Energizing industrial development

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The role of energy sources in the choice of industrial development [illegible] energy literature. Indeed, as oil prices rise, traditional fossil fuel-intensive industrial development pathways now imperil development prospects around the world. As energy security becomes a major issue, developing countries have everything to lose by simply following fossil-fuel based industrialization, and everything to gain by recasting their development strategies around the prospects for renewable energies and biofuels. This paper argues that the time is therefore ripe for developing countries to re-evaluate their stance on renewable energy sources generally, and on biofuels in particular.

Key words: energy choices, renewable energies, biofuels, peak oil, industrial development, latecomer strategies

1. Introduction

Ever since David French offered his "Ten Commandments" on renewable energy use in developing countries, over 25 years ago, the issue of the role to be played in industrial development by energy choices has been largely neglected. However, recent years have seen convulsions in the world of energy, with a new realization that greenhouse gas emissions from burning fossil fuels is causing potentially irreparable climate changes, and that global supplies of oil as the principal fossil fuel are peaking. At the same time, large developing countries including Brazil, China and India are now becoming major drivers of the uptake of renewable energy technologies. These developments suggest that the role of renewable energy sources, and energy options more generally, should be seen as having greater salience in discussions of world industrial development.

While many economists and policy specialists have addressed this issue, most see the developing world blindly following in the footsteps of the polluting developed countries; few, if any, see developing countries as part of the solution (e.g. Stiglitz, 2006). Herein lies the attractiveness of supporting biofuels and renewable energies for developing countries and development

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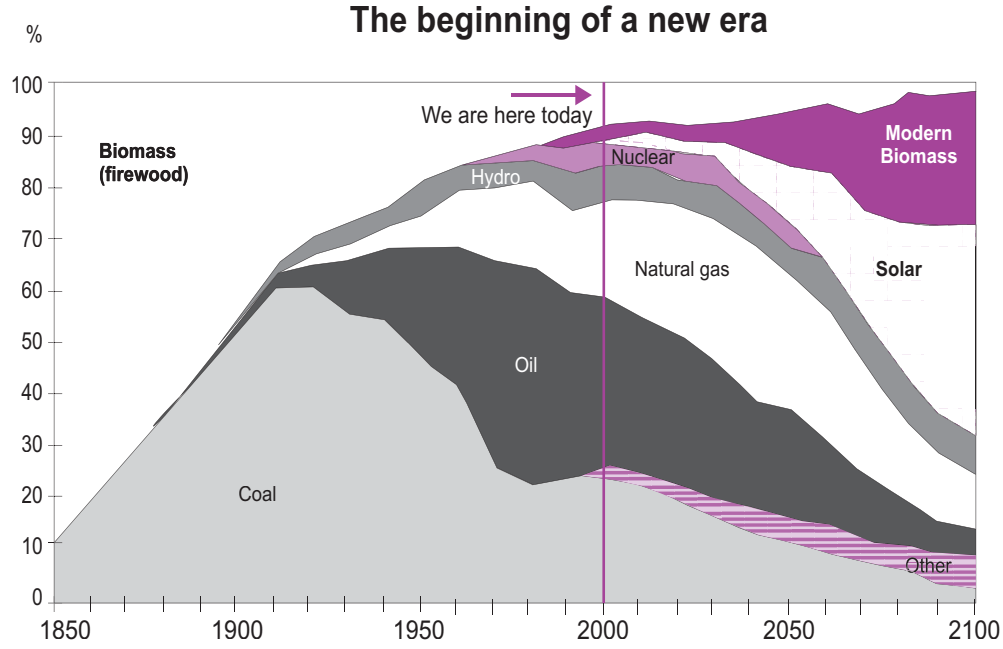
agencies like the World Bank. By doing so, they take the lead in moving the world to its destined future independence from fossil fuels, as envisaged by numerous scholars and captured most effectively by the IIASA/WEC study, *Global Energy Perspectives*, published in 1998, as shown in figure 1.

Figure 1. Changes in primary energy shares, 1850 to 2100

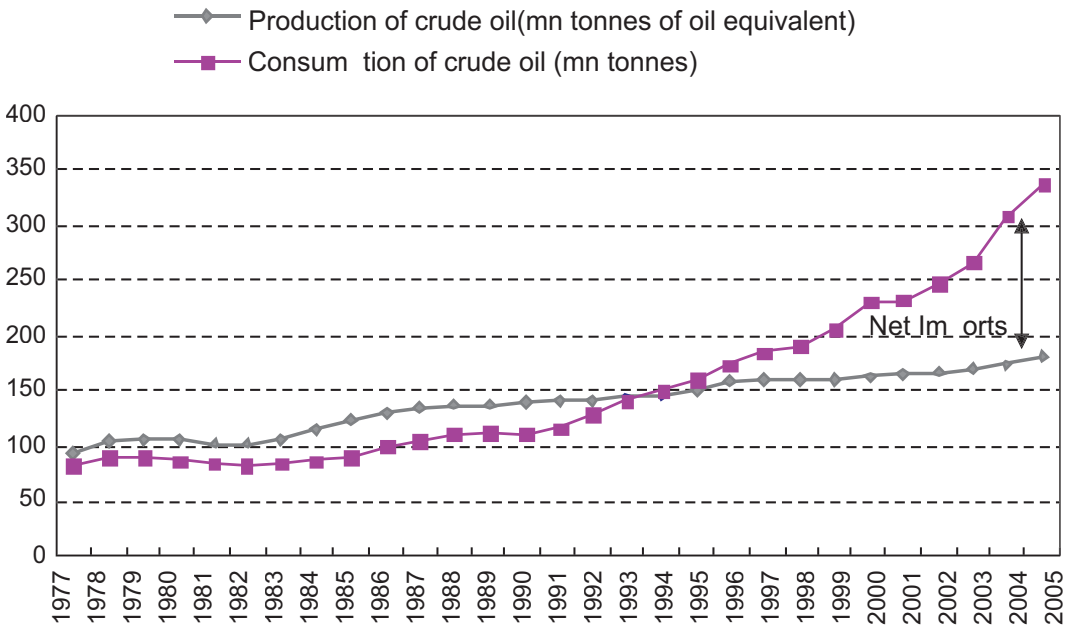


Source: Nakicenovic et al (1998) Fig 5.7 Scenario C1

As a way of illustrating the issues involved, consider the case of oil dependence in China, India and Brazil. China lost oil independence in 1993, when domestic consumption overtook production.[1] Since then, as shown in figure 2, the rise in China's oil imports has been alarmingly fast and has driven the country's frantic search for oil supplies around the world. The situation in India is even worse: the country has never enjoyed oil independence, and oil imports currently account for 75% of total oil consumed (figure 3). Rising oil prices make it unthinkable for both China and India to continue their industrialization based on fossil fuel imports. By contrast, Brazil has recently made itself oil independent, with its state-owned oil company, Petrobras, now producing more than the country consumes. Petrobras is also leading the country into a new era of biofuels, both in terms of ethanol blends for cars and biodiesel derived from vegetable oils for trucks, buses and heavy equipment.

