United Nations Conference on Trade and Development

The Biofuels Controversy

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Boxes

Nous sommes peut-être à un tournant dans l'histoire de l'énergie. Après avoir vécu pendant deux siècles dans un monde d'énergie abondante et bon marché qui a nourri une croissance économique prodigieuse, certains signes laissent présager que nous pourrions entrer dans une phase d'énergie plus rare et plus chère. L'énergie est un bien qui est à la fois public et privé. Le soleil, le vent sont des biens publics inépuisables. Le pétrole, le gaz et le charbon, sont des biens privés épuisables dont on découvre qu'ils portent atteinte à un autre bien public, le climat. Le défi du présent siècle, c'est de produire davantage d'énergie pour alimenter le développement économique des pays émergents et des pays les plus pauvres tout en gérant de façon soutenable le changement climatique. C'est le sens du développement durable. Il ne s'agit donc pas d'un troisième choc pétrolier mais plutôt d'un changement de paysage.

(Le Cercle des économistes and Erik Orsenna, *Un monde de ressources rares*, Perrin/Descartes & Cie, Paris, 2007, pp. 76–77)

1. Biofuels background

The coming of age of biofuels[1] is happening against a background of growing awareness of the urgent need to change the present unsustainable pattern of energy use, which is characterized by a profligate (mis)use of abundant and cheap fossil fuels. It is helped by the recent sharp increase in oil prices. With price of oil barrel approaching the $100 mark, some biofuels have become competitive.

The unsustainability of the present energy consumption trends was made clear in the Reference Scenario of global energy demand to 2030, prepared by the International Energy Agency (IEA).[2] That demand is projected to increase by just over a half between now and 2030 – an average annual rate of 1.6 per cent. Fossil fuels will remain the dominant source of energy, accounting for 83 per cent of the overall increase in energy demand between 2004 and 2030. The share of oil drops somewhat, but oil remains the largest single fuel in the energy mix, reaching 116 mb/d in 2030, up from 84 mb/d in 2005. Coal experiences the largest increase in demand in absolute terms, driven by power generation. The share of biomass falls a little, accounting for 10 per cent of total primary energy demand in 2030, since the traditional forms of biomass use will decrease, offsetting the growing use of biofuels and biomass-based electrical power. The share of all other renewable energy technologies will increase from 0.5 per cent today to only 1.7 per cent in 2030. Overall, nuclear power's share of world primary energy will drop from 6 per cent in 2004 to 5 per cent in 2030. Developing countries account for over three quarters of the increasing global CO_2 emissions; China will overtake the United States as the world's largest emitter before 2010.

The authors of the article conclude that "current trends in energy consumption are neither secure nor sustainable – economically, environmentally or socially. Inexorably, rising consumption of fossil fuels and related greenhouse gas emissions threaten our energy security and risk changing the global climate irreversibly" (p. 13).

A Reference Scenario is often a scenario of impossibility. The IEA had therefore prepared an Alternative Policy Scenario in which world primary energy demand in 2030 is about 10 per cent lower than in the Reference Scenario. Global demand grows more slowly – 1.2 per cent annually. Renewables have a 27 per cent share by 2030, compared with 22 per cent in the Reference Scenario. Global oil demand stands at 103 mb/d instead of 116 mb/d. Measures in the transport sector produce close to 60 per cent of all the oil savings, with more than two thirds coming from more efficient new vehicles.

[1] The FAO defines biofuel as fuel produced directly or indirectly from biomass such as fuel wood, charcoal, bio-ethanol, biodiesel, biogas or biohydrogen.

[2] For the presentation of the IEA scenarios, see C Mandil and F Birol, What role for biofuels in the global energy scene? *Revue des Ingénieurs*, March/April 2007, pp. 12–14.

Biofuels will account for 7 per cent of the road-fuel consumption in 2030, up from 1 per cent today and 4 per cent in the Reference Scenario. Biofuel production increases from 15.5 Mtoe in 2004 to 97 Mtoe in 2030 in the Reference Scenario and 147 Mtoe in the Alternative Scenario. Ethanol is expected to account for most of the increase in biofuel use worldwide.

However, the authors consider that rising food demand, which competes with biofuels for existing arable and pasture land, will constrain the potential for biofuels production using the current technology. About 14 million hectares of land are used for the production of biofuels for transport at present, equal to about 1 per cent of the currently available arable land. That share rises to 2 per cent in the Reference Scenario and 3.5 per cent in the Alternative Policy Scenario. The authors recognize that second-generation biofuel technologies could greatly increase the future role of biofuels, but they do not incorporate them into their Alternative Scenario.

This question is discussed by S. His and D. Babusiaux.[3] Second-generation biofuels are those that utilize ligno-cellulosic biomass, the most abundant source of renewable carbon on our planet. The authors estimate that worldwide at least 5 per cent of total production of biomass could be harnessed to the production of energy: 13.5 billion tons of raw material representing about 6 billion toe, which is about half of the present world consumption of energy.[4] Only 20 per cent of that potential is currently being used, mostly in the form of fuelwood (80 per cent), and only 1 per cent for transportation in 2005. That potential could reach about 18 billion tons of biomass in 2050, corresponding to 9 Gtoe of primary energy.

Only part of that potential will be transformable into biofuels, and we lack at present a reliable estimate. However, a worldwide extrapolation for 2050 of a 30 per cent rate of replacement of fossil fuels by biofuels envisaged by Europe and the United States for 2030 would require 1 billion toe of biofuels. This is an ambitious yet feasible goal, given the availability of biomass.

Brazil and the United States are the leading producers of ethanol, while the European Union is at present the main producer of biodiesel.

According to the Brazilian Agroenergy Plan 2006–2011, the demand for sugarcane ethanol in Brazil, including prospective exports, could reach 30 billion litres by 2015. Some studies go so far as to suggest a fivefold increase in the current number of sugarcane plantations (from 6 to 30 million hectares). However, M. Jank, chairman of UNICA,[5] estimates that the present area used for sugarcane will grow from 6.3 to only 14 million hectares in 2020, with allowance being made for the increase in ethanol production from 18 to 65 billion litres per year. After that, further increases in ethanol production will not require additional land since they will benefit from the second-generation biofuel technologies and

[3] S His and D Babusiaux, Les biocarburants: de quoi parlons-nous ?" *Revue des Ingénieurs*, March/April 2007, pp. 15–18.

[4] 2.36 Gt for forest products, 5.33 Gt for non-agricultural non-edible products, 3.5 Gt for agricultural residues, 2.1 Gt for wood industry residues and 0.19 Gt for other residues (animal fats) – a total of 13.5 Gt.

[5] Unica (União da agroindústria canavieira de São Paulo) is an association representing the sugarcane-based agro-industries in São Paulo, from where the bulk of Brazilian production of sugar and ethanol comes.

high yield varieties of sugarcane.[6] However, there is an urgent need to regulate the sugarcane-based industry.[7]

With regard to biodiesel, Brazil's present production capacity is 954 million litres per year, with 25 plants functioning. Another 10 units will be inaugurated by the end of 2007, and this will bring the total capacity to 1.2 billion litres per year. The Government is considering anticipating a 5 per cent blend of biodiesel to diesel, originally foreseen for 2013. At present, 63,000 families of small farmers are involved in the production of vegetable oils for biodiesel: this number is expected to increase to 210,000 in the next year.[8]

As for the United States, the US Senate approved in June 2007 the new Energy Bill, which sets the production of 136.1 billion litres of ethanol as a goal for 2022. In spite of its unfavourable energy in/energy out ratio, US ethanol produced from maize received $9.4 billion in subsidies in 2005. That fact has given rise to the criticism that the United States has "energy politics", not an "energy policy", and represents "the sum of all lobbies", not "the sum of best ideas".[9]

Europe is at present the leading producer of biodiesel. A law on biofuels will be presented by the end of 2007 following a proposal by the European Commission that, by 2010, all petrol and diesel used in the European Union have 10 per cent biofuel content. The European Union has decided to reduce by 20 per cent its emissions of greenhouse gases (GHGs) by 2020 and may be prepared to go as far as 30 per cent if other industrialized countries follow suit.

Much controversy surrounds the future of biofuels. Brazil aspires to play a major role in the transition from the oil to the post-oil age and to become an important exporter of ethanol. Its President, Luis Inácio Lula da Silva, is adamant that the production of biofuels

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[6] Quoted by T Romero, Álcool em abundância, Agência FAPESP, 2 October 2007. At present, Brazil produces 8,000 litres of ethanol per hectare of sugarcane (compared with 3,000 litres from corn in the United States). New technologies should increase the yield to 14,000 litres per hectare.

