Greening of Development Strategies

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While the evidence accumulates that many countries are fashioning aspects of green development to complement their 'black, fossil-fuelled industries, the case for a wholesale adoption of green development strategies is seldom made. Instead it is frequently assumed that green development can only follow black development, and that it is only for countries that have reached a certain income level. In this paper the argument is reversed, and the case for a greening of development strategies even in the case of the poorest countries, is mounted. The advantages that can flow from a greening of development are identified and strategies for capturing these advantages, based on notions of leapfrogging and capturing latecomer advantages, are developed. The case for greening is independent of issues of global warming, but the fact that green development strategies combat climate change, and ameliorate conditions for the least advantaged, are in their favour.

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JEL Classification: O14, O16

I. Introduction

The countries that have achieved wealth today industrialized through a common pattern, involving access to energy sources of unprecedented power (steam power, then electric power, based on fossil fuels), access to resources at unprecedented levels of exploitation (largely through exploitation of extra-territorial colonial possessions), and the targeting of

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finance to facilitate the construction of a vast industrial infrastructure (through new industrial banks such as the Deutsche Bank). Latecomers such as the East Asian countries of the past half-century (Japan, then Korea and Taiwan and Singapore) faced a situation where they could deploy the same industrial model but exploiting latecomer advantages, developing novel strategies for the building of their own industrial corporations and accessing export markets through cost-driven mass production capacities. Now in the 21st century we find industrial giants like China, India and Brazil likewise looking to industrialize and bring their vast populations up to something comparable to first world standards, and looking to that same conventional industrial model as the means to do so.

The problem — or inconvenient truth — is that the conventional industrial model will not 'scale' to satisfy the aspirations of these 21st century industrial giants — let alone the aspirations of the many countries in Africa, South and Central America, South and Central Asia that are looking to upgrade their wealth and income through industrialization. The earth's resources are already overstretched by the actions of the 'first' industrializers, which have led to around 1 billion people enjoying a prosperous life style. To bring up to 6 billion people to a middle-class lifestyle by mid-century (as foreseen by economists such as Michael Spence) would call for a sixfold expansion of these activities, with intensity multiplied by the accelerated pace of change. China and India are both courting disaster, from rising oil prices, increasing vulnerability to a handful of oil suppliers and exacerbating tensions with existing industrialized countries and their 'carbon lock-in.'

The answer to this conundrum is not for China and India to turn their back on growth and industrial development, but to build a new kind of industrial system and a new kind of development pathway. This alternative is what is known as the 'green' industrial system (green growth, green development) — and the current interest of the UN and all development-oriented agencies is to ascertain to what extent a green industrial system really is being fashioned and implemented in these countries, and to what extent it may represent a fresh option for the many developing countries coming after them. Such a green development strategy is the **inevitable choice** for China and the BICs because these countries can leapfrog to the lead with green technology and because they have such huge populations for which the traditional model would not scale. Chinese scholars like Hu Angang see such a development as the 'inevitable choice' for China — and by extension, for the rest of the

developing world.[1]

There has been a stream of recent reports extolling green growth as a development strategy as well as a favourable turn by newly-industrialized countries such as Korea.[2] But the case is generally made in terms of the world's collective interest in green outcomes. In this paper I am concerned instead with the benefits that accrue to the individual countries that pursue a green development (GD) strategy.[3] While the term 'green development' or 'green growth' is subject to various interpretations, the key ideas are that an industrial system based on something other than fossil fuels and extensive resource throughput is being constructed — with small initial steps but always aimed at minimizing the fossil-fuelled footprint.[4] The goal of such an approach is to build energy systems that can increasingly live off their renewable energy income, and materials processing industries that tend to minimize virgin resource inputs. Both aspects have profound implications for countries' development prospects.

Two factors are taken into consideration by countries that deem their future to be green. The first is that the cost reductions (the learning curve, or experience curve) are being driven more rapidly as China enters one green business after another — **making it easier for emerging developing countries (EDCs) to enter these sectors as well**. The upfront costs are being steadily reduced — as discovered by countries that are installing solar PV panels in villages such as in India as a means of providing households with electric power prior to being connected to the grid.

