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Instrument: Integrated Project

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**Advanced Biorefinery Concepts: A Feasibility and Reality Check**

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Preface

More than 25% of all EU legislation has a significant scientific and technical basis. As a service of the European Commission, the JRC provides in-house customer-driven scientific and technical support for the conception, development, implementation and monitoring of EU policies, independent of commercial and national interests.

The mission of the JRC Institute for Energy is to provide support to Community policies related to both nuclear and non-nuclear energy in order to ensure sustainable, secure and efficient energy production, distribution and use. The Energy Systems Evaluation Unit objectives, in collaboration between JRC institutes are to collect, harmonise and validate information on energy technologies, to perform related techno-economic assessments, to establish, in collaboration with all relevant national partners, the scientific and technical reference required for the debate on a Sustainable Energy strategy in an enlarged EU and in the context of global sustainable development.

The strategic objectives of the JRC enlargement and integration activities are to help the new member states, candidate countries and potential candidate countries deal faster with the “EU acquis” in areas of JRC competence and to contribute to the development of the “European Research Area”. The main target is to achieve a full working involvement between the ascending and candidate countries and the JRC, consistent with the level enjoyed by current member states. The main instruments towards achieving these goals are:

- Extending JRC core projects to focus on specific needs of new member states, candidate countries and potential candidate countries
- Involve new member states, candidate countries and potential candidate countries organisations in JRC networks
- Host visiting scientists, seconded experts, fellows
- Organise advanced training courses and workshops
- Other information and awareness actions

In the context of the Biosynergy Project this Enlargement and Integration Workshop is held in order to disseminate advanced biomass processing concepts and technologies beyond EU borders, in countries / regions that have promising biomass / bioenergy potential. On average, new member states, candidate countries and potential candidate countries have larger land area per capita, lower level of bioenergy penetration and higher import dependence on fossil fuels (oil and gas) than the elder EU-15/25 member states. The goal of the workshop is to exchange views and information on the potential of bio-refineries in the new member states, candidate countries and potential candidate countries, targeting policy makers, industrial stakeholders and researchers, including NGOs, and to have a brief SWOT snapshot on the perspectives of biorefinery concepts in these areas.
1 IP Biosynergy: Overview & Status

1.1 Background

The key drivers that will shape the future of the EU energy sector are the security and diversity of energy supply, the reduction of greenhouse gas emissions and ensuring of general environmental compliance and the improved competitiveness of the European economy.

As oil and gas become increasingly expensive and given the fact that Europe is short of both – there is a need to search for alternatives. The EU policy towards the sustainability, security of supply and competitiveness of the energy system proposes the following targets by 2020:

- Achieving a reduction of at least 20% on GHG emissions with regards to reference levels
- Improving energy efficiency by 20%
- Covering 20% of the energy needs by renewable energy

Regarding biofuels this translates to a proposal for a binding minimum target of 10% by 2020; “provided that 2nd generation biofuels from lignocellulose are commercially available”. There is a strong debate on policy targets and the introduction of sustainability/certification criteria for biofuels, which highlights the need to stimulate 2nd generation biofuels from lignocellulose and provide a sound scientific background as a support for policy decisions.

Biosynergy is a 6th Framework Programme Project looking into the integrated co-production of chemicals, fuels for transport, power and heat from biomass (biorefinery), through advanced fractionation and conversion technologies both through biochemical and thermo-chemical pathways. It involves full process development from lab-scale to pilot-scale as well as a demo concept for larger integrated facilities. The focus is on bioethanol-side streams, building upon the advanced BCyL lignocellulose ethanol plant of Abengoa in Salamanka (Spain). All concepts developed in the project will also be studied in terms of market competitiveness and environmental compliance.

The difference between 1st versus 2nd generation biofuels for transport lies in the different feedstock and conversion technology used for their production, shown simplified in Figure 1.1. Second generation transport fuels from lignocellulose have potential advantages over their first generation counterparts such as the larger availability of biomass and waste for their production, which is not in competition with food sources, and the higher CO₂ reduction percentage at lower cost.

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**Figure 1.1: Simplified schematic of the pathways to 1st and 2nd generation biofuels**
Biorefining is defined as the co-production of biobased products, materials and chemicals biofuels for transport, power and/or heat in a technically, economic and ecologically fully optimised integrated system. The objective of biorefining is to maximise the economic added-value of biomass by producing multiple products, to lower biofuels costs by generating co-products and to maximise the environmental benefits of biomass use via an optimal mix of products.

Biorefinery systems can be categorised according to feedstock as follows:

- Lignocellulosic feedstock biorefinery, which uses “nature-dry” raw material or waste. It includes “two platforms concept”, the sugar platform and the syngas platform
- Whole crop biorefinery which uses raw material such as cereals or maize (grains + straw)
- Green biorefinery which uses nature-wet biomass such as green grass, alfalfa, clover, or immature cereal

Comparison of the basic-principles of the petroleum refinery and the biorefinery with regards to the use of biomass/biobased intermediates in existing refineries is a topic in both Biosynergy and Biocoup integrated projects.

1.2 Overview of the Biosynergy Integrated Project

Biosynergy stands for : BIOmass for the market competitive and environmentally friendly SYNthesis of bio-products – chemicals and/or materials – together with the production of secondary enERGY carriers – transportation fuels, power and/or CHP – through the biorefinery approach.

The BioSynergy project is supported by the European Communities through the Sixth Framework Programme for Research and Technological Development (2002–2006) with a grant up to 7.0 million Euros under contract number 038994 – (SES6). The project addresses Thematic Priority “Sustainable development, global change and ecosystems”. It started on the 1st of January 2007 and has a duration of 48 months.

Biosynergy combines (bio)chemical and thermochemical pathways from process development on lab-scale to demonstration at pilot-scale towards four main general scientific and technological project objectives:

- To develop the best thermochemical/(bio-)chemical conversion and fractionation technologies for major side-streams of an ethanol fermentation plant, which will also be applicable for other wet and dry feedstocks.
- To define the potential of identified platform chemicals for both (fine) chemical and petrochemical industries.
- To go from lab-scale to pilot-scale processes using techno-economic assessments and clear exploitation guidelines.
- To make the production of biofuels more cost competitive

The Biosynergy Consortium comprises 17 partners from industry, R&D institutes and Universities from 10 EU countries. The work is divided into the following work packages:

WP 0 – Management activities
WP 1 – Advanced physical/chemical fractionation
WP 2 – Innovative thermo-chemical conversion
WP 3 – Advanced biochemical conversion
WP 4 – Innovative chemical conversion and synthesis
A brief overview of the progress of the different work packages during the first year of the project is provided below. R&D shows good progress with the development of integrated processes being one of the major challenges. For updates, newsletters and further information please refer to the project webpage [http://www.biosynergy.eu/](http://www.biosynergy.eu/)

### 1.2.1 WP 1 – Advanced physical/chemical fractionation

The work package objective is the lab-scale development and optimisation of physical and chemical treatments for the separation of cellulose, hemicellulose and lignin, their monomeric constituents (sugars, aromatics) or structural derivatives.

Up to date the laboratory set-up has been designed and established and distribution and characterization of the following feedstocks has been performed:

- Wheat straw
- Barley straw
- Pre-treated wheat straw
- Poplar wood
- Spruce wood

Furthermore a literature review on available fractionation technology has been performed and lab scale fractionation experiments have been launched on 5 different routes with benchmarks defined. Work has also started on lab scale enzymatic hydrolysis.

### 1.2.2 WP 2 – Innovative thermo-chemical conversion

Work package 2 deals with the lab-scale development of (catalytic) staged degasification and pyrolysis (thermo-chemical refineries) for fractionation and conversion of lignin and biomass into chemical intermediates and secondary energy carriers. The goal is the integrated development of high-efficiency separation technology for chemical intermediates from thermochemically derived product mixtures.

In the first year the work involved proof-of-principle staged de-gasification concept, procedures for low-mineral homogeneous bio-oil production and assessment of applicable separation technologies for thermo-chemically derived products from mixtures.
1.2.3 WP 3 – Advanced biochemical conversion

The aim of work package 3 is the development of advanced biochemical processes for conversion of sugars and lignin into value-added products or intermediates - higher alcohols, platform chemicals, functional lignin derivates, etc.

In the first year of the project the work package has been busy with acetone-butanol fermentation, rapid screening and strain characterization, production of platform chemicals from xylose, production and analysis of functional lignin derivates – lignin nanoparticles and enzymatic lignin modification and separation by rotating disc contactors.

1.2.4 WP 4 – Innovative chemical conversion and synthesis

This work package deals with the development and analysis of lab-scale chemical conversion technologies for valorisation of C5-sugars, lignin and thermo-chemically derived bio-based intermediates, as well as with processes for synthesis of final products from value-added intermediates.

Up to now there has been production and characterisation of platform chemicals, products from platform chemicals, pentoses (C5-sugars) valorisation as raw materials for surfactants and application of innovative membrane reactor concepts for product recovery.

1.2.5 WP 5 – Conceptual design Biorefinery pilot-plant plant of ABNT in Salamanca

Work package 5 has the task of the conceptual design of an innovative biorefinery plant at an existing bioethanol site (ABNT, Salamanca) consisting of integrated physical/chemical or thermochemical fractionation processes coupled to advanced biochemical or (thermo)chemical conversion processes for the co-production of upgraded bio-products (chemicals, materials), transportation fuels, power and/or heat

This work package will benefit from the results of the previous tasks. In the meantime a database with physical & chemical properties for process design is being set-up, along with an integrated model prepared for the base case and the upgrading concept of the demo-plant. A draft econometric model is also constructed to evaluate the different design concepts.

1.2.6 WP 6 – Integral biomass-to-products chain design, analysis and optimisation

Using the input from the other work packages work package 6 has the task of identifying the most promising biorefinery chains for the European Union and for some specific market sectors based on technical performance, energy efficiency, environmental performance and costs. Based on input from
the industrial partners it will also identify options for integration of biorefineries with conventional oil refineries.

In anticipation of the findings of the other work packages a literature review is performed and a methodology is set up to identify the optimum process routes from the group of technical possibilities arising from the lab tests. Data collection is initiated and the main structure of the Life Cycle Assessment model is defined.

1.2.7 WP 7 – Demonstration at pilot-scale

The objective of work package 7 is to use pilot-scale facilities to produce samples of bio-based intermediates for lab and bench-scale technology developments (WP1-4) thus examining the scale-up potential of developed technologies. As this work package builds on the results of work packages 1-4 most of its work is scheduled for later parts of the project. Up to date the pre-treated raw material has been delivered and the adaptation of Abengoa’s pilot plant has started along with the pilot-scale pyrolysis in a rotating cone reactor by BTG.