[7] See on this point José Dirceu, A hora da regulação, *Jornal do Brasil*, 28 June 2007. The author, a former minister-chief of President Lula's Civil House, mentions eco-economic zoning, and measures to protect biodiversity and reduce pollution, and calls for foreign acquisition of land and biofuel industries to be restricted. The Government and the National Congress should take the necessary steps to regulate the sugarcane-based industry in order not to transform the new opportunities arising from bioenergy into degradation of the environment, destruction of small properties, wealth concentration, creation of cartels, monopolies and servile labour. The need for clear rules for public–private cooperation in the field of agro-energy has also been emphasized by Roberto Rodrigues, former Minister of Agriculture and a leading authority on the subject (*Folha de São Paulo*, 9 June 2007). His successor informed the press that the Government is considering the creation of an agency to deal with agro-energy. For its part, the National Institute of Colonization and Land Reform (INCRA) is considering a revision of loans, which regulate the purchase of land by foreigners (*O Estado de São Paulo*, 10 June 2007). At a meeting at the International Labour Organization, the Brazilian Minister of Labour, Carlos Lupi, recognized the need to improve the working conditions of sugarcane cutters in Brazil (*O Estado de São Paulo*, 11 June 2007).

[8] *Carta Capital*, 13 June 2007.

[9] TL Friedman, America's green bubble, *International Herald Tribune*, 4 June 2007. According to Friedman, the elements of such a policy would be the following: a clear long-term price signal (carbon tax or a cap-and-trade system with a binding national ceiling on carbon dioxide emissions); a commitment to buy a fixed volume of solar and wind power for government buildings and army bases for 10 years; the setting of a norm for newly produced cars – 35 miles per gallon within 10 years; the establishment of government loan guarantees for companies willing to build nuclear power plants; and the building of a national transmission grid. Increasing ethanol production by 8 will require a shift to other sources of biomass and the introduction of cellulosic ethanol into the market. One possibility is to extract ethanol from switch grass.

can be greatly expanded without impairing food security and without endangering native forests such as the Amazon forest. Brazil will provide all the social and environmental guarantees for the production of biofuels. Speaking at the opening of the 62nd session of the United Nations General Assembly, he rightly observed that hunger is not due to a shortage of food, but a lack of purchasing power, which affects 1 billion people. He emphasized that for many Latin American, Asian and, above all, African countries, ethanol can provide energy autonomy, create employment and income, and foster family agriculture.[10]

The opposite stance was taken by the Cuban President, Fidel Castro, who sees the boom for biofuels as threatening hunger for many millions of people.[11] Castro's view is shared by several environmental action groups. For instance, in an article full of flawed data, Eric Holtz-Jiménez argues that biofuels are neither necessary nor desirable, as many local replacement alternatives are quite successful (but he fails to name and locate them). On the other hand, he commends the functioning of small local cooperatives producing biodiesel in the United States, implying that industrialized countries should not transfer to the developing countries the burden of their excessive consumption of energy. As a quid pro quo, developed countries erect protectionist barriers against developing countries, preventing them from exporting biofuels.[12] In many quarters, there are fears about the impact of the growing demand for biofuels on agricultural prices [13] and water availability.[14] Other critics of biofuels argue that renewables are "boutique fuels": they look attractive when they are quite small, but if large-scale production begins, the consequences will be dreadful.[15]

Some of the above-mentioned articles are quoted by Jean Ziegler, the United Nations Special Rapporteur on the right to food, in the report presented to the United Nations General Assembly to support his plea for a five-year moratorium on the production of biofuels.[16] The report starts with an impassioned denunciation of biofuels that may bring hunger in their wake:

> the sudden, ill-conceived, rush to convert food – such as maize, weed, sugar and palm oil – into fuels is a recipe for disaster. There battle between food and fuel that will leave the poor and hungry in the developing countries at the mercy of rapidly rising prices for food, land are serious risks of creating a and water.

Reporting on Ziegler's presentation, the media focused mainly on those polemical remarks and on the plea for a moratorium. However, if his recommendations are examined

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[10] See T Monteiro, Na ONU, Lula lança cúpula sobre biocombustível e defende etanol", *O Estado de São Paulo*, 26 September 2007.

[11] Fidel Castro, *Granma* (Havana), 27 March 2007.

[12] E Holtz-Jiménez, Les cinq mythes de la transition vers les agrocarburants, *Le Monde diplomatique*, June 2007; and Green or mean? The biofuel myths, *International Herald Tribune*, 11 July 2007. In Brazil, Frei Betto, a former close adviser to President Lula, is one of the rare critics of the biofuel programme (L Paraguassú, Frei Betto ataca biocombustíveis, *Estadão*, 24 July 2007).

[13] See the joint OECD–FAO *Agricultural Outlook 2007-2016*, released on the day President Lula was discussing the prospect for biofuels with the European Commission. Brazilian commentators played down that fact, arguing that the report did not pay enough attention to the impact of higher oil prices on food prices.

[14] This concern was widely discussed at the 17th International Week on Water, held in Stockholm in August 2007 (AFP, 16 August 2007).

[15] This is the position of Jesse Ausubel of Rockefeller University in New York. He says that "if we want to minimise the rape of nature, the best energy solution is increased efficiency, natural gas with carbon capture and nuclear power" (P McKenna, Renewable energy could "rape" nature, *New Scientist*, 25 July 2007).

[16] J Ziegler, *Draft Report of the Special Rapporteur on the Right to Food to the General Assembly, 62/2007*. See also J Chade, "Relatório pede moratória na expansão do etanol", *O Estado de São Paulo*, 25 September 2007.

carefully, the apparent sharp contradiction between his stance and that of President Lula disappears to a large extent. Ziegler's main recommendations, in addition to the moratorium, are as follows:

- Promoting the reduction of overall energy consumption and improving energy efficiency;
- moving immediately to second generation technologies for producing biofuels so as to make complementary the production of food and biofuels;
- adopting technologies that use non-food crops, particularly those that can be grown in arid and semi-arid regions (in particular jatropha);
- ensuring that biofuel production is based on family agriculture rather than industrial models of agriculture;
- organizing cooperatives of small farmers.

If those recommendations are implemented, Ziegler argues, biofuels could be an important tool with which to combat hunger and poverty. That position is not so different from the positions taken by President Lula and by the Director General of the United Nations Food and Agriculture Organization (FAO), Jacques Diouf. In a recent article, the latter set out the conditions that must be met in order to take advantage of biofuels' enormous potential for accelerating growth in many of the world's poorest countries, fostering agriculture and providing modern energy to one third of the world's population.[17] According to him:

- A fair share of bioenergy ought to be produced by farmers and rural workers in developing countries.
- Small farmers should be given the opportunity and the necessary credits to organize themselves into cooperatives to produce and process biomass for fuels.
- Commercial barriers imposed on ethanol imports in some member countries of the Organisation for Economic Co-operation and Development (OECD) should be reduced.
- A system of socioeconomic certification of biofuels should be established.
- The debate should move beyond the replacement of fossil fuels in transportation and also focus on the importance of bioenergy for the reduction of poverty through helping two billion people to satisfy their daily domestic energy needs.

In this author's opinion, instead of asking for a moratorium, Jean Ziegler would do better to recommend the immediate application of the conditions set by him so that biofuel production becomes a lever of socially inclusive and environmentally sustainable rural development.

[17] J Diouf, Biofuels should benefit the poor, not the rich, *Financial Times*, 15 August 2007. See also J Graziano da Silva, Biocombustiveis para os pobres, *Folha de São Paulo*, 31 August 2007.

2. How do we move forward?

In an important article published on the occasion of the G-8 meeting, the United Nations Secretary-General, Ban Ki-moon, announced a special High-level Meeting on Climate Change to be held at United Nations headquarters in September 2007. He then summarized the situation as follows: [18]

- First, the science is clear. The earth's warming is unequivocal; we humans are its principal cause.
- Second, the time for action is now. The cost of not acting will exceed the costs of acting early by several orders of magnitude.
- Third, carbon trading, new technologies, energy conservation, forestry projects and renewable fuels must all be part of a long-term strategy.
- Fourth, the most important issue is that of equity. Global warming affects us all. Rich nations possess the resources and the knowledge to adapt, and people living in developing countries are much more vulnerable. Moreover, none of the Millennium Development Goals (MDGs) will be achieved unless the pace of their implementation is accelerated.[19]

The Stern Report,[20] the three volumes of the Fourth Assessment Report recently released by the influential Intergovernmental Panel on Climate Change (IPCC)[21] and Al Gore's celebrated documentary *An Inconvenient Truth* have put climate change at the top of the international agenda. This culminated in the award of the 2007 Nobel Peace Prize.[22] A wide consensus is emerging on the need to cut GHGs by half by 2050 in order to prevent catastrophic and, to some extent, irreversible consequences of global warming.[23]

To move in that direction, the following elements of a road map were suggested in a recent United Nations Foundation publication:[24]

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[18] Ban Ki Moon, Hear the first victims of climate change, *International Herald Tribune*, 5 June 2007.
See on this last point R Conniff, Third World to bear brunt of global warming", *Environment: Yale*, Spring 2007. The poorest nations on earth will bear the brunt of the costs. And the wealthiest nations, which are the main source of the problem, will in some cases actually benefit.

[19] See the United Nations *Report on Millennium Development Goals*, New York 2007 (quoted by PNUD Brasil, *Noticias*, 2 July 2007).