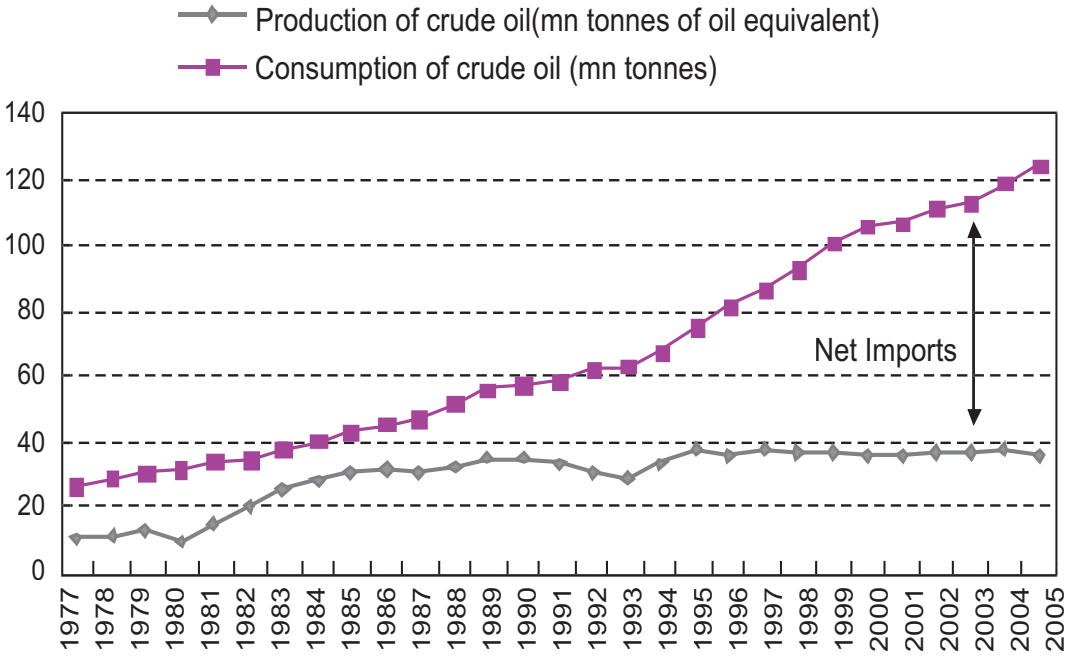
[1] The same thing had happened to the United States over 20 years earlier in 1970.

Figure 2. China's oil production and consumption, 1977-2005



Source: Based on BP Amoco, BP Statistical Review of World Energy © Euromonitor International 2006.

Figure 3. India's oil production and consumption, 1977-2005



Source: Based on BP Amoco, BP Statistical Review of World Energy © Euromonitor International 2006.

The report by Goldman Sachs, *Dreaming with BRICS: The path to 2050*, made the widely noted prediction that by 2050, China would become the world's largest economy, India the third largest, and Brazil the fifth largest (Goldman Sachs, 2003). This report was a wake-up call

for many, showing that economic growth was likely to take today's developing countries to world leadership by halfway through the century. Yet curiously, the Goldman Sachs report made no mention of energy – not of fossil fuels, nor of biofuels, nor of any other renewable energy resource. But with the double influence of peaking of global oil supplies and of the rising apprehensions related to emissions of greenhouse gas emissions, such neglect of fundamental energy questions is no longer feasible.

This paper canvasses the issues involved, probing the likely implications for the industrial development process of the peaking of global oil supplies and of the rise of concerns over global warming, and also the prospects for developing countries to move towards (and indeed take leadership in) the application of renewable energy options. The purpose of the paper is to ask explicitly what effects the choice of energy options would entail on countries' industrial development prospects. This is a typical question posed by Sanjaya Lall in his many discussions of technological capabilities and the sources of advance on the part of developing countries. In one of his later contributions, made together with Carlo Pietrobelli, Sanjaya examined the prospects for development in Sub-Saharan Africa and the role to be played in the process by institutions of technology transfer and indigenous R&D, and concluded on a pessimistic note (Lall and Pietrobelli, 2005). Yet, with the rise of renewable energies as options for such developing countries, and in particular the grasping of opportunities in the field of biofuels, it is precisely the role of technology transfer institutions that is vital to the eventual success of such projects. Sanjaya himself would no doubt agree, were he to be able to witness these new and arresting developments in the fields of renewable energies and biofuels.

2. Energy choices and development

Until recently, it was the conventional wisdom that renewable energies would be a marginal and costly alternative, that might make some headway over a century or more as technologies improved. But the case of Brazil, China and India shows that renewables – led by biofuels and in particular ethanol – are competitive here and now, and moreover represent an exceedingly attractive option for developing countries.

The advantages for developing countries of ethanol and biodiesel over their fossil fuel counterparts as transport fuels are many, and include the points that:

- they are currently cheaper than oil;
- they provide energy security as opposed to dependence on imports from unstable oil regimes;
- they burn more cleanly;
- they generate fewer greenhouse gases;
- they promote rural development;
- they can generate new export industries for developing countries; and
- even countries with a less advanced level of science and technology can get a start with biofuels.

Strategizing around renewable energy options, it will be argued, is fundamentally different from securing strategic supplies of fossil fuels, in particular oil. To engage in global strategic games (with their deadly consequences in the form of resource wars) in pursuit of security of oil supplies is one thing – and Brazil, China and India are all playing that game, with increasing sophistication and success, to the consternation of the United States and its western allies. The key issues here are military strength, international political and military alliances, and diplomatic manoeuvring.

