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Prezentare platforma
Statut
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Lista membri fondatori

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Cereri de tehnologii
Oferte de tehnologii

ARTICOLE

Articole
Noutati din domeniu

PROIECTUL

Despre proiect
Contactati-ne

Considerations upon the potential of Romania

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Abstract. The paper presents the Romanian potential for biofuels production and use in the European context. A strong knowledge and expertise exists in Romania in this area, both for biochemical and thermochemical systems. It started years ago (in early '80ies) and knows to day an exponential development.

The study pointed out that Romanian agriculture has all the necessary conditions to develop a sustainable biodiesel production & use and to become one of the most important European producer of biofuels. In the same time the production of fuels that protect the environment as well as provide an economical and sustainable source of income in the rural areas is extremely important for Romania.

It will be necessary, while supporting the implementation of currently available biofuels, to promote the transition towards second generation biofuels, which will be produced from a wider range of feedstock and which will help to reduce costs of "saved" CO2

Energy, pollution and biofuels

According to the demands of the technological development and the life quality increasing, during the last 50 years, global consumption of commercial energy has risen more than fourfold, far outpacing the rise in population and all this energy comes from natural resources whether fossil fuels such as coal and oil, living resources such as timber and biomass, nuclear fuel such as uranium, or renewable resources such as flowing water and wind and the power of the sun [1]. A generation ago, there was concern that fossil fuels would run out, plunging the world into an energy crisis. Today the fear is that their continued use might be wrecking the global climate by emitting carbon dioxide (CO2) as we burn carbon-containing fuels. This anxiety is substantially increased in view of the considerable unmet demand for energy in the developing world [6].

The ***Kyoto Protocol to the United Nations Framework Convention on Climate Change*** is an amendment to the international treaty on climate change, assigning mandatory emission limitations for the reduction of greenhouse gas emissions to the signatory nations. It covers now more than 160 countries globally and has as objective the stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Countries that ratify this protocol commit to reduce their emissions of *carbon dioxide* and five other greenhouse gases (*methane, nitrous oxide, sulfur hexafluoride, HFCs, and PFCs*), or engage in emissions trading if they maintain or increase emissions of these gases.

According to the *Kyoto Protocol* Governments are separated into two general categories: developed countries, referred to as Annex I countries (who have accepted greenhouse gas emission reduction obligations and must submit an annual greenhouse gas inventory); and developing countries, referred to as Non-Annex I countries (who have no greenhouse gas emission reduction obligations but may participate in the Clean *Development Mechanism*). By 2008-2012, Annex I countries have to reduce their greenhouse gas emissions by a collective average of 5% below their 1990 levels (for many countries, such as the EU member states, this corresponds to some 15% below their expected greenhouse gas emissions in 2008). Any Annex I country that fails to meet its Kyoto obligation will be penalized by having to submit 1,3 emission allowances in a second commitment period for every ton of greenhouse gas emissions they exceed their cap in the first commitment period.

The EU road transport sector accounts for more than 30% of the total energy consumption in the Community. Actually, it is 98 % dependent on fossil fuels with a high share of imports and thus extremely vulnerable to oil market disturbance [7]. The growing transport sector is considered to be one of the main reasons for the EU failing to meet the Kyoto targets as it is expected an increase of 90 % of the CO2 emissions between 1990 and 2010.

Considering these circumstances Europe has defined ambitious targets for the biofuels development. The aim is to improve European domestic energy security, improve the overall CO2 balance and sustain European competitiveness. The development of innovative biofuel technologies will help to reach these objectives.

The current production of liquid biofuels in the EU is about 2 Mtoe, which is less than 1 % of the market. Although there have been marked increases in production and use in recent years, the market share is at risk of failing the EU policy target for 2010 of 18 Mtoe used in the transport sector.

The EU has a significant potential for the production of biofuels. It is estimated that between 4 and 18 % of the total agricultural land in the EU would be needed to produce the amount of biofuels to reach the level of liquid fossil fuel replacement required for the transport sector in the Directive 2003/30/EC. Furthermore, biofuels can contribute to the EU's objectives of securing the EU fuel supply while improving the greenhouse gas balance and fostering the development of a competitive European (biofuels and other) industry.

An ambitious and achievable vision for 2030 is that up to one quarter of the EU's transport fuel needs could be met by clean and CO2-efficient biofuels. A substantial part will be provided by a competitive European industry, using a wide range of biomass resources, based on sustainable and innovative technologies. Biofuel development will create opportunities for biomass providers, biofuel producers and the automotive industry. Also, the European technology will be used in 2030 in many countries exporting biofuels to Europe.