[20] N Stern, *The Economics of Climate Change: The Stern Review*. Cambridge University Press, Cambridge, 2006.

[21] Climate Change 2007, *IPCC Fourth Assessment Report*, 3 vols, Cambridge University Press, Cambridge.

[22] The 2007 Nobel Peace Prize was awarded to the Intergovernmental Panel on Climate Change (IPCC) and Albert Arnold (Al) Gore Jr. "for their efforts to build up and disseminate greater knowledge about man-made climate change, and to lay the foundations for the measures that are needed to counteract such change".

[23] This is independent of the controversy about the role played by anthropogenic action in global warming, which divides the scientific community. Whatever its causes, mitigation of climate change calls for a drastic reduction of the emission of GHGs, and therefore the gradual phasing out of the consumption of oil and other fossil fuels, side by side with measures aimed at capturing CO2 emitted by plants producing power from fossil fuels. A demonstration unit at Värtan coal-fired power plant in Stockholm is said to capture 95 per cent of the CO2 emitted.

[24] United Nations Foundation, Sigma XI, *Confronting Climate Change: Avoiding the Unmanageable and Managing the Unavoidable*, Washington, DC, 2007. Report of the scientific expert group prepared for the 15th session of the United Nations Commission on Sustainable Development. See also The future in our hands: addressing the leadership challenge of climate change, United Nations, New York, 24 September 2007; Chair's Summary, available at http://www.un.org/climatechange/2007highlevel/summary.shtml, 5 November 2007.

1. Accelerate implementation of win-win solutions: improving efficiency in the transport sector; improving the design and efficiency of commercial and residential buildings;[25] expanding the use of biofuels; promoting reforestation, afforestation and improved land use practices; and designing and deploying only coal-fired power plants that will be capable of cost-effective and environmentally sound retrofits for capture and sequestration of their carbon emissions.

2. Implement a new global policy framework for mitigation, including mechanisms that establish a price for carbon, such as taxes or "cap-and-trade" systems, and a mechanism to finance incremental costs of more efficient and lower-emitting energy technologies in low-income countries.[26]

3. Develop strategies to adapt to ongoing and future climate changes. Create and rebuild cities to be climate-resilient and GHG-friendly.[27]

4. Increase investments and cooperation in energy technology innovation: advocating the tripling or quadrupling of global investments in energy technology research; promoting a comparable increase in resources for demonstration and accelerated commercial deployment of energy technologies with substantial mitigation benefits; using United Nations institutions to promote public–private partnerships; and drawing upon limited public resources to provide loan guarantees and interest rate buy-downs.

Reaching those targets will require drastic changes in the use of energy. The present pattern of the world economy is predicated on a profligate use of abundant and, up until the recent past, inexpensive yet highly polluting fossil fuels – oil, gas and coal. That pattern is clearly incompatible with the goals of sustainable development.[28] There is thus a need to moderate the demand profile for energy by changing lifestyles, consumption patterns and, above all, modes of transportation,[29] as well as the design of future cities.

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[25] José Goldenberg rightly insists on the wide array of mandatory and fiscal incentives that could be easily introduced to promote greater efficiency of the existing energy systems and newly produced equipment. In California, energy consumption per capita is only half of the national average and has not increased since 1980, thanks to an active policy of energy conservation (J Goldenberg, Energia: outra morte anunciada, *O Estado de São Paulo*, 17 September 2007).

[26] On 28 August 2007, the Secretary-General of UNCTAD announced that UNCTAD had started its own Carbon-Neutral Initiative with a view to developing a carbon mitigation strategy, to be announced at UNCTAD XII .

[27] Work on eco-cities is progressing in several countries. In China, a carbon-neutral eco-city, Dongtan, is being built to house 500,000 people. The first phase of Dongtan is scheduled for completion by 2010. The United Kingdom is one of several countries supporting carbon-neutral urban projects. Five eco-towns, each with 10,000 to 20,000 houses, are to be created. In the desert of Abu Dhabi, British architects are designing a six-million-square-metre walled complex – the world's first zero-carbon, zero-waste city. The centrepiece of the design is a new university that will offer programmes in sustainable design (K Brass, Breaking ground on eco-cities, *International Herald Tribune*, 29 June 2007.)

[28] See on this point B Laponche, "L'énergie dans le monde : enjeux et prospective", in: P Jacquet and L Tubiana, eds., *Regards sur la terre 2007*, Les Presses Sciences Po, Paris, pp. 71–83. Laponche rightly observes that the most serious energy crisis is that of firewood. Two billion people worldwide depend on traditional fuels such as wood and charcoal used for cooking and heating, with serious negative implications for the environment and health. Traditional biomass accounts for an astonishing 82 per cent of energy use in Africa. A total of 1.6 million deaths per year are attributed by the World Health Organization to indoor air pollution. (IEA, *World Energy Outlook*, 2006.)

[29] The data referring to distance covered by a passenger in France with one kilo of petrol equivalent are quite eloquent:

Simultaneously, efforts must be made to improve efficiency in the production and final use of energy. The challenge is to double the global output of the world economy while reducing by half the material inputs, along the lines proposed in *Factor Four*.[30] Additionally, efforts should be focused on the replacement of fossil fuels by the full spectrum of renewable and clean energies,[31] side by side with efforts to evolve technologies for clean burning of coal[32] and sequestration of GHGs. Special attention should be given to co-generation of bio-electricity by sugarcane-ethanol-producing plants. One third of the energy from the sugarcane available in its straws and tops is at present lost because of manual harvesting, which requires burning of the cane in the field.[33] According to a report prepared by Greenpeace and the European Council for Renewable Energy, generation of electrical energy from renewable sources has significant potential and could provide substantial savings, as compared with a scenario based on fossil and nuclear energy.[34]

Resorting to bioproducts other than biofuels may also result in indirect fossil energy replacement. Green fertilizers, bamboo and timber building materials, natural fibres, plastics and other products of green chemistry are less fossil-energy-intensive than cement, metals and petrochemicals. More generally, we ought to explore the whole potential of a modern, knowledge-intensive, biomass-based civilization running on solar energy captured by photosynthesis.[35]

3. Biofuels are not a panacea

Producing biofuels is thus only a part of a comprehensive energy strategy. The addition of ethanol to gasoline and of biodiesel to diesel can reduce the consumption of oil-

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- **Urban**: tramway, 193 kilometers; metro, 65 to 140 kilometres; bus, 36 to 47 kilometres; car, 18 kilometres.
- **Intra-urban**: TGV, 172 kilometres; normal train, 107 kilometres; bus, 91 kilometres; car, 39 kilometres; plane, 18 kilometres (B Dessus, Changer de paradigme, *Technology Review* (édition française), no. 2, June/July 2007).

[30] E von Weizsacker, AB Lovins and LL Hunter, *Factor Four: Doubling Wealth, Halving Resource Use: The New Report to the Club of Rome.* Earthscan Publications, London, 1997. See also P Hawken, AB Lovins and LH Lovins, *Natural Capitalism: The Next Industrial Revolution.* Earthscan Publications, 1999.

[31] Nuclear energy belongs to the latter category; however, resorting to it is a matter of controversy that will not be taken up in this report. Advocates of nuclear energy claim that it is safe and that problems of disposal of nuclear waste can be handled properly. Its critics point to the conjunction of an extremely low probability of nuclear accident with the likelihood of devastating consequences, to the dangers of proliferation of nuclear energy for military purposes and to the yet unsolved problems of nuclear waste disposal.

[32] See MIT, *The Future of Coal: Options for a Carbon-constrained World – An Interdisciplinary Study*, directed by J Katzer, Cambridge, Mass., 2007.

[33] In Brazil, about 2,000 MW are generated at present, with the potential to reach 20,000 MW in 2020, about 20 per cent of the country's needs, the equivalent of two Itaipu hydro-electrical plants, at a cost much lower than that of nuclear energy (MS Jank, Bioletricidade eficiente e sustentavel, *O Estado de São Paulo*, 20 June 2007; Metas do açucar, etanol e bioeletricidade, *O Estado de São Paulo*, 4 July 2007). About 40 out of about 900 CDM-registered projects are related to energy derived from bagasse. Those projects are largely concentrated in Brazil, China and India. However, there is not a single ethanol project registered under the CDM. Source: http://cdm.unfccc.int/Projects/projsearch.html, last visited on 5 November 2007.

[34] The report *Future Investments: A Sustainable Plan in the Electrical Sector to Save Climate* was released on 6 July 2007. It calls for an annual investment of $22 billion in renewable energy, pointing out that coal and natural gas receive at present $250 billion in subsidies (press release from Greenpeace dated 6 July 2007).

[35] See I Sachs, Da civilização do petroleo a uma nova civilização verde, *Estudos Avançados*, 19 (55), 2005 pp. 197-214.

based liquid fuels in the near term, and assist in the reduction of exclusive dependence on oil-based liquid fuels at a later date. However, biofuels should not be viewed as a panacea.

For more than a hundred years we have been living in an oil age. However, according to many geologists, production of oil will soon reach its peak, and will decline thereafter. The newly discovered reserves of oil do not match the current demand prospects, and there is consequently a trend towards depletion and higher prices. High prices and projected shortages make biofuels increasingly competitive.

