Results and follow-up of the UNIDO Countrywide Feasibility Study for a Potential Croatian Biodiesel Industry

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Summary

The paper 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, help improve the quality of environment and diversify production and employment in agriculture and industry. The intention of the paper is to give insight into the gathered knowledge which can 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.

Feedstock cost and availability are the main factor affecting the competitiveness and profitability of biodiesel production in Croatia. Consequently, the importance of the Government intervention with appropriate measures is highlighted throughout the paper 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.

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.

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.

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1 Introduction

After almost 15 years of continuos promotion of biofuels benefits and recent and still ongoing rapid development of biofuels industry in almost every European country, biofuels are finally being produced in Croatia. The first produced biofuel was biodiesel from modest capacity, but new and exciting large scale biodiesel and bioethanol projects are already under development.

Croatia is a country with very limited 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 2006 and more growth is expected in the future.

Similar to most transition economies, Croatia has gone through severe changes in the labour market since the 1990s. with unemployment rate ranging between 15 to 35% depending on the region. Nowadays, Croatia is a candidate country for joining the EU with promising economic horizon. The country experienced an economic revival starting from the beginning of 2000 and remaining constant (4.8% growth rate in 2006) with strong development of the services sector where tourism, banking, and public investments are leading the way.

The production of biofuels was perceived as one of the promising options to provide an integrated solution to energy, environmental and socio-economic concerns for a long time. In 2003, the Government of Croatia has asked UNIDO to finance and provide technical assistance to achieve the aforementioned objectives. In the frame of a preparatory assistance project phase, by the end of 2005, 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.

The UNIDO activities and the final report were well received in the country and initiated a number of follow-up developments described in this paper.

2 Croatian National Strategies and Legal Framework for Biofuels

The first efforts to prepare a national energy strategy for Croatia started in 1995 when the research and scientific project *Planning and Organisation of the Croatian Energy Sector* (PROHES) was launched and financed by the Croatian Government. Project activities involved the analyses of present conditions and relations within the energy sector and its sub-sectors, potential development scenarios and the organisation of the energy sector. In addition, the project analysed management practices within the energy sector, the impact on the country's economic development, and environmental aspects of energy sector development. As a result, twelve National Energy Programmes were initiated. Biodiesel production was a part of the National Energy Programme BIOEN launched by the Croatian Government in February 1997.

In 2001 the Croatian Parliament adopted a legislative framework defining the relationships within the energy sector that includes the following: Energy Law, Law on Electricity Market, Law on Oil and Oil Derivatives Market, Law on Gas Market and Law on Regulation of Energy Activities. Later on, in December 2004 and July 2007, some changes and additions were introduced in the framework. Energy Law, for the first time, precisely articulated the positive attitude of the Republic of Croatia toward renewable energy sources, and biofuels were recognised as an especially valuable component.

The current Energy Sector Development Strategy of the Republic of Croatia has been developed under the umbrella of a much larger project of the Croatian Government entitled *Croatia in the 21st Century*. The Energy Sector Development Strategy of the Republic of Croatia published in 2002 is a logical continuation of the strategy developed in 1998. According to this important document there is a significant energy potential for RES exploitation in Croatia. For heating, the best option would be biomass, geothermal and solar radiation; while for electricity production the identified potentials consider small hydro, wind, geothermal and energy generated through photovoltaics. Liquid biofuels and biogas have a great potential and importance, especially for rural parts of country.

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 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 Directives are already partially transposed into the national legislation through the Regulation on the quality of biofuels (OG 141/2005) and should be aligned completely through the Biofuels Act which Ministry of Economy, Labour and Entrepreneurship announced for 2008. At the moment the Regulation on the quality of biofuels prescribes the national indicative target of 5.75 percent share of biofuels in total consumption of fuels on the domestic market by 31 December 2010. In addition, Some analyses were made in the form of and/or a part of studies, but no effects of the use of biofuels in diesel blends above 5 percent by non-adapted vehicles were monitored. However, the Regulation on the quality of biofuels sets limit values for the quality features of biofuels and standards. The issue of public information on the availability of biofuels and other renewable fuels will be addressed and regulated through legislative framework, which will be set in the forthcoming period. The Regulation on the quality of biofuels specifies informing the public on the availability of biofuels and other renewable fuels and labelling obligation of biofuels added to mineral oil derivatives with more than 5 percent of methyl ester or 5 percent bioethanol.

3 Key Factors affecting Establishment of Biodiesel industry in Croatia

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.

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 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. In 2005 overall national rapeseed production amounted to only 41.275 t which is not sufficient base for a successful development of a national biodiesel industry.

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 subsidy for rapeseed (2.250 HRK/ha) is about three quarters higher than those for wheat (1.650 HRK/ha) and maize (1.250 HRK/ha) , 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 Osijek-Baranja 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.

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.

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).

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. 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.

A critical factor for establishing a sustainable biodiesel industry in Croatia would be 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.

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:

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 Macroeconomic analysis of biodiesel production impact in Croatia

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. 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 in line with the described EU legislation.

