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# Biofuels between Euphoria and Scepticism: Brazil as a Pioneer?

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## 1. Introduction and history

The ever-rising oil price has opened a race for alternative ways either to defend the globally prevalent structures of mobility or to change them fundamentally. Both options claim biofuels as a win-win way out. Automobile clubs, oil companies and agrobusiness associations join forces and efforts in order to substitute fossil fuels with as little change as possible in distribution channels, settlement patterns and automobile technologies, whereas ecologists and concerned scientists propagate radical changes in lifestyle and see biofuels as one of the major instruments to bring about decentralized, local community ways of living within pathways of eco-development into a "modern biomass civilization" (Ignacy Sachs 2005), and to bring peace to a world threatened by violent conflict about oil.

However, both of these rather euphoric pro-biofuel interest groups and schools of thought encounter advocates of scepticism and even fierce enemies. You find automobile freaks who depreciate present day biofuels as totally inefficient and proclaiming the need for R&D efforts in the direction of hybrid motors, hydrogen solutions and – if at all – "second generation" biofuels in the future, side by side with ecologists who draw attention to the rise in food prices, the incursion of rain forests and swamp biotopes and the poor energy balance of ethanol and biodiesel made from grains and most vegetable oils. Thus you find strange bedfellows among the advocates as well as the critics of biofuel which makes it difficult to orient oneself – a challenge for one's own judgement.

Sometimes euphorics and sceptics form even more crisscrossing alliances, for instance, when agrobusiness farmers associations with commercial soybean interests as well as Green party politicians and ecologists prefer to say "agrofuels" instead of "bio-fuels" in order to avoid either *a priori* positive "organic" connotations for the consumer on the one hand side, or restrictions on the use of pesticides and conventional fertilizer for the producers, which go along with organic "bio"-food on the other. In the academic international discussion on climate change and energy, the term "biomass" including wood and algae, i.e. important non-agro raw materials, has assumed a very prominent place in the last

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few months. This word does not carry any "green" smack, and since this paper is directed toward an academic audience, the well established term "biofuel" is being used in the following.

Because of its long history of biofuel, which started on a larger scale as early as 1975 with the PROÁLCOOL programme based on sugarcane, Brazil's broad experience is unique in the world. A whole gamut of studies and a lively debates in the media, universities, ministries, non-governmental organisations (NGOs) and interest groups make this country a natural pioneer for sorting out the arguments, presenting empirical evidence and discussing future scenarios for biofuels. Brazil is more than a national biofuel champion and model, because its ethanol is clearly the most competitive on the world market, and its recently launched biodiesel programme is also partly directed toward export markets. That is why the international trade issues figure high on its biofuel agenda, and as an important player in the present Doha Round of the World Trade Organisation (WTO), Brazil is about to shape the emerging global biofuel regimes in a decisive way.

The "Programa Nacional do Álcool – PROÁLCOOL" of 1975 was the child of a coincidence between steeply rising oil prices after the war in the Middle East and an equally drastic fall in international sugar prices so that ethanol, made from sugarcane, was the logical solution for the influential sugar lobby with its century-old tradition in Brazilian politics, as well as for the automobile sector with its endeavours to instill the public with the wish to participate in the global automobile civilization, or more precisely, to keep up with it. The second oil crisis in 1979/80 coincided again with an important event, namely the invention of an automobile motor for "hydrous" alcohol, i.e. ethanol with an approximately 93 p.c. alcohol content and about 7 p.c. of water, by the research institute of the Brazilian Air Force. Whereas "anhydrous" ethanol, the one with a 99.7 p.c. alcohol content, can be mixed with gasoline up to 25 p.c. without major problems, a special engine was needed for "hydrous" ethanol. Of course, the special alcohol motor was an innovation which attracted immediate interest of the international carmakers. Thus the Brazilian government did not have major difficulties to get those firms, the sugar interests and the then still monopolist national oil company PETROBRAS around the table in order to coordinate supply, distribution and taxes on oil and ethanol, making sure that the buyers of alcohol cars would not be without fuel, once the oil price or the sugar price or the taxes or tax exemptions should change.

For a certain while, in the 1980's, nearly all the passenger cars were driven with hydrous alcohol, whereas in the 1990's, with the fall of the oil price, gasoline became prominent again on the domestic market, and Brazilian sugar exports filled the supply gap of the former Soviet Union countries substituting Cuba. Since 2003, the scene is dominated by the "flex-fuel" car which can com-

bine all degrees of mixture of hydrous or anhydrous ethanol with gasoline so that price has become the only parameter for the consumer. And starting from Brazil, flex-fuel cars have begun to be built and sold all over the world, with the effect that ethanol has become a commodity which is daily being traded at the Commodity Exchange under the heading of "energy" along with gasoline, gasoil and crude oil.