How to organize an orderly transition from the oil age to the post-oil age, and how to cope with the volatile and often explosive geopolitics of oil, will certainly dominate the international scene throughout the 21st century.[36]

The United Nations Energy Task Force recently released a comprehensive report entitled *Sustainable Bioenergy: A Framework for Decision Makers*,[37] which raises a number of important questions that need to be addressed, namely:

- Will biofuels push out food crops, raise food prices and threaten food security?
- Will biofuels create unexpected negative rather than positive external environmental effects?
- Could biofuels even exacerbate the impact on the climate when the entire production chain is taken into account?
- How will increased investment in biofuels affect trade patterns?
- What would be a sustainable approach to bioenergy?

Another set of questions was raised by the distinguished Brazilian environmentalist Washington Novaes:[38]

- Will the ethanol boom have an inflationary impact?
- Will Europe impose the certification of Brazilian ethanol to avoid the expansion of sugarcane plantations in ecologically fragile regions such as Amazonia and Pantanal?
- Will the increase in land prices due to the sugarcane boom drive food production and cattle breeding from São Paulo to the Amazon region?
- What ought to be done to change the unhealthy and unjust working conditions of sugarcane cutters?

The following is an attempt to answer some of the questions raised above in the context of assessing the prospects for liquid biofuels, as well as in discussion of the range of policies[39] capable of ensuring that the increased output of those fuels will not clash with the

[36] See on this point JL Wingert, *La vie après le pétrole, de la pénurie aux énergies renouvelables.* Paris, Autrement 2005; H Prévot, *Trop de pétrole, énergie fossile et réchauffement climatique.* Paris, Editions du Seuil, 2007; and I Sachs, A revolução energética do século XXI. *Estudos Avançados,* 1997, 21 (59), pp.21–38.

[37] United Nations, UN Energy, *Sustainable Bioenergy: A Framework for Decision Makers.* New York, 2007. See also among the many recent reports G Rothkopf, *A Blueprint for Green Energy in the Americas,* Interamerican Development Bank, Washington, DC, 2007; and P Hazell and RK Pachauri, eds. *Bioenergy and Agriculture Promises and Challenges*, 2020 Focus No. 14, IFPRI/TERI, Washington, DC/New Delhi, 2006.

[38] W Novaes, O debate crucial dos proximos anos, *O Estado de São Paulo,* 11 May 2007.

[39] Such as economic-ecological zoning, mandatory "cap-and-trade" regulatory systems, carbon taxes, price floor on oil, fiscal incentives, tax rebates and proactive steps to spur the biofuels industry. See D Hayes, R Ballentine and G Mazurek, Harvesting fuel, *Blueprint Magazine,* 23 April 2007. Many authors recommend carbon tax as a

paramount goal of food security, or cause tropical native forests to be felled. It should be pointed out that food security can be jeopardized by diverting prime croplands from the production of food or by linking the prices of goods such as sugar, palm oil or corn to oil prices. An increase in oil prices could result in poor people being deprived of access to staple foods.[40] It is important to note that people most often starve not because of a shortage of food but because of a lack of purchasing power to buy it.

Garten Rothkopf suggests that the expansion of biofuels production should rest on four pillars:

(a) Innovation;
(b) Capacity expansion;
(c) Infrastructure;
(d) Building of a global market.[41]

It is suggested that a fifth pillar is equally relevant: biofuels production should be predicated on institutional settings and production models capable of generating a new cycle of rural development, aimed at creating an appreciable amount of opportunities for decent work. These would include the production and processing of biomass for fuel, productive uses of by-products and waste, technical services and transport. The innovations required should be knowledge- and labour-intensive, but land-, water- and capital-saving.

central tool (see e.g. N Hulot, *Pour un pacte écologique*, Paris, Calmann-Lévy, 2006), to be offset by a reduction of taxes and charges on labour, so as to be neutral from the fiscal viewpoint and at the same time employment-creating (JC Hourcade and F Ghersi, La taxe carbone: une bonne idée à ne pas gâcher", *Dossier pour la Science*, January–March 2007). The controversial question is how high it should be to become effective. According to Patrick Criqui, to change behaviour, prices of fuels should double between now and 2050 (quoted by *L'Expansion*, no. 721, July/August 2007, Taxe carbone: panacée ou usine à gaz?).

[40] See on this point the already-mentioned joint OECD–FAO report, which was criticized by Brazilian commentators on the ground that it did not fully acknowledge the impact of rising oil prices.

[41] Rothkopf, op. cit.

4. Biofuels against food?

The well-known American environmentalist Lester Brown sees a dramatic conflict looming between 800 million car owners (they will soon number more than 1 billion) and the 2 billion hungry people competing for scarce agricultural land.[42] However, the warnings coming from neo-Malthusians are premature, to say the least.

A recent FAO report on food security concluded that there is enough land to accommodate additional food crops and biomass production to be transformed into biofuels.[43] A similar conclusion was reached by a report prepared by the European Environmental Agency.[44] José Graziano da Silva, FAO's representative for Latin America, has commented that the real problem is not arithmetic but social. In most cases, as already mentioned, people are not hungry because of the scarcity of food, but because they lack the purchasing power to buy food. There are at least five ways to reduce the competition for scarce agricultural land between biofuels and food crops:

- Concentrating the production of biomass for biofuels on waste and deforested land, with prime agricultural land being left for food crops;[45]
- Promoting integrated food-energy systems (integration of biofuels production with dairy cattle, crop association and crop rotation, agro-forestry systems) which result in higher global yields per hectare and release pastures for crop production;[46]
- Shifting, as quickly as possible, to second-generation cellulosic biofuels, produced from non-edible parts of food crops, forest residues, wild grasses, tree crops, animal fat and all types of green residues;

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[42] LR Brown, Ethanol could leave the world hungry", *Fortune*, 16 August 2006. See also M Mennig, Haro sur les biocarburants ?, *Défis Sud*, no. 78, July–August 2007.

[43] The FAO Committee on World Food Security proceeded to an assessment of the world food security situation at a meeting held in May 2007. The resulting document concluded prudently that "bioenergy offers both opportunities and risks for food security. The impacts will vary over space and time depending on the evolution of market forces and technological developments, both of which will be influenced by policy choices at national and international levels. It is necessary to develop an analytical framework that takes into consideration the diversity of situations and specific needs of countries." See also the thought-provoking Duisenberg Lecture (Singapore, 17 September 2006) entitled "Biomass for food or fuel: is there a dilemma?, delivered by Professor Louise O. Fresco (published by Rabobank, Amsterdam).

[44] European Environment Agency, *How much Bioenergy can Europe Produce without Harming the Environment?*, Brussels, 2007. The study concluded that "significant amounts of biomass can technically be available to support ambitious renewable energy targets, even if strict environmental constraints are applied" (p. 6).

[45] The Indian agro-energy programme is essentially based on growing jatropha on wasteland. According to *Fortune* (Bright prospects for a poisonous plant", 17 September 2007), about 100,000 hectares of jatropha are under cultivation in India. Africa is also betting on the same source of biodiesel. In June, BP signed a $160 million deal with the British biodiesel producer D1 Oils. The new company aims at becoming the world's largest producer of jatropha oil by 2011. It expects to have nearly 1.2 million hectares under cultivation within four years and to process 2 million tons annually – 18 per cent of Europe's expected biodiesel demand. According to UNDP's 2007 Annual Report, China has launched the so-called Green Poverty Reduction project, which provides poor farmers with technologies to produce jatropha curcas trees. In 2010, the project is expected to reach 200,000 farmers and be scaled up to nearly 1.2 million hectares.

[46] See box 1. In 1983, the United Nations University launched the Food–Energy Nexus Programme addressing such issues as more efficient use of energy in the production, processing and consumption of food, food-energy systems in diverse ecosystems, household economy in rural and urban settings, and the role of women and children in the provision of food, fuel and water. See I Sachs and D Silk, *Food and Energy Strategies for Sustainable Development*, United Nations University Press, Tokyo 1990, and also the work carried out on the subject by EMBRAPA Florestas (Colombo, Paraná).

- Promoting further increases in yields per hectare of both food and biofuel crops; resorting to agro-ecological practices predicated on the concept of "evergreen revolution";[47] and seeking knowledge and labour-intensive, yet land-, water- and capital-saving production functions accessible to small farmers, and characterized by low-fossil-energy inputs;
- Supporting research aimed at identifying new oil-producing plants (with special reference to different very promising kinds of palm trees); improving the productivity of the biofuel crops already in use; and expanding the spectrum of biofuels.

Box 1

Two models of integrated food energy systems

Considerable savings of land for the production of biofuels can be achieved by integrating the production of sugarcane for ethanol and vegetable oils for biodiesel with confined or semi-confined cattle breeding through use of the tops of sugarcane and the residues of oil extraction as feed.