The analysis undertaken for the assessment of the impact of biodiesel production to the Croatian economy was input-output (I/O) analysis which is published and recommended jointly the United Nations, the Commission of the European Communities, the International Monetary Fund, the Organisation for Economic Co-operation and Development, and the World Bank.

I/O analysis is a quantitative tool that can contribute substantially to the understanding of the nature of a national or regional economy. It traces out the sources of each sector’s inputs, whether they are purchased from other firms in the economy, imported or contributed by labour (wages and salaries). It also provides a breakdown of each sector’s output, with sales to other industries and of final demand (consumption, gross fixed capital formation and exports). Thus, portraying the total economy by a number of sectors, I/O models assess the effects of changes in one sector on all other sectors of the economy; both the direct and indirect impacts.

The contemporary I/O analysis is performed according to the System of National Accounts - a conceptual framework that sets the international statistical standard for the measurement of the market economy. The analysis itself bases in Leontief I/O model which is in its core a system of linear equations containing productive coefficients which describe the relation between inputs used by the sector and the final product. Its specific structural characteristics are thus reflected in the numerical magnitude of the coefficients of these equations.

Despite the indisputable logic behind the I/O concept and its technical coefficients, one should be aware of some limitations that this tool has as the I/O table is based on certain assumptions:
- The inter-industry flows from *i* to *j* depend exclusively and entirely on the total output of sector *j* for the period observed;
- There is no effect of economy of scale;
- The products are homogeneous,
- There are no externalities in the production procedure,
- There are no capacity constraints in the use of factors of production,
- The coefficients of production are fixed and, as such, provide a static snap shot of an economy

With the intention of identifying forward and backward linkages of biodiesel production that induce direct and indirect effect on the economy, a biodiesel production chain was constructed that covers four different stages of biodiesel production:

- Rapeseed growing – production of seed;
- Seed preparation – storage;
- Oil pressing and esterification – production of RME plus rape seed cake, glycerol and potassium fertilizer as by-products.
- Blending and sale – substitution of mineral oil diesel with diesel (EN590).

At the time of the UNIDO project, there was no actual biodiesel production in Croatia. The model hypothetical biodiesel production was constructed in order to avoid limitations of the methodology and to assess impacts to the economy assuming that Croatia will comply with the EU Biofuels Directive – Directive 2003/30/EC which recommends proportions of biofuels and other renewable fuels placed on the national market (2% and 5.75% calculated on the basis of the energy content, of all petrol and diesel for transport purposes placed on their markets by 31st December 2005 and 2010, respectively). In that sense the model assumptions were:

- One biodiesel processing plant will have the capacity of 50.000 tones per year;
- Rapeseed will be used as biodiesel feedstock;
- Oil pressing and esterification will be done in the same (annex) factory;
- Building and storage facilities already exist;
- Biodiesel will be blended with mineral diesel in the ratio of 5/95%;
- Biodiesel will be exempted from excise tax and HAC fee (Croatian Highway fee).
- All inputs are of domestic origin and all outputs are utilised in the country.

In that sense, the biodiesel production block constructed represented a self sufficient economy that produces only biodiesel where the total supply at purchasers' prices is equal to the total output of industries (total product supply at basic prices) plus trade, transport margins and taxes, less subsidies on product (VAT). As such, biodiesel production block could serve as a basis for biodiesel impact assessment to any country that starts with biodiesel production.

The basic biodiesel production block has to be adjusted to national peculiarities which are directed first on the methodology itself (i.e. the adoption of SNA in a country) and economic framework (taxation system, economy, structure trade balance, agriculture policy, land availability etc.). Croatian peculiarities were, apart the fact that the latest available I/O table for Croatia is the one made in 1997 with the RAS method:

- Rapeseed yield of 3 tons per hectare
- Competing agriculture activities: maize and wheat growing
- Penalty fee for idle agricultural land
- Agricultural subsidies system
- Structure of mineral diesel price (wholesale price, excise tax, Croatian Motorways fee, VAT of 22% and retail price)
- Availability of inputs (i.e. biodiesel production plant came from imports).

Given the assumptions, if the biodiesel produced were to be sold as pure biodiesel at gas station and were to follow the same cost structure of mineral diesel, the price at gas station would be between 7.093[3] and 7.4215 HRK/l which is 18 to 24% higher than the mineral diesel price[4], depending on the scenario. However, when blended to ratio 5/95 with mineral diesel and the biodiesel part is exempt from excise and fee, the difference shrinks to 0.03 to 0.05 HRK more for a litre of biodiesel blend.

If the governmental intervention were excise and fee exemption, without changes in agriculture sector, the impacts of biodiesel production on Croatian economy would be direct losses of 53 million HRK from excise tax, which is about 0.7% of total current Governmental revenue from excise taxes and 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.

