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# Renewable Energies: For an Ambitious but Pragmatic Development

*by*
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***National Assembly report no. 3415 – Senate report no. 94 - www.assemblee-nationale.fr - www.senat.fr***

*The state of the art of renewable energies and their prospects were analysed by Mr Claude Birraux, Member of Parliament, and Mr Jean-Yves Le Déaut, Member of Parliament, in their report of 2001 adopted unanimously by the Parliamentary Office for Science and Technology Assessment, a National Assembly and Senate joint body.*

*That report studies, from a scientific and technical viewpoint, the potential role of renewable energies in the energy policy and also the development prospects of each of them on the basis of inquiries made by the Rapporteurs in France, Germany, the United Kingdom, and Denmark and hearings of 180 researchers and specialists conducted with the help of a working group of ten experts.*

***Executive Summary***

## *Diversity of renewable energies and of their uses*

Renewable energies – *hydropower, wind power, solar power, geothermal power, and biomass* – are energies which have been used since time immemorial, to which modern technologies grant new forms and new efficacy.

Their development has focused in the past decade on the production of electricity. This priority was enshrined in the European Union Directive of 27 September 2001 on the promotion of electricity produced from renewable energy sources, for which the aim in France is to reach 21% of the total in 2010. Electricity production is therefore a preferred application for traditional renewable energies like large and small hydropower systems, or else renewable energies which are really taking off like wind power or photovoltaic power, or else ones which are still very much in development like high temperature geothermal power.

But the development of renewable energies cannot be limited to the production of electricity. These energies also allow either the direct production of heat and hot water with wood energy, thermal solar power or thermodynamic solar, heat pumps and geothermal power, or the indirect production of biofuels from biomass.

The development of renewable energies must consequently be diversified, particularly in a country like France where nuclear electricity generating plants produce one of the least expensive electricities in Europe, and where the reduction of greenhouse gas emissions should intervene as a priority in the transport and residential-service industry sector.

## *Technical complementarity of renewable energies and other forms of energy*

Renewable energies have considerable assets.

Available in unlimited quantities, renewable energy sources do not emit greenhouse gases. In most cases, these energies, which lend themselves to decentralised production, provide solutions for isolated sites not connected to an electricity or natural gas grid. Also the roll-out of renewable energy sources provides hands-on experience in energy conservation. As producers in many applications, consumers become more responsible and have an incentive to save energy.

However like any form of energy, renewable energies also have their limits and even disadvantages.

The investment costs and production costs of renewable energies are not generally competitive with those of mass produced energies, even if the external environmental costs of the various energies are factored in. Also, renewable energies have limited specific powers which do not make them suitable for mass production, with the exception of hydropower. Varying, furthermore, with wind intensity, luminosity, rainfall or crop yields, their production is for the most part intermittent. This

makes it necessary not only to combine them but also to have traditional fossil or nuclear energies to take over from them when necessary. Connection to a grid may also be necessary to ensure continuity of supply.

All in all, renewable energies offer new solutions for an energy demand which is continuing to rise and may take on new forms. Although they cannot be substituted for fossil or nuclear energies, they are complementary to them.

### *Strong growth in global demand*

The prospects for renewable energies in the global market are strong in developed countries and immense in the developing world.

Pursuant to the 1992 United Nations Convention on Climate Change, the Kyoto Protocol, opened for signature in 1998, enshrined the need to reduce greenhouse gas emissions and therefore to develop alternatives to fossil fuels, which has contributed to strengthening the interest for renewable energies. By laying down, in 2001, goals for the production of electricity from renewable energies sources, the European Union is promoting their development throughout the Member States. This policy has since been completed by the promotion of biofuels and the laying down of standards on the energy performance of buildings.

In major industrialised countries as a whole incentive development programmes for renewable energies have been introduced, opening up new market prospects.

There is an even more important aspect. As they are suitable for decentralised production, particularly in rural settings, renewable energies will play a key role in providing electricity to two billion people worldwide who currently lack it. If international solidarity rises to the challenge of funding problems, then there will be a considerable global market, for instance for solar panels, small and medium wind turbines, solar refrigeration and geothermal power.