Reaching the vision means considerably increasing domestic biofuel production, while balancing it with international biofuel trade. This will not only require substantial investment in biomass production, harvesting, distribution and processing, but also calls for agreed biofuel and biofuel-blend standards.

The majority of engines available in 2030 will require liquid fuels, although their molecular composition might have evolved from today's fuels. It will be beneficial if the new fuels are similar to, or at least compatible with, today's fuel types and specifications. Ability to mix fuels from alternative sources with current, conventional fuels without jeopardising the standard fuel specifications, and making use of existing infrastructure, is a very effective means for the implementation of these fuels.

Thus, the challenge is to increase substantially the production of biofuels that are commercially viable, CO2-efficient and compatible with vehicle engines, by using innovative processes and technologies. To achieve this, it is necessary, while supporting the implementation of currently available biofuels, to promote the transition towards "second generation biofuels", which will be produced from a wider range of feedstock (including waste biomass), reduce competition for land and food, and which will help to reduce costs of "saved" CO2.

According to these realities research and development are paramount in reaching the vision. A phased development is envisaged based on short-term improvement of existing feedstock and technologies, RTD&D (research, technology development and demonstration) and commercial production of 2nd generation biofuels (mainly from lignocellulosic biomass), RTD&D and implementation of full-scale integrated biorefineries, and new energy crops.

For supply of the biomass feedstock, sustainable land strategies must be created that are compatible with the climatic, environmental and socio-economic conditions prevailing in each region. In Romania the **BIOCOMB Consortium** is responsible for the **National Strategy for Biofuels** and **Biomass Action Plan** designing.

The production and use of both the primary and residual forms from agricultural, forestry and industrial operations must be promoted. In the same time, the research on improving crop yields and energy input/output, as well as key quality characteristics using advanced technologies, should be taken carefully into account.

Romanian biofuels potential

Agriculture is an efficient energy provider, by converting the solar energy during the photosynthesis in biomass energy. Part of the harvest biomass can used for different biofuels production covering the fuel technological necessities.

With a surface area of 238,393 km², Romania is the largest country in southeastern Europe and the twelfth-largest in Europe. In the same time, Romania has very harmonious physical features: 31% of Romania's surface is covered by mountains, 33% by hills and tablelands, and 35% by plains. The Carpathian Mountains dominate the centre of Romania, with fourteen of its peaks reaching above the altitude of 2,000 metres. The highest mountain in Romania is Moldoveanu Peak (2544 m). In south-central Romania, the Carpathians sweeten into hills, towards the Bărăgan Plains. Romania's geographical diversity has led to an accompanying diversity of flora and fauna. The country has the largest brown bear population in Europe, while chamois are also known to live in the Carpathian Mountains, which dominate the centre of Romania.

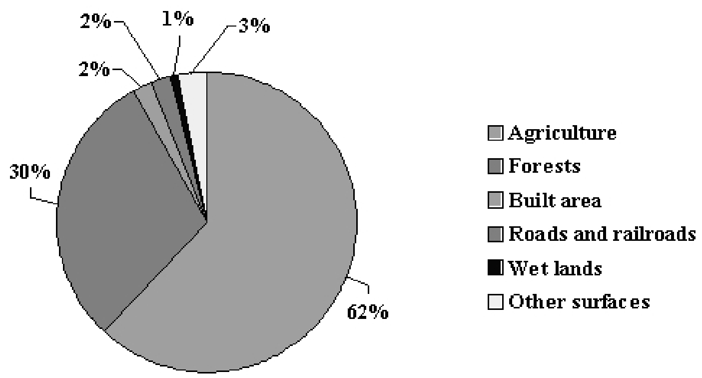

Fig. 1 Romanian country surface distribution
Of the total surface of the country (237,500 km2), 62 % represents agricultural land, 26,7 % is forest, 3,7 % is covered by water and 7,3% represents other surfaces (fig. 1).