On the other hand, new economic activity generates multiplier effect expressed as income from employment and entrepreneurship. The multiplier effect depends on the labour intensity of the

[3] The average exchange rates in 2004: 1 USD = 6.03122 HRK; 1 € = 7.49568 HRK
[4] The average mineral diesel price in 2004: 6.00 HRK/l, in 2005 6.96 HRK/l and in 2006 7.26 HRK/l

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 change in demand. Within the methodology standard for I/O 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 existing agricultural subsidizing system at the agricultural part of biodiesel production that have inflated income from employment. These results provide estimations of the macroeconomic impacts of the biodiesel production in Croatia which accuracy could be corrected for when the biodiesel actually occurs in the near future and when the I/O tables are to be updated.

Nevertheless, when considering the biodiesel production block and closing the economy for international trade (assuming self-sufficiency), the results show that, biodiesel production is worthwhile to subsidize as it seems to be beneficial in terms of both industry development, income and labour direct and indirect effects despite the significant amount of funding given through agricultural subsidies. However, one should be careful in interpreting the results as in reality as the actual economy of a country in question might not be able meet the net final demand from its own sources and the multiplier effect could be outsourced to the exporting economies. Nevertheless, the availability of a Social Accounting Matrix in order to perform a SAM impact analysis instead of an I/O could give more detailed results for the role of biodiesel sector. Future research should pursue possible impacts in terms of employment, household income or net tax benefits for the economy in order to further clarify the economic and social role of biodiesel production. The methodology of constructing a biodiesel production block for the purposes of I/O and SAM impact analysis may be applicable to any country where biodiesel is a new activity.

5 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.
- 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 rapeseed 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.

6 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.

Parallel to the implementation of the UNIDO project, a number of follow up activities were triggered:

- In 2005, the Ministry of Environmental Protection and Physical Planning prepared the *Regulation on Biofuels Quality* which regulates issues regarding the biofuels quality and gives some targets for national consumption in line with the Directive 2003/30/EC.
- Construction works for building a biodiesel processing plant using rapeseed as feedstock in Ozalj finished in early 2006. The plant of 20.000 t/yr capacity is owned by Modibit, a local SME. One part of the biodiesel production is used to supply public transport buses in the city of Zagreb.
- In late 2006, the first biodiesel processing plant, Vitrex ltd., for production of biodiesel out of waste cooking oil was ready to start its production. The plant has capacity of 6.000 tons per year.
- In December 2006, Ministry of Economy, Labour and Entrepreneurship developed the *Plan of placing biofuels on the domestic market in 2007*, which prescribed the share and amount of biofuels which fuel suppliers have to put on the domestic market, in order to achieve the national indicative target of 5.75% by the end of 2010.
- New and exciting large scale biodiesel and bioethanol projects are already under development followed by strong political support. New projects include biodiesel from rapeseed and waste edible oils as well as bioethanol from corn and sugar beat.

Production and utilization of biofuelsl 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 ongoing development already indicates, further projects, some of them even on a regional base could be expected very soon.

7 References and Further Reading

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[6] Annual Energy Report: Energy in Croatia 2005, Ministry of Economy, Labour and Entrepreneurship, Republic of Croatia, 2006, Available at www.mingorp.hr

[7] Šegon, V. and Šćulac-Domac, M., 2006. *Renewables in Croatia: Latest developments 2005-2006*, presentation published in proceedings from Data Gathering on Renewable Energies for New Member States and Candidate Countries, Cavtat-Dubrovnik, Croatia, 15-16 November 2006

Annex

Table 1 *Assumptions on agricultural production of rapeseed*

Cultivation area for rapeseed	**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

Table 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

Table 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: 85 430 t Glycerol: 9 700 t Potassium sulphate fertilizer: 750 t
By-product prices*	Cake: 1 150 HRK/t Glycerol: 1 290 HRK/t Potassium sulphate fertilizer: 1 371 HRK/t
RME production:	50 000 t Density: 880 kg/m^3 equals 56.8 million litres
Processing costs:	Low: 10 170 HRK/ton of RME Medium: 10 353 HRK/ton of RME High: 10 537 HRK/ton of RME
RME selling prices:	Low 8 066 HRK/t (7.0983 HRK/l) Medium: 8 250 HRK/t (7.2599 HRK/l) High: 8 434 HRK/t (7.4215 HRK/l)

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

Table 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

Table 5 *Assumptions regarding the blending of biodiesel with mineral diesel*

Blending ratio	**Total amount of pure biodiesel: 56 million l Substitution equivalent of diesel: 52 million l Total amount of diesel for blending: 1 117 million l Total amount of diesel (EN590): 1 174 million l**	
Substitution	Total amount of diesel (EN590):	1 174 million l
	Substitution equivalent to diesel:	1 170 million l
Retail price of mineral diesel		6.39 HRK/l at gas station
Hypothetical selling prices of pure biodiesel	low	7.09 HRK/l
	medium	7.25 HRK/l
	high	7.42 HRK/l
Hypothetical retail prices of diesel (EN590)	low	6.42 HRK/l
	medium	6.43 HRK/l
	high	6.44 HRK/l

Table 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