The second factor is that EDCs stand to benefit from latecomer ad-

[1] See Spence (2011) and Hu (2006a, 2006, 2011).

[2] See recent reports from the UN (2012); UNEP (2011), ADB/UNEP/UNESCAP (2012), OECD (2011), WB (2012) and for more theoretical treatment by World Bank economists, Hallegatte *et al.* (2012).

[3] See Mathews (2007a, 2007b, 2008) for early statements of this view. Likewise the "ecological modernization" perspective has argued that ecological reforms such as a shift to renewable energies can carry economic and industrial benefits. See Mol and Spaargaren (2009) for a recent overview.

[4] Recent contributions to the debate over 'green growth or 'green development' express a caution that needs to be added to the more optimistic reports from UNDP and other agencies. They include those by Schmalensee (2012), where he focuses on the long-term costs of such a strategy with little regard to the benefits. See van der Ploeg and Withagen (2013), where they note the difficulties of launching green growth strategies at a time of economic crisis, and Barbier (2012) who notes the failure of the G20 summit in Mexico in late-2012 to pay any more than lip-service to policies favouring green growth.

vantages and can pursue **leapfrog strategies**.[5] These work to these countries' advantage of in general, but in the case of green investments there is a decided advantage for EDCs in that the developed countries suffer from carbon lock-in, and exhibit a marked reluctance to invest in green businesses, even when the technologies are available. But the developing countries can take advantage of the underlying trend in techno-economic paradigm shifts.

Indeed a strong case can be made that there have been several such techno-economic paradigm shifts since the Industrial Revolution, and that latecomers have been able to deploy leapfrog strategies to enter the global industrial system as each new shift asserts itself. Thus the most recent (the fifth) was getting under way in the late 1970s and 1980s, and involved the introduction of microelectronics, integrated circuits and information technology (IT), creating space for newcomers to become involved. Prior to that, there was the rise of mass production and the oil-based automotive industry (early 20^{th} century), and prior to that the third such transition (steel, chemicals and electric power), the second (iron, steam and railroads) and the first (factory production). Now there could well be a peaking of the fifth techno-economic transition and the possibility of a secondary surge, lasting from around 2012 to 20120, driven by investments in renewable energies and resource efficiency — where EDCs can play a leading role while developed countries are having to deal with their carbon lock-in problems.[6]

The best leapfrog strategy of all is to utilize innovative forms of finance that tap into the previously untapped institutional investors' capital market, to finance 'at scale' investments in green technology in EDCs. So far, investments in green technologies in EDCs have been discussed in terms of public finance (derived ultimately from tax revenues) — yet it is clear that private sector funding will be needed to reach the scale of billions, and trillions of dollars of investments being mentioned by the IEA as needed to effect a shift in the global energy regime. The fact is that institutional investors are looking for sustainable ways of diversifying their portfolios away from carbon-intensive investments (as discussed in several recent OECD reports, discussed below), while the best prospects

[5] See the classic paper on leapfrogging by Perez and Soete (1988), and its application to the case of renewable energies (Walz 2010).

[6] On the successive technoeconomic shifts that have accompanied changing industrial drivers, see Mathews (2013) for a recent assessment. Zysman and Huberty (2011) likewise argue that green growth will move 'from religion to reality' only when energy reforms become systemic and pervasive.

for such investments are to be found in the EDCs. Here is the possibility of a major match, to be effected by development banks that singly and together can issue the required green bonds to channel investments at scale to renewable energy and other green projects — bypassing the players in the fossil fuel economy that effect and prolong carbon lock-in. Here indeed is a powerful way of framing the green development industrial policy challenge.

Greening of development strategies needs to be seen in this light — not as a luxury that few countries can afford, but as a necessity to avoid energy insecurity and the potential for disastrous resource wars as countries are forced to struggle over access and the fuels become more and more insecure in supply. It is smart policies and particularly tapping into novel forms of financing that bypass fossil fuel interests which hold the key to further development — as may be observed in many industrializing countries, and reflected in reports from multilateral agencies. This is the starting point for the argument developed in this paper.

