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CONTENTS

INTRODUCTION

The research sector has for years been committed to the exploration of new outlets for agriculture but, with a few rare exceptions, research findings have hitherto had a negligible impact on European agriculture.

Recently, owing to a combination of factors unrelated to research, such as the crisis caused by over-production in European agriculture, the difficulty of finding outlets on the world markets, the escalating costs to be borne by the public exchequer (Community and national), and the need to ensure reasonable prospects for our young farmers, fresh consideration has been given to potential new outlets for agriculture by those actively engaged in agriculture and research, both at Community and national level, by the professional agricultural organizations and by various industrial sectors.

But the fact that so much interest is now being paid to the use of agro-forestry by-products as a source of energy and even to the development of energy-producing plants should not unduly raise our expectations.

Since 1975, the Commission of the European Community has supported research programmes on biomass. The most recent programme, for the period 1985-1989, provides financial support amounting to 20 mio ECU. The caution shown by the Commission in the chapters devoted to these issues in the green paper entitled 'Perspectives for the CAP'[1] is not without significance.

The Agriculture Division of the Directorate-General for Research and Documentation considers that it would be useful to summarize in this document some of the information available[2] concerning the biomass, energy-producing crops and their possible uses.

Our aim is simply to provide a general picture of the situation obtaining in the sector in question; more detailed and comprehensive information on the various issues may then be furnished in response to individual requests.

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[1] COM(85) 333 final

[2] A bibliographical list of the main sources is attached.

1. ENERGY-CONSUMING OR ENERGY-PRODUCING AGRICULTURE?

Apart from a few beneficial effects such as land productivity gains and a rise in farmers' incomes, the development of modern agriculture and, above all, intensive agriculture - already widespread in Europe - has also had adverse consequences such as the surge in direct and indirect energy consumption.

The high level of mechanization and the increasing use of chemical fertilizers and pesticides and of specially selected crop varieties are an indication of how more and more energy is being expended on the output of basic agricultural products.

A study carried out by the FAO in 1976[3] compared the consumption of energy - in kg oil equivalent - in the production of fodder maize in modern agriculture and traditional agriculture in America and Mexico.

Table 1: Fodder maize production - energy consumption and yields using modern and traditional systems

	Modern system	Traditional system
Total energy consumption (kg oil eq.)	715.6	4.1
Yield (kg/ha)	5 083.0	940.0
Yield (kg/kg oil eq.)	7.1	237.0

The final result, which shows the per kg oil equivalent production difference does not allow for the human energy expended in the traditional system.

The difference is obviously striking, especially in the light of the spectacular rise in energy costs over the past ten years.

3 'The State of Food and Agriculture', FAO, 1976

According to data supplied by the Commission, European agriculture has gone beyond a certain intensification threshold, i.e. the increase in agricultural production has been outstripped by the increase in energy costs.

Despite this, the input/output energy ratio is still considered to be positive (1 : 2.5), in other words, for every kilocalorie used, European agriculture produces 2.5 kilocalories of food or fodder.

Needless to say, if the observed trends were to continue, the energy ratio - at least for certain crops - could well fall below parity.

Those engaged in European agriculture have therefore begun, especially in view of the rise in energy costs, to look for every possible means of making energy savings in the production process. But of even greater importance has been the commencement of research studies into the possibility of converting agriculture from an energy-consuming into an energy-producing industry.

This can be achieved through improved exploitation and transformation of the biomass, involving not only the use of existing products and by-products for the generation of energy, but also the development of energy-producing crops. An analysis of these possibilities is the subject of this paper.

2. THE ENERGY-PRODUCING BIOMASS

The biomass is the sum total of plant and animal organic materials and their by-products present on Earth. In terms of energy exploitation, it also includes industrial and urban organic waste and residues.

The biomass derives from solar energy, which is absorbed by plants and converted by photosynthesis into chemical energy. It thus constitutes a renewable but diffuse source of energy which is at times untappable using present-day techniques. Even so, it could turn out to be a valuable energy resource, especially if it is exploited in the agricultural and forestry sectors.

