100%	
Oil processing companies	100%	
Expert/researcher	100%	
SMEs		100%

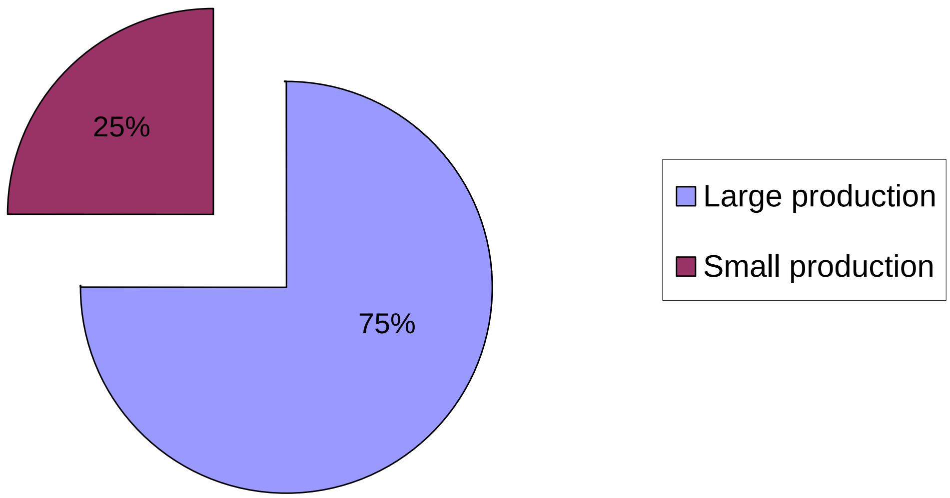

Figure 7 *Which biodiesel production model would be the most appropriate for Croatia – answers in percentages*