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THE TERRESTRIAL BIOMASS: FORMATION AND PROPERTIES (CROPS AND RESIDUAL BIOMASS)

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Agriculture engineer from Agricultural University of Athens, Greece with MSc on environmental planning. She is working at CRES, Center for Renewable Energy Sources, as the head of Biomass department, and has twenty years of experience in a range of R&D activities, related to research and evaluation of growth and productivity of several energy crops, as well as the technical evaluation of integrated bioenergy chains. Her expertise is focused on a) research and evaluation of the adaptation, growth and productivity of several energy crops (Arundo donax, Miscanthus sinensis x giganteus, Cynara cardunculus, sweet sorghum, etc.) under Greek conditions, on marginal and fertile lands, for the substitution of conventional fuels, b) research and evaluation of the energy potential of agricultural and forest residues, c) evaluation of the biomass and energy potential of a wide range of energy crops grown in experimental field trials in a wide range of soil and climatic conditions, under several growing techniques, d) optimisation of the bioenergy system, matching production possibilities, use of multiple feedstocks and crop logistics to conversion requirements for sustainable biomass production, as well as prefeasibility / feasibility / case studies for implementation of bioenergy schemes at regional and national level.
She is involved in several European and national projects as scientific responsible and as coordinator in the projects FAIR CT96 2028 "Giant reed (Arundo donax L.) Network" (completed), ENK-CT-2001-00524 "Bio-energy chains from perennial crops in South Europe" (completed), EIE-05-113 'Promoting favourable conditions to establish biodiesel market actions' (completed) and KBB7-208-2B-227299 "Non-food-crops-to-industry schemes in EU27" (on-going). Recently she is working in a large collaborative project EUROBIOREF "European multilevel integrated biorefinery design for sustainable biomass processing" researching the suitability of a range of energy crops and the relevant logistics for diversified final marketable products. Her research work has been presented in several papers in international journals and conferences.
She was involved the Biomass Action Plan for Cyprus and recently was a member of the Governmental Committee for drafting the National Renewable Energy Action Plan (NREAP) of Greece. She is a member of the National Committee responsible for the harmonisation of the recent Directive 2009/28/EC and the National representative in the Mirror Group of the European Technology Platform on Biofuels, and in the European Committee for the sustainability in biofuels and bioliquids.

The feedstock resources for the several biorefinery options are sourced from agricultural and forest residues (cereal straw, wood) and new potential resources (oil and lignocellulosic crops).
Although the existing approaches cover a wide range of feedstock types and biomass potentials still lack a coherent structure to allow the estimation of technical potentials under sustainable development policies taking into account direct and indirect land use, soil and water conservation and air pollution aspects. The residual biomass types refer to cereal straw and woody biomass (from forestry and related activities), as these are the main residual forms of biomass available in

large quantities throughout Europe, they represent residual biomass with no major other uses and have well known feedstock chemical and bio-chemical characteristics. When it comes to straw, France, Spain, Germany, Italy, Poland and Romania are the main producers according to the reported studies. France, Germany, Finland, Austria, Italy and Sweden are the top producing countries in wood. The provided information focuses on geographical distribution and yields, economic considerations and markets, and environmental considerations.

Regarding the oil crops, approximately 120 million tons of vegetable oils were produced worldwide in 2009. In the recent years, the produced amounts have continuously increased by around 3% per year. It is predicted that this trend will continue in the medium and long terms. Four main vegetable oils dominate the industry, accounting for around 82% of the worldwide vegetative oil production in 2009: *soya oil* (31%), *palm oil* (20%), *rapeseed oil* (18%) and *sunflower oil* (11%). In addition, a number of other oil crops are produced around the world, including *peanut, cottonseed, palm kernel, coconut, linseed, groundnut* and *corn oil*. While European oilseed production is dominated by *rapeseed* (Brassica napus) and *sunflower* (Helianthus annus) accounting for the 59% and 20% of the total vegetable oil production respectively, a number of other oilseed crops are produced, and this range has increased with the accession of the new European states. Oilseed rape dominates in most northern countries and sunflower in most central and southern countries. Although the largest proportion of the produced oil was used for food purposes, a significant proportion was used for non-food. *Soya bean* (Glycine max) cultivation was shown to be increasing in southern Europe, accounting for the 16% of the total vegetable oil production in 2009; the area of *linseed* (Linum usitatissimum) was shown to fluctuate and was largely subsidy driven, and considerable quantities of, primarily tropical, oilseeds were imported to supplement European production. From the selected crops only *safflower* (Carthamus tinctorius) production is commercialized with 0.10% of the total vegetable oils production. The main producers are India (54,000 tons), USA (39256 tons) and Argentina (27460 tons). Note that with the recent 'food vs. fuel' debate, more oil crops are being considered worldwide. For several oil crops cultivation in European level is not at a commercial scale, so for most of the crops yields are reported from USA mainly. For certain crops like castor seed and safflower there is considerable research going on in the Mediterranean area, thus it is highly likely that these crops could be candidate for larger-scale development. In the cold climate of Central Europe only crambe seem to have a potential to grow as it shows similar performances as rapeseed.

The oil crops dealt in this work focus on castor seed, crambe, cuphea, jatropha, lesquerella, lunaria, safflower and jatropha. These non-food crops do not compete with food crops in terms of agricultural lands as they can grow on less fertile lands, with low inputs (water, nitrogen, pesticides etc). Their selection was also based on their favourable oil properties for the various green chemical products dealt in this project. The provided information focuses on geographical distribution and yields, economic considerations and markets, and environmental considerations.

The lignocellulosic crops include perennial crops and short rotation forestry. Such crops have low input requirements over 10-25 years of productive life coupled with high yielding potential. They offer not only an important energy resource but can positively contribute to biodiversity, soil protection, landscape improvement etc. In the past decade, the EU has provided funds to research and develop perennial crops in a wide range of European environments. There have been several sizeable pan-Europe initiatives for perennial rhizomatous grass species.

The selected crops are cardoon, giant reed, miscanthus and switchgrass. Cardoon can show a wide variation in yielding potential, from 3 to 15 t/ha dry matter, but has the advantage of being a winter crop and thus it is not water demanding and can be grown in marginal lands. Miscanthus has gained interest in energy market are its high biomass potential, perennial nature, low inputs and good biofuel characteristics (i.e. low moisture content at harvest time in spring). Annual yields of 10-12 and 20-25 odt/ha are expected under commercial conditions in central-north and south Europe, respectively. Likewise, the recorded yields of giant reed from a large number of experiments indicate that under real conditions and supply of sufficient water a yearly production of 10-15 odt/ha could be feasible. The yielding potential of switchgrass is achieved from the third year onwards and the best varieties can yield from 16 to 22 odt/ha, depending on the irrigation and fertilisation provided.