II. China, India, Brazil: green and black development

China (and India and Brazil) have been taking important initiatives in new green growth strategies. **China** has been building its Renewable Energy (RE) industries as fast as it can, and so far with notable success. In wind power, for example, China has risen from a marginal position in 2005, doubling its wind power capacity each year, to the point that it was world leader in terms of production of wind power generators and size of domestic wind power market, by the end of 2010. By 2010, China was adding more power generating capacity in hydro, nuclear and 'new' renewables than in conventional thermal power stations — an extremely important milestone, for China and for the world. Its 12^{th} Five Year Plan has notable goals of raising these levels. In terms of electric power, China's leadership, in the form of the planning body — the National Development and Reform Commission (NDRC) — anticipates that electric power capacity will be rated at 1.6 TW by 2020, and of this, 500 GW (0.5 TW) will be generated from renewable sources — hydro, wind, solar — *i.e.* renewables accounting for 30% of electric power capacity by 2020.[7]

[7] On these targets, see Mathews (2011) and Mathews and Tan (2013). On China's green development strategies, see the chapter on China in Zysman and

India is likewise pursuing an advanced renewable energy strategy, even as it builds up its black energy supply systems to feed its growing manufacturing and industrial might. In August 2011, India's installed electric power capacity stood at 182 GW (compared with China's 1000 GW), of which 65% is generated from conventional coal-fired plants, 22% from hydroelectric sources, and 3% from nuclear, plus 10% from renewable sources (mostly wind and biomass). India is now going through the same kind of intensive expansion of its coal-fired power generation system — a 'black development' pathway — as China has done for the past decade. But in the case of India this black development pathway is stalling because of severe problems in getting coal to the users (to be discussed in a moment). In such a situation India has everything to gain by seeking also to pursue an industrial strategy of building its green energy sources as rapidly as possible. This it is doing on all the fronts available — solar, wind, bioenergy. Like China, India is developing five-year targets for renewable energy development. In 2010 India had installed wind power capacity of 14.6 GW (exceeding the 11^{th} Five-Year Plan target of 10.5 GW). In 2009, the government announced an ambitious $19 billion plan to produce 22 GW of solar power by 2022 (*i.e.* by the end of the 13^{th} FYP), up from 2 GW today — the *Jawaharlal Nehru National Solar Mission*. Institutional innovations include the Indian Renewable Energy Development Agency (IREDA) as well as a Ministry of New and Renewable Energy (MNRE, formerly Ministry of Non-Conventional Energy Sources), ensuring that renewables receive maximum political and financial support.

India's problems with getting sufficient power from its chaotic coal supplies provide an object lesson in why renewables make sense for all developing countries. India's electric power supplies are endlessly frustrating for businesses, with blackouts and brownouts common, even daily occurrences. Vikas Bajaj described in vivid detail what the effects have been on India's economic prospects in an influential article in the *New York Times* in April 2012.[8] The result for India has been a loss of

Huberty (2011).

[8] Bajaj described how India's power problems are bad and getting worse, because of the mistakes made in exploiting domestic coal reserves. Annual industrial growth has diminished to 7% over the past two years largely due to this problem.

The story comments:

> India has long struggled to provide enough electricity to light its homes and power its industry around the clock. In recent years, the government

industrial output — with the growth rate reduced from 10% in 2010 to an estimated 7%, largely attributable to losses of power and fuel supplies. Plans for coal-fired power stations continue to be promoted, but it would make so much more sense for a huge country like India to break this 'carbon lock-in' and go instead for a fresh approach.