When PROÁLCOOL was introduced, Brazil was still largely dependent on imported oil so that energy security and import substitution were important political objectives. Since (2005 or) 2006, the exploitation of new oil and gas fields have made Brazil self-sufficient in oil, and new discoveries as well as the Venezuelan connexion with the planned *gasoduto* crossing the Amazon region, are about to turn the country into a major fossil energy player – and a net oil exporter.

Brazil's refineries are not yet up to the structure of internal supply and demand so that diesel oil has still to be imported in large quantities. Stimulated by the rising international oil price and the expectation of a booming biodiesel demand in the USA and Europe, the Lula government has launched its National Biodiesel Programme in 2004 whose implementation has been rather rapid so that the target of an addition of 2 p.c. biodiesel to the fossil fuel can be realized somewhat earlier than expected, namely already in 2008.

Ethanol production of about 17 bn liters per year absorbs 3.5 million hectares of land. Domestic consumption of ethanol amounted to 15 bn liters, substitution 10.4 bn liters of gasoline and therefore representing 36 % of the fuel used nationwide in otto motors, i.e. cars driven by gasoline and/or alcohol (not diesel oil). With a total of 851 million hectares of land, about 178 million covered by pastures, the total acreage of agricultural land comprises around 77 million hectares so that "only" about 4.5% of this is used for fuel. However, the present investment boom in ethanol factories and plantations envisages doubling or even tripling this area by as early as 2015. Little more than 7.2 million hectares would be enough to substitute gasoline totally in Brazil - only for the present car fleet. In any case, much of this capacity will be destined for exports. If the ethanol need of only Germany for covering its total need for otto engine biofuel would have to be covered by Brazil, another 26 bn liters, that is about 5.5 million hectares of Brazilian land would have to be used – taking again present consumption figures. If other EU importers, the US, Japan and China were to increase their purchases in a similar way and with similar volumes, the whole of Brazil would be covered with sugarcane plantations – only for private passenger cars and SUVs (special utility vehicles).

Biodiesel figures are no less dramatic: Soybean production for food and fodder covers already 20 million hectares of land in Brazil. Additional soybean

oil production for fuel would already cover 1.5 million hectares for a 2% addition to diesel oil in Brazil, as envisaged for 2008 or 2009, since the average yield of soybean oil is about 540 kg/ha. Total substitution of diesel oil would thus cover nearly the whole of Brazil's agricultural land, namely 75 million hectares, not even counting the energy input. Oil palms yield about four times that much, namely 2,700 kg/ha, but even those data and quantitative relations make massive, let alone total global substitution of fossil through biofuels simply impossible. And in view of the rivalry between food and fuel, let alone the protection of nature, that scenario would also be highly undesirable.

These rough calculations show very clearly that the present fossil fuel demand can never be met by biofuels and that ecologists and other sceptics are right when warning against the business-as-usual strategies of the oil companies and the automobile industry culminating in increasing additions of biofuel to fossil gasoline and diesel oil, without major other changes.

The bulk of the biofuel produced in Brazil is still used for transport purposes within the country. However, export interests are strong and enhanced, since import substitution is no longer a valid argument, in view of the strong and fast growing national petroleum and natural gas sector. The global outlook is thus becoming more and more important so that a close look at the economic costs and benefits of biofuels in world market terms is warranted.

## 2. Economic viability of ethanol

The input-output relations and linkages of biofuel in general are shown in figure 1: Local resources are used for foodstuff (including animal fodder) or fuel or industrial purposes (the latter being ignored in the following, since fundamentally, there the same arguments apply as for food); some important biofuel inputs consist of residual matter, be it from animal slaughtering, wood processing, sugar production or cooking; even soybean oil has been called a "residual", namely from the production of soymeal as animal fodder from soybeans. The end uses are the internal consumption markets and exports. Not only physical and biological inputs signify costs, but also the non-realization of alternative opportunities, those famous "opportunity costs" in economic jargon. On the other hand, the benefits of biofuels lie in the substitution of fossil fuels so that every hike in oil prices increases their profitability, - but since there are alternative energy sources for securing mobility, such as coal, electricity and energy saving, no direct and linear correlation should be assumed. The principle of "opportunity costs" applies also to the benefits.