Adecoagro, an enterprise located in Santa Fé, Argentina, which owns 240,000 hectares of land in Argentina, Brazil and Uruguay, proposes to extract 210 million litres of ethanol a year from 500,000 tons of corn and produce feed for 45,000 confined cows, in order to export 50,000 tons of milk powder and cheese. One million tons of cow dung processed in biodigesters is projected to produce 37 million cubic metres of biogas, which is more than enough to meet all the electrical energy needs of the operation, and biofertilizers, which will be put on the market. Adecoagro also expects to benefit from carbon credits. (*Agência Dinheiro Vivo*, São Paulo, 19 April 2007).

This example of an integrated food energy system is open to two criticisms. First, it will operate with corn, which has an unfavourable energy in/energy out ratio. Second, it has been designed as a large-scale capitalistic enterprise.

By contrast, Petrobras, the Brazilian State-owned oil enterprise, which is increasingly becoming an energy enterprise, is carrying out an experimental project in the State of Rio Grande do Sul, Brazil, working with a peasant cooperative and testing micro-distilleries of sugarcane ethanol (which has a very favourable energy in/energy out ratio). Each farmer will grow 2 hectares of sugarcane and engage in other agricultural activities. The sugarcane tops will be fed to milk cows.

If successful, the second model could be quickly reproduced in many rural areas of Brazil and other developing countries (*O Valor*, 18 June 2007).

Serious complications may result from linking the price of certain foods used as raw material in biofuels to the volatile price of oil. In recent months, the price of maize has almost doubled on account of the United States' plan to expand the production of maize-based ethanol. The price of tortilla, the staple food of Mexicans, followed suit, with severe social consequences. In the same way, increases in the price of palm oil may affect the consumption patterns of poor people in many developing countries, since that vegetable oil is part of their daily diet.

[47] This term was coined by the leading Indian agronomist M. S. Swaminathan. French agronomists use the term "doubly green revolution" to signify that both yields per hectare and respect for environment must go hand in hand.

Linking food prices to biofuel prices driven up by the oil price poses a serious problem, with far-reaching social consequences. There are no easy solutions in sight, at least not without resorting to such instruments as price controls, production quotas and taxation of windfall profits, which are currently seldom used. Of course, the problem does not arise for non-edible crops dedicated to fuel production and to the so-called second-generation biofuels in so far as they will be produced from agricultural and forest waste.

Therefore, there is a need to carefully plan and organize food and biofuel production, taking into account the linkages between the two. **Food security and energy security must be looked at simultaneously within the framework of regional and local development strategies.** To move in that direction, the following policies are appropriate:

- Carrying out detailed economic-ecological zoning to determine which crops are more suitable for each micro-region; using, whenever possible, degraded and already deforested areas for biofuel production;
- Institutionalizing a procedure to evaluate and license new biofuels projects not merely on the basis of least-cost assessment, but also taking into account criteria such as energy efficiency, environmental impacts (yield per hectare, water demand, emissions of greenhouse gases, protection of native flora and fauna) and social impacts (direct and indirect employment per hectare, incomes per head, human development index and food security);
- Instituting mandatory social and environmental certification of biofuels, applicable to products sold on the domestic and international markets, so as to ensure that they conform to a set of clearly specified norms;[48]
- Helping farmers involved in biofuels production to secure access to carbon credits;[49]
- Providing technical assistance, training, credit and fiscal incentives to small farmers willing to diversify their operations, so as to include them in integrated food-energy systems; promoting all forms of collective entrepreneurship and, above all, farmers' cooperatives; encouraging, whenever possible, the installation of local processing facilities; and assisting the local population in

[48] European countries wish to protect themselves against importing "dirty ethanol", as *El Mundo* (6 July 2007) put it in an article commenting on the biofuels conference held in Brussels in the presence of President Lula. On the same occasion, *La Repubblica* mentioned the existence of forced labour in sugarcane plantations in Pará (Brazil). At a public consultation organized by the European Commission, it was suggested that no tax incentives be applied to biofuels if their production involves the emission of more GHGs than would eventually be saved. Wetlands and peatlands which are situated on high stocks of carbon would be excluded from support. This stand reflects the negative environmental consequences of palm oil grown on peatlands in Indonesia, home to endangered species such as the Sumatran tiger, the Orangutan, the Sumatran rhinoceros and the Malaysian sunbear. (D Cronin, EU finds green reasons against biofuels", *IPS*, 2 July 2007). The European Trade Commissioner, Peter Mandelson, while recognizing that ambitious goals for biofuel use should not be an excuse to subsidize domestic farmers, stated that "Europeans won't pay a premium for biofuels if the ethanol in their car is produced unsustainably by systematically burning fields after harvests. Or if it comes at the expense of rainforests" (quoted in the *Financial Times*, 5 July 2007).

[49] The present procedure, based on the Clean Development Mechanism, entails considerable costs related to a CDM project's formulation, with a legion of consultants profiting most. Small farmers are at lost. According to J Kanter, carbon offsets require standardization and transparency. Other may have been sold several times, and this may give the market a reputation for shoddy practices. The effectiveness of certain offset projects has been challenged. Important banks advocate stricter credit standards and greater transparency. (Banks seek CO_2 credit standards, *International Herald Tribune*, 29 June 2007). In another article the same author discusses the rapid emergence of carbon finance in London, raising the question whether carbon will become the world's biggest commodity market or even the world's largest market overall (London financiers pull gold from green, *International Herald Tribune*, 21 June 2007).

replacing traditional biomass fuels with environmentally sound, locally produced biofuels;[50]

- Disseminating agro-ecological practices for food and biofuels production; combining fair yields per hectare with low-fossil-energy inputs;
- Identifying new sources of biomass for biofuels, with special reference to perennials producing non-edible oil-seeds and quick-growing species of trees;
- Choosing the set of policy instruments best suited to carrying out the tasks outlined above at the national, regional, state and local levels, namely taxes (first of all a carbon tax), mandatory measures, and fiscal and credit incentives.

This is a challenging agenda. However, if the measures outlined above are undertaken, greatly expanded biofuels production need not clash with the food production targets that need to be met if food security is to be ensured in the decades ahead. As previously mentioned, the most immediate problem is the detrimental linkage of food prices to oil prices.

[50] A note of caution is in order here. Localism is not always the most environmentally sound solution if more emissions are generated at other stages of the product life cycle than during transport. Scientists working on the subject reached surprising conclusions. Lamb raised in New Zealand and shipped 11,000 miles to the United Kingdom produced 1,520 pounds of CO2 emissions per ton, while British lamb produced 6,280 pounds of CO2 per ton because poorer British pastures force farmers to use feed. (JE McWilliams, Homegrown isn't always best", *International Herald Tribune*, 7 August 2007). Along the same lines, Nobel Prize winner Paul Crutzen claims that biofuels can contribute by up to twice as much as fossil fuels to the greenhouse effect because the emissions of N2O have so far been greatly underestimated. Other scientists contest those findings (S Foucart, L'essor des agrocarburants pourrait aggraver le réchauffement climatique, *Le Monde*, 25 September 2007). As Louise O. Fresco (op. cit.) says, as is often the case, the devil is in the detail.

5. Innovations to reduce the conflict between biofuels and food

In assessing the potential conflict between biofuels and food in their competition for limited cropland, due allowance must be made for technological progress.

On the energy-demand side, much can be expected from the coming of age of a new generation of ultra-light vehicles in which steel and metals are replaced by composite materials such as carbon fibres. Carbon fibre weighs one fifth as much as steel. It is also highly shock-absorbent and therefore very safe. Intelligent construction can reduce a vehicle's weight by 60 per cent, with a consequent fuel consumption reduction of at least 30 per cent[51]. However, the "retooling period" for moving from the present to the future generation of motor cars is fairly long – 10 to 15 years or more. Hybrid electric vehicles (particularly Toyota's Hybrid Synergy Drive), plug-in hybrid electric vehicles[52] and flex fuel cars are part of the search for fuel-efficient and less polluting vehicles.[53]

Research is less advanced as far as aircraft are concerned, but Boeing is sponsoring studies of "green kerosene", and new models such as the 787 Dreamliner are designed with a view to reducing fuel consumption.[54]

Moreover, replacing road transport by railways, and individual motor car transport by collective urban and inter-urban transport and bicycling, has to be actively pursued as a means of reducing energy consumption.

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[51] *UBS Research Focus*, January 2007, p. 51. Amory Lovins has an even more optimistic estimate of the energy savings by the new generation of vehicles. It is claimed that a futuristic prototype of a car, designed by a German engineer and weighing 450 kg, can travel 100 kilometres using just 1.5 litres of fuel (*Time*, 17 July 2006).

[52] See J Romm and P Fox-Penner, Electric wheels, *Blueprint Magazine*, 23 April 2007.

[53] In Brazil, the success of flex fuel cars is the main reason for the growing demand for ethanol. By the end of 2007, there will be 4 million flexfuel cars out of a total of 20 million cars. That number is expected is to rise to 12 million by 2012 (T Romero, Álcool em abundância, Agência FAPESP, 10 October 2007).