Each year, the land mass of the Community receives a considerable quantity of solar energy, equivalent to approximately 110 times the amount of energy it consumes. More than 50% of the energy consumed in the Community is imported from third countries.

Despite this quantity of solar energy, the energy output potential of the biomass is reduced by a number of factors :

(a) The photosynthesis process has a low yield. For the whole year it lies between 0.4 and 0.8% for most of the vegetation of the European land mass and varies not only according to the biological properties of the plant life, but also according to climatic conditions (light, temperature, rainfall, etc.) and pedological conditions (the water and nutrients content of the soil, etc.).

(b) There is insufficient rainfall in most parts of the Community, particularly in the Mediterranean area ; this may make it difficult to obtain maximum biomass energy yields in the absence of irrigation.

(c) The processes for converting the primary biomass into usable forms of energy have often fallen far short of maximum efficiency, with resulting high losses in the energy units obtained.

(d) Since priority has traditionally been given to food and fodder production, there is a limited supply of plant material for energy-producing purposes.

These limiting factors are just some of the considerations, both positive and negative, which are central to the debate on the use of the biomass as an energy resource. By way of example, we shall now outline some of the arguments deployed.

Table 2: Use of the biomass as an energy resource

Main advantages	Main disadvantages
Scope for storing solar energy	Dispersion over the land mass
Renewable, usually each year	Competition with conventional crops in the use of arable land
Technologies unsophisticated and undeveloped, but considerable scope for improvement	Need to obtain new cultivable land for the production of agro-energy
Exploitation of organic waste and its reintegration into the natural cycles	Need to resort to fertilization and irrigation
Few ecological risks	Risk of an energy budget deficit
In general, no need for a high level of investment	Lack of competitiveness with synthetic chemical products
Scope for creating decentralized jobs	

Source: COMES (biomass-energy committee): 'Etude et recommandations pour l'exploitation de l'énergie verte', May 1980, p. 15

3. VARIOUS SOURCES OF ENERGY-PRODUCING LAND BIOMASS

The basic constituent materials of the land[4] 'energy-producing biomass' in Europe include agricultural waste and residues, forestry waste and residues and a few plants of natural vegetation and, most importantly, energy-producing crops.

Although the energy-producing potential of these resources is modest, it is not negligible. Of the renewable energy sources, the biomass is regarded as being the one which, in the medium term, will be able to make the largest contribution towards meeting the Community's energy requirements. Cautious estimates have been made which suggest that by the year 2000 it could be used to cover 4-5% of the Community's energy needs. Roughly half the energy output will be obtained by recovering and utilizing the Community's agricultural and forestry residues, while the remaining half will probably come from the energy-producing crops, whose cultivation will not require radical changes in farm practices or in the use of land but rather the more intense use of arable land and the exploitation of some unused land.

The methods most commonly used for converting the biomass into energy (heat) or into energy-producing products (alcohol, methane) are biochemical methods, which enable the humid biomass to be used, thus avoiding dessication of the raw materials, and thermochemical methods, which require relatively dry materials (straw, wood) and high temperatures.

The principal sources of biomass may be divided into two groups : residues and energy-producing crops[4].

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4 The biomass falls into two very broad categories : the land biomass and the aquatic biomass. The latter, which comprises freshwater or seawater micro and macro-algae, is excluded from this study, as are other energy-producing biomass sources such as industrial and urban waste and residues.

Table 3 provides a comprehensive picture of the energy-producing potential of the main residues in the Community of Twelve.