Figure 1 does not show the monetary flows resulting from sales, subsidies, taxes and tax relieves which are not included in the graph. However, it is the

monetary sphere which determines the outcome, be it profits in the private sector or fiscal considerations on the side of the government authorities. Public or semi-public oil companies such as PETROBRAS and their oil extraction and production play a special role. They are normally the first ones to get hold of the oil rent, and their natural interest lies in fending of national and local parliaments and governments which try to get hold of the rent in form of taxes and royalties of various types. Since the oil companies are also in charge of refineries and important parts of the retail distribution system, it is only logical that they try to use the oil rent for the incorporation of biofuel into their realm of influence.

The linkages of figure 1 are substantiated in figure 2 showing the economic viability of ethanol in Brazil: Whenever high oil prices coincide with low sugar prices on the world markets, sugarcane is converted to ethanol, and when sugar prices are high and oil prices low, producers go for sugar. With low prices for both sugarcane products, other products become more profitable, as indicated by the box in the lower left corner of the graph. That was the situation during a good part of the 1990s, when often sugar prices were below 6.8 UScts/lb, because the European Union was dumping its excess sugar on the world market, and gasoline prices were below 50 US$/b (see the dot for 05/1997). In those years, the sugar industry in Brazil stagnated and had to be pampered by the state, whereas in other sugar producing countries like Cuba the whole industry collapsed, and oil prices were too low to warrant the production of ethanol as a fuel. Recent oil price hikes until 100 US$ per barrel and the reforms of the European sugar regime have driven up the price of sugar, and if the markets have their say, prices should not move too much away from the indifference curve. Fiscal incentives and taxes, certification requirements, quota and tariffs intervene and make the picture more complicated and different from country to country, but the basic relationship of figure 2 remains significant.

The graphic also depicts the basic critical point with regard to the Brazilian alcohol programme since its beginning: Before the recent oil price hike, sugar or other agricultural products had always been more economically viable than ethanol. During all these years, the Brazilian taxpayer had to bear the costs of making alcohol viable as an alternative to gasoline. Considerable direct and indirect subsidies were thus given to the well entrenched sugar interests and to the middle and upper class passenger car owners, since ethanol is a fuel which can only be used as an alternative of or additive to gasoline in Otto engines for passenger cars. For the year 1982, estimates ran up to US$ 1.8 bn (Borges / Freitag / Hurtienne / Nitsch 1988: 98), in 1989 the Folha de São Paulo reported World Bank figures of about 2.5 bn (03.09.89), and for 2004, data from the Agencia Nacional de Petróleo summed up to US$ 1.7 bn (Nitsch / Giersdorf 2005: 11). Critical comments not only refer to the not so basic needs being met by private passenger cars, but also to their problematic ecological impacts. The

employment argument is also rather weak, because of miserable working conditions in the harvesting of sugarcane, with mechanization looming around the corner, once wages should increase. The only highly favourite point is the 8:1 energy balance: Ethanol production from sugarcane makes very efficient use of solar energy, much more so than alcohol from corn or sugar beets where only little more energy is gained than has to be provided as an input. For every unit of commercial energy input, only 1.5 or even 1.0 units of energy output in the form of ethanol is gained. Only interested lobby calculators can present figures up to 2.4, because there are no established standards of what to include in the input catalogue.

With rising energy prices, ethanol from sugarcane produced in tropical climates like Brazil's has therefore a good chance to prevail over other alternatives to gasoline. However, low production costs around the equivalent of a gasoline price under 50 US$/barrel, as shown in the graph, have to been looked at a little more closely and deserve some comments. Firstly, those costs prevail in the most efficient production units in the State of São Paulo, whereas the national average lies considerably higher, let alone the costs of marginal producers. Secondly, the expectation of on export boom for ethanol, sugar and other agricultural commodities as well as the zoning efforts under way with which the Federal Government tries to impede the expansion of sugarcane into the vulnerable and largely protected areas of the Pantanal and the Amazon regions, might easily lead to rising land prices, i.e. costs, in the sugar regions. Thirdly, the spectre of Brazilian ethanol production invading valuable landscapes, driving out peasant food production, and flooding the world market, once import barriers would be reduced in the EU and the USA, contains a grain of truth, because ethanol from corn and sugar beets can certainly not compete, and profits from ethanol production in Brazil would increase; however, market prices do not depend on the costs of the most efficient producer, but on those of the *marginal* supplier (otherwise the price of oil would be around 5-10 US$!); they depend also on government intervention, and just as the oil rent is being appropriated by the state in the form of royalties and other fiscal means in all countries, the rent from ethanol exports is also likely to be taxed, in whatever form that may be.