1.2.8 WP 8 – Training of people and knowledge dissemination

The objectives of work package 8, which deals with training and knowledge dissemination include:

- the dissemination of policy options/suggestions to national and European stakeholders and policy makers
- external knowledge dissemination to promote the project results to the European community
- to promote developed technologies, strategies and products in different markets
- to foster a two-way continuous communication between the project consortium and existing and potential future stakeholders
- to train persons of relevant stakeholders, and to contribute to policy development of both national and European stakeholders and policy makers
- to ensure the visibility of the IP Biosynergy through participation at international events and publications.
- to establish international cooperation and collaborations with developing countries as well as with the USA, Japan and other running EU-initiatives

Several international initiatives are under way and will be further elaborated in the coming period. More intensive activities in this area are expected in the upcoming stages of the project, when more results become available for presentations in international conferences and other exchange fora. It is also clear that the dissemination activities undertaken by the Biosynergy consortium (website, Newsletters, press releases, workshops, Roadshow, publications, etc.) will form the starting point for the establishment of new international contacts and cooperations.

This Enlargement and Integration workshop is part of the activities of work package 8. Participants are encouraged to further disseminate knowledge within the relevant sectors of their countries and establish further contact and collaboration with IP Biosynergy where they feel that such opportunities arise.
2 Biorefinery Case Studies

2.1 Abengoa

Abengoa is a technological company that applies innovative solutions for sustainable development in the infrastructure, environment and energy sectors. It is present in over 70 countries where it operates through its five Business Units: Solar, Bioenergy, Environmental Services, Information Technology, and Industrial Engineering and Construction. Abengoa Bioenergy generates energy from renewable resources, thus contributing to Abengoa’s main focus on sustainable development. The short term focus is on first generation technologies, while it moves to second generation technologies in the medium to long term (Figure 2.1).

![Diagram](image-url)

Figure 2.1: Abengoa’s strategic vision for bioenergy development as part of a sustainable energy system

In the following an overview of the state-of-the-art processes and technologies that are pursued by Abengoa is given and their weak points are identified, along with the ongoing research for their improvement and commercialisation.

2.1.1 The Biochemical Pathway

The feedstock is transformed into sugars; the process would change depending on the chemical composition: each feedstock yields different co-products.

**Enzymatic hydrolysis process**

The process is defined as the fractionation of the biomass into its main components (cellulose, hemicellulose and lignin) for further fermentation of sugars to ethanol and valorisation of the remaining residue (lignin).

There is interest in this process as it is an alternative to the traditional production from cereals and sugar beet and could unlock the potential for biofuel production. Its advantages include the possibility to use a higher raw material range of lower cost and not linked to the human food and animal feed market, lower production costs in comparison with first generation conversion technologies and higher environmental sustainability.
Currently no commercial technology exists for this process. Abengoa Bioenergy is the world-leader in the technology development. It is the unique player with pre-commercial facilities:

- York pilot plant – 1 tonne/day
- Salamanca demonstration plant – 70 tonne/day

Innovation is required in the areas:

**Biomass pre-treatment**

The objective is the development of a pre-treatment method able to modify the structure of the lignocellulosic biomass to make cellulose accessible to the enzymes. Abengoa Bioenergy has developed and protected a thermochemical pre-treatment based on steam explosion and is currently carrying out studies to improve performance and reduce severity.

**Biomass fractionation**

The aim is to develop a process configuration to fractionate the biomass into its three main components. Abengoa Bioenergy has developed a concept and has implemented it at its York pilot plant where they are analysing its performance and performing optimisation studies.

**Enzyme production**

The goal is to develop an enzyme mixture able to deliver a competitive production cost measured in Euros per litre of ethanol produced. This is currently pursued through strategic investment in Dyadic International inc.

**C5 fermentation**

The engineered microbial systems have to be able to achieve:

- high yield with complete sugar utilisation, minimal by-product formation, and minimal loss of carbon into cell mass
- higher final ethanol titer
- tolerance to inhibition present in hydrolysates
- higher overall volumetric productivity, especially under high solids conditions (use of both C5 and C6 with high yields over 95%)

Progress in this area is also pursued through a strategic alliance with Nature Works for the development of a satisfactory organism.

**Other biomass fractions valorisation**

The objective is to produce value added products (chemicals or building blocks for the chemical industry) mainly for lignin but also for other biomass fraction as hemicellulose. Abengoa Bioenergy is participating in the Biosynergy IP project and is in contact with chemical companies to advance in this field.
2.1.2 **Thermochemical pathway**

The process could be defined as the initial transformation of the biomass into gas and further conversion of the gas stream into products, ethanol and alcohols in this case. Currently a commercial technology does not exist. There are projects in the demonstration phase to produce diesel and methanol.

The thermochemical pathway is an alternative to the biochemical process that could transform any kind of biomass, including fractions not converted by the biochemical pathway. As an advantage the process can simultaneously generate electricity and the energetic yields are fairly high. It also profits from zero fossil fuel consumption and low emissions as well as low production costs.

Innovation is required in the following areas:

**Catalyst development**

Research is needed to discover new catalytic systems for gas conversion into ethanol.

**Process design**

Further research and development effort has to be put into the conceptual design of the process, analysis of different options and technology selection. Promotion of design and construction of pilot and demonstration facilities is needed to facilitate scaling-up to industrial size.

2.1.3 **Hybrid refinery - Biorefinery concept**

The Biorefinery concept is understood as a further stage in the development of technologies based on biomass as feedstock. It is the optimal combination of biological, thermo-chemical, and chemical processes, aimed at producing a complete range of products, using a wide range of feedstock, and taking advantage of synergies between technologies.

Hybrid technologies are the first step towards the biorefinery concept. ABNT is participating in the Integrated Project Biosynergy funded by the European Commission for the conceptual design of an advanced biorefinery concept based on the Salamanca demonstration facility. Furthermore, the US DOE has recently awarded Abengoa Bioenergy with $76 MM for the construction of the first of a kind commercial facility to produce ethanol from lignocellulosic biomass.

The Main Abengoa Bioenergy´s Biomass Project features a total investment of $300 MM on a hybrid concept for the production of 15 MGPY of biomass ethanol based on enzymatic hydrolysis technology and 85 MGPY of ethanol based on starch technology. Biomass gasification energy is used in the...
process which improves the life cycle environmental impacts. The start-up of operations is expected in 2010.

2.1.4 Conclusions

Lignocellulosic biomass is able to improve biofuels production capacity. There are two main different technologies of interest: biological (fermentation) and thermochemical (synthesis). The biological pathway is in demonstration status. There are possible improvements by means of biological pre-treatment, biomass fractionation and C5 fermentation. Process integration and demonstration is critical. The thermochemical pathway is in partial demonstration status for biomass gasification. The critical terms are the ethanol synthesis and gas cleaning. Process integration in the pilot stage and further demonstration are critical.

Ethanol consumption will increase. Since the ethanol production capacity from cereals is limited, it is necessary to produce it from lignocellulose. The introduction of lignocellulosic biomass technologies will be carried out by means of hybrid plants based on both cereals and biomass. Both biological and thermochemical pathways can be included into a common process that allows maximal use and optimisation of biomass

2.2 Green Biorefinery

2.2.1 Some basic problems of renewable resource processes

Green biorefineries deal with renewable resources and as such have to adapt to deal with the differences between conventional and renewable resources. Conventional chemical processes have as input standardised raw materials, which are continuously available from centralised sources, and thus logistics play a negligible role in the process structure. On the other hand renewable resource processes use raw materials, which differ in quality, their availability shows strong time dependence and they come from decentralised sources, and as a result logistics and storage have an impact on the process structure.

Some of the challenges for renewable source processes are resource competition, size optimisation and structural optimisation. For example the Borealis plastic materials production company in Austria is situated next to both a refinery and an airport. To replace their raw material supply with renewable resources would require the total arable land available in Austria. The fossil centralised structure is not applicable to renewable resources. We have to adjust and think differently when it comes to biomass. Renewables involve new questions, which may require both adapting the process but also bringing it to the raw material. Processes for renewables also suffer from a lack of experience and unknown heuristics (membrane technologies, chromatography). One of the basic problems for renewable resources is logistics. In a fossil-oriented system biomass presents a transport problem due to its different density to fossil fuels. Apart from the transport density, the short shelf life, limited storage time and decentralised production are also presenting a logistical challenge.

Some answers to the above may be provided by integrating the logistics in the process design from the beginning. Finding the right size for processes by weighing economy of scale vs. minimal transport is essential. Economy of scale is not the issue when dealing with biomass but rather what is important is resource availability in a given area. Local production of renewable resources is important as is utilising agricultural wastes, minor quality products and side streams. These resources are not integrated in the food chain so their use is better economically and avoids competition for resources.
Security of raw material supply requires a sustainable agriculture in the long term. While moving away from oil dependence, we need to make sure the next resource will be sustainable and available in the long run otherwise the problem is not solved. By 2010 in Austria ca. 100,000 to 150,000 ha of meadows will be not used for milk and meat production any more. By law grassland may not be turned to arable land. This is the chance for agricultural areas to progress and move forward.

2.2.2 The Austrian Green Biorefinery

Figure 2.5 shows a simplified schematic of the main processes and products of the Green Biorefinery. The main challenge is the complexity of separating the acids and other products from the press juice. The price of biogas is good so it is a preferred product. New fibre products are investigated but their introduction is risky due to the low market prices at the moment. Fibre could also be used for 2nd generation biofuels but this is not looked into currently.

The focus is in optimising processes such as the mechanical fractionation (pressing procedure) and the processing of the juice (LA and AA separation). The State of the Art research and development regarding amino acids production from silage (hydrolyzed proteins) gives a ~60% rel. recovery rate containing all essential amino acids, however the juice composition is complex. The market niche for these products is nutrition, while personal care applications are also feasible. These sectors are targeted as they are low volume high revenue niche markets.

For the production of lactic acid ~85% recovery of lactic acid from silage feedstock can be achieved aimed at further applications such as bulk chemical, solvent or bio-polymer (PLA). A combination of separation technologies (patent pending) is used and the market perspectives appear promising as lactic acid is considered the platform chemical of the future. There is a big existing market, which is an advantage and the border prices are favourable.

Green Biorefinery is also looking into utilising the grass fibres and for that reason fundamental characterisation of the press cake was performed. Various applications have been tested (fibre boards, fleeces, insulation material, building products...). The fact that grass fibre products are not known on the market is a disadvantage as it makes grass fibre utilisation in such applications risky in terms of economic aspects. The industry was contacted and shown materials produced on a prototype base but they were not very receptive to changing over from conventional materials. The current strategy is to use the press cake for biogas production since there is good potential in this field and this is the main application for grass fibres at the moment.

2.2.3 Summary and Conclusion

Figure 2.6 shows a schematic of a model for Green Biorefinery operation. By locating the biorefinery in the centre of a supply area it is possible to integrate the surrounding region. A 15 km radius equals to 40,000 tons of dry matter supplied by 4,000 hectares of grassland. If the press juice is movable the catchment area can be extended and then the fibre can be processed in a centralised biogas plant.
Looking at Green Biorefinery on an European level, there are different players in several countries working on the development of Green Biorefinery concepts, among which:

- Germany (LA fermentation)
- Switzerland (fibre utilisation)
- Netherlands (fresh grass)
- Ireland
- Austria (silage feedstock)

The main message and points to consider regarding Green Biorefinery concepts are:

- Border conditions for renewables are quite different to conventional resources
- Process synthesis is a method to generate complex utilisation networks. Green Biorefinery applies future key-technologies for separating valuable substances
- There are no general solutions but rather the focus should switch to regional embedded systems. Different processes are better suited to different regions
- Green Biorefinery is a technology concept for using the whole plant. While Green Biorefinery can be easily linked to a biogas digester it is a way to get more revenue out of the biomass before going to that stage
- Logistics will become a part of the process with regional “embedding” of technologies. Examining the processes without logistics might lead to errors.