Table 3: Energy-producing potential of the main agricultural and forestry residues in the EEC, Spain and Portugal

COUNTRY	Gross energy content of the main residues theoretically available				Gross energy content of the main accessible dry residues (straw, wood)				Quantity of energy recoverable from direct combustion of the accessible dry residues			
	Plant residues	Animal residues	Forestry by-products	Total	Plant residues	Animal residues	Forestry by-products	Total	Plant residues	Animal residues	Forestry by-products	Total (b)
	millions of toe				millions of toe				millions of toe			
F.R.G.	9,1	11,0	2,3	22,4	2,6	2,4	3,2	8,2	3,0	1,0		4,0
Belgium and Luxembourg	1,2	1,7	0,4	3,3	0,1	0,5	0,6	1,2	0,4	0,3		0,7
Denmark	2,7	1,8	0,3	4,8	1,1	0,5	0,1	1,7	0,8	0,2		1,0
France	20,0	11,3	2,2	33,5	5,1	3,7	7,3	16,1	6,3	1,5		7,8
Greece	1,7	0,5	-	2,2					0,7	0,1		0,8
Ireland	0,7	2,8	-	3,5	-	0,6		0,6	0,2	0,4		0,6
Italy	8,4	4,6	0,8	13,8	1,9	1,2	3,1	6,2	3,0	0,6		3,6
Netherlands	1,0	2,6	0,1	3,7	0,1	0,6	0,1	0,8	0,4	0,4		0,8
United Kingdom	8,9	6,4	1,5	16,8	1,2	2,0	0,5	3,7	2,0	0,9		2,9
EUR - 10	53,7	42,7	7,6	104,0	12,1[a]	11,5[a]	14,9[a]	38,9[a]	16,8	5,4		22,2
Spain	8,5	2,7	1,2	12,4					2,3	0,4		2,7
Portugal	0,7	0,6	0,5	1,8					0,2	0,1		0,3
EUR - 12	62,9	46,0	9,3	118,2					19,3	5,9		25,2

(a) EUR-9 (b) Plant residues and animal residues only

Source: EEC Commission, EUR 7937

Differences in the data are due to the use of various statistical sources and methods of calculation.

A. Plant residues

The main plant residues in energy terms are straw and the so-called green residues.

Straw fulfils an important role in the European Community[5]. Although there is some doubt about the total available stocks of this material, the energy content of cereal straw, together with rice straw and fodder maize straw, has been put at more than 33 million tonnes oil equivalent.

In the short term, competitive uses determine the prospects for exploiting the energy-producing potential of straw at regional level in each Community country. The scope for developing this resource for energy purposes is closely linked not only to the distribution, quality and quantity of the residues actually available, but also, and more importantly, to their global density, expressed in tonnes per hectare of UAA per annum. If we take as an output threshold a density equal to or greater than 1.5 t/ha of UAA/year, 20 regions in Europe, including eight in Germany, seven in France, three in northern Italy and the rest in Denmark and the east of England, might be interested, in the medium term, in developing the energy-producing potential of straw and fodder maize stalks.

In these regions, surpluses could economically justify using the potential energy elsewhere than on the farm, even allowing for the cost of transporting material to centralized conversion plants.

Straw can readily be turned into a source of energy using various conversion treatments - direct combustion, pyrolysis, gasification, - and it may also be possible to convert it through hydrolysis into ethanol, a fuel for motor cars.

Green residues are to be understood as the by-products with high humidity, of crops intended for human consumption : fruit and vegetables, sugar beet, potaetoes, legumes, etc.

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[5] Straw is classified among plant materials with low humidity, which may vary, for example, between 15 and 20% in the case of cereal straw and between 12 and 20% in the case of the straw of oleaginous plants (COMES - p. 20).

Although the total energy yield is far lower than that of straw, for example, the existing concentration of these products - especially potatoes and sugar-beet -, in some agricultural regions of the Community such as Picardy and Champagne in France, Belgium, Emilia-Romagna in Italy and the Netherlands, suggests that it would be profitable to use them for energy purposes. Moreover, the possibility of using anaerobic digestion as a conversion technique is conducive to the production of energy from green plant residues, especially in the Netherlands and Belgium, where, in view of the quantity of gas that can be extracted from the waste of stock- farming, the digestion energy output is far higher than that obtainable from the treatment of straw alone.