But to strategize around renewable energy sources calls for calculations of a quite different kind. It calls for interventionist industry policies to kick-start new renewable energy industries, such as those based on growing and distilling biofuels; on capturing solar energy (e.g. manufacturing PV solar cells); or on building wind farms (e.g. manufacturing wind turbines). But more than this, it calls for a sophisticated design of the institutional settings in which a transition to utilization of renewable energy may be effected – from mandating the use of ethanol-petrol blends in motor vehicles, and extending such mandates to diesel-powered machines; to mandating rising proportions of electric power generation from renewable sources; to implementing tax measures that offer incentives to move towards energy conservation and efficient fuel usage and disincentives to inefficient fuel use (such as indiscriminate use of SUVs in cities); and to creating incentives to encourage firms to become active in the supply chains that feed renewable energy supply systems.

Brazil has taken an early lead in biofuels, driven by its huge domestic ethanol programme that has seen its use as a blended fuel mandated by the federal government, backed by subsidies to sugar producers to enable them to produce ethanol as well as sugar. Now Brazil has a thriving export industry for biofuels, with firms operating

bioreactors at its core. In these reactors, the decision to produce sugar or ethanol can be taken on a daily basis at the flick of a switch, depending on the prevailing world prices. In 2005, Brazil started to replicate its success with bioethanol through a biodiesel programme. Already by late 2006, this programme had generated 100,000 jobs in the northeast of the country, producing biodiesel from oil crops such as castor oil and palm oil. The Brazilian national energy company, Petrobras, introduced a new biodiesel product, dubbed H-Bio, in 2006, the first in the world to do so.

China and India are Brazil's largest export markets for ethanol, and are themselves rising fast as producers: they are now third and fourth largest ethanol producers in the world. They are also rising fast in the biodiesel stakes as well. Many other tropical developing countries in Asia and in Central America are also becoming active in biofuels. In promoting renewable energy, in their own interests, developing countries can thereby create a new agenda for solving the wider problem of global warming. China is developing a range of alternative energies, including wind energy, solar thermal and photovoltaics and biogas digesters, which represent the seeds of a new low-carbon economy. India, too, is developing renewable energy industries, with firms like Suzlon becoming a world leader in wind turbines manufacture, and with institutional innovations such as a Ministry of Non-Conventional Energy Sources to coordinate developments.

The pattern of development of renewable energy sources in developing countries is likely to follow its own "latecomer effect" logic. While in the developed world, dependence on biofuels is an expensive option (because of intensive land use and need for fertilizers for fuel crops) in the developing world, such as Brazil and Africa, biofuels can be produced at much lower costs. And, many developing countries have much larger land resources to devote to generating energy – from crops, from sun (PV cells) and from wind. The developing world can adapt an "agricultural model" to cultivating renewable energy sources – or what might be called an *ergocultural* model. The twenty-first century is likely to see major scientific and technical advances in the use of land for food (agriculture) and for energy (ergoculture), with the developing world taking the lead in both.

Thus, the era when industrial development strategies could be formulated without reference to energy sources looks to be over (Asif and Muneer, 2007; Barnwal and Sharma, 2005; Wright, 2006). When we look just at developing countries, of the world's 47 poorest countries,

no fewer than 38 are net oil importers, and 25 are completely dependent on oil imports – victims of commitments made during the times when the price of oil was seen as low forever (Ren21, 2006). Yet, these are the countries that have generally favourable conditions for producing energy from renewable sources.

If the argument of this paper is sound, then it means that renewable energies – starting with biofuels – represent a unique opportunity for developing countries, and one that has the potential to change the terms of world trade in energy and tip the balance favourably towards industrial development in tropical countries around the world. The key to their success is mastery of the technologies involved, many of which will have to be imported from developed countries, through licensing, FDI or through movement of human capital – exactly as described by Sanjaya Lall in his numerous studies on this process.

3. Arguments in favour of a fossil fuel-independent strategy

The conventional development wisdom has it that developing countries will have to follow the energy steps of the developed world, emulating their pathways to development. But what the conventional wisdom failed to foresee was that some developing countries would find an alternative pathway – one based not just on fossil fuels and extreme dependence on oil imports, but on a different trajectory, namely one of energy independence and in particular independence from fossil fuels.[2] Unlike Russia, which is playing strategic games with its vast oil and gas reserves, Brazil, China and India are strategizing so as to build energy independence through a variety of renewable fuels and energy sources, starting with liquid biofuels, partly in order to reduce their vulnerability to balance of payments difficulties due to rising oil import bills. In this way, the debates over renewable energy, which rose to prominence in developed countries during the 1970s but died away as oil prices fell,

[2] It has to be recognized that China and India will remain large-scale users of coal for many decades to come, just as the European countries and the United States in the 19th century used coal as the primary energy source. The point being made is that alongside their use of coal these countries are demonstrating that they can "energize" their development with renewable sources as well, and actually utilize them as seeds of new industries that can compete with those of the advanced world, and capture latecomer advantages in so doing. At the same time, they can deploy advanced technologies such as combined cycle power generation to reduce greenhouse gas emissions from their use of coal – as China is planning to do, in advance of the developed world.

are now being replayed in the developing world – and this time with real prospects of success.

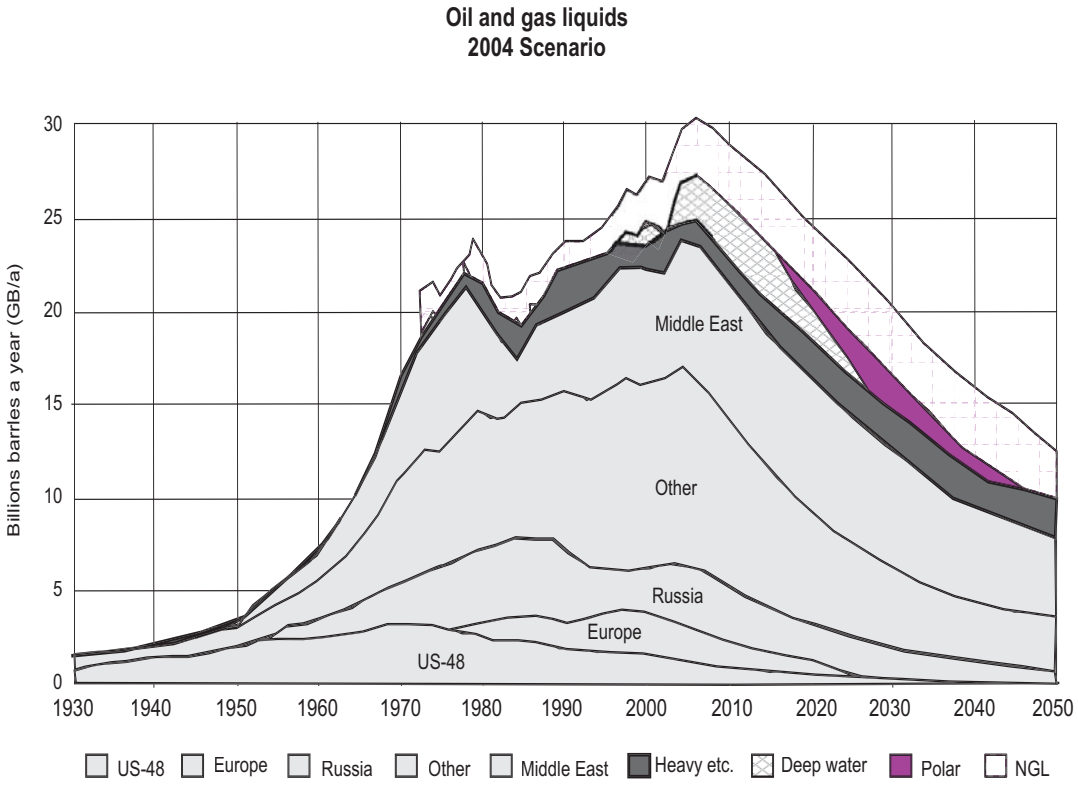
The issues to be considered as developing countries move vigorously towards promotion of renewable energy and biofuels industries may be rehearsed under the following ten headings, to emulate the approach of French (1982):