[54] Boeing and NASA are sponsoring research on biokerosene derived from babaçu nuts, carried out by Professor Expedito Parente from Fortaleza, Brazil, a distinguished scientist who runs a successful biodiesel firm called Tecbio. Parente used biokerosene in a plane in 1984, but no attention was paid to his discovery until 2005, when he received the Blue Sky Award at a United Nations conference (K Fernandes, Boeing põe em teste bioquerosene de inventor brasileiro, *Folha de São Paulo*, 10 February 2007). According to G Bisignani, Director General of IATA (Aviation and global warming, *International Herald Tribune*, 21 September 2007), aviation today is responsible only for 2 per cent of global CO_2 emissions, with a total climate change impact of 3 per cent. Projections for 2050 speak of 3 per cent of global CO_2 emissions, with a total climate change impact of 5 to 6 per cent. With 28 per cent of costs coming directly from fuel, the airline industry has a strong incentive to keep fuel consumption low. Airlines are investing heavily in more fuel-efficient aircraft. In the last 40 years, fuel efficiency increased by 70 per cent and will improve by another 25 per cent by 2020. Biofuels are relevant here. According to Bill Glower, a director at Boeing Commercial Airplanes, research is being conducted on different blends of biofuels with conventional fuels. A 50 per cent blend would reduce the carbon footprint by 20 to 25 per cent (US Department of Energy, Energy Efficiency and Renewable Energy Biomass Program, 14 June 2007).

Even greater energy savings can be achieved through intelligent building construction, but here the "retooling period" will be longer than in transport, as retrofitting of the existing housing stock poses many problems and may be quite expensive.[55]

According to Amory Lovins, if the most efficient existing technologies could be disseminated in the United States, they could potentially halve the amount of oil burnt per dollar of GNP, at an average cost of $12 per barrel of saved oil.[56] Replacement of the remaining half by more efficient use of gas and large-scale production of second-generation biofuels would cost $18 per barrel saved, much less than the present cost of oil.

This brings us to the second-generation biofuels, such as cellulosic ethanol, that can be processed from lignocellulose using the inedible parts of food crops, wild grasses, forest residues and trees.

Different industrial processes are being explored: enzymatic hydrolysis, thermochemical fuels obtained via gasification (Fisher-Tropsch liquids, methanol, MTBE, gasoline, dimethyl ether, mixed alcohols, hydrogen), hydrothermal upgrading oils and pyrolysis oils.[57] The first industrial plants are being set up, and it is hoped that within a few years some cellulosic biofuels will be brought to the market cost-effectively, with a significant reduction, if not complete elimination, of the competition between those biofuels and food crops for land.[58]

"Treethanol" has a particular appeal in countries that have a large number of trees and import a large amount of fossil fuel, such as New Zealand and Sweden,[59] and also in tropical countries such as Brazil, where there are several hundred thousand square kilometres of deforested areas to be reforested and suitable climatic conditions for planting fast-growing species such as eucalyptus.

Research on oil-producing crops and perennials, including several varieties of palm trees in addition to the oil palm, is being actively pursued. A recent biotrade project of the Brazilian Ministry of Environment identified 775 species of native plants with economic potential. Brazilian researchers report that such palms as inajà (*Maximiliana maripa*), pupunha (*Guilielma speciosa*) and babaçu (*Orbignya martiana*) have significant potential as sources of biodiesel.

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[55] EcoManor, the first certifiably green mansion built recently in Atlanta, used the following innovations: solar tubes redirecting natural light throughout the house, hidden photovoltaic panels on the roof to convert sunlight to power, high efficiency insulation underlying the roof, a geothermal system using the ground temperature to heat and cool the house, rainwater and "grey" water from sinks and showers recycled to irrigate the lawn, and drought-tolerant indigenous landscaping requiring less water and maintenance (*Fortune,* 19 March 2007). In France, for houses built before 1970 the average domestic consumption for heating, producing hot water and lighting is estimated at 500 kWh per square metre. Recent constructions consume between 170 and 250 kWh. Under a law adopted in 2005, newly built houses will be consuming from 50 to 70 kWh per square metre (I Rey-Lefebvre, Maisons la fin du grand gaspillage, *Le Monde,* 21 and 22 January 2007).

[56] A Lovins, Getting off oil, *The World in 2007,* Economist Publications, London, p. 115.

[57] See ED Larson, Biofuel production technologies: status, prospects, and implications for trade and development, UNCTAD Biofuels Workshop, 30 November 2006, Geneva (UNCTAD/DITC/TED/2007/10).

[58] The US Department of Energy is investing $385 million in six biorefineries over the next four years; they are expected to produce more than 130 million gallons of cellulosic ethanol a year (DOE Biomass Program, 28 February 2007).

[59] Woodstock revisited, *Economist Technology Quarterly,* 10 March 2007.

According to Professor Parente, biodiesel can be extracted from babaçu and other nuts in very small processing units. He therefore advocates the establishment of "energy-producing islands" in remote regions in order to produce biodiesel for local purposes. A recent project sponsored by Petrobras is testing micro distilleries of ethanol operated by cooperatives of small farmers, each growing 2 hectares of sugarcane.

Researchers are looking at improving the yields per hectare of sugarcane and the amount of ethanol extracted per ton of cane. At present, the average output of ethanol in São Paulo State is 85 to 90 tons per hectare, but the output of new varieties of *cana-energia* is likely to reach 200 tons per hectare.[60]

Work on fuels more efficient than ethanol is also under way. A joint venture between DuPont and BP resulted in the production of biobutanol, and there are great hopes for isoprenoids, which have the right characteristics to replace petrol and to make "biocrude".[61]

Note should also be taken of progress in research on food crops, whose productivity is likely to improve, with a consequent offsetting of the pressure on cropland due to population increase, and, hopefully, a less inequitable distribution of income leading to a higher consumption of food per capita. According to Philippe Collomb, in order to feed the population of our planet by 2050, agricultural production in Africa should be increased by 5.14, in Asia by 2.34 and in Latin America by 1.92.[62] Theoretically, a knowledgeable farmer who has excellent seeds, a favourable climate, sufficient water, fertilizers and pesticides can feed up to 30 persons throughout the year on one hectare with vegetables, fruits, cereals and vegetable fats. If the same area is used for the production of eggs, milk or meat, the number of persons fed varies from 5 to 10.[63] But we should not forget that genetics is still a very young science. The present controversies about genetically modified organisms show that there is an urgent need to redefine the objectives of genetic research, to establish the necessary safeguards and to thoroughly revise the agreements on intellectual property.

Mention should also be made of some futuristic lines of research, such as the production of biodiesel from marine micro-algae. A study carried out by the Massachusetts Institute of Technology points to a yield of 100,000 litres per hectare.[64] Furthermore, according to D. Despommier, from Columbia University, it would be possible to build vertical farms to grow vegetables using rooftop solar panels to power 24-hour grow lights and NASA-like technology to capture evaporating water for irrigation, as a result of which the amount of land required would be drastically reduced.[65]

Much can be expected from new ultra-thin solar panels, which are particularly tempting for Africa, since in one hour the earth receives more energy from the sun than

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[60] M Caetano, Á luz da biotecnologia", *Globo Rural,* April 2007, p. 64. FAPESP has just published a book entitled *Brasil líder mundial em conhecimento e tecnologia cana e etano: a contribuição da FAPES*, which describes all the research projects on sugarcane and ethanol supported by that foundation (Agência FAPESP, São Paulo, July 2007).

[61] Ethanol, schmethanol", *Economist*, 29 September 2007.

[62] The corresponding coefficients for North America, Oceania and Europe are 1.31; 1.61 and 0.91. Quoted from B Parmentier, *Nourrir l'humanité: – les grands problèmes de l'agriculture mondiale au XXIe siècle*, La Découverte, Paris, 2007, p. 29.

[63] Parmentier, op. cit., p. 38.

[64] *Globo Rural,* April 2007. Research is also proceeding on fertilizing oceans; cultivated algae by sprinkling micron-sized iron shavings could turn seawater into a greenhouse absorber (*Fortune*, 9 July 2007).