2.3 Discussion

The delegates were interested in the energy consumption per amount of ethanol produced by the different technologies and the potential for energy production per hectare. When ethanol is produced from straw with cogeneration and electricity export the efficiency is 45%. This is higher than what is achieved for 1st generation ethanol production. Maximising production of a single product is not the best way of utilising primary energy input. The projection is that by optimising for more products the process efficiency could reach 55%. Energy production per hectare is highly dependant on the crop and the agriculture specifics, for example, sugar beat is the best crop for the Netherlands.

Since a grant from the US was mentioned there was a request for information on financial support received from European sources for the development of these concepts and any special tax schemes that may apply. BCYL is constructed from a 5th framework grant. First generation plants are built without support but all 2nd generation biofuel plants enjoy some form of financial support or subsidy. A total of 1 billion USD is channelled to 2nd generation plants in the US.

As electricity is also produced in the thermochemical pathway there was interest in the price achieved for feeding it to the grid. However, the electricity produced is only for internal use covering the needs of the entire plant and there is no export to the grid.

In view of the fact that the plants are not financially viable the question arose whether the EU is reviewing the GM crops decisions for feedstock used as input for these plants. The cost of the biomass is about 25% of the plant costs. However, as GMO issues are more related to agriculture than to energy policy, the overall position on GM crops should be taken into account. This is first an agricultural and consumer protection issue and it should be ensured that GMO crops for energy are not
used for other purposes. Thus there should be a position on GMO from the agricultural point of view, and the issue is beyond energy policy alone.

Another subject of interest was information on waste from the biorefinery processes and the associated cost for its treatment and disposal. This depends on process configuration. The main residues from bioethanol production are the lignin fraction and solids from distillation. Lignin can be burned, gasified or sold. Several uses for the distillation residue are under investigation. One idea is to also burn it. Another possibility is to mix the solids from the distillation column in with the cereal stream. ECN had a big project for producing lactic acid from straw. All residues from the process (50 kg per 700kt of calcium sulphate) can be used for fertiliser or building material. By also recycling all the water it is possible to make a waste free plant. Information on the study can be found at the ECN site (www.ecn.nl) along with a lot for other studies in the subject area.

The discussion also turned to the viable radius for straw collection for such projects. For the ECN project just mentioned above this would have to be 125km – all of the Netherlands – but the equivalent distance would be 50km in France. The change in the climate is affecting the yield of different crops due to the uncertainty in water availability. Because of the low density of straw there is investigation in fast pyrolysis to liquefy the straw before transporting it. The transport radius also depends on the available transport means; if transport by truck is considered then 40km might be the break-even radius.
3 Situation and Prospects in Enlargement and Integration States

3.1 Albania

Albania is a relatively small country with a limited energy market. As Albania has signed the Stabilization and Association Agreement with the EU the harmonisation of energy legislation with EU Acquis Communautaire is an ongoing process. The Albanian economy is a high energy intensity - poor energy efficiency economy and has been suffering a severe power crisis since 2001. Self-reliance considering all energy products is about 50%; the corresponding figure considering oil products alone is 25%. There is great potential for developing renewable energy sources as the agriculture sector remains an important sector for the Albanian economy.

The first draft of a National Energy Strategy (NSE) was prepared with EU technical assistance in 1996-1998; a NSE was only adopted in 2003, and its updating is now under process. Medium to long-term development scenarios for the energy sector show that self-reliance in the energy sector is expected to decrease over the next years. In view of that the Objectives of the National Energy Strategy are:

- The establishment of an efficient energy sector from the financial and technological point of view, enhancing competition and liberalisation in the sector
- To increase the security and reliability of the energy supply in general and electricity generation in particular
- The establishment of an effective institutional and regulatory framework
- The promotion of energy efficiency and the utilisation of RES
- The optimization of the supply system with energy sources based on the least cost planning principle and minimal environmental impact

To achieve these objectives and improve the security of energy supply, the high energy intensity and energy production cost in Albania, and the high transmission and distribution losses of the power system have to be reduced and technologies that are not based on fossil fuels have to be used. However as technologies alternative to fossil fuels (e.g. SHPP, Solar Heaters, Wind, Biomass) cannot yet compete in a free market support is needed for energy efficiency and renewable projects.

There is potential for biomass utilisation in Albania; the contribution of biomass for the year 2005 has been 254 ktoe and it is expected to reach about 400 ktoe by 2025.

Forests occupy 1.045 million ha or 36% as coverage of the country’s territory, with a standing timber volume of 84 million m$^3$ and an average annual growth of 1.4 m$^3$ per ha. The major forest tree species in the forest structure of Albania (presented in Figure 3.1) are:

- Beech (Fagus silvatica), 160000 ha (=17 %);
- Pine (Pinus spp.), 142000 ha (=15%);
- Fir (Abies spp.), 13000 ha (=2 %);
- Oak (Quercus spp.), 300000 ha (=32%);
- Other broadleaved species, 510000 ha (=34%).

![Figure 3.1: Forest structure in terms of the percentage of different timber type for Albania.](image-url)
Table 3.1 shows the energy potential from available forest matter, while Table 3.2 and Table 3.3 summarise the biomass resources from agricultural crop residues and livestock waste respectively.

### Table 3.1: Available technical energy potential of forests in Albania

<table>
<thead>
<tr>
<th>Unit</th>
<th>Thin Branches</th>
<th>Branches</th>
<th>Bark</th>
<th>Logs</th>
<th>Blockhead</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>WOOD MASS PRODUCTION</td>
<td>10^3 m^3/yr</td>
<td>18482</td>
<td>47019</td>
<td>10104</td>
<td>2262</td>
<td>10671</td>
</tr>
<tr>
<td>HARDWOOD</td>
<td>10^3 m^3/yr</td>
<td>17599</td>
<td>44329</td>
<td>9033</td>
<td>2022</td>
<td>9990</td>
</tr>
<tr>
<td>EVERGREEN</td>
<td>10^3 m^3/yr</td>
<td>884</td>
<td>2690</td>
<td>1071</td>
<td>240</td>
<td>680</td>
</tr>
<tr>
<td>ENERGY POTENTIAL</td>
<td>GWh/yr</td>
<td>55</td>
<td>140</td>
<td>30</td>
<td>7</td>
<td>32</td>
</tr>
<tr>
<td>TECHNICALLY FEASIBLE FOR ENERGY PRODUCTION</td>
<td>10^3 m^3/yr</td>
<td>15843</td>
<td>42205</td>
<td>9074</td>
<td>2024</td>
<td>9579</td>
</tr>
<tr>
<td>TECHNICALLY FEASIBLE ENERGY POTENTIAL</td>
<td>GWh/yr</td>
<td>47</td>
<td>126</td>
<td>27</td>
<td>6</td>
<td>29</td>
</tr>
<tr>
<td>ECONOMICALLY VIABLE ENERGY PRODUCTION IN THE NEXT 10 YEARS</td>
<td>GWh/yr</td>
<td>63</td>
<td>169</td>
<td>36</td>
<td>8</td>
<td>38</td>
</tr>
</tbody>
</table>

### Table 3.2 Available technical energy potential of agriculture residues in Albania

<table>
<thead>
<tr>
<th>Unit</th>
<th>Wheat</th>
<th>Barley</th>
<th>Rye</th>
<th>Corn</th>
<th>Oats</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>ANNUAL PRODUCTION</td>
<td>kt/yr</td>
<td>208618</td>
<td>79206</td>
<td>9462</td>
<td>56553</td>
<td>2672</td>
</tr>
<tr>
<td>ENERGY POTENTIAL</td>
<td>GWh/yr</td>
<td>913</td>
<td>326</td>
<td>41</td>
<td>231</td>
<td>11</td>
</tr>
<tr>
<td>TECHNICALLY FEASIBLE FOR ENERGY PRODUCTION</td>
<td>kt/yr</td>
<td>124272</td>
<td>51480</td>
<td>7571</td>
<td>45239</td>
<td>1737</td>
</tr>
<tr>
<td>TECHNICALLY FEASIBLE ENERGY POTENTIAL</td>
<td>GWh/yr</td>
<td>544</td>
<td>212</td>
<td>32</td>
<td>185</td>
<td>7</td>
</tr>
<tr>
<td>ECONOMICALLY VIABLE ENERGY PRODUCTION IN THE NEXT 10 YEARS</td>
<td>GWh/yr</td>
<td>731</td>
<td>284</td>
<td>44</td>
<td>248</td>
<td>10</td>
</tr>
</tbody>
</table>

### Table 3.3: Available technical energy potential of livestock waste in Albania

<table>
<thead>
<tr>
<th>Unit</th>
<th>Bovine</th>
<th>Horses</th>
<th>Pigs</th>
<th>Poultry</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>NUMBER</td>
<td>10^3 heads</td>
<td>186</td>
<td>70</td>
<td>47</td>
<td>3450</td>
</tr>
<tr>
<td>ANNUAL PRODUCTION OF BIOGAS</td>
<td>10^3 m^3/yr</td>
<td>55234</td>
<td>18300</td>
<td>2889</td>
<td>13223</td>
</tr>
<tr>
<td>ENERGY POTENTIAL</td>
<td>GWh/yr</td>
<td>361</td>
<td>114</td>
<td>18</td>
<td>92</td>
</tr>
<tr>
<td>TECHNICALLY FEASIBLE BIOGAS FOR ENERGY PRODUCTION</td>
<td>10^3 m^3/yr</td>
<td>52472</td>
<td>11898</td>
<td>2744</td>
<td>12560</td>
</tr>
<tr>
<td>TECHNICALLY FEASIBLE ENERGY POTENTIAL</td>
<td>GWh/yr</td>
<td>343</td>
<td>74</td>
<td>18</td>
<td>87</td>
</tr>
<tr>
<td>ECONOMICALLY VIABLE ENERGY PRODUCTION IN THE NEXT 10 YEARS</td>
<td>GWh/yr</td>
<td>460</td>
<td>100</td>
<td>24</td>
<td>118</td>
</tr>
</tbody>
</table>
In February 2008, a new law on biofuels was approved by the Albanian Parliament (no. 9876, dt. 14.02.2008). It reflects the requirements of the EU Directive 2003/30 of May 8, 2003 on the promotion of biofuels or other renewable fuels for transport. The purpose of this law is to promote the production and use of biofuels and other renewable combustibles used for the replacement of oil products in the transport sector. It also aims to promote renewable energy resources through cultivation of energy crops and support the protection of the environment and thus contribute to accomplishing the commitments under Kyoto Protocol regarding climate change.