Until recently, sugar was nearly always more profitable than ethanol. However, in the last few years, high oil prices seem to have changed the picture, because ethanol as fuel has become competitive in relation to sugar as well as to gasoline, as shown in figure 2. However, the price for sugar cannot yet serve as a valid indicator for food prices, because of those very special sugar regimes in the EU and other countries so that care should be taken before proclaiming economic viability for ethanol as a biofuel. A look at figure 1 reminds us of the interdependencies, and rising food prices have already alarmed the world. But before the purchasing power of the car owners is weighed against the need of man for food and against the protection of biomass as part of nature, let us look at

biodiesel, the other fuel which is largely used for trucks and busses so that the ecological malus of the private passenger car does not apply here.

## 3. Prospects for biodiesel

When it comes to biodiesel, the picture is not very different from sugar, as depicted in figure 3 for september 2007: High oil prices have recently made the production of fuel from raw materials otherwise used for food, more profitable, as already experienced globally with palm oil and, in the case of Brazil, with soybean oil as the main source of fuel in its National Biofuel Programme "Programa Nacional de Produção e Uso de Biodiesel (PNPB)" of 2004. Since vegetable oils are more important than sugar in human nutrition, the expectation of prices along the line of equivalence stirs even more criticism. Furthermore, the legal obligation to add biofuel to diesel by 2 p.c. now and 5 or even 10 p.c. in the future, not only in Brazil, but also in the European Union and the US, should make the demand for biofuel much less dependent on the markets. If not modified, those regulations would drive up the prices of vegetable oils well beyond the levels shown in the graph, since huge quantities are at stake. Volume targets always signify that prices have to adjust to a given demand.

Castor oil is a special case. It is not edible, but serves as a valuable input into the pharmaceutical industry – many may know it as a laxative from personal experience. It is also a highly esteemed lubricant for industrial purposes. Brazil is a large supplier on the world market, but the volume of production and trade is rather limited, and the mode of producing castor oil is rather rudimentary, with small farmers harvesting quite a large variety of the little nuts, and small oil mills making and marketing the oil to a variety of customers. Only very few plantations are in place providing the supply for the world market. However, the main propaganda for the Brazilian biodiesel programme is centered around the promising prospects of castor oil for the advancement of the peasants in the poverty-stricken Northeast and other small producers, because the plant grows without sophisticated inputs on poor soils and does not need expensive inputs nor much water. However, critics remind us that the long-lasting high price for that commodity in the past would already have kindled much more supply, if things were so easy. But a good deal of research is on its way, certification schemes and special credit programmes are in the making, and new oil mills have sprung up so that it remains to be seen what will come out of this part of the biodiesel programme.

Among vegetable oils, only palm oil has a favourable energy balance of 3-5 : 1, whereas rapeseed and sunflower lie barely over 1, and soybean oil around 2. Rising energy prices are therefore likely to make these oils considerably more

expensive in the near future. And as already pointed out, massive compulsory addition to diesel fuel will certainly add to the price pressure.

## 4. The value chain of energy

Energy is embodied in different forms, and man uses it in a cascading way in a value chain: Solid fuel is used to make liquid fuel and heat, and fuel is used for making food and light. The corresponding price ladder makes it normally uneconomic to heat with food or electricity. In common language, at least in German, energy in form of food is more "noble" than coal or crude petroleum, traditionally making it a "sin", not only economic nonsense, to use human food as fodder for animals or to heat with wheat. The question is, whether this hierarchy will remain so or re-establish itself, when oil prices soar. Energy balances and historical trends lead us in this direction. If human food is always in the "premium" segment of the energy markets, any fuel which passes through a form of human food, should have no future. Vegetable oils are already food (or a valuable pharmaceutical or industrial input), and the same applies to sugarcane juice, which would mean that these "first generation" biofuels do not really have a chance in the future. What makes the "second generation" more promising, then, is the fact that those new fuels are made from solid biomass, such as wood and straw, or from algae, or garbage, weed and other residues. Until now, they are not yet competitive on the market; however, with rising oil and food prices and technological advances, they are expected to flourish.

Electricity is another joker in the energy game: As an indispensable input in lighting and all kinds of mechanical and communication equipments it enjoys a high degree of "nobility" and generally also a high price. However, ever since the electric street-car and the electric train, electricity has been an important energy source for mobility, and the hybrid motor has even carried it already right into the modern passenger car. Hydrogen made from cheap hydro-energy or solar, geo-thermic, tidal or wind energy has also made its path into the not too futuristic car industry so that biofuels converting human food into fuel for cars and trucks, busses and airplanes are not the only alternative to fossil oil and gas when it comes to securing mobility in the future.