### *The necessary strengthening of national research and industry*

Research on renewable energies has an unsatisfactory position in France. However, as the types of energy and fields of application are very numerous, it would admittedly be difficult to cover the entire R&D required and to be competitive at the same time. Most countries have in fact chosen to specialise in the energies they are best endowed with – wind energy for Denmark – or in the segments deemed most promising, where their industry also enjoys comparative advantages – photovoltaic solar energy for Japan or Germany.

In any case, whether or not there is specialisation, it appears necessary for French R&D on renewable energies to be greatly strengthened. Otherwise that would mean sacrificing any chance of participating in technological breakthroughs which could increase even more the interest for renewable energies.

Similarly, the French renewable energies industry is not in a favourable situation with respect to other countries. This is the case for instance with wind turbines where Denmark and Germany dominate; and with photovoltaic solar energy where Japan, the United States and Germany lead worldwide. For each type of energy or application France does have innovative companies offering quality products, but their critical size is most often insufficient with respect to their foreign competitors.

Any policy to develop domestic demand for wind, photovoltaic, or thermal solar systems, for instance, should therefore be combined with a strong structuring of the sector by public companies.

### *Changes since publication of the report*

*The CNRS drew up in 2002 a new three year interdisciplinary programme on energy research whose director is Mr Bernard Spinner, a member of the experts working group set up by Messrs. Birraux and Le Déaut.*

*Among the aims of this programme appears the development of the contribution of renewable energies and modern technologies in the production of heat, fuels for transport, and electricity.*

*The Ministry of Research and New Technologies (MRNT) decided in 2003 to contribute funds from the Fonds national pour la science (National Fund for Science) to this programme which has since become a CNRS-MRNT concerted project enjoying support from the Direction générale de l'armement (General Armament Directorate).*

### *Hydropower, the foremost French renewable energy*

Hydro-electric power stations supply approximately 15% of the French production of electricity, with 70 TWh on average, fluctuations in hydraulicity being non-negligible however from one year to the next.

Hydropower represents, in any case, the foremost French renewable energy for the production of electricity, and will probably remain so for several years yet.

Large power stations supply most hydroelectric production - 90 % on average.

The potential of large hydropower systems does not appear to be able to grow in France as the sites allowing large developments have all already been taken and public acceptance difficulties appear insurmountable for new facilities.

Forming the other facet of hydropower, there are approximately 1700 mini and micro hydro-electric power stations in France with a unitary power lower than 8 MW, producing in all approximately 7 TWh per year.

Despite local acceptance difficulties and environmental protection regulations, micro power stations can be developed in France.

To facilitate the development of small hydropower systems by giving small producers a long term guarantee, the contractual provisions and energy purchase rate for producers were revised in 1997 for medium voltage supplies and in 1999 for low voltage supplies.

### *Changes since publication of the report*

*Mr Serge Poignant, Member of Parliament, published in October 2003, an information report on the support policy for the development of renewable energies.*

*He feels that 'local environmental protection rules hindering production excessively should […] be reviewed'. 'The classification of waterways should therefore be revised today. […]'.*

### *Wind power: neither exclusively nor passionately*

Wind turbines are often shown as symbols of renewable energies and can be classified technically in two categories: small and large wind power systems.

Small wind power systems aimed at the production of electricity for isolated sites – hamlets, villages, small island networks, for instance. The various types of aerogenerators – on the basis of the machines sold by the French manufacturer Vergnet – range from a power of 5 kW for a 12 metre high mast and a 5 metre diameter propeller, to 275 kW power for a 55 metre high mast and a 32 metre diameter propeller.

Large wind power systems are aimed at the industrial production of electricity for large dimension electricity grids. Forming the category with the most rapid growth, large wind turbines are regularly increasing in power and dimensions. At the beginning of 2000, the most advanced models were characterised by a power of 2 MW, for a 70 metre high mast and a rotor diameter of 72 metres, but machines of 3.5 MW were on the drawing board for sea wind power where masts could reach 150 metre height and feature 100 metre diameter rotors.

In 2000, France, with 60 MW of installed capacity, was lagging considerably behind Germany (5432 MW), Spain (2099 MW) or Denmark (2016 MW), which launched very early into the twin industrial adventure of the production of aerogenerators and of wind electricity. Hence the introduction of a policy to catch up, which has been speeded up since 2000. The Éole 2005 programme, the first main step of the policy encouraging the development of wind energy in France, was launched in 1996 and based on invitations to tender. Its aim is an installed capacity situated between 250 and 500 MW in 2005.