- Energy security and the peaking of oil supplies globally;
- Biofuels as tested substitutes for fossil fuels;
- Abundance of land for producing energy crops in tropical countries;
- Biofuels' potential to reduce fuel import bills and fossil fuel dependence;
- Biofuels production is a rural industry and can promote social inclusion;
- Countries with even low levels of science and technology can get a start in biofuels, and they can create thereby a "development bloc" that can drive industrial development;
- Biofuels are potentially greenhouse gas neutral and can earn countries carbon credits;
- Developing countries can develop their own distinctive latecomer institutional innovations to capture benefits;
- Biofuels represent simply the first step on a clean technology development trajectory; and
- A Biopact between countries of the South exporting sustainably produced and certified biofuels and countries of the North importing them could resolve concerns over biofuels and break the world trade logjam.

4.1 Energy security and the peaking of oil supplies globally

The relentlessly rising long-term costs of oil pose a major brake on industrializing efforts by developing countries. Looking at the global picture, the data reveal a relentless build-up of consumption, with production trying to keep up; but the discovery of new fields is in steep decline. Indeed, new discoveries peaked in the 1960s. Production must fall following these declines eventually. Just when this occurs is currently the subject of intense debate (Kerr and Service, 2005). The graphic utilized by the Association for the Study of Peak Oil and Gas is shown in figure 4.

Figure 4. Peaking of global oil supplies



Source: www.peakoil.net.

Here, we see how oil production in the United States peaked in 1970; then Russia emerged as a source, but is now declining; and how Europe – largely through the North Sea – also had its time in the sun, but is now rapidly fading. Other sources such as Latin America, West Africa and now Central Asia have also come to play a role, but they will see steep declines even as early as 2010. Non-conventional sources of oil and gas, such as tar sands, will simply not be able to pick up the slack, because of high costs, technical difficulties or political resistance as in the case of drilling in Arctic areas. In the face of such difficulties, with their widely expected impact in terms of rising oil prices, developing countries should adopt a conservative posture, namely to assume the worst and prepare for it. This would imply making provision with all due speed for renewable energy sources.

4.2 Biofuels as tested substitutes for fossil fuels

There is tension in the scientific community over the extent to which biofuels can fill the looming gap in fuel supplies. Writing in

Science in 2006, Professor Hoffert and his colleagues offer the view that "All renewables suffer from low areal densities". They go on to comment, "… photosynthesis has too low a power density (~0.6 W/m2) for biofuels to contribute significantly to climate stabilization" (Hoffert et al., 2002, p. 984). But it turns out that they are considering the case only for developed countries. Against this, Steven Koonin states unequivocally in the same journal that "with plausible technology developments, biofuels could supply some 30% of global demand in an environmentally responsible manner without affecting food production" (Koonin, 2006, p. 435).

The reality is that for developing countries where sunshine and desolate landscapes are not in short supply, there is vast scope for producing biofuels, particularly from degraded and abandoned land.[3] In India, for example, there are now several major investment programmes underway in ethanol and biodiesel production, utilizing vast areas of degraded or under-utilized land, and planting under-utilized crops such as *Jatropha curcus*. These projects can also capture latecomer advantages through utilizing the latest in biorefinery technology – as described in a recent article in *Science* (Ragauskas et al., 2006).

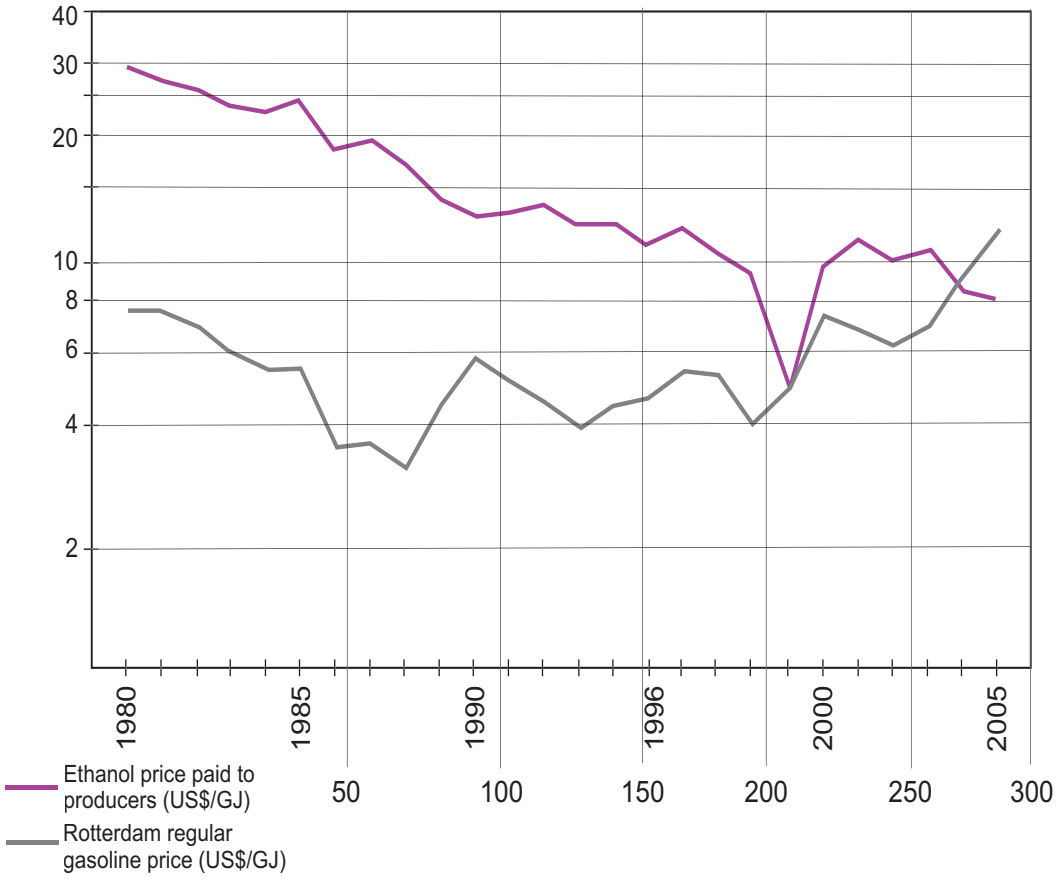
There is a huge literature hostile to biofuels, accusing them of being energy-intensive in cultivation; taking land from food crops; and encouraging monoculture. But these are largely arguments stemming from developed countries and describing developed country conditions – particularly in the United States and northern Europe. But the situation in developing countries is quite different. Brazil produces ethanol from sugar cane (the fastest growing crop on the planet) with an energy gain of up to 8:1, because of the favourable conditions in which the fuel is produced.[4]