B. Animal residues

Another important usable resource for the production of energy in the Community is animal manure and, in particular, the faeces of cattle, pigs and poultry, whose potential energy content in relation to the Community's livestock resources is of the order of 40 million tonnes oil equivalent. On average, however, only about 35% of this material is recoverable as gross biogas energy, which could possibly be used for the local generation of electricity.

A number of limiting factors reduce, however, the potential amount of energy obtainable from organic animal waste. Not all the residues can be recovered, especially if the rearing methods involve permanent or temporary grazing, as in the case of many dairy herds. This factor is particularly important in the case of sheep, whose residues are not easy to collect and reclaim for energy purposes.

According to some experts, the installation of a digester within the farm becomes economically viable provided that it is large enough for rearing at least 100 head of cattle or 1 000 pigs or 10 000 hens.

The 'limit' values could be lowered in the light of future progress in anaerobic digestion techniques, oil price increases, and the economic benefits deriving from the use of anaerobic digestion for the treatment of residues carrying a high risk of pollution, especially in the intensive stockfarming areas.

Alternatively, digestion plants run by cooperatives could be installed, especially in regions with a high concentration of agricultural activity. Commission studies show that 20 Community regions have such a high density of stockfarming per unit of utilized agricultural area that cooperative schemes would in future be justified. In order of decreasing importance, they include four regions in France, six regions in the Federal German Republic, three in the United Kingdom, two in Italy and one in the Netherlands, Belgium, Luxembourg, Denmark and Ireland.

Compared with straw, organic animal residues allow of less flexibility in energy conversion treatment. At present, anaerobic digestion is the most economical and practical process, and is the one normally used. The products are biological methane (biogas), which can be used, for example, to generate electricity for the farm or, where the plants are larger, for small communities or rural industries, and residual material which, because its nutritive value is only slightly less than that of the original material, can be used as a fertilizer.

C. <u>Forestry residues</u>

Potential sources of wood biomass include residues from the working of forests and the processing of wood, undeveloped or underdeveloped copses and undergrowth, and the products of clearings that are not at present marketed. Compared with those obtained from farm crops, these residues are a smaller resource. They are, however, easier to use in that they are more concentrated and localized. The gross energy potential, based on residues obtained from the collection and processing of wood, is of the order of 9.3 million tonnes oil equivalent for the Community of twelve.

The values could in future be raised through improvements in the use and management of forestry resources such as copses, which at present are often under-utilized, and through the reafforestation of unproductive farmland, particularly in the United Kingdom and Ireland.

In the medium term, however, the rate of development of the forest biomass for energy purposes will be largely determined by the total consumption of wood within the Community. At present, the demand, especially by industry, for forestry products such as wood for building purposes, paper and chipboard, cannot be met by internal Community production and the shortfall is covered by massive imports which in all likelihood will gradually become more expensive and difficult to obtain in view of the growth in world demand for forestry products.

In the Federal German Republic, France, the United Kingdom, Spain and Italy, however, real opportunities could exist for tapping the energy potential of the forestry biomass. These countries are in a position to recover larger quantities of residues from the total national area covered by forests. In France, Italy and Greece, in particular, considerable importance could attach to the exploitation of copses and undergrowth which cover large areas. Indeed, of the total Community resources reclaimable from this type of forest material, 60% and 24.4% respectively come from the French and Italian forest areas.

In economic terms, it is not yet possible to form a broadly accurate opinion as to the advantages of exploiting the forest biomass, since many variables have to be taken into account: changes in the price of oil, the development of exploitation techniques, the costs of the raw material and of the conversion and storage processes. Nevertheless, in some areas such as France, forestry residues can already provide energy at a price which is competitive with that of fossil fuels, provided that the gathering, processing and transport costs are low.