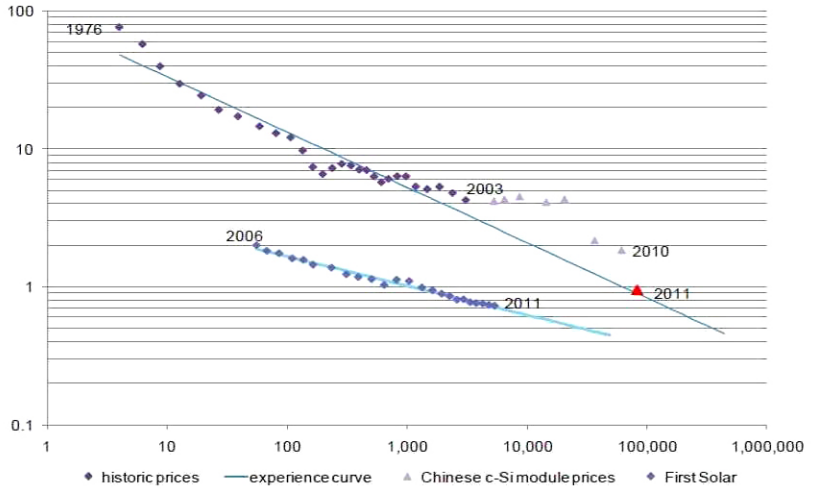
The developing country that has managed its ongoing transition to a green economy is **Brazil**, thereby setting a different kind of benchmark for other EDCs. Recent government initiatives in Brazil have lifted 40 million people out of poverty, and the country is focused on green development through the Rio + 20 conference on sustainable development envisaged for 2012. Brazil is already a major user of renewable energy sources, meeting 85% of its energy needs from renewables, both in the form of hydropower in the electric power sector and of biofuels in the transport sector. According to Brazil's 2008 National Energy Balance, total electric power capacity was just over 100 GW (around $1/10^{th}$ of China's capacity), of which 78 GW was hydropower, 23 GW conventional coal-fired plants, 2 GW of nuclear and so far only a small 414 MW (0.4 GW) of wind power. This puts Brazil in a uniquely favourable position amongst emerging and developing countries, in that it is less exposed to energy insecurity and international pressures — while maintaining a strong incentive to build its own energy industries as the core of its development strategy. (Brazil's biofuels programs are described below.)[9]

All these unprecedented investments by China and the BICs in development of green power sources are driving down costs, not just for China but for all developing countries. The issue is: can the costs of shifting to a renewable energy pathway (as called for in the UN *Secretary-General's Sustainable Energy for All* program) be moderated so that developing countries are enabled to enjoy the advantages of shifting to such sources, while not paying a penalty in terms of excess costs and reduced competitiveness. Now, data supports the argument that the costs of renewables are relentlessly coming down (due to the learning curves)

and private sector sought to change that by building scores of new power plants. But that campaign is now running into difficulties because the country cannot get enough fuel — principally coal — to run the plants. Clumsy policies, poor management and environmental concerns have hampered the country's efforts to dig up fuel fast enough to keep up with its growing need for power.

See *New York Times*, 19 April 2012.

[9] See Frischtak (2011) for a recent elaboration of Brazil's GD strategies.



Source: BNEF Bazilian *et al.* (2012), Fig. 1.

FIGURE 1
PHOTOVOLTAIC MODULE EXPERIENCE CURVE, 1976-2011

while the costs for fossil fuels can only be expected to rise (driven by rising demand from the newly developing countries). This is the factor that is going to give latecomers who build their industrial strategies on green development a decided advantage. And it is China's arrival as a major industrial power that is driving down the costs of renewables, making them accessible to all developing countries. Consider the situation for solar photovoltaic power (PV). The Figure 1 reveals that the **costs for solar PV are falling at 45% per year**, and that grid parity will be achieved (or is already being achieved) by 2015.

The data that now need to be considered in framing any development strategy are those relating to the falling costs of power produced from renewable sources. The Bloomberg/New Energy Finance team in London have recently produced a White Paper on 'Re-considering the economics of photovoltaic power' (Bazilian *et al.* 2012) where they make some very important points.