[65] A 21-storey vertical farm would cost $84 million and earn $18 million a year (*Fortune*, 24 September 2007).

human beings consume in a year.[66] The world's largest solar farm – in California's Mojave desert – where more than 400,000 mirrors cover 10.3 square kilometres, produces 354 megawatts of electricity, enough for 900,000 homes. America's south-western deserts are an abundant source of sunshine that could meet US power needs several times over. According to the US energy department, 7,000 megawatts will be available by 2020 from concentrating solar power plants.[67]

At the same time, research is being conducted on biofuel from power plant CO_2. At the heart of the technology is a plastic cylinder full of algae, which literally sucks the CO_2 out of a power plant's exhaust. The algae can in turn be converted into biofuel.[68]

Finally, French researchers in the Picardie and Champagne-Ardennes regions are working on a bio-refinery with zero waste, using the whole plant to produce bioenergies, biomaterials, biomolecules and food.[69]

[66] N Norbrook and G Mithembu-Salter, Termites and tilting at windmills", *Africa Report*, no. 7, July 2007.
[67] *Economist*, 15 September 2007.
[68] The project is being conducted by GreenFuel Technologies in Cambridge, Mass. (P McKenna, Biofuel made from power plant CO2, *New Scientist*, no. 2572, 7 October 2006). "GreenFuel claims that over the course of a year, a hectare of its reactors should be able to produce 30 thousand litres of oil, which could be used as biodiesel and enough carbohydrates to be fermented into 9 thousand litres of ethanol" (Old clean coal, *Economist Technology Quarterly*, 8 September 2007).
[69] *I.N.R.A. Magazine*, no. 1, June 2007 (dossier "puiser le carburant dans les plantes", coordinated by B Masson, p. VIII). A leading Brazilian petrochemical industry, Braskem, is building a plant to produce plastics from ethanol. Petrobras and Oxiteno, a subsidiary of the Ultra group, are also moving into alcochemistry. The city of Piracicaba is planning to open a technological park to attract foreign enterprises, such as Total and BP. L Morais, O plástico verde da Braskem, *Isto é dinheiro*, 27 June 2007. The ultimate dream is a multiproduct biorefinery making profitable use of all the byproducts. The challenge, however, is that the market for the fuels is like two orders of magnitude greater than for the chemicals that could be produced alongside the fuel (see H Rosner, Beyond biofuels: scientists seek profitable uses for the leftovers" *International Herald Tribune*, 8 August 2007).

6. Mitigation of global warming? Yes, but …

Over and above energy security, the main interest of biofuels as opposed to petroleum products lies in the reduction of CO_2 emissions, and consequently air pollution. While burning gasoline is a net CO_2 emission, burning bioethanol results in emitting CO_2 which was previously captured by the plants.[70]

It is intended that biofuels be carbon-neutral – that is, that they provide a zero-sum balance between the carbon release generated by the burning of the fuel and the carbon absorption provided by the growing of the plant that will be used for the production of fuel.

In practice, biofuels are not carbon-neutral, because energy is required in order to grow and process crops into fuel, and other adverse environmental effects have to be balanced for the purpose of achieving a positive effect. The amount of energy spent during biofuel production has a great impact on the overall greenhouse gas emissions savings achieved, and attention has to be given to avoiding an increase in nitrous oxide emissions.[71]

At first sight, replacement of petrol-based liquid fuels by ethanol and biodiesel may considerably reduce the emission of GHGs. However, it is the energy in/energy out ratios that determine the amount of reduction of GHGs. As previously mentioned, that ratio is highly positive in the case of sugarcane ethanol (1 to 8), quite satisfactory for palm oil (1 to 5), but disappointing for maize ethanol (1 to 1.4, or even less). On the other hand, the advantage mentioned above may be offset by predatory methods of land clearing used to grow sugarcane or oil-seed plants. Burning of native forests in Indonesia and then draining of wetlands to start plantations of palm-oil trees resulted in a major environmental disaster that released vast amounts of GHGs. However, such emissions resulted from the way in which the land was cleared and cannot be attributed to biofuels as such.

Needless to say, such land clearing methods should be proscribed; where that proscription is ignored, they should be severely punished by the Governments concerned. In that connection, effective monitoring of the territory is required, the more so since land in forest areas is much cheaper than in less remote regions. At the present time, pastures in the State of São Paulo are being turned into sugarcane plantations, while cattle migrate further north to Mato Grosso and other Amazon region States.[72]

In order to ascertain the actual amount of GHGs emissions prevented, it is necessary to take into account, among other things, changes in land use for growing feedstock, raw materials (feedstock) and production technologies used, the distance between the site where biofuels are produced and the places in which they will be consumed, and the mode of

[70] In reality, the net emission of CO_2 when bioethanol is being burnt is not nil, since the production of bioethanol requires energy, fertilizers, transformation, transport and so forth, which all emit CO_2. Nevertheless, in the case of sugarcane, for instance, the net emissions of CO_2 are over 80 per cent less than for emissions from fossil fuels. UNCTAD, Challenges and opportunities for developing countries in producing biofuels (UNCTAD/DITC/COM/2006/15).

[71] The carbon emissions produced by biofuels are calculated using a technique called Life Cycle Analysis, which uses various approaches to calculate the total amount of carbon dioxide and other greenhouse gases emitted during biofuel production, from the seed put in the ground to the fuel's final use.

[72] For the devastating effects of extensive cattle breeding in the Amazon region, see J Meirelles Filho, *O livro de ouro da Amazônia*, 5th edition, Ediouro, Rio de Janeiro, 2006, pp. 160–179.

transport used. In continental countries such as Brazil, the pros and cons of small-scale production for local purposes should be carefully examined.

Other environmental criteria, such as soil depletion,[73] water demand and protection of biodiversity, must also be taken into account.

At present, some 2 billion people depend on traditional forms of biomass energy, such as wood, dung, agricultural residues and charcoal for cooking and heating. Those products are at times acquired through devastation of native forests, not to mention widespread child labour practices and perilous labour. The smoke released in closed spaces from the burning of traditional biomass feedstocks has detrimental health effects.

Therefore, in addition to introducing modern biofuels, produced in environmentally and socially sustainable conditions, urgent measures are required in the realm of energy for domestic purposes, at production and end-use levels, particularly the following:

- Socio-environmental certification of charcoal from planted trees, agricultural residues and grasses;[74]
- Promotion of small-scale biodigesters producing biogas for domestic purposes from dung, human waste and other residues;
- Dissemination of improved stoves, side by side with the introduction of solar cookers to reduce the consumption of biomass energy.

[73] That is why part of agricultural waste must be returned to the soil.

[74] One possibility is to move to "green charcoal". Pro-Natura International, a Paris-based NGO member of IUCN, has developed and patented a prize-winning continuous process of pyrolysis of vegetable waste (agricultural residues, wild-grown biomass), which transforms it into green charcoal. That domestic fuel performs the same as charcoal made from wood, but at half the cost. Furthermore, it avoids the indoor air pollution that kills more than 1.6 million people each year. The process is being tested in several African countries.

7. A lever for inclusive and sustainable rural development?

Environmental considerations cannot be separated from social concerns that go beyond the question of food security. According to United Nations statistics, the world's population is at present equally divided between urban and rural areas. The majority of poor people still live in the countryside, and 2.5 billion people or more survive by means of primitive farming. Only 28 million own a tractor and 600 million use animal energy. Over 1 billion depend solely on human effort.[75] The labour productivity gap between advanced and highly mechanized agriculture and the most primitive farming methods still in use is 1 to 1,000 or more. In other words, a few million modern farms could easily wipe out 2 billion small farmers, condemning them to migrate to shanty towns. Already almost three out of four urban dwellers in sub-Saharan Africa live in terrible slums.[76]

Contrary to a strongly entrenched belief, it is no longer possible to reproduce, on a worldwide scale, the transition from rural agricultural to urban industrial society that occurred in industrialized countries in the 19th and 20th centuries.[77] There are at least three reasons for that. First, Europe was once able to send tens of millions of peasants to the Americas, whereas today China and India would need to find another destination for a few hundred million peasants. Second, tens of millions of Europeans were killed in the two world wars and in concentration camps and gulags; hopefully, this will never happen again. Third, in the past rural migrants would find jobs in labour-intensive, rapidly expanding industries, but this is no longer the case. Demographically speaking, we have entered a *deindustrialization age*: most industries grow today through increases in labour productivity. Thus, we cannot afford not to discuss a new cycle of rural development if we really want to find a solution to the acute lack of opportunities for "decent work" as defined by the International Labour Organization (ILO).[78]

[75] ATTAC, *Les OGM en guerre contre la société*, Mille et une nuits, Paris, 2005, p. 39.

[76] See M Davis, *The Planet of Slums*, Verso, London, 2006. Quite significantly, this important book was published in French under the title *Le pire des mondes possibles: de l'explosion urbaine au bidonville global* (La Découverte, Paris, 2006).

[77] The UNFPA report entitled *State of World Population 2007: Unleashing the Potential of Urban Growth* (New York 2007) offers a good example of the illusory faith in the virtues of urbanization as a powerful tool to overcome poverty (see box 2).

[78] The concept of decent work implies not only fair remuneration, but also reasonable work conditions and relations.

Box 2
Rural or urban bias?

In his influential book *Why Poor People Stay Poor: Urban Bias and World Development.* (Temple Smith, London and Harvard University Press, 1977) Michael Lipton showed that the bulk of investment in developing countries was going to industries and cities, to the detriment of the majority of population composed of small farmers and casual agricultural labourers, many of them living in abject poverty. The latest report by the United Nations Population Fund, entitled *State of World Population 2007: Unleashing the Potential of Urban Growth* (New York, 2007), took the opposite stance. Somewhat surprisingly, it accuses planners in developing countries of an anti-urban bias, urging them to abandon this ineffective and often counterproductive attitude on the ground that, historically, the statistical connection between urbanization and economic growth has been strong. The report considers further rapid urbanization to be both unavoidable and positive. It foresees a doubling of the urban population in Asia and Africa during the lifetime of one generation, from 2000 to 2030. Furthermore, it argues that past policies to retain people in rural areas have failed.