As far as energy budgets are concerned, the utilization of forestry residues is of particular interest. Compared with other plant biomass sources, wood requires low energy inputs for production and conversion.

The technologies for converting forestry residues into energy are today at a fairly advanced stage of development. Various methods are suitable for use: direct combustion, pyrolysis and fermentation for the production of ethanol and, in particular, gasification, from which liquid fuel can be obtained in the form of methanol.

4. ENERGY PRODUCING CROPS

These include agricultural or forest crops which are cultivated solely for the production of energy, or plant species, including a few plants from the natural vegetation, which are not normally cultivated and cannot immediately be used as foodstuffs.

In the normal production cycle, these crops may assume either a principal role - i.e. they replace another crop - or an intercalary role, which implies a more intensive cultivation of the land following the harvesting of a principal crop.

In recent years, the Community has displayed a growing interest in these crops and, in particular, in three categories of plant.

A. Sugar and starch-based plants

These are plants whose sugar sap, extracted directly or after hydrolysis, may be converted through fermentation into alcohol (ethanol) and, after distillation, an expensive process in energy-producing terms, blended with petrol. Many sugar and starch-based plant species can be grown for this purpose and adapted to European climatic conditions. Sugar-beet and fodder beet are two examples. Despite its lower sugar content, fodder beet has a higher dry substance yield than sugar-beet and, consequently, a higher per hectare ethanol yield.

Sweet sorghum and the Jerusalem artichoke could be of considerable value, especially from the viewpoint of a total energy-conversion budget. These crops provide either the glucides that can be converted into alcohol or the fuel needed for the distillation process. In addition, they both yield by-products that can be used as animal feed.

It should be pointed out that the Jerusalem artichoke and sorghum can adapt to climatic and soil conditions found in Southern Europe.

The alcohol yields of those crops are high. Under optimum growing conditions, they are equal to 30 hl/ha for sorghum, 45 hl/ha for beet and 63 hl/ha for the Jerusalem artichoke.

B. Oleaginous plants

These plants have a high oil content which, after extraction through pressing or using solvents, could be used in diesel engines. There are, however, problems of lubrication. The plants include colza, rape, sunflowers, flax, etc. On average, the energy obtained from the extraction of colza oil is equivalent to 1 toe per hectare.

C. Other crops

These are crops from which high dry material yields can rapidly be obtained. They include rapidly rotated copse plantations, mixed plantations of, for example, poplar, willow, plane, eucalyptus and alder, and various other plants, some of which belong to the natural vegetation, such as the Provence reed (Arundo donax).

5. THE SCOPE FOR USING THE BIOMASS AS A SOURCE OF LIQUID FUELS

Apart from the possibility of using biomass-produced energy close to the place of production, consideration is being given to the possibility of manufacturing fuels from energy-producing crops. If this were a truly practicable proposition, it would obviously open up new horizons for European agriculture and could completely alter its appearance.

As we have already seen, one possibility would be to use colza oil, which is easily extracted and, technically, could replace gasoil used in diesel engines. However, supplies of plant oil in the Community fall well short of current demand (only 30% of requirements are being met, and approximately 1.5 million hl would be needed to cover demand in the foodstuffs sector alone).

Another, longer-term, possibility would be to produce methanol from cellulose (straw and wood). The advantage here is that uncultivated land (about 5 million ha) could be used without posing a competitive threat to agriculture. As for the disadvantages, quite apart from the absence of an afforestation policy for uncultivated land, which certainly cannot be introduced in the short term, a whole series of technical problems are posed by the production of methanol on a large-scale and the necessity to adapt car engines to enable it to be used.

While the above two possibilities may not be followed by any practical developments in the short term, it is the third possibility, the production of ethanol, which has attracted most attention even though opinion on it is divided and problems associated with its use are legion.

The case of ethanol

The use of ethanol derived from sugar-beet, fodder maize or wheat is thought by some experts[6] to be a non-starter in both economic and energy terms.