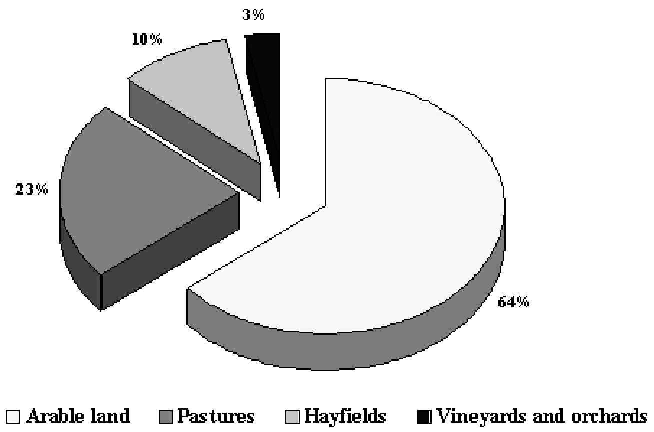

Fig. 2 Romanian agricultural surface distribution

From the agricultural surface (total 9398500 ha, from which 7012666 ha EU eligible) main part is arable land and the rest of it is divided between pastures, hayfields and vineyards & orchards (fig. 2).

The two pathways presently used in Europe at large scale are (see table 1): ***ethanol production*** from sugar crops or starch (grain crops) and ***bio-diesel*** from oil-seed crops (rapeseed, sunflower, soy bean and other raw materials) converted into methyl esters (Fatty Acid Methyl Ester or FAME). Actually, in Romania biodiesel production is the most used technology for biofuels.

Ethanol can be incorporated in the gasoline pool, but only to a limited percentage (at present 5 %, based on the current gasoline norm EN228) without engine modifications. Some ethanol is also used as a 85 % blend (E85) in flexible fuel cars, mixed with diesel using a stabilizing additive (e-diesel), and as fuel for diesel buses (with ignition improver). The most frequent use of ethanol in Europe at present is, however, through conversion into derivatives such as ethyl tertiary butyl ether (ETBE) (etherification of ethanol and isobutene, a by-product of refinery processes), although they may have (like other etheroxygenates) some disadvantages, such as potential ground water contamination. Its use can also be limited by the availability of isobutene.

Pressed vegetable oil as such has been tested in vehicle fleets with controversial results. Conversion of oil of biological origin (plants/animals) by esterification with methanol results in a fuel widely accepted by diesel engineers. It is used both in pure form and admixed to diesel from mineral oil. Esterification of oils from biological origin with bioethanol will be discussed further in order to generate biodiesel independent from fossil fuels. Today, fossil methanol is used for the esterification. A better option in the future would be to use bio-methanol in the FAME production, or the production of Fatty Acid Ethyl Ester (FAEE) bio-ethanol instead of methanol.

The production of biogas is a third available pathway, but it is very limited at the moment, in Romania. It can be either produced in dedicated facilities from organic wastes or recovered from municipal solid waste landfills. The recovery of biogas is important not only as a resource, but also for avoiding the discharge of a greenhouse gas in the atmosphere. Upgraded biogas compressed at a pressure around 200 bar can be used as an engine fuel. This option has to be better assessed, but presently represents a niche market.

Table 1
Biofuels first two generations

First generation (conventional) biofuels			
Biofuel type	**Specific names**	**Biomass feedstock**	**Production process**
Bioethanol	Conventional bioethanol	Sugar beet, grains	Hydrolisis & fermentation
Vagetable oil	Pure plant oil (PPO)	Oil crops (rape, soia, sunflower)	Cold pressing/extraction
Biodiesel	Biodiesel from energy crops	Oil crops (rape, soia, sunflower)	Cold pressing/extraction & transesterification
Biodiesel	Biodiesel from waste (FAME/FAEE)	Waste/cooking/frying oil/animal fat	Transesterification
Biogas	Upgraded biogas	(Wet) biomass	Digestion
Bio-ETBE		Bioethanol	Chemical synthesis
Second generation biofuels			
Biofuel type	**Specific names**	**Biomass feedstock**	**Production process**
Bioethanol	Cellulosic bioethanol	Lignocellulosic material	Advanced hydrolysis & fermentation
Synthetic biofuels	Biomass-to-liquids (BTL) Fischer-Ttropsch (FT) diesel Sythetic biodiesel Biomethanol Heavier (mixed) alcohols Biodimetylether (Bio-DME)	Lignocellulosic material	Gasification & synthesis
Biodiesel	Hydro-treated biodiesel	Vegetable oils and animal fat	Hydro-treatment

Biogas	SNG (Synthetic Natural Gas)	Lignocellulosic material	Gasification & synthesis
Biohydrogen		Lignocellulosic material	Gasification & synthesis or biological process

A strong knowledge and expertise exists in Romania in this area, both for biochemical and thermochemical systems. It started years ago (in early '80ies) and knows to day an exponential development.