The law is applicable to biofuels and other renewable combustibles used for internal combustion engines in the transport sector when the production and use of biofuels and other renewable combustibles in their pure or mixed form for transport is in compliance with European standards. There are specific licensing procedures for persons engaged in the production of biofuels and the biofuels market is coordinated with the market of oil products. Licensees in wholesale and retail market of oil products are obliged to report on:

- biofuels and other renewable combustibles
- biodiesel mixed with diesel for vehicles of minimally 5% per volume
- bioethanol mixed with gasoline of minimally 5% per volume

Indicative annual national goals have been set in terms of the percentage of biofuels and other renewable combustibles used for transport, which also determines the minimal annual amount of biofuels and other renewable combustibles in the market. Starting from 2010 the minimal annual amount shall not be less than 3% of total fuels traded in the market while from 2015 and after, this amount can not be less than 10%.

A special tax regime applies for the production and trading of biofuels. From the date the law became effective to 2018 there is no excise tax for these products; also from the date the law became effective to 2012 no custom duties and VAT shall be applied on:

- equipment, materials and agricultural machinery used by local farmers for energy crop cultivation
- primary and secondary technological equipment and machinery used in biofuels and other renewable combustibles plants

In conclusion, there is a potential for the development of biofuels in Albania and the energy policies for development of biofuels are in line with EU policies. The development of biofuels would reduce the Albanian energy sector reliance on imports, encourage the development of the agriculture sector, and would improve the quality of the air by reducing emissions.

### 3.2 Bosnia & Herzegovina

As fossil energy is becoming more expensive every day and is slowly diminishing in the world, our direction is to exchange fossil energy with alternative sorts of energy. At the same time the European Union and Kyoto Protocol requests demand the reduction of CO\(_2\) and solid particles emission, which have negative effects on climate change. According to the world’s literature petroleum, gas and coal will run out in several decades, so we need to focus on alternative sources or energy consumption from renewable sources such as: hydro energy, wind energy, solar energy, geothermal energy and biomass energy. In EU countries the objective is for the renewable energy contribution to reach the amount of 12% of total energy needs until 2010.
In the last ten years the effects of climate change caused by the increase of pollutant emissions in the atmosphere are more apparent and the last five years contained the four warmest years recorded in the last century, which has also been the warmest since the EU Climate Change Committee has started measuring. Literature data dealing with climate changes indicate that the trend of increase in environmental pollution can be controlled by using energy from renewable sources, such as the use of biofuels instead of fossil fuels for traffic purposes. Table 3.4 shows the difference in air pollutant emissions arising from the use of biodiesel compared to conventional diesel fuel and the reductions that can be achieved for most pollutants.

A number of international documents have been signed towards the reduction of greenhouse gas emissions. The UN Framework Convention on Climate Change from 1994, and the Kyoto Protocol, signed in 1997, ratified in B&H in 2007 commits industrial countries to reduce their greenhouse gas emissions by 5.2 percent by 2012, as compared to the reference year 1990. On the other hand there are European Union requests, like the Lisbon Agreement and other international agreements regarding climate change demanding the reduction of greenhouse gases. Among the Kyoto Protocol signatories there are 157 countries investing considerable resources in the research of new alternative energy sources, also making funds available for the financial support of less developed countries, which might also be used by ex-Yugoslavian countries in the following period.


In September 2007 a Regulation on quality, types and contents of biofuels blended in fuels for motor vehicles for the purposes of traffic was adopted in RS, while in the Federation of B&H a Draft Regulation was submitted for parliamentary procedure, thus conditions are created for biofuel circulation. The regulation stipulates on the quality and types of biofuels to be placed on the market of Bosnia and Herzegovina and Republic of Srpska, and the contents of biofuels in fuels for motor vehicles for the purposes of traffic. This amount is planned to be up to 2% of total fossil fuels consumption, or it is estimated that during 2008 about 10 thousand tonnes of biofuels shall be placed in a blend with motor petrol and diesel fuel.

The fuel quality and methods of examination are in accordance with the European standards BAS EN 228 and BAS EN 590. European automotive diesel standards EN 590 allow the addition of biodiesel up to 5% without labelling retail outlets. Methods of examination of biofuel quality shall be conducted according to European standards EN 14214 and these standards are adopted in B&H, BAS EN 14214.

Also, according to Directive 2003/96/EZ allowing tax relieves on biofuel turnover for clean biofuels and for blends of biofuels and fossil fuels we initiated activities regarding provisions of sale subsidising this type of fuel in the B&H market. Up to now the Government of the Republic of Srpska subsidises biofuel production through incentives for rapeseed production in the amount of

\[
\begin{array}{|c|c|}
\hline
\text{Pollutant} & \text{Reduction}\% \\
\hline
\text{Carbon monoxide} & -42.7\% \\
\text{Carbohydrates} & -56.3\% \\
\text{Matter particles} & -55.3\% \\
\text{Nitrogen monoxide} & +13.2\% \\
\text{Toxins} & -60\% - 90\% \\
\text{Sulphates} & -100\% \\
\hline
\end{array}
\]
150 KM per tone, but this amount could be increased in the following period with an additional 50 KM per tone.

For the purpose of efficient implementation of the provisions of Directive 2001/77/EC of the European Parliament on the promotion of electricity produced from renewable energy sources in the internal market, regarding renewable energy sources we are planning to draft and adopt the Law on Renewable Energy Sources in the next year.

Bosnia and Herzegovina possesses opportunities for sustainable development. As far as biomass energy is concerned biodiesel, biogas and bioethanol production is possible. Use of biomass for energy will promote security of energy supply, reducing the energy dependency of the country, while supporting rural development and fulfilling the obligations in the process of the accession to the European Union.

Biodiesel is produced from crops such as rapeseed, sunflower and soy. In view of the situation in Bosnia and Herzegovina, biodiesel production can be based on rapeseed and recycled or waste edible oil processing. The possibility of domestic biodiesel production in our areas is of great significance, especially from the point of view of regional economy development incentives and employment opportunities.

One hectare of rapeseed can give on average 2.5 t/ha of crops, or 1.1 t/ha of rapeseed oil. To produce 1 tonne of biodiesel 1.12 – 1.14 tonnes of rapeseed are required. Rapeseed is the most suitable of all oil plants for biodiesel production since it contains good proportions of certain fatty acids. It is very important that the oil has a low percentage of fatty acids, because this provides easier evaporation of methyl ester in the working temperature of an engine. This type of biodiesel has a suitable low ignition temperature, which is very important for the operation of the engine, especially in the winter period.

Bosnia and Herzegovina has the opportunities for the development of cattle breeding and this also means opportunities for the production of biogas, but the population is not provided with enough information, there are no incentive resources and therefore the use of this biofuel must be promoted. Experiences of developed countries show that in the countries with developed agricultural-cattle breeding production financial incentives are provided for biogas production, which is used as an substitute for fossil fuels. In cattle farms in Bosnia and Herzegovina by-products like stable dung are not used sufficiently to increase the total earnings of the farm.

For biogas production it is necessary to install a plant for methane fermentation in the stable, which shall create methane and carbon dioxide by means of methane bacteria. According to literature, the amount and value of biogas produced indirectly from one ox in a day on a farm correspond to the energy value of one litre of petroleum (11.7 KWh). Therefore, a farm consisting of 4000-6000 bovine cattle can produce bioenergy or biogas amounting to 4 to 6 tones of petroleum a day. It is important to point out that on the farm stable dung is continuously being produced, which enables continuous production and consumption of biogas.

The latest findings show that biogas production from stable dung is technically and technologically improved. It is estimated that each farm household even with a little plant for biogas of 20 KW power can realise an income of about thousand Euros annually out of stable dung. In Austria it was calculated that an economy with 220 bovine cattle with biogas fermentation receives 5 million KW of electricity. This type of biogas installations are represented on over 2000 farms in Germany and their price is about 1.2 million Euros. Today there are smaller and cheaper plants in the form of containers, they are easily installed and they are put in operation quickly. With regard to the existing results in biogas production in the western countries, in Germany and Austria especially, a conclusion can be drawn that biogas production from stable dung has great possibilities. Currently,
biogas production does not exist in our country, although there were attempts before the war and a very humble biogas production existed. However, there is an interest of cattle breeding farms in the area of Gradiška Municipality, so we think that in the following period this type of biofuel production will be revived.

HPK “Draksenić” Kozarska Dubica is one of the up-to-date factories in the Republic of Srpska and Bosnia and Herzegovina planning bioethanol production as fuel for traffic purposes. With regard to the crop production structure, biodiesel production from rapeseed is the most appropriate for Bosnia and Herzegovina which has flat-country areas in the area of Semberija, Posavina, Krajina and the other parts of B&H land. The climate is continental with optimum average temperatures and sufficient precipitation during vegetation, which additionally explains favourable conditions for the production of crops such as rapeseed, corn, sunflower etc. In the last 24 years the areas where rapeseed was sown in the Bosnia and Herzegovina and Republic of Srpska varied from 5.019 ha in 1983. to 30 ha in 2000, so the average crops varied from 1,40 t/ha in 2000 to 2.50 t/ha in 2006, as given in Table 3.5. At the same time crops of the examined sorts and hybrids in the implemented experiments reached more than 4 t/ha. The stated data are registered in the Bureau of Statistics of the Republic of Srpska. Currently in the area of the city of Banja Luka rapeseed producers achieved yields of 3 t/ha and there is a possibility for increased production up to 4 t/ha. With such crops of rapeseed of 3-4 t/ha a production of about 1.5 t/ha of biodiesel is possible. It is estimated that in average 100 to 150 l/ha of diesel fuel are required for the effect of sowing certain crops. Consequently, one hectare of cultivated rapeseed can provide biodiesel fuel for 7-11 ha of arable land.

Table 3.5: Sowing areas and rapeseed crops in B&H

<table>
<thead>
<tr>
<th>Year</th>
<th>Area (ha)</th>
<th>Crops (t/ha)</th>
<th>Year</th>
<th>Area (ha)</th>
<th>Crops (t/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1983</td>
<td>5019</td>
<td>2.15</td>
<td>1993</td>
<td>10</td>
<td>-</td>
</tr>
<tr>
<td>1984</td>
<td>4817</td>
<td>1.14</td>
<td>1994</td>
<td>1621</td>
<td>2.20</td>
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<tr>
<td>1985</td>
<td>5423</td>
<td>1.63</td>
<td>1995</td>
<td>1364</td>
<td>2.00</td>
</tr>
<tr>
<td>1986</td>
<td>4246</td>
<td>2.19</td>
<td>1996</td>
<td>1201</td>
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<tr>
<td>1987</td>
<td>8848</td>
<td>2.30</td>
<td>1997</td>
<td>1749</td>
<td>1.20</td>
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<tr>
<td>1988</td>
<td>4201</td>
<td>2.18</td>
<td>1998</td>
<td>705</td>
<td>1.50</td>
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<tr>
<td>1989</td>
<td>4155</td>
<td>1.82</td>
<td>1999</td>
<td>767</td>
<td>1.60</td>
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<tr>
<td>1990</td>
<td>3210</td>
<td>2.37</td>
<td>2000</td>
<td>30</td>
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<td>480</td>
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<td>-</td>
<td>-</td>
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<td>2005</td>
<td>872</td>
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<tr>
<td>-</td>
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<td>2006</td>
<td>1417</td>
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<tr>
<td>-</td>
<td>-</td>
<td>-</td>
<td>2007</td>
<td>1200</td>
<td>-</td>
</tr>
</tbody>
</table>

With regard to available data and following world trends biodiesel production was initiated in the Republic of Srpska from field crops and recycled oil, and the construction of a biodiesel factory in the Municipality of Srbac and Šamac has started, while there is an interest in the Municipality of Bijeljina also, which has been mentioned before.