## 5. Summary and policy implications

Economic viability along world market prices is certainly not the only guide to future scenarios and responsible policies. However, every critical observer and every politician, whether euphoric or sceptic, should be well aware of the constellation he or she is facing. It makes an enormous difference, whether

you are stemming the tide of the markets or opening barriers and guiding the market forces into desired channels.

Brazil has a huge potential of land, labour, know-how and technology for commodities like sugar, ethanol, palm oil, soybeans, castor oil, etc. as well as for the products further up and down the production chain and the linkages of figure 1, such as all kinds of timber and celulosis, fodder and food. On the internal markets, it remains to be seen how the struggle between fossil and bio energy develops in the future. If oil and natural gas prices do not rise too much, the markets would lead toward fossil energy for fuel and biomass for food, and fiscal as well as distributive objectives would also point in that direction. However, political pressure by compact interest groups, futuristic *ufanismo* (national euphoric sentiments) and climate change considerations are prone to perpetuate the present pattern of expensive incentives for bio-energy from food crops without fundamental changes in the automobile civilization model which guides Brazil's development policies. Even very high international oil prices would not make much difference, since the production costs are moderate, even in the deep sea. PETROBRAS (2007) reports extraction costs of only 6.59 US$ per barrel of oil for 2006, which means that there is an enormous oil rent to be distributed or used for empire-building. With regard to the world markets, Brazil is basically indifferent, whether its customers use vegetable oils and soybeans for food, fodder or fuel, or buy sugar or ethanol. However, the pressure for certifications of various sorts will certainly increase, and the access to all those food as well as fuel markets will also remain a permanent issue of negotiations – in view of a failure of the Doha Round of the WTO which is quite probable.

European and North American countries will try to rescue their lifestyle and their auto-industrial civilization as well, and the compulsory addition of biofuel to mineral fuels will probably remain the main instrument for this purpose. Rising food prices, dramatic climate change consequences and the resulting rising consciousness about the viability – or better: inviability – of continuous materialistic affluence and resource squandering will probably lead to technological advances and eventually to who knows what kind of energy regime in the long run. For the foreseeable future, biofuels will be considered and fomented as a tool to postpone radical change of the established fossil structures so that profitable international biofuel trade flows can be expected – with all their global consequences for land use and food price hikes which are already being felt and discussed today.

Other countries will have to make equally dismal choices between food and fuel, nature and industrial development, environmental costs now or in the future. In the modern age, all that takes place not only under the eternal veil of ignorance and uncertainty, but also under the rather recent responsibility for

man-made global environmental risks which are part of the contemporary *condition humaine*.

So far, our calculations and reasonings are prone to result in a rather pessimistic outlook - biofuels as a *pseudo* solution which is doomed to failure and cannot work. However, some critical self-reflection on this line of rather narrow arguments reveals a gnawing political and moral trilemma in the present situation: Is it nobler in the mind and in the discourse,