[3] Campbell et al (2008) provide a reliable scientific estimate of the availability of such degraded lands in countries of the South, in opposition to the common claim that biofuels are being driven by deforestation.

[4] On the experience with biofuels in Brazil, see Goldemberg et al (2004) for a succinct summary, and Macedo (2005) for a collection of studies on the efficiency and energetics of Brazilian ethanol production based on sugar cane, including the estimate of energy yield of 8:1. The most recent estimates for the sugar cane crop of 2005/06, by Macedo, Seabra and Silva (2008), raise the energy gain to 9.3:1, while GHG savings were 2181 kg CO2eq per cubic metre of E100 ethanol, compared with release of GHG emissions from ethanol production of 436 kg CO2eq per cubic metre – a gain of 1745 kg CO2eq per cubic metre of ethanol.

Developing countries, led by Brazil, China and India, are in fact taking the lead in the development of biofuels as alternatives to fossil fuels (Barnwal and Sharma, 2005; Li et al., 2005; Liming, 2007). In Brazil, the programmes go back to the 1970s, when the Proalcool programme was launched, involving the mandated use of an ethanol blend for gasoline, known as gasohol. This generated a huge rural industry growing sugarcane for ethanol production as well as sugar. The comparative advantages Brazil enjoys in such production – land, sunshine and cheap labour – have been enhanced through the country's own R&D efforts, which resulted in the development of better crop strains and understanding of soil types; these have led to reductions in production costs so that ethanol is now cheaper than oil – as shown in figure 5. This demonstrates that developing countries can reap benefits from renewable energies and biofuels through adding their own R&D and innovations to those technologies adopted from the developed world.

Figure 5. Price paid to ethanol producers and gasoline cost



Source: Datagro.

4.3 Abundance of land for producing energy crops in tropical countries

Tropical developing countries are not as limited in their choice of feedstock as temperate, developed countries. They have the options of using sugar cane itself, as well as a variety of starchy inputs such as cassava and, for biodiesel, any of a variety of oilseeds that have traditionally been viewed purely as foodstuffs. In fact, many of the oilseeds now being cultivated for biodiesel are inedible – such as castor oil. In India, the wonder oilseed, *Jatropha curcus*, which is also being investigated in Brazil, grows in hostile conditions on degraded land. As such, there is little question of the cultivation of these crops competing with food supplies or with land that is potentially cultivable for food. Indeed, one area where intensive R&D efforts are needed is the investigation of the potential of existing and little known plants for biofuel production in developing countries. These options are being explored by Brazilian, Chinese and Indian ethanol and energy producers in tropical countries.

But, of course, land can be misused in the pursuit of biofuel crops, and clearances of rain forest in the Amazon and in South-East Asia (e.g. in Borneo and Sarawak) represent the front line of such concerns. Countries that allow unchecked clearances of forests are defeating the very conditions that give them a developmental advantage – and giving rise to global campaigns such as those concerned with the threat to the habitat of the orang-utan (FoE, 2005). If developed countries can be given an excuse to block imports of biodiesel from tropical countries on the grounds that it is derived from mass clearance of rainforest, then clearly the whole biodiesel enterprise is imperilled. That is why countries of the South have every reason to seek the most stringent certification processes for their biofuel production as meeting sustainability targets, and can best do so through negotiation of a global Biopact – as discussed in subsection 4.10 below.

4.4 Biofuels' potential to reduce fuel import bills and fossil fuel dependence

For a developing country, it is all the more perverse to neglect the biofuel option while imports of oil are placing an ever-increasing burden on the country's balance of payments. Brazil has estimated the savings on its fuel import bills since the launch of the Proalcool programme to be of the order of $50 billion per year – which is far larger than the country has spent in promoting ethanol. Likewise, the savings for China

and India in foregone oil imports will be of the order of hundreds of billions of dollars – the difference between success and catastrophe in their development efforts. Since the lack of foreign exchange is a major barrier to industrialization, displacement of fossil fuel imports represents a major strategic advantage.

This issue also has the developmental advantage in that the country is forced to consider its energy production as an industrial issue calling for business and developmental strategy, and not just as an issue of importing "stuff" from abroad. To "grow" industries is the core of the development process – and it can start with energy as with any other branch of production, as discussed in the context of seeding "development blocs" in subsection 4.6 below.

4.5 Biofuels production as a rural industry and promotion of social inclusion

Brazil sees biofuels production as a way to promote rural industry and to curb the migration to the cities from the countryside. Biodiesel produced from castor beans in Brazil's arid northeast *sertao*, for example, is promoted not just for the biodiesel but also for the fact that it creates thousands of jobs in this otherwise impoverished region. Promotion is through fiscal incentives, such as tax breaks offered to families producing the raw materials needed for biodiesel production. The more the production of castor beans for biodiesel and sugar cane for ethanol production spreads, the greater the rural employment generating possibilities are, which help to curb migration to the big cities. In India, the production of biodiesel from Jatropha is also explicitly promoted as a rural industry capable of generating village-based enterprises and local employment. Indian national firms, like Reliance Industries, already a player in the oil business, are now moving into production of biodiesel from plantations established in Andhra Pradesh.