According to the authors, people intuitively perceive the advantages of urban life. However, those who migrate to urban areas are often rural and environmental refugees, deprived of access to land and expelled from the countryside. It is true that cities function as a kind of "lottery of life", with some winners and many losers. There are always people eager to try their luck and take a chance.

The term "urbanization" should be used in a more restrictive way, only in the context of people who already have a decent dwelling and a reasonable job, and who enjoy conditions enabling them to exercise real citizenship. This is not the case of the majority of slum dwellers, who account for almost 75 per cent of the "urban population" in sub-Saharan Africa. At best, those people are candidates for urbanization still to come. Their claiming the "right to the city" is certainly a commendable objective, but how realistic is it within the context of the emerging "planet of slums", to use Mike Davis' term (see footnote 76)?

Slowing down the flow of rural migrants to urban areas should not be abandoned on the ground that many past policies have failed. Nor can one take at face value the assertion that cities offer people the potential to improve their lives at lower cost than in rural areas, particularly when account is taken of the investment that is needed to create opportunities for decent work. Precarious and poorly paid activities in the informal sector in urban areas help people to survive, but should not be mistaken for development.

Development will depend on the kind of policies devised for rural areas. If the concentration of land in the hands of a small minority of large landowners, agro-businesses and investment funds continues concurrently with labour-displacing modernization of agricultural activities, small-scale farmers will be further marginalized and expelled to urban slums. Six to 7 per cent of the economically active population working in modern agriculture would easily feed the world population. However, another pattern of rural development is still possible if we consider farmers to be the keepers of the planet (water, air, biodiversity, landscapes), and not only food producers, offering decent work, food security, social inclusion and habitat for 1 billion of them. This is the conclusion of an important book by Bruno Parmentier (*Nourrir l'humanité: les grands problèmes de l'agriculture mondiale au XXIe siècle*, La Découverte, Paris, 2007). The unfinished agenda of land reforms must not be abandoned, and access to land by multinationals and agricultural investment funds interested in promoting labour-displacing agricultural techniques on a very large scale ought to be regulated. Biofuels and agro-energy as a whole may be used as levers for this socially and environmentally progressive model of rural development. At the same time, it should be borne in mind that agriculture is both culprit and victim where climate change is concerned. The livestock sector alone accounts for 18 per cent of global GHG emissions, and deforestation for 18 per cent of carbon dioxide emissions. Rice is perhaps the main source of anthropogenic methane, with some 50 to 100 million metric tons emitted per year (data quoted by A. Müller, Assistant Director General of FAO, at the workshop on "Adaptation Planning and Strategies", Rome, 10 September 2007).

The challenge is daunting, in view of the disparities in labour productivity mentioned above. Conditions must be put in place to accommodate a new cycle of rural development for a fair proportion of small-scale farmers, one that allows them to improve their labour

productivity, incomes and living standards, and at the same time frees them from the most painful forms of manual labour. This is certainly the case in Africa, as strongly emphasized by the former United Nations Secretary-General, Kofi Annan, who now presides over the Alliance for a Green Revolution in Africa.[79]

The emerging biofuels boom may act as a lever for rural development, insofar as it may create many opportunities for work in the production and processing of biomass for biofuels, as well as in related technical and transport services. As already mentioned, special attention should be given to integrated food and bioenergy production systems. Furthermore, modern rural development does not limit itself to purely agricultural activities. It also includes the production of environmental services. According to FAO, a growing proportion of rural family income derives from non-farm activities of the different members of farmers' families.[80]

However, progressing along those lines will depend on Governments' ability to channel biofuels production into appropriate social models, involving small-scale farmers. Such a result is by no means automatic. The expansion of biofuels production can be imagined in a completely different social context: for example, producing sugarcane on large estates dependent on casual rural labour[81] or the processing of biodiesel from soybeans grown in highly mechanized and very large estates that require very little labour – according to some estimates no more than one job per 200 hectares.

The experience of the Brazilian Pro-Alcool programme, launched in the 1970s, proved extremely successful in technical and economic terms, yet resulted in a socially disruptive concentration of land and income, not to mention proliferation of casual rural labour – the *boias frias*.

The Brazilian biodiesel programme addresses that issue through the use of a social label for biodiesel producers who buy the raw material from small farmers. Those producers are entitled to fiscal incentives, which are regionally differentiated. However, so far, the social label has not been extended to sugarcane for ethanol production.

Accordingly, there is an urgent need to identify and evaluate alternative social models for the production of biofuels, so as to integrate them into socially inclusive and environmentally sustainable development strategies.

The creation of small-farmer cooperatives for the production and processing of biomass into biofuels offers an interesting option, especially since fair trade circuits might be established between producer and user cooperatives.

Quite often, small-scale biomass producers supply large biofuels-producing enterprises on the basis of individual contracts. Those linkages should be screened with a view to ensuring fair conditions for the farmers. The establishment of long-term, transparent contracts that are subject to accountability rules is called for and may involve negotiation among all the stakeholders in the rural development processes.

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[79] See K Annan, Pour une révolution verte en Afrique, *Le Monde*, 11 July 2007.
[80] See FAO, *Rural Income Generating Activities: A Cross-Country Comparison*, Rome, 2007.
[81] Many sugarcane cutters in Brazil, the so-called *boias frias*, are recruited among inhabitants of urban *favelas*, having been expelled from the houses they once were allowed to occupy in the *fazendas*. As sugarcane cutting is being more and more mechanized, *boias frias* are in danger of losing even this temporary work.

The most difficult challenge is posed by large-scale agricultural estates integrated with biofuels-producing industries. Working conditions on those estates often do not meet ILO standards. Other environmental risks (loss of biodiversity) are associated with large-scale monocultural plantations. Policies ought to be designed to enforce the ILO labour standards, and to encourage association (and/or rotation) of energy and food crops. Workers employed by the estates should be provided with plots of land for housing and small-scale agro-ecological food-producing schemes for self-consumption and sale. The opening of ecological corridors, the restoration of native riparian vegetation and respect for natural reserves are also indispensable. Social and environmental certification may become an important policy instrument in that respect.

8. National development strategies and international cooperation

Energy security, food security and provision of opportunities for decent work through rural development are paramount and closely interlinked goals. In the age of globalization, national development strategies still have a crucial role to play, as envisioned by the United Nations Conference on Trade and Development (UNCTAD) on several occasions.

It is up to each country to evaluate its needs and potentialities with respect to the production and/or import of biofuels, within a strategy of gradual substitution and phasing out of oil and, possibly, other fossil fuels. Relevant questions for the formulation of national policies are the following:

- What should be the ideal sequencing of a pragmatic biofuels programme that takes full account of the economic, social, energy and sustainable development imperatives of developing countries?
- What should be the pace of import replacement in oil-importing countries?
- How and where should the growing of biomass for fuel be organized with the aim of benefiting small-scale farmers and promoting inclusive and sustainable rural development?
- What policies are required for helping small-scale farmers ensure development gains through greater access to land, technology, training, credit and markets?
- How should the production of biofuels be distributed between local-level, small-scale processing units and large-scale plants?
- Can the equipment required in biofuels production be produced domestically?
- What kind of research should be fostered in order to accelerate the pace of innovation?

Those are questions to which there are no obvious answers. Hence, it is important to investigate how other countries have answered them, by exchanging experiences without necessarily looking for ready-made models to be replicated. United Nations affiliated bodies – FAO, UNEP and UNCTAD – are at present engaged in organizing a forum for such exchanges.

The potential for South–South cooperation should be actively explored in connection with technical assistance, training, exchange of students, research, purchase of equipment and trade in biofuels.

Finally, steps must be taken to organize the emerging international markets for ethanol and biodiesel. The world economy is embarking on a long transition from the oil to the post-oil age, which is likely to last for many decades. Every effort should be made to ensure that that transition is as orderly as possible, with the cooperation of all the leading players, including oil producers, being sought.

On the basis of the above remarks, an agenda for **UNCTAD's BioFuels Initiative** may be suggested for the years 2008–2011, to be considered at UNCTAD XII in Accra, Ghana, in April 2008. The UNCTAD Biofuels Initiative should concentrate its activities on the following three activities:

(a) Organizing the international markets for biofuels by:

- Fostering dialogue among all stakeholders for an orderly transition from the oil age to a less carbon-intensive era;
- Developing guidelines for long-term contracts between producers and consumers of biofuels, with special reference to cooperatives acting on both sides (fair trade);
- Promoting non-discriminatory social and environmental certification at the international level;
- Simplifying the procedures for the emission of in accessing carbon credits linked with carbon reductions achieved with biofuels projects;

(b) Providing technical assistance to developing countries, particularly the LDCs, that wish to integrate agro-energy into their sustainable development strategies, and to use it as a lever for rural development and the improvement of income levels of small farmers;

(c) Fostering South–South cooperation in scientific, technical and commercial activities related to the production and marketing of biofuels, as well as the development of capital goods industries necessary for producing the equipment needed, with special reference to small-scale machinery for local production.