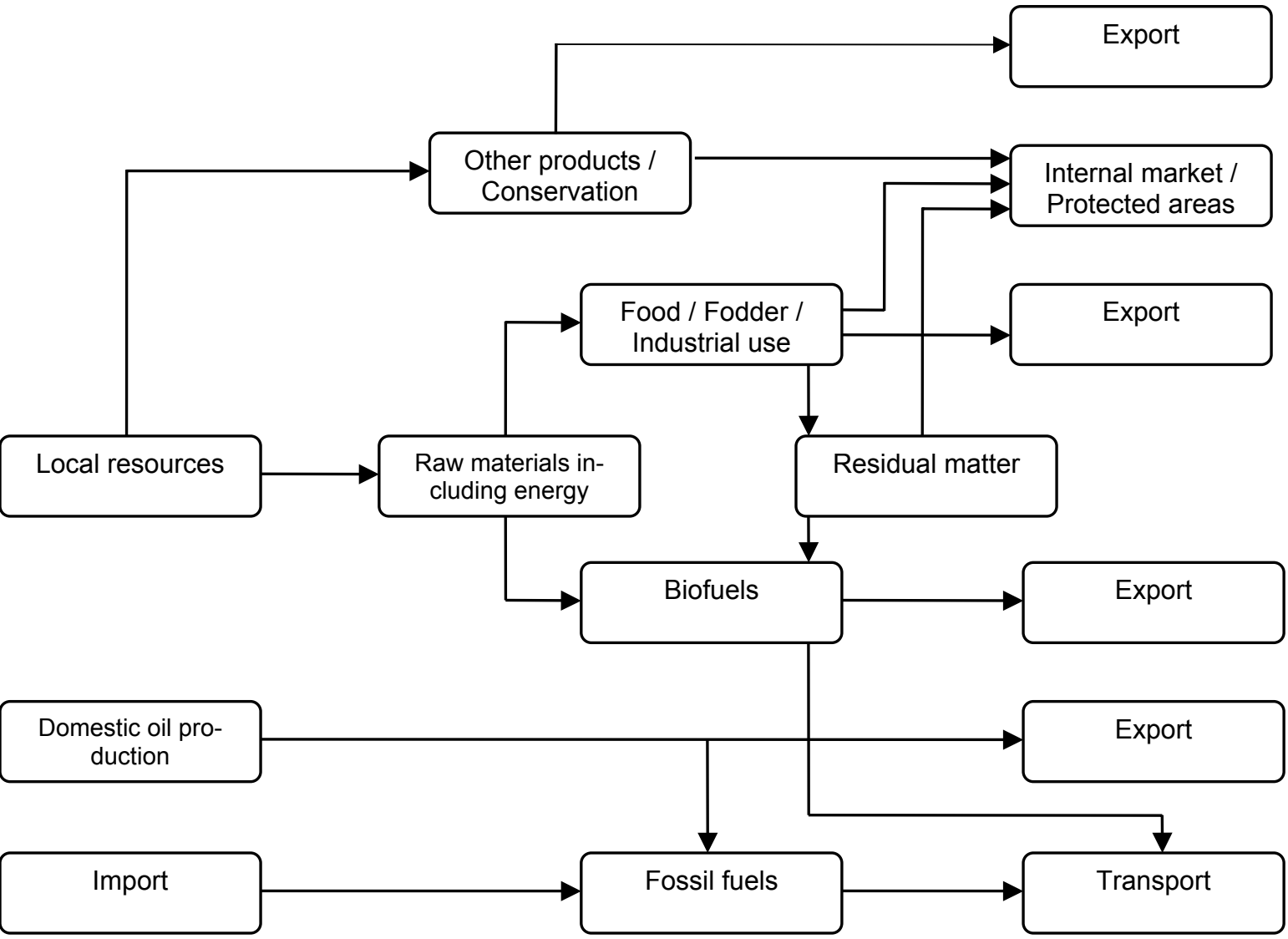
- to denounce biofuels as a costly *fata morgana* strategy, or
- to face the hard facts of the end of the petroleum age and its lifestyle through a loudly alarming speech, possibly inciting international conflicts and even more warmongering, or
- to propagate "business as usual", risking climate change disasters and a long-term hard landing with even starker ecological and political consequences?

Figure 4 depicts the options in **A** between the alternatives **B**, **C**, and **D**: The direct path toward sustainable mobility in **D** is blocked by a political barrier in that general consciousness does not allow drastic cuts in energy use so that green parties seldom get more than 10% of votes. In Germany, even the introduction of a general speed limit such as exists everywhere else in the world is hardly possible. Business as usual (**B**) might be possible for the next few years, however, the epistemic community of scientists is rather unanimously convinced that there is a formidable ecological barrier to be faced, for instance, the increase in sea level of the oceans which could change the face of the world in really drastic ways. As pointed out in the introduction, a biofuels world (**C**) seems to be a win-win compromise between status quo defenders and drastic change proponents; however, the resource barrier makes this option inviable, since too much food and too many protected areas would be necessary to come close to that goal.

Well – what to do in this trilemma now? Perhaps the "opportunity costs" of *not* deciding in favour of biofuels make them some kind of second- or third-worst option, as an intermediate step and a realistic, if only *quasi*, but no longer false or *pseudo*solution - for the time being and for the present state of the art in energy technologies. Optimists might even count on Hegel's "cunning of reason" and on the ancient Greek goddess of the Earth Gaia's grace, when today's first-generation biofuels should make food so expensive and climate change through further automobilization so dramatic that global public consciousness would rise to the necessary height for drastic change. The Brazilian word would be "*conscientização*", and the more business-like term "learning curve". Without any green dictatorship, eco-lifestyles could gradually become fashionable, and great technological leaps forward could make possible a safe and viable energy and mobility regime. By then, hopefully unexpectedly high degrees of resilience