Following European and world trends, the Bosnia and Herzegovina and the Republic of Srpska have committed themselves for the production and use of biomass fuels with the aim of providing:

- Energy efficiency
- Reduction of CO₂ emissions, which negatively affect the environment
- Positive macroeconomic effects
- Employment of local population in the preparation of feedstock for biofuel production
Rural development
Security of supply

Biofuels and their blends represent an excellent substitute for mineral diesel and they provide a range of advantages from the economical and from the ecological point of view, but also from the point of view of introducing new types of energy in the structure of energy sources consumption and energy balance. Special attention should be given to promotion policy and other mechanisms of financial support and laws and decrees should be adopted to encourage production and to provide sustainable biofuels development.

In 2010 the percentage of biodiesel in fuels is estimated to reach 5% in Republic of Srpska and 5.75% in Federation of Bosnia and Herzegovina. So we estimate that during 2008 there will be about 10 thousand tonnes of biofuels blended with motor petrol and diesel fuel placed on the market. Bioethanol production is also possible in our country. HPK-Draksević is one of the most modern factories in Bosnia and Herzegovina and it could be the bearer of this production. According to available data it can be concluded that there is about 30% of uncultivated areas in Republic of Srpska available for rapeseed production, which realistically can be the base crop for biodiesel production.

In the interests of successful realisation of the above mentioned activities biofuel producers, with the support of competent authorities from this area, should organise and establish an Association dealing with the activities of:

- energy production from renewable energy sources
- upgradng and protection of the environment
- providing information and education for the public on the advantages of renewable energy sources.

Bioenergy investments must be carefully planned on the national, regional and local level in order to avoid negative consequences or new ecological and social problems caused by the production of this type of energy.

3.3 Bulgaria

Looking at the final energy consumption in 2003 and 2005 for Bulgaria there is an overall increase of 1% however with the consumption in the industry and the household sections decreasing. This is due to the energy consumption for transport increasing by 13.8% at the same time, thus also increasing its share in the total energy consumption by 4% in the same 2 year period. The biggest increase is observed in the consumption of diesel fuel – up by 22%. While a lot of LPG is also used, the prediction is that there will be an even bigger increase of the diesel cars in the industry, which constitutes problem for Bulgaria.

![Figure 3.2: Land coverage in Bulgaria](image-url)
While there has been an increase in the GDP by 20%, there is a negative foreign trade balance and activity in the agriculture sector has been reduced with the use of land not being optimised. The total country area: is 11.1 Mill ha, a quarter of which is arable land (Figure 3.2) the share of crop cultivation in Bulgaria – based on the use of arable land in 2006 is shown in Figure 3.3. With regard to the area devoted to oil crops, sunflower crops were reduced by 5% from 2005 to 2006 while there has been a quadrupling of rapeseed crop area at the same time. The yield of rapeseed is considered better than that of sunflower crops, especially in connection with the climate situation in the recent years, as the yield is connected to rainfall and irrigation. For the period in question sunflower seed production halved while rapeseed production more than tripled as shown in Table 3.6.

![Figure 3.3: Share of crop cultivation in Bulgaria (use of arable land in 2006).](image)

Table 3.6: Yield of different oil crops for the period 2005-2007 in Bulgaria

<table>
<thead>
<tr>
<th>Yields variability (t/ha)</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>3.2</td>
<td>3.4</td>
<td>2.2</td>
</tr>
<tr>
<td>Maize</td>
<td>5.3</td>
<td>4.5</td>
<td>1.5</td>
</tr>
<tr>
<td>Sunflower</td>
<td>1.5</td>
<td>1.6</td>
<td>0.9</td>
</tr>
<tr>
<td>Rapeseed</td>
<td>1.9</td>
<td>1.8</td>
<td>1.7</td>
</tr>
</tbody>
</table>

The following projects exist for biodiesel production:

- There is a pilot installation for biodiesel production with a capacity of 3-4 thousand tonnes annually in North-West Bulgaria.
- In the Rousse area there are 2 700 ha of rapeseed crops for the Prista oil plant.
- In Vidin a new refinery for biodiesel is under construction (2008, capacity 400 000 tonnes of seeds) – basic crop is rapeseed on 250 000 ha.

Further on the agrobioenergy potential, there is interest for oil crops production in Bulgaria. As already mentioned, the rapeseed crop area has increased by a factor of 4 in the last 3 years, while the prices of the oil crops doubled. For sunflower seeds in particular the price has increased by a factor of 2.2 times during the last 2 years. The yield of traditional oil crops depends very much on the climate conditions during the year, thus testing and adapting new oil crops suitable for the local pedo-climatic conditions is needed. The following non traditional oil crops are tested in 2 pedo-climatic regions of Bulgaria:

- Crambe (Crambe abyssinica),
- Gold of pleasure (Camelina sativa),
- Lalemantia (Lalemancia liberica),
- Safflower (Carthamus tinctorius),
- Millet (Panicum miliaceum),
- Sorghum (Sorghum bicolor),
- Sunflower (Helleanthus annus),
- Castor bean (Ricinus communis).

So far the highest crop yield is given in the area of Vrajdeba by Safflower (Carthamus tinctorius) and in the area of Burzia by Lalemantia (Lalemancia liberica). In terms of fibre yield the best results were achieved by Gold of pleasure (Camelina sativa) for Vrajdeba and Safflower (Carthamus tinctorius) for Burzia.

### 3.4 Croatia

Croatia has significant bioenergy potential but few existing plants. There is a lack of technical knowledge and awareness, but it is a promising area for future developments. The high potential comes from the agriculture, forestry and wood industry (Table 3.7, Table 3.8) with the total technical potential being app. 39 PJ. Existing and planned projects are in the area of combined heat and power and district heating plants, biofuels, pellets and charcoal and are aimed at a rapidly developing market. There is intensive international cooperation on the subject (bilateral, FP6, FP7, IEE, etc.)

In terms of biofuels production there are two plants in operation – Modibit Ltd., biodiesel (rapeseed) 20000 t and Vitrex Ltd., biodiesel (rco) 6000 t – supplying fuel for the public transport sector. More specifically the City of Zagreb had 10 buses running on biodiesel in 2007 and this number will increase to 50 in 2008 while the city of City of Samobor had introduced 17 such vehicles in September 2006. There is a push for the use of biofuels from public opinion. The bottleneck is in agriculture as not enough oil crops are produced and hence imports are necessary to cover the needs.

The installed capacity and heat generation from biomass compared to other renewable sources is shown in Table 3.9.

<table>
<thead>
<tr>
<th>Source</th>
<th>Energy potential (PJ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>State-owned forests</td>
<td>16.83</td>
</tr>
<tr>
<td>Private forests</td>
<td>3.88</td>
</tr>
<tr>
<td>Wood processing industry</td>
<td>9.06</td>
</tr>
</tbody>
</table>

Table 3.7: Woody biomass in Croatia. The share of private forests is increasing

<table>
<thead>
<tr>
<th>Source</th>
<th>Energy potential (PJ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biogas</td>
<td>2.09</td>
</tr>
<tr>
<td>Fruit trees</td>
<td>0.69</td>
</tr>
<tr>
<td>Fruit processing</td>
<td>0.03</td>
</tr>
<tr>
<td>Wheat, corn, barley</td>
<td>11.07</td>
</tr>
<tr>
<td>Other -agriculture</td>
<td>0.34</td>
</tr>
</tbody>
</table>

Table 3.8: Agricultural biomass in Croatia. Currently only used in very small local plants

<table>
<thead>
<tr>
<th>Source</th>
<th>Energy potential (PJ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar</td>
<td>N/A</td>
</tr>
<tr>
<td>Wind</td>
<td>0</td>
</tr>
<tr>
<td>Biomass</td>
<td>510 MW*</td>
</tr>
<tr>
<td>Small hydro</td>
<td>0</td>
</tr>
<tr>
<td>Geothermal</td>
<td>114 MW</td>
</tr>
</tbody>
</table>

Table 3.9: Electricity and heat production from renewable resources in Croatia

<table>
<thead>
<tr>
<th>Source</th>
<th>Thermal capacity</th>
<th>Thermal production</th>
<th>Electricity capacity</th>
<th>Electricity production</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar</td>
<td>N/A</td>
<td>N/A</td>
<td>12.74 kW</td>
<td>12.63 MWh</td>
</tr>
<tr>
<td>Wind</td>
<td>0</td>
<td>0</td>
<td>5.95 MW</td>
<td>1.96 GWh</td>
</tr>
<tr>
<td>Biomass</td>
<td>510 MW*</td>
<td>16230 TJ**</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Small hydro</td>
<td>0</td>
<td>0</td>
<td>26.7 MW</td>
<td>126.3 GWh</td>
</tr>
<tr>
<td>Geothermal</td>
<td>114 MW</td>
<td>542 TJ</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

*Only industrial heating plants
**Total, includes fuel wood for households heating
There is a wind of change regarding renewables in Croatia with a lot of support from public opinion, resulting from concerns about climate change and pollution which has been triggered by the overall improvement in living standards and awareness of European trends. There is a growing level of knowledge, expertise and participation – both from people and institutions; however this has now to be taken from this level of enthusiasm to realisation by professionals. Recent research revealed that 75% of the public willing to pay more for renewable electricity. As a result a tariff system for renewable electricity has been introduced (Table 3.10).

In conclusion there is significant energy potential and some existing experience and technical knowledge. This is a promising area for international cooperation with good funding opportunities (national, EU, others). Research already performed in the subject of resources and their potential use includes Studies on Regional Potential (1998-2001) and WISDOM Croatia: GIS Database of Biomass Resources (2008) a FAO Sustainable Charcoal Industry TCP project which contains extensive information on resources and is a unique tool for planners and policy makers.

### 3.5 FYROM

Having in mind the official status of the state as a candidate for membership in the European Union on 17 December, 2005, we have the obligation to adjust legislation to the legislation of the EU (acquis communautaire), as well as to implement that legislation in practise.

The process of reforms is put into action in the country, which also has reforms concerning the agriculture and the energy sector. In order to provide guaranteed energy supply, to reduce the pollution of the environment and to provide greater social benefits, the EU supports the development of biofuels production.

The “Programme for stimulation of the agriculture development in 2007” included measures for supporting the production of oil from biomass (sunflower, soya, oil beet and others) in a total amount of 635 000 EUR or around 12 500 hectares productive area, a stimulation of around 70EUR per hectare. It is planned that the measure will stimulate the agricultural economies to implement oil production and to make a mid-term plan for this activity as financial equalizer of its economy.