Others, however, while entertaining misgivings about the economic aspects, consider ethanol to be both viable and desirable as a form of energy.

It should perhaps be pointed out that two countries, Brazil and the United States, are already using ethanol as a petrol co-solvent, additive or substitute. The United States is particularly keen to develop this application and has adopted a major programme of direct and indirect (tax abatement) investment aid with the aim of providing an outlet for its cereal surpluses, reducing atmospheric pollution and cutting back on imports of petroleum products.

The Federal Government, for example, has guaranteed a tax exemption of 60 cents in the dollar on the purchase of every gallon of ethanol until 1992. Other subsidies are provided by individual States.
Furthermore, even the conversion technology has been perfected in the United States, since there already exist 45 industrial concerns producing ethanol from the biomass.

[6] For example, Ahner and Farget in the report: The Agricultural and Forestry Biomass, EUR 7937

Some experts take the view that, in terms of energy production, the incorporation of ethanol in petrol gives results which are even better than those obtained from the oil-based competing products (MTBE or TBA), because ethanol raises the octane rating. From the economic point of view, despite the existence of a number of variables, it seems to have been established beyond doubt that the cost of ethanol would be very much higher - about 3 times higher - than the cost of competing products.

From the technical point of view, assuming a petrol/ethanol mix of 7% - a figure midway between 5% and 10%, the two percentages usually envisaged - 6.3 million tonnes of ethanol, equivalent to the processing of approximately 21.8 million tonnes of cereals, would be needed. One tonne of cereals yields 350 litres of ethanol and 300 kg of protein by-products for use as animal feed, which could reduce the Community's imports of soya cake and maize gluten.

In its latest document on the 'perspectives for the CAP', the Commission realistically appraises the case for and against the use of ethanol, without concealing the fact that, as matters stand at present, the difference between the selling price and offer price is such that to correct it would entail costs that were higher, in purely budgetary terms, than the EAGGF's current expenditure on the disposal of the basic products concerned, both within the Community and elsewhere.

In the final analysis, the problem is a political one. What is needed is a medium-term assessment of:

- the amount of aid that can be directly granted by the Community;

- the tax relief that can be granted by the Member States with a view to the marketing of ethanol;

- the costs involved, as compared with the costs incurred by the present system for the disposal of surpluses;

- the job-creation impact on related sectors;

- the impact on employment levels in the agricultural sector.

The answers to these points will have to be evaluated in the light of the political options open, not least in view of the obligation on the Community countries to introduce lead-free petrol by 1989.

6. SOCIO-ECONOMIC CONSIDERATIONS

In a background paper such as this, it is necessary to give some consideration to socio-economic studies on the use of biomass. However, with the exception of ethanol, which has been dealt with separately, research studies of this kind have not been particularly fruitful.

In spite of the dearth of precise reference material, it would be useful to take stock of the microeconomic and social aspects of developments in the use of the biomass in the Community.

The investments needed for the exploitation of the biomass must be sufficient to finance not only the conversion plants (boilers or digesters), but various other potentially more expensive operations and requirements.

(a) The collection and transport of the residues are major operations whose economic implications must be assessed carefully. The wide distribution of the waste and its transport to the treatment centre could be major determinants of the final costs of energy.

(b) The storage of the waste has to be taken into consideration. The products of the biomass are often somewhat bulky and account must be taken of the need for adequate space and storage facilities in any costing exercise.

(c) The fuelling of the treatment centres will have to be automatic; according to the Commission, an automatically fuelled straw boiler costs four to five times more than a manual one.

(d) Competition for the use of land may discourage the producer, who will agree to use resources to switch to energy-producing crops only if his returns are equal to or greater than those obtained from traditional crops. State support measures and state incentives (prices) for the cultivation of traditional products will have to allow for this factor.