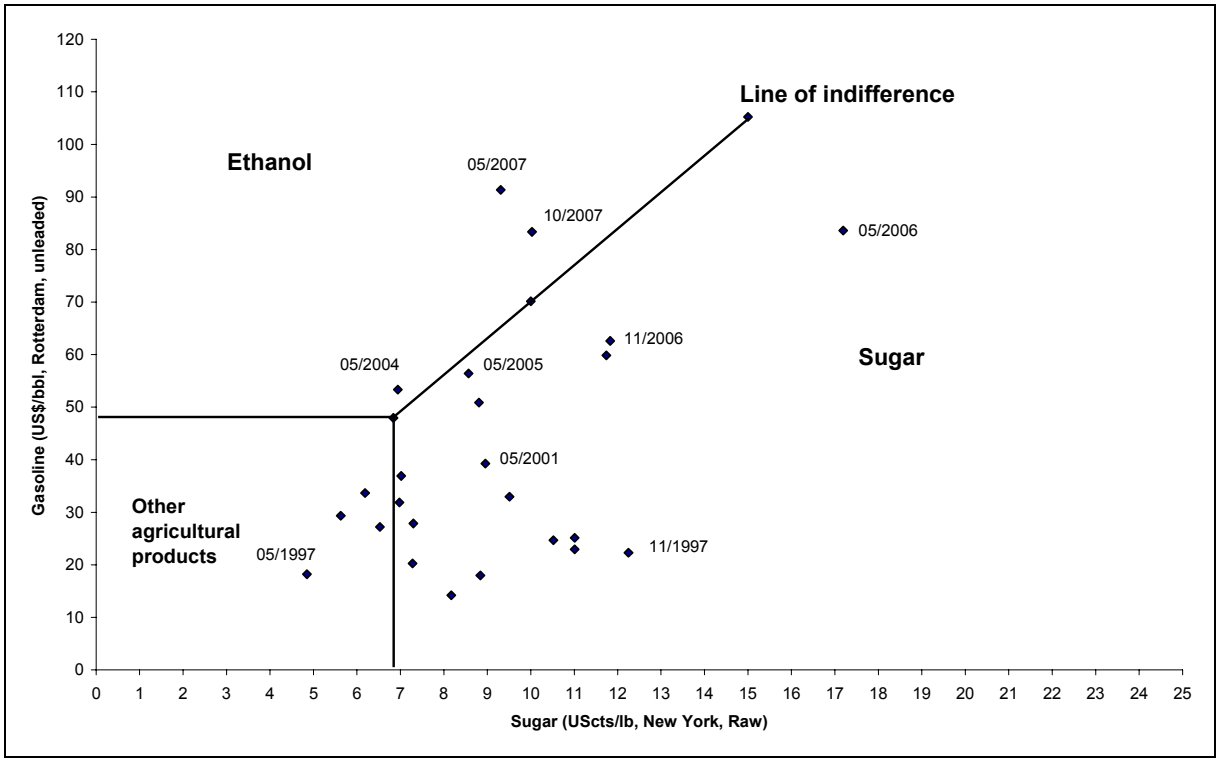
of the Earth's ecosystems were to lead us, mankind and nature together, into a truly win-win sustainable future.

# Figure 1: Linkages of biofuels
(without reverse monetary flows, subsidies and taxes)



# Figure 2: Economic viability of ethanol vs. sugar

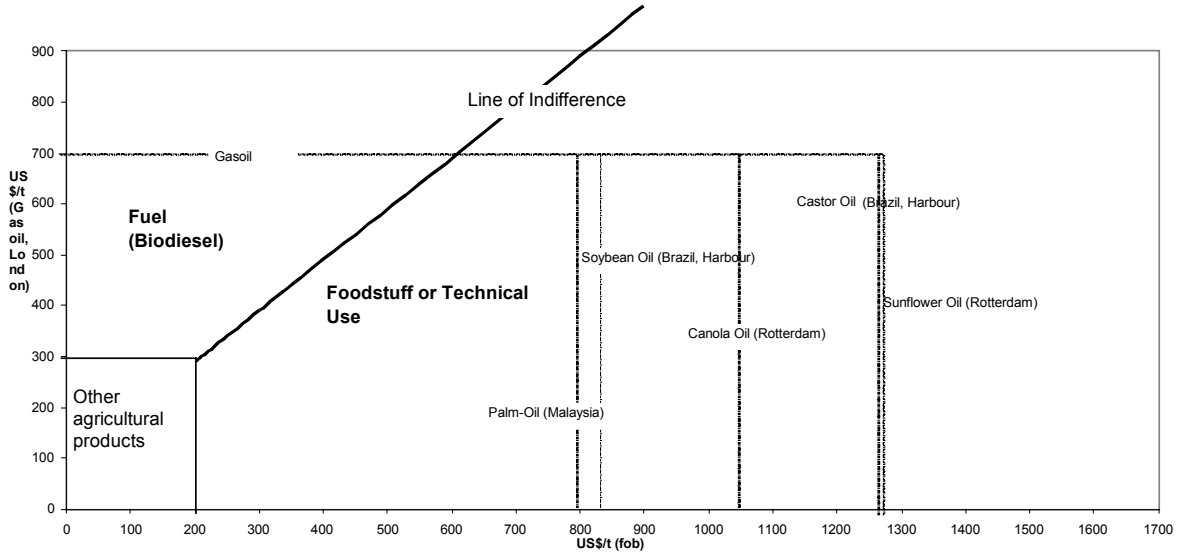
(world market price combinations, 1996 – 11/2007)