The second main step corresponds to the entry into force of mechanisms set forth by the Law of 10 February 2000 on the modernisation and development of the public electricity service. An obligation has been introduced for EDF to buy the electricity produced by facilities of less than 12 MW, combined with an incentive rate set forth by the decree of 8 June 2001, considerably higher than the production cost. Consulted on this rate, the Electricity Regulation Commission

felt that the annual cost premium entailed by an installed wind power of 5000 MW in 2010, in comparison with the cost of nuclear power, would reach approximately 10 billion € over all the 2003-2025 period, i.e. approximately 3 €/MWh. Therefore wind power cannot be claimed in France or in any developed country to be the miracle solution to cover the increase in electricity needs.

However, in actual fact, the purchase rates of electricity produced by wind turbines laid down in June 2001 do not call for any specific remark insofar as there is a 1500 MW capacity ceiling, which allows the 'windfall' effect of wind power investment to be controlled while this technique is taking off in France.

In actual fact the purchase rates meet the need to diversify energy sources by promoting the reasonable development of wind power in France. However, it would be necessary to precisely quantify the network development costs and develop departmental location plans for wind turbines in cooperation with local authorities. Similarly, it would be necessary to resolutely start structuring the French wind power industry so that it can supply the expanding French market and take its place in export markets. This should have been done before subsidies were granted to wind turbine operators.

### *Changes since publication of the report*

*The installed wind power capacity in France at the end of 2003 reached 231 MW compared with 150 MW at the end of 2002.*

*The goal of 2000 to 6000 MW of installed wind power capacity before 1 January 2007 was laid down by the decree of 7 March 2003 on the multiannual programming of investments (PPI) .*

*To reach the PPI goal, in addition to the Eole 2005 programme and the purchase rate incentive, invitations to tender are planned at the end of 2003, beginning of 2004: an invitation to tender consisting in two 500 MW tranches for land facilities of over 12 MW, and another 500 MW invitation to tender for sea facilities over 12 MW.*

*Lastly, to explain and facilitate the local procedures to be respected in the implementation of wind turbine projects, a legal framework was set in place by the Law of 3 January 2003 on gas and electricity markets and on the public energy service and by the Town Planning and Housing Law of 2 July 2003, which set forth the possibility of regional wind power plans after the opinion, in particular, of departments has been given. In addition, two circulars have been circulated to prefects on the promotion of land wind energy and the location of wind turbines at sea.*

### *Photovoltaic solar energy awaiting a national test market for a booming global market*

Photovoltaic solar energy is the technique allowing the direct production of electricity by the action of light on semiconducting materials like silicium.

Of all known materials, silicium, especially crystalline silicium, has the best conversion yields and dominates markets. Other materials like cadmium and tellurium have not yet encountered the success expected. Thanks to the high increase in production in recent years silicium is continuing to progress, with higher outputs and regularly decreasing production costs. In future years, a technological breakthrough is hoped for with the development of thin layers or polymer plastic photovoltaic cells used as solar panels or as construction material additives.

Given the importance of the potential applications of photovoltaic solar, it appears in any case essential to strengthen the means, currently far too insufficient, of French research in this promising field. In effect photovoltaic solar has rapidly launched applications both in developed and developing countries.

For sites connected to an electric grid, photovoltaic solar is not competitive with mass produced electricity. But it presents an obvious interest for isolated sites where, coupled with batteries or possibly other means of production like wind turbines or even standby diesel generators, it provides access to electricity in the absence of an electric grid.

Also various industrialised countries have set up site equipment programmes connected to the electric grid, such as houses or institutional facilities. In this case photovoltaic solar supplies the electricity needs of local users and any surplus production over consumption is reinjected into the grid.

For instance Germany introduced in 1999 its 100,000 solar roofs programme comprising, on the one hand, loans at advantageous rates for the purchase of equipment and, on the other hand, a purchase rate for electricity produced, far higher than the market price.

Given the investment cost of solar panels, of control electronics and of batteries and bearing in mind the still low conversion yields of

silicium, photovoltaic solar connected to the grid cannot constitute a mass production means of electricity. But the development of this type of applications effectively helps the industry to take off, as shown by the example of Germany, and even more by that of Japan, the world leader of the sector owing to the strength of its microelectronics industry and its roll-out programme for residential photovoltaic solar set in place as early as 1994.