(e) Continuity of supplies is an important factor in determining the size of the treatment centre and the length of the amortisation period. The yield of energy-producing crops is subject to climatic conditions and, as with all products, there will be good years and bad years. In the case of forestry residues, financial provision will have to be made for replanting, failing which the initial investments would be wasted for want of raw materials.

(f) The effect on the soil is, according to the experts, a problem in the case of marginal land. It has to be borne in mind that such land is usually unproductive and difficult to cultivate. Using it to cultivate energy-producing crops could impoverish the soil, risk erosion and cause yields to fall below the planned thresholds.

(g) Publicity is also a factor that must not be neglected. The development of energy-producing crops or the use of traditional crops for new purposes should be made known through an extensive publicity campaign, financed for the most part from the public purse.

Having considered these microeconomic factors, which it is important to bear in mind, there are two other aspects, which will need to be considered in far greater detail.

(h) Exploitation of the biomass as a means of increasing employment is one of the arguments often put forward by the biomass lobby. But this is a matter which calls for extreme caution. While jobs could be created for the construction of treatment centres - specialized labour would be required, often outside the rural centres - the recovery of waste and the substitution of energy-producing crops for food crops would probably have only a very small impact on employment levels. Furthermore, if the goal is to make 'green' energy competitive with traditional energy, efforts will have to be made to hold down costs and, consequently, to introduce a higher level of mechanization, which will have adverse consequences for employment.

(i) The environment would be particularly affected by a large-scale use of the biomass. One positive but limited effect would be the reduction in pollution levels resulting from a cut-back in traditional energy production methods. Moreover, the probable decentralization involved in the production of biomass energy would facilitate the assimilation of waste matter and residues by the environment. On the other hand, the large number of processing plants required could have a negative impact because of the greater difficulty of ensuring that they were properly managed.

7. CONCLUSIONS

In the context of the long-standing debate on the future of the common agricultural policy, the idea of developing a branch of agriculture unrelated to food production may indeed have its attractions. In some quarters, however, it is looked upon with considerable suspicion, not least in the agricultural community with its traditional outlook and resistance to passing fashions.

But the crisis in the agricultural sector has now become a matter of deep concern both for our political leaders because of the burden it places on the national exchequers and the tensions it creates in international trade, and for the production sector, whose very role has been changed as a result of the drive and efficiency displayed by farmers, particularly over the past ten years.

Fresh prospects must be opened up for future generations of farmers, even if, as the European Parliament has acknowledged on various occasions, this may require sacrifices such as reductions in production aid or quotas, although the specific and distinguishing features of European agriculture will have to be kept intact.

As the Commission rightly points out in the introduction to its green paper of July 1985 : 'An agriculture on the model of the USA with vast spaces of land and few farmers, is neither possible nor desirable in European conditions in which the basic concept remains the family farm'.

It is to the Commission's credit that it has not left itself unprepared for the search for new policies. For some time, both its agriculture directorate and its directorate for scientific affairs, research and development have been engaged in studies which, when assessed for their practical merits, may be adopted as a basis for the development of new policies.

In conclusion, it is difficult to say whether the biomass will actually be able to offer an alternative to traditional agriculture. From the work of experts, we have compiled and reproduced in this paper a variety of factual and analytical material, in the belief that the European Parliament must not only monitor the activities of the Commission, but also fully discharge its function as a spur to the Community institutions as a whole and to the shaping of European public opinion.

BIBLIOGRAPHIE SELECTIONNEE - BIBLIOGRAFIA SELEZIONATA - SELECTED BIBLIOGRAPHY

AUSGEWÄHLTE BIBLIOGRAPHIE

Ahner D. - Farget M.A. "La biomassa agricola e forestale - Una fonte di energia per l'Europa ?" Energia - Direzione generale dell'Agricoltura - Commissione C.E. (EUR 7937 (1983))

COMES - Commissariat à l'énergie solaire, "L'énergie solaire - Biomasse" - Service de diffusion de l'Information sur l'Energie solaire (SDIES), Paris, 1980