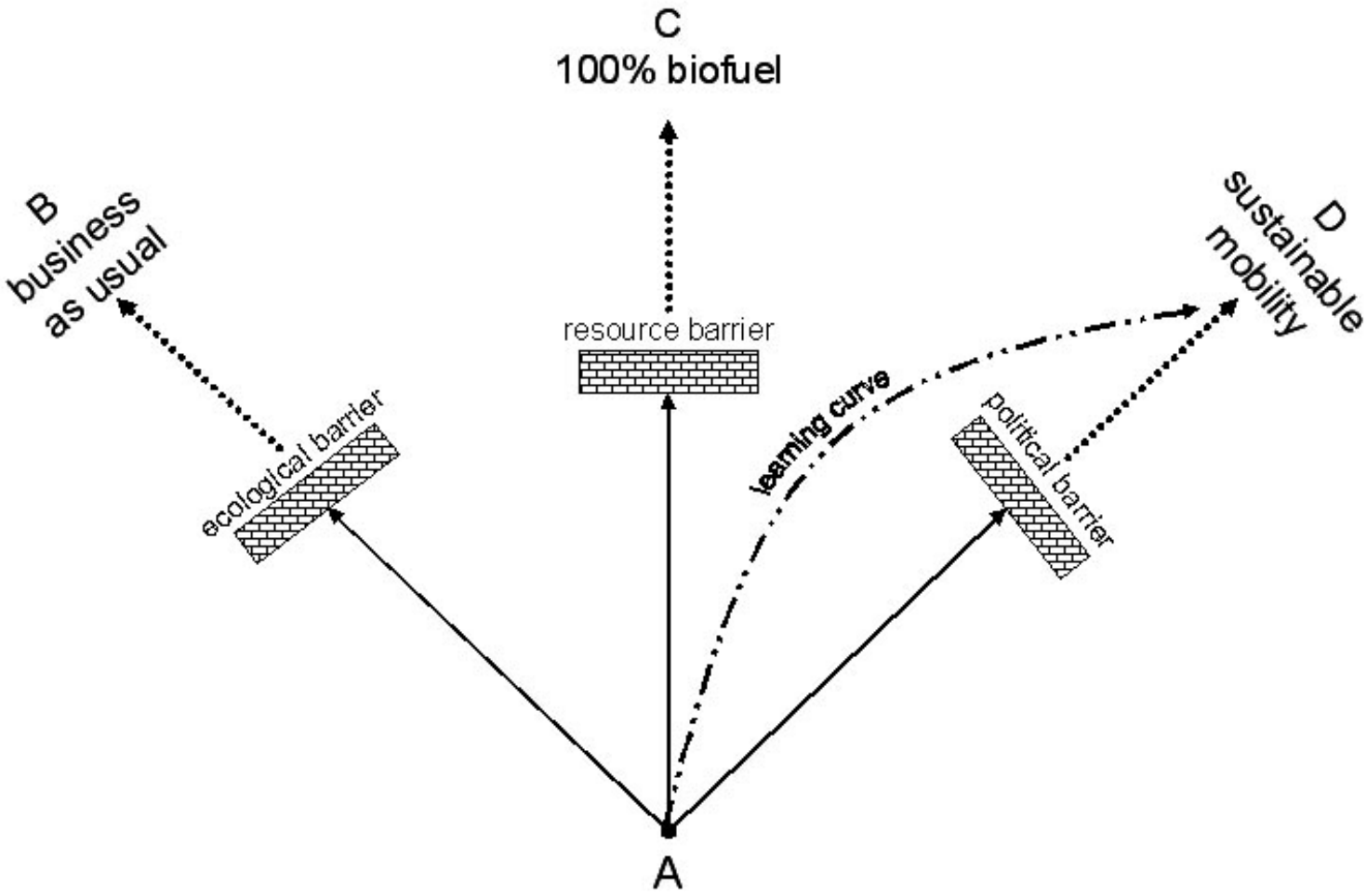



Combination of prices for unleaded gasoline (Rotterdam) and for raw sugar (New York) from May and November of every year from 1996 to 2007

# Figure 3: Economic viability of bio-diesel
(September 2007)



# Figure 4: Scenarios for Future Mobility



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