In this chart, based on and updating the chart on experience curves contained in the recent IPCC report on Renewable Energies (IPCC 2011), the overall experience curve is shown in the upper blue line, indicating that costs had reduced to the long anticipated point of $1 per watt by the end of 2011 and bringing solar photovoltaic (PV) power within the

range of almost all emerging and developing countries. The years immediately preceding this show that costs hovered for several years (2004 to 2008) at around four times this level ($4/W) — a phenomenon now understood to be due to suppliers being able to command feed-in tariff rates locked at these levels, while restricted silicon supplies meant that there was little price competition. It was this that led many to believe that costs of renewable energies would always exceed those of conventionally fuelled power. But as silicon supplies became more flexible, so manufacturers reduced their prices, which in turn reduced input costs for solar cell producers, and their prices fell as well. The bottom blue line represents the cost curve for thin-film solar cell producers, dominated by the US firm First Solar. Because TF PV cells utilize much lower quantities of silicon their costs have always been lower — but are not yet enjoying the economies of scale of amorphous silicon cells (the dominant technology, where China has excelled).

The message for developing countries is clear: the costs of solar PV cells are falling at around 45% per year. In many EDCs with above-average insolation (which means countries right across the tropical belt, including the majority of EDCs) this means that producing electric power from solar PVs is now cheaper than producing power from, *e.g.* stand-alone diesel generators. Thus the way is opening to the realization of the UN Secretary-General's *Renewable Energy for All* program.

III. Motives for a green development strategy

These considerations compel a reconsideration of development strategy. Even less than a decade ago, it was possible for the World Bank and other agencies, such as the multilateral banks, the OECD Development Centre and journals like *World Development* to discuss development with zero reference to energy or to the negative consequences of dependence on fossil fuels (and particularly fossil fuel imports). A 'business as usual' fossil fuel-based and resource-intensive development pathway was simply assumed — it was beyond discussion. Now the situation has changed, and it is the result of a 'perfect storm' of three inter-related trends or issues — that of energy security, economic security and environmental security. A 'business as usual' (BAU) development pathway now appears to be fraught with danger.

A. Energy insecurity

A BAU development pathway creates severe energy insecurity, as fossil fuel imports would become more and more contested, their costs and prices rise, and extreme dependence on imports become increasingly problematic. Small developing countries such as those in the Caribbean (*e.g.* Jamaica and Trinidad/Tobago) are actually 100% dependent on oil imports for their energy — while the islands exist in the midst of natural resource abundance.

B. Economic insecurity

The BAU development pathway creates economic insecurity through the inevitability of rising prices for energy and resource inputs, by contrast with the absence of extra costs for the 'fuel' involved in tapping of renewable resources. Of course the technology for tapping into renewable flows of energy, or for recycling resources through industry, is not cost-free — but its short-term costs need to be weighed against longer-term security.

C. Environmental insecurity

The debates over global warming are just the most pointed of the growing awareness of the environmental security created by reliance on fossil fuels and high resource throughput development model. It is in fact becoming clear that it will be the poorest who suffer most from the effects of global warming and climate change — and so there is even more incentive for the poorest developing countries to lead the transition to a green development pathway.

To these points there need to be added others such as the impossibility for developing countries today to secure resources through military conquest, as was open to the European and North American countries in their earlier experiences of industrialization. Thus BAU development is simply not available, or generates such extreme insecurities, that an alternative has to be found. And such an alternative is being found, as China *et al.* scale up their clean technology GD pathways as fast as, or faster, than the conventional fossil-fuelled black development trajectory. Which wins is obviously a matter of great importance.

IV. Reasons for the Efficacy of Green Development Strategies

In addition to avoiding the problems or impossible options created by the BAU development pathway, an alternative based on green development offers many advantages to developing countries that look to raise their living standards through industrialization and industrial catch-up with the West. Assuming that the strategy is directed towards building cleantech industries, and not just cleantech markets, we can identify at least nine inter-related advantages of moving towards GD pathways.

A. Renewable Resources are Available to All

A GD pathway will be based on technologies that capture renewable flows of energy or reduced resource input requirements, and thus will be based sustainably on endlessly renewing resources. These resources are abundant — particularly in tropical developing countries — and widely dispersed, meaning that countries can frame their strategies without regard to accidents of geography. A GD pathway provides a secure and sustainable foundation for a development strategy — as opposed to the insecurities, costs and foreign dependence associated with the BAU pathway. Since the renewable resources are widely dispersed and hence open to all, they do not privilege some countries or regions by geographic accident. And since the capture of renewable energies and the recycling of resources calls for sophisticated technologies, the latecomer pursuing them is required to think in terms of development as the building of technological capabilities complementing the diffusion of technologies — rather than just on extracting wealth from quarries, mines or plantations.