4.6 Biofuel development strategies for countries with low levels of science and technology

Biofuels in tropical countries can be grown with scarcely more input than seed, land, sunshine and labour. If the country has a comparative advantage in labour-intensive activities, then it can start with production activities with a low level of technical sophistication – and move up from there. Brazil is demonstrating how this can be done, through its ethanol programme involving sugar cane, and now its

biodiesel programme involving vegetable oil seeds such as castor and soybean crops. In the words of the country's president, Luiz Inacio Lula da Silva, this programme had, by July 2006, already generated 100,000 new jobs in growing soybeans and other oil crops in the northeast of Brazil. The biodiesel programme has been designed as much with social goals as with fuel supply goals. The point is that a country in Africa can emulate this example and devote large tracts of land to fuel crop production. Domestic consumption can provide an initial market, since the fuel produced can substitute for expensive oil imports. As technical sophistication is acquired, export markets may be opened up. As the industry develops, advanced distillation systems installed, and technological know-how in the country can be enhanced. This will then have spillover effects in other sectors.

As a biofuel industry becomes established, it is likely to drive industrial development through linkages and complementarities. Biofuels and other renewable energies promise to play the role of a critical "development bloc" for Brazil, China and India in the first instance, and for wider swathes of developing countries through the tropics more generally. The concept of *development bloc* was introduced and defined by the Swedish development economist, Erik Dahmén in 1950, based on his studies of entrepreneurship in the Swedish economy (Dahmén, 1950/1970, 1989). He defined it as "sequences of complementarities which by way of a series of structural tensions, i.e. disequilibria, may result in a balanced situation" (Dahmén, 1989, p. 111). Such a suprafirm system provides a striking description of how firms may collectively strategize in the context of a disequilibrium economy, and build on each others' efforts to improve their own prospects. J. P. Carlsson and Eliasson (2003) have taken up the concept and renamed it *competence bloc* to emphasize that such a collective capability is needed to support and sustain technological innovation. If the technological system represents the supply side of industrial dynamics, then the development bloc or competence bloc represents the demand side. The competence bloc captures the notion that if new technologies are to be taken up, or absorbed, then firms must have the requisite capabilities, and the product ranges, to be able to make use of the technologies. It is the blockages due to such inadequacies and bottlenecks that accounts for poor uptake of new technologies, rather than unwillingness or conservatism on the part of managements. Thus a development bloc represents the systemic counterpart to the consideration of market demand as well as supplier competence in the microdynamics of technological trajectories. It generates the forward and backward linkages that can drive industrial

development. Development blocs formed around value chains involved in renewable energy production and bioenergy are precisely the kinds of industrial templates needed for development today. And renewable energies are already providing the business around which transnational corporations (TNCs) from the South are already forming – as demonstrated by such firms as Petrobras and Bunge from Brazil (in biofuels); Suzlon from India (in wind turbines manufacturing); and Suntech Power from China (for photovoltaics production).

4.7 Biofuels are potentially greenhouse gas neutral and can earn countries carbon credits

Biofuels like ethanol are potentially greenhouse gas neutral, in the sense that every carbon atom burned is simply replacing a carbon atom taken by the plant during photosynthesis. This is by far their most appealing feature from a long-term environmental perspective. Of course, this neutrality has to be qualified by the fact that fossil fuels are consumed along the value chain producing the ethanol – but again much of the concern voiced on this issue emanates from a developed country perspective and is much less relevant in a developing country. For example *The Washington Post* ran a story in July 2006 captioned "The false hope of biofuels" in which the main charge was that the energy gain is little after deducting amounts involved in fertilizer, harvesting, transport, processing, etc. These considerations change dramatically when considered in the context of a low-cost developing country, where input resources including land and sunshine are abundant, and processing takes place close to where the crops are grown. The greenhouse gas emission abatements can then serve to generate carbon credits under the Kyoto protocol.

Again indiscriminate clearance of forest to plant energy crops defeats the gains in greenhouse gas emissions that are potentially there for the taking. It is to curb such behaviour and hold governments to a standard of accountability that is one of the principal arguments for global institutions like the World Bank to become more directly involved in promotion (and to some extent regulation) of the development of biofuels.

Developing countries have the opportunity to take a fresh initiative on this matter, and channel part of their biomass into production of biochar (produced through slow pyrolysis) which can then be put back into the soil as a fertilizer substitute. Biochar was actually invented by

pre-Columbian civilizations of the Amazon, where it created fertile soil patches named by the Portuguese as *terra preta*. Its reintroduction into biofuel production by tropical developing countries would thus be a means of reclaiming this ancient invention, and provide the basis for producing biofuels that are demonstrably *carbon-negative* – in the sense that they sequester more carbon from the atmosphere than is put back through burning of the fuel. Biochar amendment of the soil is a way of drastically enhancing fertility while conserving soil, avoiding run-off, enhancing water retention, reducing nitrogen emissions and providing the opportunity for production of carbon-negative bioenergy.[5]

4.8 Biofuels and renewable energies as a first step on a clean technology development trajectory

Biofuels and renewable energy options are not an end in themselves, and it will be necessary to lead a country along a trajectory that will involve many more biofuel innovations and clean technologies. Brazil for example started with ethanol, and, since 2005, it has launched a biodiesel programme that promises to rapidly take the country to world leadership in biodiesel. All developing countries can expect to pass through the same two phases, probably in an accelerated manner. Within the next decade, a third phase can be expected to become significant, namely the use of biomass generally (such as through forest plantations, or municipal waste) as feedstock for general bioreactors (Somerville, 2006). This phase will depend on the development of enzyme packages that are currently in the test stage in R&D companies such as Iogen. But it is highly likely that this stage will be accelerated through innovations developed in Brazil, China and India, given their track record.

Countries do not need to see biofuels or any other source of renewable energy as a total solution or substitute for fossil fuels. They all contribute to a portfolio of renewable energy options that will vary depending on the comparative advantages of the country concerned. Even the simplest kinds of renewable energy options, such as biodigesters producing gas, electricity, heat and light from biomass or village waste, represent powerful ways of enhancing energy per capita usage in advance of electrification grids and without promoting heavy fossil fuel-dependent industrialization.