Having in mind the fact that this is a developing country and that it totally depends on the oil and operating fuels import, the use of alternative fuels which do not demand big investments in the process of adaptation of the infrastructure and engines is very important. The Ministry of economy takes all the necessary actions for the preparation of the Strategy for the exploitation of renewable energy resources. The mentioned Strategy will be adopted at the end of 2008. The Strategy for the exploitation of renewable energy resources shall be adopted for a period of at least 10 years.

The Strategy for the exploitation of renewable energy resources defines the aims of renewable energy resources exploitation and the modalities of achieving these aims, namely:

| Table 3.10: Tariff system for RES electricity (€/kWh) |
|-----------------------------------------------|----------|----------|
| Small hydro                                  | 9.2      | 5.6 – 9.2|
| Wind                                         | 8.55     | 8.66     |
| Biomass, forestry and agro                   | 16.0     | 13.9     |
| Biomass, ind. wood residues                  | 12.7     | 0.63     |
| Geothermal                                   | 16.8     | 16.8     |
| Biofuels                                     | 4.8      | 4.8      |
| Biogas                                       | 16.0     | 13.9     |
| Landfill gas                                 | 4.8      | 4.8      |
| Wave, tidal                                  | 8.0      | 6.7      |
| Solar pv, <10 kW                             | 45.3     | -        |
| Solar pv, 10-30 kW                           | 40.0     | -        |
| Solar pv, >30 kW                             | 28.1     | -        |
the potential of renewable energy resources
the feasibility for exploitation of the potential of renewable energy resources
the target volumes and timeline for the consumption of electricity from renewable energy resources in the energy balance
defining transitional measures for the support of exploitation of renewable resources, including preferential tariffs for producers of electricity, and other support mechanisms

In order to introduce biofuels with the stated quality for the needs of the transport, and in the direction of reaching bigger ecological, economical, energetic effects, and with aim for approximation with the EU Legislation from the European standards for liquid fuels quality in July 2007 the Ministry of economy adopted the Rulebook for quality of the liquid fuels.

With this Rulebook the EU Directive 2003/30/EC from 8 May 2003 on the promotion of the use of bio-fuels and other renewable fuels for transport, was transposed into the national legislation. The abovementioned Rulebook regulates introduction of two bio-fuels, i.e. bio-diesel and bio-ethanol which mix with the fossil diesel and petrol. This resolution results from the fact that these two bio-fuels are the most current and representative transportation bio-fuels. These fuels, in the first phase of introducing the bio-fuels in the transportation sector, are proposed to be used for mixing, due to the fact that the utilisation of pure bio-fuels for transportation needs appropriate adaptation of the motor vehicles, thus additional time.

The Rulebook prescribes a time frame for the achievement of the introduction of biofuels for use in transport, until 2020 as follows:
- 2.5% until 31.12.2007
- 5.75% until 31.12.2008
- 8.0% until 31.12.2009
- 10% until 31.12.2010
- 12% until 31.12.2013
- 15% until 31.12.2015
- 20% until 31.12.2020

One of the measures for increasing the biofuel production and use is the stimulation of the agriculture in order to increase the production of sunflower, oil beet and soy. This will have useful affects of the agricultural sector in several ways: the use of additional land which is not used at the moment, finding extra and more stable incomes for the farmers, better use of the mechanisation and equipment, and in this way, improvement of the agricultural production and environmental protection. This new area does not only demand technical research, but also knowledge of the influence over the economy and the living standard of the population.

The measures which are possible and necessary are as follows:
- Increasing the number of agricultural raw materials for the production of biofuel
- Introducing new types of beet and improving the way of production, which will help the improvement of the energy efficiency and the environmental acceptability of the whole production chain
- The custom tax in case of import of biofuels is zero
- Stimulating the international science and technological collaboration and research and development in the field of biofuel production
- Stimulating the small companies and individual producers to understand the production process for biofuel and to start investing in this branch of agriculture
- Stimulation of biofuel use
- The biofuel producers are to be taxed according to an authorised tax rate
The oil and gas retailer Makpetrol has opened the first biodiesel plant in August 2007. The plant has an annual capacity of 30,000 tonnes, following an investment of 8 million Euro. The biodiesel plant will meet European standards EN 14214 (Accreditation Laboratory Makpetrol A.D. Skopje), and Makpetrol aims to sell its production both at home and abroad. The primary resource is oil from rape oil. In order to produce 30,000 tonnes biodiesel from rape oil, 30,000 hectares fertile soil are needed. The fertile soil is available, but still not in use (approximately 100,000 hectares).

From 1 hectare fertile soil cca. 1 tonne rape oil can be produced from 3 tonnes of green mass. For 1 hectare of rapeseed 5000 m$^3$ water are needed for irrigation (in a period in which there is not enough sufficient water, June and July).

### 3.6 Montenegro

The Energy of Montenegro is based on the activated potential of rivers Zeta and Piva (cca. 180 GWh/yr.), the coal in the Pljevlja Basin (cca. 1,300,000 t/yr.), imported petrol derivatives (cca 300,000 t/yr.) and electric energy 1/3 of which (1,300 GWh/yr.) is imported. The following points give an overview of the developments in the energy sector of Montenegro:

- The Energy Law was adopted in 2003.
- The Energy Regulatory Agency was established in January 2004.
- An Energy Policy was adopted in February 2005.
- An Energy Efficiency Strategy was adopted in October 2005.
- Montenegro signed the Energy Community Treaty in October 2005.
- A Strategy for Small Hydro Power Plants Development was adopted in April 2006.
- The Energy Development Strategy until 2025 was adopted in 2007.

The facts reported on biomass and biofuels are mostly based on the following documents:

- “Energy Development Strategy until 2025”, Government of Montenegro
- “Estimation of Potential of Renewable Energy Sources in Montenegro”, Italian Ministry for the Environment, Land and Sea

In those documents biomass is mostly not considered in the light of co-production of chemicals, transportation fuels and energy.

The estimation of the energy potential from biomass in Montenegro is oriented on forestry, waste wood and agriculture. Maps of vegetation display the heterogeneous nature of the Montenegrin landscape. The distribution of agricultural land over the whole territory of Montenegro is quite uneven: there are 21 municipalities, and more than 50% of the total agricultural land is concentrated on the territory of 5 municipalities. Figure 3.5 shown the share of agricultural, forest, grassland etc. for Montenegro.
Forest wood used for heating and wood scraps from the wood processing industry are the most important biomass source in Montenegro. Forests cover 6750 km$^2$ or 42% of the country area. The estimated annual chop from public forests is 381 000 m$^3$, of which 121 000 m$^3$ is used for heating. The estimated annual chop from private forests is 60 000 m$^3$, and it is mostly used for heating. Thus the total average annual chop of wood is estimated around 2.06 m$^3$/ha, while actual average annual consumption of wood is ca. 1 m$^3$/ha. Thus the estimated annual increment of wood is between 850 000 and 1 050 000 m$^3$.

Forest wood is traditionally used as firewood for heating (mostly in households and less in the public and commercial sectors). The estimated amount of waste wood that is generated in the forests during exploitation is 150-200 000 m$^3$. Its collection and use cannot be economically justified and additional research is necessary to obtain more reliable data. Wood scraps from the wood processing industry are used for steam generation for self-consumption.

Based on the respectable potential of biomass from forestry and the wood processing industry, a preliminary economical analysis for electric energy production was carried out for the installation of power plants of 2MW, 5MW and 10 MW. The results of the analysis indicate that with the actual current prices of electric energy such a power plant cannot be an attractive investment.

The “Strategy of Energy Development until 2025” does not foresee wood fired thermal power plants, although the available potential of wood biomass is estimated to be enough for at least 3 to 5 small thermal power plants with a total installed capacity of 10 MW. However, the “Strategy of Energy Development until 2025” does foresee cogeneration power plants with a total installed power capacity of 5 MW (2 MW in 2020 and 3 MW in 2025) so there is enough space for private investors to show their interest. The foreseen investment cost until 2025 is 7.5 million Euro.

There is an outline scheme for a Biomass Power Plant, which would collect biomass from 3 municipalities (Berane, Rožaje and Andrijevica) over a max distance of 35 km. The installed power would be 2(4) MW and the annual production 14(28) GWh. However more detailed pre-feasibility and feasibility studies are necessary.
In terms of biofuels, for the time being the Strategy for Energy Development in Montenegro foresees additional research to obtain more reliable data for biofuel production from biomass.

In conclusion, analysis of the potential of biomass as RES indicates that Montenegro has a good potential for the development of energy systems that would be based on biomass. The obstacles that hinder wider use of biomass and other RES in Montenegro are the low price of conventional energy sources, the lack of financial assets combined with a low interest for investment in RES technologies, and the lack of appropriate legislative framework that promotes use of RES.

3.7 Romania

The Romanian economy is based on industry (23.5 %), agriculture (6.6 %) and commerce & services (69.9 %). There are 9 million hectares of farmland but the contribution of the agricultural sector to the economy is decreasing. This is partly also due to climate conditions which have been very bad for agricultural production in the previous years.

Romania has medium potential for biomass and biogas, estimated around 318 PJ. There is already some experience with alternative fuels:

- **Methanol**: A National Program was initiated in 1980, it has been a by-product in the chemical industry and has been used in fuel mixtures for Diesel engines
- **Ethanol**: A National Program was initiated in 1980, based on sweet sorghum and by-products from food processing
- **Compressed Natural Gas**: A National Program was initiated in 1980, the gas was compressed up to 25 bar and used in public transport busses
- **LPG**: A National Program was initiated in 1978 for city cabs
- **Hydrogen**: A National Program was initiated in 1976 for production, storage and fuel cells. Currently there is the MENER National Program along with participation to the European Technology Platform for Fuel Cells and the Project HyWays.
- **Biogas**: In 1990 there were 25 000 biogas units
- **Biomass**: experience with wood processing sawdust, briquettes and pellets and rape oil

Given climate and soil conditions both rapeseed oil and sunflower oil are produced through traditional cultivation in Romania. Although rapeseed has medium yields it was cultivated on 80 000 hectares 10 years ago but has now reached 370 000 hectares. Crude rape oil is blended for biodiesel. There is a World Bank Project for cultivation technologies and strategies while National and EU projects for testing on engines are also ongoing.

The current situation regarding market implementation is the following:

- 1st July 2007 2 % Biodiesel
- 1st January 2008 3 % Biodiesel
- 1st July 2008 4% Biodiesel
- 1st July 2009 4% Ethanol

This plan refers to an estimated market of 25 million Euros. The potential for raw material (sunflower, rape, soy beans) is 500 – 550 000 t/year. There are three main players with capacities higher then 100 t biodiesel/day and a number of small and medium producers and importers.

Among the strengths of the Romanian case is a potential for RES and the existing experience in the processing industry, oil processing industry, food and chemical processing sector, sewage treatment...
and biotechnologies and bio-processing. There are a number of research facilities and expertise, specialised research institutes and National Programmes (MENER, BIOTECH), which form a network of industry and research. It is also worth mentioning the National Platform for Energy and the Industry Working Group on Alternative Fuels.