While in developed countries having large electric power stations and transmission networks covering all their territory, photovoltaic solar applications are necessarily limited, the same does not apply in developing countries.

In the countries of the South, photovoltaic solar is already a technically and economically effective solution. It indeed provides in these countries a service superior to traditional means – candles, batteries, kerosene lamps, low power generators – at a lower cost, by supplying small appliances for individual or institutional use – refrigerators for health products, lighting for schools, radio-cassette recorders, televisions, and pumps.

All in all, photovoltaic solar appears to be a response to one of the major challenges of development, the provision of electricity to vast rural populations, and it also stands out as a sector with immense export prospects.

To take part in global industrial competition, the French photovoltaic industry must therefore be strengthened to face up to the strong competition from Japan, Germany, the United States and the United Kingdom.

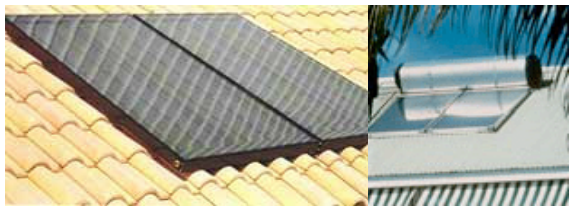
Complementary to the necessary restructuring of the sector's companies, equipment subsidies and purchase rates for electricity produced must be set at sufficient levels so that a broad showcase is set in place in metropolitan France, on the basis of the example of Guadeloupe.

### *Changes since publication of the report*

*GENEC (Atomic Energy Commissariat - CEA, Cadarache) is studying the feasibility of a photovoltaic solar panels endowment programme for rural populations in Senegal.*

*A microcredit organisation would fund the purchase of solar panels made available to households in exchange for reimbursement over two to three years at the rate of 10 euros per month. This amount corresponds to the average expenditure of rural African families for archaic sources of electricity – chemical batteries, candles, kerosene lamps. The life duration of a solar panel far exceeds the reimbursement period, which will then allow electricity to be obtained at nil cost. The sums thus saved will then make it possible to fund the mechanisation of certain village activities.*

*The project has attracted the attention of several NGOs and should be presented at the end of 2003 at the Ministry Delegate for Industry.*



### *Thermal solar energy and bioclimatic housing: two key sectors for France*

One of the most important sources of renewable energies is no doubt thermal solar energy using parallepipedal or cylindrical collectors installed on roofs of housing or institutional facilities.

Considerable savings can then be made for domestic hot water, and even for the heating of housing with the direct solar floors technique.

New applications with a great future are opening up to this technique, with solar air conditioning, thermal solar refrigeration, as well as direct transport technologies for cold and heat.

Despite its fragmentary nature, the French thermal solar industry is highly successful in export markets.

However, to cope with the forthcoming explosion in thermal solar and solar air conditioning markets, in a context where large foreign companies dominate, resolute direct and indirect support for French industry should be a priority of the public authorities.

To promote the growth of the thermal solar industry, which is necessary to reduce the costs of water heaters, an ambitious ***mobilising programme*** should be launched. Such a programme, which could be called ***Face-Sud***, should set as its first aim the installation of 200,000 solar water heaters per year in 2010.

There would be support from industrial public companies for SMEs-SMIs of the sector and a regulatory obligation would be introduced to use thermal solar energy in public buildings and social housing.

In any case, the growth of energy consumption in the residential-service industry sector, the highest of all the sectors, absolutely must be slowed down.

The energy performance of buildings should therefore be improved. Thermal regulations on the insulation of buildings should also concern the maximisation of solar contributions.

In this respect, the concepts of bioclimatic architecture should be deepened and taught to designers – architects, engineering and design departments – and to building professionals.

In addition, in order to contribute to the supply of energy to buildings, the future no doubt belongs to new thermal-photovoltaic materials, which would be used on large surfaces, enabling heat and electricity to be collected.

The intrinsic advantage of the Mobilising plan Face-Sud is that such a programme would give French industry a comparative advantage in global competition.