[5] See Mathews (2008a) for a discussion of carbon-negative biofuels, utilizing biochar amendment of soil, and Lehmann (2007a, 2007b) as a representative sample from a fast growing literature on the scientific evaluation of biochar's properties.

4.9 Developing countries distinctive latecomer institutional innovations in biofuels

Brazil, having accomplished a successful biofuels industry, shows other countries how it can be done. In the 1970s, it suffered under a dictatorship, but out of that experience came an understanding as to how the country could benefit from its comparative advantages in sugar cane growing and processing, turning these into competitive advantages. In the most recent period, Brazil has seen its use of biofuels leap ahead under the twin impact of flex-fuel vehicles (FFVs) and the mandated provision by fuel companies of ethanol blends (from E25 to E85) all across the country.

Other developing countries can learn from this example, without having to go through all the painful episodes of Brazil's history of the past 40 years. They can accelerate their uptake of biofuels, with all the advantages that this can bring (in terms of energy security, savings from reduction in oil imports, rural development and cleaner city air) to create new and vibrant export industries, simply through the double measures consisting of:

1) mandating supply of flex-fuel vehicles (directed at the automotive industry); and
2) mandating provision of ethanol-petrol blends (starting with E10 and moving to E25) within a few years.

So much of the discussion of the past decade on renewable fuels has been driven by supply-side considerations, namely costs and technologies. But the key to getting these new industries off the ground – as in every successful case of deliberate industry creation – is to influence demand; in this case, the demand from the automotive industry for cars that run on ethanol blends, and demand from the motoring public for such ethanol blends.

So any developing country today can benefit from this experience, and move to establish a biofuel industry with relative certainty as to the outcomes. The key is to start with ethanol blends ("gasohol") rather than seeking to jump straight into pure ethanol or other biofuels, and to do so at a measured pace, building demand for the ethanol blend by drawing the automotive sector and oil sector along with the programme.

The institutions established to drive the uptake of biofuels are likely to have a knock-on effect, facilitating the development of other industrial sectors, formed initially as support sectors for the biofuel

industry. Good institutions develop during an economic activity. When a committed government engages in a partnership with a proactive private sector, they jointly begin to design and implement appropriate institutions. So while institutions are the key, the causation may be from the start of an activity in response to a government trigger (tax break for example), to the unfolding of institutions that help to trouble shoot as the process rolls along. Of course, the process will be highly inefficient in the beginning, as countries learn to make these institutions work more effectively. This is best illustrated in Brazil's own follow-up to the ethanol programme, namely its Biodiesel programme.

Brazil's biodiesel programme – a successful latecomer strategy

This latest biofuel initiative from Brazil shows just what can be achieved by a developing country that focuses its institutional innovations on capturing its latecomer effects. The Brazilian biodiesel programme, which was launched in January 2005, has been well crafted and executed. We can identify at least four latecomer institutional features to the programme that have not been widely recognized.

First, it is a carefully managed incremental programme, moving through three phases that have been widely discussed in Brazil. The first, voluntary phase, brings the country up to a level of 2% biodiesel, following the example of the Proalcool programme. By 2008, this 2% minimum becomes mandatory, and rises to 5% minimum blend by 2013, athough the success of the programme in its first 18 months means that it is widely anticipated that the mandatory 5% blend (B5) will take effect at an earlier date, possibly as early as 2010. Thus, the country as a whole is being brought to a position where it produces 5% of all diesel requirements from vegetable oils by 2013 at the latest (and possibly as early as 2010), bringing it abreast of world leaders. The programme is overseen by the Ministry of Mines and Energy.

Secondly, the capacity of the country is being ramped up in the initial, voluntary stage, by means of staging national auctions for biodiesel. Ten such auctions had been staged by the end of 2008, by the National Petroleum Agency (ANP), the motor fuel standards agency (now renamed the National Agency for Petroleum, Natural Gas and Biofuels). These auctions have encouraged bids from potential suppliers who are thereby induced into the market. The state-owned oil company, Petrobras, acts as the buyer of last resort, thereby ensuring that the auctions bear some relationship to market reality.

Third, there is a distinct and explicit social goal to the biodiesel programme – again, learning from the experience of the Proalcohol programme. The Ministry of Agrarian Development (MDA), which is pro-small farmers, has shaped the biodiesel programme with its "seal of social responsibility" meaning that small farmers have to contribute over 50% to a large trader's or distributor's biodiesel. It is only with such a seal that large companies receive tax credits and are allowed to bid at the auctions. The impact has been dramatic, President Lula, who backs this programme as the central initiative of his presidency, claims that 100,000 jobs have been created in Brazil's impoverished northeast region through growing oilseeds (mainly castor oil).This is backed by data from the MDA showing that since the launch of the programme, just over 200,000 small family-owned farms have been induced into growing oilseeds. Moreover the favoured oilseeds are castor oilseed and palm oil (from a variety of native Brazilian species), rather than soybeans that are grown in the centre and southeast of the country. This is in addition to the 500,000 rural jobs maintained by the Proalcool program, plus the 500,000 jobs indirectly linked to rural alcohol production.

Fourth, Brazil is backing a wide variety of oilseeds in these early stages of the programme to see which ones turn out to be best in a tropical country (and bearing in mind that European experience is confined exclusively to rapeseed and United States experience to soybean). Certainly, output is currently dominated by soybean and palm-oil, but cottonseed and castor oil are also picking up, under the influence of the MDA's social inclusion or rural smallholder development strategies. New candidates are coming on to the scene, such as the wonder oilseed, Jatropha curcus, widely utilized for biodiesel in India.[6] There are as well conventional but under-utilized sources such as beef tallow, obtained from slaughterhouses. The broader Brazil's scope of oilseed culture is, the more it is able to take advantage of changes in world prices for these vegetable oil commodities, switching between them. Thus, it is a smart latecomer strategy to invest in variety at this early stage of the biodiesel industry. The oilseed varieties in use in Brazil are shown in table 1.

Note that these four central features of the programme are driven by four Ministries, all in the pursuit of highly creative latecomer strategies: the Ministry of Mines and Energy, backing renewable energies generally; the ANP, safeguarding standards and conduct the auctions; the MDA, launching a new land reform programme with the biodiesel

[6] Jatropha curcus grows under harsh conditions; it is a perennial that can be harvested regularly; and above all it is inedible, meaning that its cultivation will never be seen as a threat to food supplies.