Currently, agricultural and forestry systems exploit only part of their production, i.e. "primary" products, while they leave unexploited significant "residual" quantities. The use of both the primary and the residual resources through integrated and sustainable pathways should be promoted. It will also be necessary to utilize biomass fractions that are presently discarded and to make the best use of the whole plant. Specific non-food, high yield biomass can be developed but needs to take account of issues, such as biodiversity and labor conditions.

Dedicated energy feedstock in the form of energy crops represents for Romania a promising outlet to security of supply issues for future biofuel production. Like the other biomass resources, they can be converted into virtually any energy form. However, their main advantage is that they can be developed to optimize key characteristics for energy applications and their sustained production can better ensure long term large-scale supplies with uniform characteristics. Energy crops may also have significantly higher yields per unit of land area than natural stands. These higher yields improve their cost effectiveness over conventional crops and minimize land requirements, associated chemical use, and hauling requirements.

Developing innovative technologies can secure new jobs in rural areas, but also within industrial companies. The employment balance of biofuels is estimated to be about 16 jobs per ktoe, nearly all in rural areas (each 1 % proportion of biofuels in total fossil fuel consumption will create between 45000 and 75000 new jobs in rural areas). Innovative technologies are needed to produce biofuels in an energy efficient way, from a wider range of biomass resources and to reduce costs. The options, which will be developed, need to be sustainable in economic, environmental and social terms, and bring the Romanian industry to a leading position. This means that apart from purely economic factors, e.g. investment, operating cost, and productive capacity, other factors have to be taken into account such as the greenhouse gas and energy balances, the potential competition with food production and the impact of biomass production on the environment.

Table 2

Land requirement for biofuels production to meet the EU Transport Directive target

Country	Needed area (ha)	Arable land (1000 ha)	Needed share of arable land	Set aside land (1000 ha)	Needed share of set aside land
AT	130	1400	9%	107	120%
BE	130	820	16%	24	537%
DE	1500	11800	13%	1137	133%
DK	80	2300	4%	213	38%
EL	40	2700	1%	30	119%
ES	2100	13300	16%	1329	159%
FI	120	2200	5%	177	65%
FR	1200	18400	6%	1489	78%
IE	30	1100	3%	29	101%
IT	80	8000	1%	231	33%
NL	150	910	16%	16	910%
PT	450	2000	23%	80	567%
SE	240	2700	9%	264	90%
UK	190	5900	3%	567	34%
BG	1	3500	0%	293	0%
CZ	160	3100	5%	70	224%
EE	18	1100	2%	220	8%
HU	0	4900	0%	215	0%
LT	12	2900	0%	300	4%
LV	10	2900	0%	443	2%
PL	520	14100	4%	130	402%
RO	130	9900	1%	500	27%
SK	120	1500	8%	29	408%
SI	14	170	8%	10	137%
EU15	6400	73500	8.7%	5693	113%
EU+10+2	1000	44100	2.2%	2210	45%
EU15+10+2	7400	118000	6.3%	7903	94%

Conclusions

The study carried on pointed out some conclusions from which the most important are considered to be:

Humanity has at its disposition enough fossil energy carriers for several centuries, if it accept increasing prices.
Renewable energies will come in operation step by step when they become competitive or they have support from the governments.
To ensure the reduction of CO2 emissions, a market mechanism will be required to ensure that CO2-efficiency of bio-fuels is acknowledged and rewarded. Mechanisms (e.g. a certification scheme) could be used to promote the production and use of "more CO2-effective" biofuels.
Agriculture and forest-derived material must be processed on a decentralised basis to avoid uneconomic shipping costs. An option to be considered is pre-processing difficult to handle biomass and transporting the processed form. This is more efficient both in terms of energy value per transport unit and reduced costs.
There is a great unused potential for energy crops cultivation in Romanian agriculture.
According to its natural conditions for agriculture, Romania can be one of the most important biofuels producer in Europe. Here can be easily produced about 2,5 106 t of biofuels on the non subvention agricultural land.
In important challenge is to increase substantially the production of biofuels by using innovative processes and technologies, which are both competitive and sustainable.
It will be necessary, while supporting the implementation of currently available biofuels, to promote the transition

towards second generation biofuels, which will be produced from a wider range of feedstock and which will help to reduce costs of "saved" CO_2.

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