COMES - Commissariat à l'énergie solaire - Comité Biomasse-Energie, "Etude et recommandations pour l'exploitation de l'énergie verte", (mai 1980)

Commissione delle C.E., "Prospettive della politica agricola comune - Il Libro Verde della Commissione", Note rapide dell'Europa Verde, n. 33, Bruxelles (luglio 1985)

Convery F.S. - Dripchak K. , The Economic and Social Research Institute, "Energy crops, forestry and regional development in Ireland", Paper 110-114, Criterion Press Ltd, Dublin (October 1983)

Coombs J. - Hall D.O. - Chartier P., Commission of the E.C., "Plants as Solar Collectors - Optimizing productivity for Energy", Solar Energy R and D in the European Community - Energy from Biomass - Series E, Vol. 4 - D. Reidel Publishing Company - Boston, London (EUR 8575) (1983) (p 210)

Farget M.A., "Valorisation énergétique de la biomasse d'origine agricole - Un bilan de réalisations en France et en Italie", Politique de la Science et Technologie - Série FAST 15 - Direction générale Science, Recherche et Développement, Commission C.E., EUR 8666, 1983

General Technology systems Ltd - Studio per la Commissione delle C.E., "The distribution of biomass opportunities in the European regions", 1981

Gibbs D.F. - Greenhalgh M.E., "Biotechnology, Chemical Feedstocks and Energy Utilization", A report from the FAST Programme of the Commission of the E.C. - Frances Pinter (Publishers), London and Dover EUR 8650 (1983)

Grassi G. - Palz W. - Commission of the E.C.,"Proceedings of the EC Contractors'meeting held in Brussels - 5-7 May 1982", Solar Energy R and D in the E.C. - Energy from Biomass - Series E, Vol. 3 - D. Reidel Publishing Company - London, Boston (1982)

Jayet P.A. - Sourie J.C., "Les valorisations énergétiques des biomasses. Difficultés et promesses", Revue de l'Energie, Paris, année 35, n. 367 (octobre 1984)

O.C.D.E., "La biomasse : forces et faiblesses de "l'énergie verte"', L'observateur de l'OCDE, Paris, n. 128 (mai 1984)

O.C.D.E., "Aspects économiques et politiques de l'utilisation énergétique de la biomasse", Rapport général OCDE Comité de l'Agriculture (novembre 1983)

Palz W. - Chartier P. - Hall D.O. "Energy from biomass", 1st EC Conference CEE - Applied Science Publishers'Ltd, London (1981)

Palz W. - Chartier P., "La biomasse ressources et perspectives d'avenir dans la Communauté européenne", Editions du Moniteur, Paris (EUR 6809) (1982)

Palz W. - D. Pirrwitz - Commission of the EC, "Proceedings of the Workshop and EC Contractors'meeting, held in Capri, 7-8 June 1983", Solar Energy R and D in the EC, Series E, Vol. 5, D. Reidel Publishing Company, London-Boston - EUR 8829 (1983)

Pellizzi G. - CNR, "Studio per la FAO : energie nuove e rinnovabili in agricoltura", (Roma 1980)

Piermont L., "L'énergie verte", Editions du Seuil (1982)

Rexen F. - Munck L., "Cereals crops for industrial use in Europe", CEE, EUR 9617 (1984)

Schepens G. - Louveaux F. - Buydens C., "Biomasse et régions", Série FAST 14 - Politique de la Science et Technologie - Direction générale Science, Recherche et Développement, Commission CE.E., EUR 8554 (1983)

Second Solar Energy R and D Programme (1979-1983), "Proceedings of the first coordination meeting of Contractors", Energy from Biomass (Project E), 18-19 September 1980, Amsterdam - Energy Directorate general for Research, Science and Education, Commission of the EC, EUR 7160, 1981

Strub A. - Chartier P. - Schleser G., "Energy from Biomass", 2nd EC Conference CEE - Berlin, Applied Science Publishers (1982)

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