Table 1. Biodiesel and Brazilian vegetable oil sources

	Castor oil	Sunflower	Soy	Palm	Cottonseed
Crop yield (kg/ha)	1,500	1,500	3,000	20,000	3,000
Oil contents (Per cent)	47%	42%	18%	20%	15%
Oil yield (kg/ha)	705	630	540	4,000	450
2005 production in Brazil ('000 cubic meter per year)	90	23	5,600	151	315

Source: Petrobras.

projects, in its direct appeal to "social inclusion" as a national goal of the programme; and the Ministry of Agriculture, promoting a wide variety of oilseed crops and not just soybean. The success of the programme to date indicates successful collaboration between these four ministries.

This Brazilian strategy stands in marked contrast with the cautious approach to biofuels and bioenergy development advocated by NGOs such as Oxfam (2008), which continue to see biofuels as agents of lopsided development or even of under-development. As Oxfam puts it:

> For poor countries that tend to have comparative advantages in the production of feedstocks, biofuels may offer some genuine development opportunities, but the potential economic, social, and environmental costs are severe.
>
> Oxfam recommends that developing countries move with caution and give priority to poor people in rural areas when developing their bioenergy strategies (Oxfam, 2008, p. 4).

This is of course precisely what Brazil has done. But Brazil does not assume that merely allocating land and identifying "rural groups" is enough to grow a new industry – as is apparently assumed by Oxfam. Instead, it requires careful nurturing and the building of institutional support. This is the best defence that countries of the South can mount to the threat of invasion into their nascent renewable energy and bioenergy

industries by TNCs from the North. There is no magic formula by which such companies can be utilized without letting them dominate an industry – as successful cases of development such as Singapore, and now increasingly China itself, can demonstrate.

The fact that biofuels attract a hostile press in the advanced countries of the North should be seen as an opportunity for the countries of the South – provided they can secure some form of recognition, or certification of the sustainability of their bioenergy efforts (Van Dam et al., 2008). One way to move towards such certification in the North for biofuels grown in the South is through a Biopact.

4.10 A Biopact between South and North could break the world trade logjam

Will biofuels unleash a new round of protectionism on the part of the developed world, to rival the trade barriers already erected against foodstuffs? Already, there is substantial momentum behind the enactment of subsidies to encourage production of ethanol in northern temperate climates – from corn in the United States and from sugar beet in Northern Europe – where the costs of producing the final product are far higher (two to three times) than in Brazil or India. It would make so much more sense for the developed world to produce ethanol on a small scale for their own energy security, and import the bulk of their supplies from tropical countries in Africa, Asia and Latin America. The United States, for example, operates a tariff of $0.54 per gallon against ethanol imports, at the behest of corn-belt ethanol producers, in addition to the substantial subsidies paid by state and federal government programmes and tax breaks offered to these producers (dominated by giants such as Cargill and ADM). If countries of the North were persuaded to end subsidies to their own domestic producers of bioenergy feedstocks (such as corn), then the major source for the inflation of food prices worldwide would be addressed.[7]

It is trade between the South as producer of biofuels and the countries of the North (i.e. the OECD) as consumers of biofuels that will finally make the difference. There is an historic opportunity to achieve a global trade agreement, that would open the markets of the North to products from the South, subject to tropical countries agreeing

7 Again, the debate over the impact of biofuels production on food prices reflects practices in the countries of the North rather than those of the South. For a balanced presentation of the issues, see the report by DEFRA (2008).

to Codes of Practice that ensure that biofuels be produced sustainably and responsibly. Such a comprehensive agreement might be termed a Biopact (Mathews, 2007). It is the countries of the South that need to take the determined diplomatic initiative to propose such a Biopact to the countries of the North (e.g. those grouped in the OECD) and to do so quite consciously as a step towards resolving the long-standing impasse in world trade issues where the markets of the North have been closed to primary commodity exports from the South.[8] Here, the WTO has an enormously important role to play, in ensuring that the coming biofuels century is not wrecked at the outset by short-sighted protectionist measures enacted by the developed world to obstruct global trade in biofuels.[9]

5. Conclusion: energizing industrial development

Energy options are now an essential component of a country's development strategy. Building a development pathway around renewable energies and biofuels has the potential to unlock a chain reaction of favourable activities: creating a successful national and export industry; promoting a space for local entrepreneurship and particularly rural entrepreneurship; creating an advanced science and technology-based industry that will create an incentive to stay abreast of technological developments in biofuels and bioreactors generally; demonstrating the significance of government policy in creating the right conditions for the industry to develop; and breaking down resistance to other renewable energy industries, like solar and wind, thus putting a country onto a development trajectory less dependent of fossil fuels.

Developing countries, in addition to all these advantages, can kick-start their own process of industrial development by focusing seriously and urgently on the building of a biofuels industry and on all its concomitants, such as the promotion of entrepreneurship, exports and

[8] See the letter from John Mathews to the *Financial Times*, "Biopact could end deadlock on Doha", 23 April 2008.

[9] A group of energy and biofuel experts met at the Rockefeller Foundation's Bellagio conference site on Lake Como in March 2008 to discuss these issues, and drafted a Consensus document calling for such a Biopact between countries of the South and of the North. The Sustainable Biofuels Consensus placed emphasis on a Biopact embodying the most stringent certification procedures for ensuring sustainability of the biofuels being produced. For the text of the Consensus, see: energybulletin.net/43021.html

cluster development. But the opportunity opened up by past dithering on the part of developed countries over whether to get behind renewable energies and biofuels in a big way is likely to close soon. If the World Bank were to promote biofuels industries for developing countries as a major priority, and if this commitment were matched by initiatives in developing countries themselves to build renewable energy industries, then the results could be dramatic. Not only would there emerge unexpected solutions to peak oil and greenhouse gas emission problems, but the countries concerned could energize their own development strategies.

The success of developing country programmes to harness renewable energies and biofuels for industrial development efforts as well as energy security, depends on their capacity to mobilize the technological capabilities involved – exactly as foreseen by Sanjaya Lall. In his numerous studies on this theme, such as the work conducted with UNCTAD and with UNIDO where I collaborated with him, the key to progress was always seen to be the building of technological capabilities that would enable countries to become players in the industrial dynamics of the time. The time now calls for the building of technological capabilities in renewable energies and biofuels, as keys to non-fossil fuelled development. Sanjaya would no doubt be fascinated to see these developments, and would be gratified by the role that his insights will play in bringing them to a successful conclusion.

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