### *Changes since publication of the report*

*1. The European Directive of 16 December 2002 on the energy performance of buildings sets forth minimum standards on the energy performance of new buildings and existing buildings when they have undergone major renovation. This Directive must be transposed at the latest by 4 January 2006.*

*2. In June 2003, ADEME (Agence de l'environnement et de la maîtrise de l'énergie – the French environment and energy conservation agency) selected in its 'Habitat 2010' invitation to tender the project presented jointly by the CEA (GENEC), the manufacturer of silicium and PhotoWatt solar panels, and CSTB, on the development of a hybrid thermal/photovoltaic collector for roofs and solar facades.*

*The thermal collector is approximately one centimetre thick and fits into a non-encapsulated or encapsulated module, using existing production techniques.*

*The aim is for housing equipped this way to produce as much energy as it consumes, in thermal energy for heating and photovoltaic energy to feed the grid.*

*The investment cost premium with respect to a conventional roof or facade would be around 5% of the total cost of the house.*

### *Thermodynamic solar energy, a workable solution for countries of the South*

Thermodynamic solar energy is a technique aimed at focusing light by parabolic or cylindrical/parabolic mirrors, to heat a heat transfer fluid which is then used for electricity production, refrigeration or desalination.

Thermodynamic solar was the subject in France of industrial scale facilities with the Thémis solar power plant and the Odeillo solar oven at the beginning of the 1980s.

These prototypes did not encounter the expected success owing to insufficient hours of sunshine, the immaturity of certain techniques and, all in all, its lack of competitiveness compared with other sources of electricity production.

Thermodynamic solar continues however to be the subject of pilot projects in various countries. Further, the French achievements of the 1980s are now finding their way back into the news with projected facilities in southern European and Mediterranean basin countries.

For instance a solar power plant called Solar III will be built in Spain on the basis of the experience acquired with Solar II, a 10 MWe tower solar power plant which has operated for several thousand hours in Southern California.

In any case, thermodynamic solar can cope with the energy needs of countries with long hours of sunshine, while already presenting investment and operating costs making it competitive with wind power and making it an alternative to low-power nuclear reactors possibly.

To enhance its expertise, France must not only assert itself in international scientific and technological cooperation bodies but also inspire nay steer demonstrator facilities.

It is also essential to relaunch research and set in place incentives to bring in manufacturers.

### *Geothermal power and heat pumps: effective technologies*

Comprising several types of techniques and applications, geothermal power is based on the use of heat from sun radiation or from Earth's magma, absorbed and stored by Earth's crust.

There are three types of geothermal power: low-energy geothermal, high-energy geothermal and fractured rocks geothermal.

Low-energy geothermal corresponds to the exploitation of aquifers or to the thermal inertia of substrata. It makes use of limited temperature differences, comprised between a few degrees and a hundred or so degrees. Its applications are individual heating, district heating, air conditioning, or the supply of heat to industry. Once the facilities are amortised, geothermal power proves competitive, especially when drillings are linked to heat networks. As this renewable energy is particularly useful to reduce or control energy consumption in the residential-service industry sector, there is no doubt that the studies on the French substrata, at a standstill since the end of the 1970s, should be taken up again. After a revision of the tax conditions, currently unfavourable to heat production, the applications of these techniques which for the time being are concentrated in the Paris Basin and in Aquitaine, could appear in other regions, particularly in Limagne, the Rhine rift valley and the Alsace plain.

High-energy geothermal allows electricity production using high temperature steam extracted from volcanic substrata. Once extracted, steam can be used to drive a turbine to produce electricity or in industrial processes.

France has acquired remarkable and precious experience at Bouillante in Guadeloupe, where drillings to -300 metres allow a 200° C water-steam mixture to be harnessed for a 5 MW electric power station. The inevitable technical difficulties of such a prototype have now been solved and the Bouillante experience is now profitable.

Such facilities could easily be transposed elsewhere in Guadeloupe and to many other volcanic zones, especially in Caribbean arc countries, and also in the Philippines, Indonesia, and Central America.

The last type of geothermal power, still at an experimental stage, fractured hot rocks geothermal, consists in injecting water in fractured rocks at a depth of 500 metres serving as a heat exchanger.

Once the water reaches a high temperature it is brought back to the surface and used to drive a turbine producing electricity.

The Soultz-sous-Forêts project supported by the European Commission represents in this respect a promising avenue as the geographic zones where this technique could be applied are relatively vast, for instance in Italy.

Heat pumps, another technique based on the use of limited temperature differences, improve the thermal efficiency of a facility and were relatively in vogue after the first oil crisis. Since the past few years, heat pumps have been finding new applications in the form of geothermal heat pumps.