Weaknesses include the lack of investment funds, the low economic performance and therefore the low involvement of the private and venture capitals. There is a lack of managerial and marketing culture due to the unfinished transition from a centralised economy to a free market economy. This has led to an immature energy market containing weak actors with low experience.

The opportunities lie in the fact that there is a significant national market for alternative fuels so there are a lot of perspectives especially taking into consideration the also growing EU Market. The EU funds available for research and development along with the incentives arising from the Kyoto Protocol and Post Kyoto era can support development and demonstration of technologies in the field.

In this context threats can arise from competition within the EU coming from the existence of major players that have invested in technology, have resources to enter in the market and have established marketing experience, in contrast to the Romanian emerging market players. The costs of implementation and production are also a consideration as they are higher than the equivalent for conventional fuels. Costs of marketing, distribution and service are also an unknown at this point.

Optional strategies for the promotion of biomass and biofuel production and use in Romania are:

- The definition of a National Strategy for Biomass and Biofuels, integrated in the National Strategy for Sustainable Development as part of the EU policies and considering other sectoral strategies
- The identification of niches on the EU Market through an active role in the European Technology Platforms
- The concentration of available resources and expertise through a national research and development strategy and National Technology Platforms
- The development of strategic alliances with major players in the market

Foreseen Policies at the moment include:

- Subsidies for research, the industry and the end-users
- Promotion and awareness, through the media, seminars and workshops and internet portals
- Support to NGOs
- Development of National Competence Centres for consultancy and assistance

It is also important to draw attention to a different perspective. The Black Sea is a big environmental issue, having an anoxic and an oxygen supported layer. The Black Sea has a surface of 413 488 km² and a maximum depth of 2 245 m, containing a volume of water of 529 955 km³ with an average salinity of 18 mg/litre. On a shore length of 4 790 km the riparian countries are Georgia, Russia, Ukraine, Romania, Bulgaria and Turkey. The main Rivers Danube (contribution of 250 km³/year), Dniestr, and Dnieper provide 70% of the fresh water supply, while there is an outflow of 610 km³/year through the Bosporus. The Black Sea waters are anoxic below the depth of 150 m.

The total inputs of Nitrogen to the Black Sea amount to 647 kt/year of which 20.3 kt/year are domestic, 146.9 kt/year industrial and the remaining majority 281.8 kt/year is deposited through rivers. The non-riparian countries’ contribution is 70 % of the NOx and 30 % of the ammonia.
The total inputs of phosphorus amount to 50.5 kt/year, of which 6.7 kt/year are of domestic origin, 2 kt/year come from the industry and the remaining majority 28.2 kt/year are carried to the Black Sea through rivers.

The Danube, which is the major inflow to the Black Sea has a total length of 2850 km and a mean multi-annual flow of 6399 m$^3$/s. The riparian Countries are Germany, Austria, Slovakia, Hungary, Serbia, Romania, Bulgaria, Moldavia and the Ukraine amounting to a drained area of 817 000 km$^2$. This results to a total concentration of solubles of the order of 425 mg/litre (1990) as opposed to 170 mg/litre (1900), which was the value at the beginning of the century. The ion composition is carbonates (50%), calcium (15%), chlorine (13%), sulphates (10%), magnesium (5%) sodium and potassium (5-6%). The concentration of nitrogen in recent years has been 355 kt/year (1992) versus 50 kt/year (1960) a few decades ago and the respective concentrations of phosphorus are 22 kt/year (1992) versus 14 kt/year (1960), while the maximum value observed reached 63 kt/year (1988).

The consequences of the increased concentrations of the substances mentioned above and other man-induced inflows to the Black Sea include:

- Eutrophication (Figure 3.6)
- Changes in hydrography & oxygen content (Figure 3.7)
- Presence of organic substances, trace metals, radioactivity, sewage waters
- Effects on marine ecosystems such as algal blooms, decrease of biodiversity, structural changes

Intensive agriculture and the use of fertilisers is a major source of nitrogen and phosphorus which eventually washes into large bodies of water. So biomass utilisation has to be considered in the context of sustainable development, which allows meeting the needs of the present without compromising the ability of the future generations to meet their own needs. The strategy for such development includes:

- efficiency – enhanced productivity / resource
- consistency – enhanced economies embedded in the natural cycles
- sufficiency – new concept of prosperity / satisfaction / material wealth

and is based on the following management rules:

- the use of renewable natural resources must not exceed their regeneration rates
- the use of non-renewable natural resources must not exceed the rate of substituting their respective functions
- the emissions of pollutants must not exceed nature’s capability to adapt
Figure 3.8 shows a simplified schematic, key figures and images for the concept plant of Cobadin. The plant has the best size as to ensure biodiesel for farming activities and neutralise waste at the municipal level.

Another project aiming at sustainable development is Hy-Danube. The aim of the project is to develop a Europe wide research project for developing de-polluting technologies for the river waters and wetlands by the production of biomass and conversion to hydrogen for fuelling high temperature fuel cells for combined heat and power systems. The project shall integrate the results of the last 3 decades of experiments developed in Romania for the de-pollution of different lakes and municipal sewage waters by accelerated production of biomass and processing of the obtained yields and the expertise of several European partners in the biomass reforming, high temperature fuel cells and combined heat and power systems.

Romania has a significant potential and good expertise for biomass research, production and processing, as well as a significant national market. Biomass may present a big chance for the future development of the Romanian process industry, but it should be integrated in the overall concept of sustainable development.
3.8 Serbia

The RES potential in Serbia (without solar energy and large hydropower plants) is estimated at 3.2 Mtoe, or about 25% in relation to the total primary energy consumption of which biomass accounts for 2.6 Mtoe. Serbia has 2.9 Mha of arable land, 0.3 Mha of orchards, 1.4 Mha of meadows and fields and 2.4 Mha of forested areas. Of the biomass potential mentioned above 60% comes from agricultural biomass, while the rest 40% is wood. Currently the biomass is utilised in bio-diesel plants using the Lurgy technology (producing 100 000 – 200 000 t annually) and for heating mostly at residential, quite often low efficiency use for which there is no accurate statistical data. Future biomass use could mainly be for heating, but with better efficiency in cogeneration systems, and for the production of bio-fuels.

The following documents are relevant regarding the law and regulation of the energy sector in Serbia:

- The Energy Law, adopted in 2004
- Other documents in RES domain, which deal with reduced taxes for bio-fuels trading, national bio-fuels standards and studies on RES potential

The Serbian Government supports programs promoting the use of biomass as fuel, specifically there are currently:

- 4 projects for implementation of biomass fuel supported by the Ministry of Energy and Mining - Serbian Energy Efficiency Agency
- 14 research and development projects for new technologies using biomass fuel under the Ministry of Science - National Program For Energy Efficiency - Renewable energy sources

One project looks into the development of biomass-fired boilers at the Vinča Institute. The main starting point for the project is to achieve maximum energy output from 1 ha of land, without disturbing the balance in agricultural production by:

- utilisation of waste biomass
- expending the lowest possible energy for biomass preparation
- having the lowest possible self-consumption of electricity
- high efficiency
- low level of investment and operation/maintenance costs
- satisfying the environmental protection norms
- the ability to manufacture the energy production facility in Serbia

The development path utilises experiences gained during the development of boilers with fluidised bed combustion of biomass and has the following steps:

- Design and construction of small household furnaces with heat accumulation
- Design and construction of a small boiler for the combustion of baled biomass by-products
- Design and construction of a real-scale experimental facility, in order to confirm the technology of cigarette-type combustion of large bales
- Designing of a real-scale energy production facility (hot water boiler)
- Manufacturing and commissioning of the boiler

A 1.5 MW experimental unit for burning large rolled soybean straw bales (0.7x1.2x2.7 m) has been constructed encompassing a hot water boiler (95/70°C) with a heat storage tank of 100 m³. The unit works according to the cigarette burning combustion principle with an efficiency of 77-81%.

The research activities planned for the future include:

- Monitoring of the boiler operation in long-term regimes, in order to improve applied technical solutions and achieve parameters for automatic operation
- Determination of the most suitable bale characteristics (porosity, humidity, dimensions deviations)
- Increasing the efficiency by re-circulating the flue gas
- Test operation with other types of biomass
- Development of mathematical simulations and methods for boiler thermal calculations
- Research on production and utilisation of additives for biomass
- Improvements in environmental protection measures
- Researching methods for the re-introduction of the ash into the soil

The basic goals of the research are:

- Obtaining the design parameters for the facilities of this type
- Development of furnaces and boilers for other types of baled biomass
- Expanding the knowledge of the advantages of by-product agricultural biomass utilisation
- Investigation of the viability of raising energy crops
- Linking of multi-disciplinary investigations
• Stressing out positive environmental aspects of facilities of this kind and their compliance with the Kyoto protocol

The final aim of research and development is to reach such a level of development that facilities of this kind could be offered on any market as developed facilities for combined heat and electricity production.

3.9 Turkey

Turkey has an area of 779 452 square kilometers and a population of approximately 71 million. Figure 3.12 shows the distribution of land area between different uses. The biomass potential in Turkey is estimated at 8.6 Mtoe, while the current annual utilisation is 6 Mtoe. As shown in Figure 3.12 most of the biomass is used in the rural areas for heating purposes. In this case the biomass is burned in conventional heating systems.

![Figure 3.12: Land coverage and land use shares in Turkey](image)

The current annual biodiesel production is 100 000 tonnes while annual bioethanol production exceeds 23 000 tonnes. The country’s targets for biofuel production in 2015 are 1 250 000 tonnes biodiesel and 735 000 tonnes of bioethanol respectively. This is based on an estimated potential production capacity of 1.6 million tonnes biodiesel per year from 1 900 000 hectares of oily seed...
agriculture and 1.7 million tonnes bioethanol per year from 920 000 hectares of beet and maize agriculture. The potential for biogas production is estimated at 1.5-2 Mtoe.

Currently the major agricultural crops are wheat, cotton and maize while the major fruit crops are hazelnuts and olives. Table 3.11 shows the annual yield of the most important field crops and Table 3.12 and Table 3.13 give an overview of the type and quantity of biomass residues available in Turkey.