Capturing the free calories contained in the ground, geothermal heat pumps can make a significant contribution to the heating and cooling of individual or collective housing.

To supply the same heating or cooling service at institutional facilities, geothermal heat pumps can also be linked to water tables, as in North America.

To develop this renewable energy drawn from close substrata a plan for the massive dissemination of heat pumps should be supported by EDF. BRGM (Bureau de recherches géologiques et minières – Geological and mining research bureau) could provide, for its part, knowledge of water tables.

### *Changes since publication of the report*

*In his information report on the policy supporting the development of renewable energies, Mr Serge Poignant, Member of Parliament, remarks that the lower VAT rate applies only for gas and electricity supply agreements.*

*He feels that supply agreements concerning heat networks supplied by renewable energies should also enjoy this same rate.*

*The considerable potential contribution of biomass, with wood energy and biofuels.*

A source of energy since time immemorial, plants are not only renewable but also deemed to be virtuous as regards the greenhouse effect. Carbon dioxide emission during their direct combustion or that of their derived products is indeed compensated by the fixing of carbon dioxide during the growth period on account of photosynthesis. Although this equivalence is in practice deferred in time and in space, which can reduce its impact, biomass – wood, various plants, cereals, oilseed crops, various wastes, etc. – is considered a neutral renewable energy as regards the greenhouse effect.

If the estimations of non-commercial uses are added to the figures of quantities sold, biomass is the biggest source of renewable energy worldwide. In future years the two major challenges of biomass as an energy source consist in increasing the yield of combustion processes and in improving or developing biomass-to-biofuel processes while extending the use of biofuels.

Wood energy represents a very important resource in France. The volume of 40 million cubic metres consumed annually represents almost 9 million toe. ADEME, which has set in place a wood energy programme aimed at setting up a thousand industrial or institutional new wood boiler plants, estimates that fuelwood production could be increased to 12 million cubic metres per year in economic and acceptable conditions, which requires a new structuring of the wood sector.

The potential of biofuels in France is also considerable. The current tonnage of approximately 750,000 tons, half of which is accounted for by ETBE and the other half by colza di ester, could easily be exceeded.

Technically speaking, biofuels can be prepared from plants according to two major methods based either on the use of glucides or of fats. In the first method, the starch contained in the tuber (beetroot, potato) or the seed (cereals) as well as the glucose contained in the sap (cane sugar) undergo various chemical processes – hydrolysis possibly and alcohol transformation. The main biofuels prepared using this method are ethanol and, after an additional step, ETBE (ethyl tertiary butyl ether) which can be mixed with petrol in a proportion higher than that of ethanol.

In the second method, vegetal oils from rape oil meal, or even from sunflower, which are mainly triglycerides, lead, after esterification, to diesters which are also used as biofuels.

Given its rich land and privileged climate, as well as the strength of its agriculture, biomass is an essential asset for France to rationalise its supply of energy in housing and transport. Areas under energy crop cultivation could be increased to between three to four million hectares. Pursuant to the future European Directive on the promotion of the use of biofuels for transport, a quota of biofuels in petrol should be imposed without delay. Similarly, the benefit of exemption from the TIPP (taxe intérieure sur les produits pétroliers – domestic tax on oil products) should be extended to crude vegetal oils and tax incentives should be set in place for the entire biofuels sector.

In any case, the development of the various biofuels should be accelerated simultaneously at industrial and research levels. In particular, research should be strengthened on enzymatic processes for the production of ethanol from cellulose, the main component of plant cells and as such a highly abundant resource.

A ***mobilising programme*** called Terres-énergies, grouping all these measures, should be launched without delay.

*Changes since publication of the report*

*The European Directive on the promotion of the use of biofuels for transport was finally adopted in April 2003 and must be transposed at the latest by 31 December 2003. This Directive sets forth the incentive objective of a minimum quantity of biofuels of 5.75% of petrol and diesel fuel sales in 2010. To reach this goal, areas under wheat and colza should increase by nearly two million hectares.*

*Mr Serge Poignant's report proposes on the one hand that the total tax exemption for biofuels, already planned in Germany and Canada, should also be implemented in France and, on the other hand, that new approvals should be issued in order to bring French production capacity to the level of volumes corresponding to the Directive objectives.*

***November 2003***