Table 3.11: Annual field crops in Turkey

<table>
<thead>
<tr>
<th>Agricultural Product</th>
<th>Plantation Area (ha)</th>
<th>Production (tonnes)</th>
<th>Yield (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>9300000</td>
<td>21000000</td>
<td>2260</td>
</tr>
<tr>
<td>Barley</td>
<td>3600000</td>
<td>9000000</td>
<td>2500</td>
</tr>
<tr>
<td>Corn</td>
<td>5700000</td>
<td>3000000</td>
<td>5260</td>
</tr>
<tr>
<td>Sunflower</td>
<td>5500000</td>
<td>900000</td>
<td>1640</td>
</tr>
<tr>
<td>Soya</td>
<td>14000</td>
<td>50000</td>
<td>3570</td>
</tr>
<tr>
<td>Rapeseed</td>
<td>1700</td>
<td>4500</td>
<td>2650</td>
</tr>
<tr>
<td>Sugar Beet</td>
<td>315000</td>
<td>13600000</td>
<td>42860</td>
</tr>
</tbody>
</table>

Table 3.12: Annual agricultural crop residues in Turkey

<table>
<thead>
<tr>
<th>Crop</th>
<th>Residue Type</th>
<th>Residue Quantity (tonnes)</th>
<th>Availability (%)</th>
<th>Total Calorific Value (GJ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>Straw</td>
<td>23429900</td>
<td>15</td>
<td>62909300</td>
</tr>
<tr>
<td>Barley</td>
<td>Straw</td>
<td>8963000</td>
<td>15</td>
<td>23527900</td>
</tr>
<tr>
<td>Rice</td>
<td>Straw</td>
<td>209550</td>
<td>60</td>
<td>2099500</td>
</tr>
<tr>
<td>Rice</td>
<td>Husk</td>
<td>77750</td>
<td>80</td>
<td>807350</td>
</tr>
<tr>
<td>Cotton</td>
<td>Stalk</td>
<td>2520300</td>
<td>60</td>
<td>27521500</td>
</tr>
<tr>
<td>Olive</td>
<td>Cake</td>
<td>829800</td>
<td>90</td>
<td>15452000</td>
</tr>
<tr>
<td>Hazelnut</td>
<td>Shell</td>
<td>566450</td>
<td>80</td>
<td>8745800</td>
</tr>
</tbody>
</table>

Table 3.13: Biomass residues in Turkey in terms of energy content

<table>
<thead>
<tr>
<th>Biomass Residue Type</th>
<th>Total Energy Content (Mtoe)</th>
<th>Share of Total Residues (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crop residues</td>
<td>22.8</td>
<td>62.8</td>
</tr>
<tr>
<td>Fruit residues</td>
<td>7.5</td>
<td>20.7</td>
</tr>
<tr>
<td>Poultry residues</td>
<td>6.0</td>
<td>16.5</td>
</tr>
<tr>
<td>Total</td>
<td>36.3</td>
<td>100</td>
</tr>
</tbody>
</table>

The policy makers active in the area of energy and biofuels in Turkey are:

- The Ministry of Energy and Natural Resources
- The Energy Market Regulating Authority (EMRA)
- The General Directorate for Electrical Power Resources Survey and Development Administration

The goals that these authorities aim at with the policies they put in place are:

- Ensuring resource (and supply source) diversification
- Prioritising the utilisation, and development and increasing national production of energy from natural resources
- Utilising of Turkey’s potential for becoming a commercial centre
- Ensuring an effective and efficient demand management
- Increasing fuel flexibility (promotion of the use of alternative energy sources)
- Structuring the energy sector as a functioning market based on transparency and competition
- Ensuring contribution to and integration of the regional cooperation
- Taking environmental effects into consideration in all stages

The following laws, decisions and incentive mechanisms affecting biomass and biofuels are in place:

**The Law On Utilisation of Renewable Energy Resources for The Purpose of Generating Electricity No 5346**

This law foresees that for the plants to be included in the system until the end of the year 2011, the following applies:

- There is a purchase guarantee for a price that will not be below Turkish Lira corresponding to at least 5 Euro cent/kWh for a duration of 10 years.
- Priority is given on allocation of treasury and forestry lands
- A discount at the rate of 85% is applied on the costs of license, rent, servitude right and use permit during the first 10 years of the investment and operating periods of such plants
- In the forestry lands, ORKÖY and Afforestation Special Appropriation Revenues are not collected
- There is a purchase obligation for the retail sale companies in the market for RES-based electricity generation

**Electricity Market Law No 4628 - The Main Incentive Mechanism**

The regulation provides the following incentives for RES generation facilities:

- Payment of only 1% of the total licensing fee.
- Exemption from annual license fees for the first eight years following the facility completion date
- May purchase electricity from private sector wholesale companies on the condition not to exceed the annual average generation amounts
- Priority for system connection

**Energy Efficiency Law No 5627**

The three main strategies of this law are to increase the energy efficiency awareness training, to promote the energy services activities in the market, and to increase the utilisation of renewable energy sources.

**Petroleum Market Law No 5015**

Biodiesel is defined as a product that can be blended with liquid fuel. Products, which are or shall be subject to an equivalent tax as liquid fuel, such as methyl tarsier butyl ether (MTBE), ethanol (except for those produced artificially from domestic agricultural products and bio-diesel). Liquid fuels obtained from domestic agricultural products are exempt from tax.
Biofuel incentive decision of the Council of Ministers

Ethanol and biodiesel produced artificially from domestic agricultural products can be blended with liquid fuel to an amount of 2% and is exempt from special Tax. The future target is to increase biodiesel contribution to 5%.

In terms of Research and Development, TUBITAK acts both as a funding and research organisation reporting directly to the ministry. The aim of TUBITAK is developing, promoting, planning and coordinating the research and development activities in the field of positive sciences, in respect of the priorities for Turkey’s development. It operates under a special founding act, providing financial flexibility and partial administrative autonomy. TUBITAK distributes most of the research and development funds, develops scientific and technological policies, supports and conducts research and development activities. The scientific research and technological development activities of TUBITAK are conducted through its research institutes.

Research and Development Strategies and Funding Schemes for Biomass Utilisation

Turkey became a party in the Kyoto Protocol to the United Nations Framework Convention on Climate Change. The reduction of carbon emissions via utilisation of renewable energy sources will have a considerable effect in setting the targets of energy production and consumption.

A strategy paper covering the period until 2023 has been prepared. According to this minimum of 4% of Turkish primary energy demand will be supplied from biomass, while 5% of the research and development budget will be allocated to the research on renewable energy sources.

The following funding schemes exist:

- The State Planning Organization Funds which fund the establishment of excellence centres for technologies that are of priority in Turkey.
- The TARAL (Turkish Research Areas). Distributed by The Scientific and Technological Research Council of Turkey (TUBITAK) this programme funds research projects on development of new energy production technologies from renewable sources. All the programs are open to any national applicants but branches of international firms legally established in Turkey as Turkish firms may also apply for funding. Only projects, which are not funded previously by TUBITAK can apply for the grant.
- The Techno-entrepreneurship Funding Programme, funds innovative and research and development based project ideas having a potential to create high added value in the near future. Applicants can be senior students or new graduates with undergraduate and graduate degrees and the budget is up to 100,000 YTL (approx. 50,000 €). The duration of the supported project cannot exceed 12 months.
- The Industrial Research and Development Funding Program, funds national research and development projects offered by Turkish companies. The program aims to support young entrepreneurs lacking of enough financial resources to realize their ideas. There is no specific application deadline or cut-off date for applications. The grant can be up to 60% of a project’s budget and can have a maximum duration of 3 years.
4 Brief SWOT Analysis - Conclusions

At the closing of the workshop the participants were asked to provide their input for the compilation of a SWOT table (Table 4.1) describing the state of play regarding biorefinery potential for their countries. The responses show that there is a lot of unexploited potential, in terms of biomass availability, which is not utilised at present. Wood and straw seems to be widely available but it is either not used or used in traditional low efficiency applications.

Table 4.1: SWOT table for the biorefinery potential in the New Member States, Candidate Countries and Potential Candidate Countries as reported by the representatives attending the workshop.

<table>
<thead>
<tr>
<th>Biomass resource availability</th>
<th>Bulgaria</th>
<th>Romania</th>
<th>Croatia</th>
<th>FYROM</th>
<th>Turkey</th>
<th>Albania</th>
<th>Bosnia &amp; Herzegovina</th>
<th>Montenegro</th>
<th>Serbia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Straw</td>
<td>SO</td>
<td>SO</td>
<td>WO</td>
<td>WO</td>
<td>SO</td>
<td>SO</td>
<td>WO</td>
<td>WT</td>
<td>SO</td>
</tr>
<tr>
<td>Wood-based feedstock</td>
<td>SO</td>
<td>SO</td>
<td>SO</td>
<td>SO</td>
<td>SO</td>
<td>SO</td>
<td>SO</td>
<td>WO</td>
<td>SO</td>
</tr>
<tr>
<td>Other waste / residual material</td>
<td>SO</td>
<td>SO</td>
<td>SO</td>
<td>SO</td>
<td>SO</td>
<td>SO</td>
<td>SO</td>
<td>SO</td>
<td>SO</td>
</tr>
</tbody>
</table>

| Technology availability     |          |         |         |       |        |         |                     |            |        |
| Technology in place         | WT       | WO      | WO      | WO    | WO     | WO      | WO                   | WO         | WO     |
| S&T potential, know-how (incl. transfer) | SO | S/WO | SO     | SO    | WO     | WO      | WO                   | WT         | SO     |

| Financial resources (on RES, environment, rural development etc.) |          |         |         |       |        |         |                     |            |        |
| National financial incentives | WT       | SO      | SO      | SO    | WO     | WO      | WT                   | WO         | SO     |
| External funding             | SO       | SO      | SO      | SO    | WO     | ST      | WO                   | WT         | SO     |

| Human resource availability (rural) |          |         |         |       |        |         |                     |            |        |
| Quantitative                  | WT       | SO      | WT      | WT    | SO     | SO      | WO                   | WT         | SO     |
| Qualitative (qualification, skills) | WT | WO | WT      | SO    | WO     | SO      | WO                   | WT         | SO     |

| Management experience & availability |          |         |         |       |        |         |                     |            |        |

| Regulatory framework & incentives |          |         |         |       |        |         |                     |            |        |
| RES & bioenergy                 | SO       | SO      | SO      | SO    | SO     | WO      | SO                   | S/W        | WO     |
| Environment                     | SO       | SO      | SO      | SO    | SO     | SO      | SO                   | SO         | SO     |
| Rural & regional development    | SO       | SO      | SO      | SO    | SO     | SO      | SO                   | SO         | SO     |

S – strength     W – weakness     O – Opportunity     T - Threat

There is a common agreement on the need for further dissemination of information and increased awareness of developments in the field. This is also apparent from the statement that there is a lot of human potential but without the skills and training to take up development and management of activities in this field. This is an area where improvements are needed and experience could be gained by interaction with member states more advanced in such projects.

Biomass energy is viewed as an opportunity for development in very poor rural areas but there have also been NIMBY reactions in more developed areas. The current agricultural structure might be a weakness since resistance from farmer co-operatives has been noted to certain projects.
New technologies have to start with easy, clean feedstock before they can proceed with more difficult options. However, in picking feedstock and technology we should not forget the environmental part of the biomass production and utilisation and projects should be researched to make sure they will not have negative impacts such as pollution of surface waters or soil degradation. In this respect it may be important to focus on waste streams and residues, which would also avoid conflict with other industries.

In terms of legislative and state support, it seems that relevant regulations are either already in place or being drawn up.

Given the unexploited potential present in the new member states, candidate countries and possible candidate countries and the need for knowledge dissemination observed, there is a lot of room for collaboration and technological transfer between the members of the project consortium and the new member states, candidate countries and possible candidate countries.