B. Green Development is Biased towards Rural Employment Generation

Green development (GD) pathways will bias countries to sustainable income generation, employment generation and particularly rural employment generation and protection, thus easing the transition from rural to urban based manufacturing. Social and economic polarization can therefore be mitigated by GD strategies — while enjoying all the advantages of urban, manufacturing-based development.

C. Cost Disadvantages can be Overcome

GD pathways incur initial costs which can exceed those associated with cheap fossil fuels — but offer medium — and long-term sustainable advantages. The short-term costs can be met by smart finance and tax relief policies. The medium — to long-term advantages are securely based on learning curves that relentlessly reduce costs, as opposed to rising costs of fossil fuel and resource inputs. This is a far more advantageous development strategy than one based on imports of fossil fuels, no matter how cheap they may be in the short term.

D. A GD Pathway Offers Unlimited Catch-up and Technological Leapfrogging Possibilities

Capture of catch-up and leapfrogging opportunities lie at the core of all successful development strategies. Whereas the East Asian countries such as Korea were able to catch-up in prevailing sectors such as electronics, semiconductors and telecommunications, today's developing giants such as China, India and Brazil need to focus on new technological sectors, of which renewable energies and industrial ecology (transforming one firm's waste into another's inputs) will prove to be most capable of generating industrial advantages. Brazil provides many examples of innovations underpinning biofuels development (discussed below).

E. Green and Black Development Complement Each Other

A GD pathway offers resource-abundant countries (*e.g.* most tropical developing countries) a sensible and logical path forward by tapping initially into their own resources and seeking investment to add value to these resources as a first step in successful industrialization. Thus countries such as Mozambique, where a long history of terrible civil wars delayed development, has over the past decade recovered its economic momentum and is actually building on extensive fossil fuel resources to create a modern economy peopled by modern firms, generating employment and exports. This is done in 'black economy' terms. But at the same time it is providing a means to finance green development initiatives, including hydroelectric, solar and wind power initiatives, and the beginnings of a new front in agriculture devoted to bioenergy and biofuels.[10] These considerations are the very opposite of those underpin-

[10] On Mozambique's energy choices. See Cuvilas *et al.* (2010).

ning the notion of the 'resource curse' — where development of a mono-resource (usually by foreign capital) is allowed to outweigh all other development options.

F. GD Generates Export Earnings and Reduces Import Charges

A GD pathway offers the prospect of generating a double dividend in the form of reducing import costs and generating export earnings, while building business experience. The generation of export earnings creates the funds needed to buy equipment and enter into modern manufacturing activities, thus building a wave of development across the economy. The reduction and avoidance of costs incurred through fossil fuel imports again releases further funds for investment in domestic development, and reduces costs for domestic industry which is otherwise made uncompetitive abroad through high fuel and power charges (not to mention power blackouts and brownouts). Green development through circular economy initiatives (*e.g.*, recycling and industrial ecology linkages) offer the prospect of reduced dependence on resource imports and strains on the balance of payments which can drag down countries aspiring to middle-income status.

G. A GD Pathway Generates Increasing Returns through Cross-linkages

GD offers numerous and growing possibilities for building cross-linkages that generate increasing returns and underpin an economy's growth. As opposed to resource extraction activities, which stand alone with few (if any) connections to the domestic economy, the pursuit of renewable energy and cleantech industries brings to the fore the construction of value chains and their cross-linkages. Policies designed to create domestic supply chains come to the fore. This generates a renewed emphasis on what (in development circles) used to be called the '**big push**' — meaning that development could be expected to succeed only when several industries providing markets for each other were developed simultaneously.[11] Now the same idea can now be translated into green development terms. Criss-crossing value chains constitute the skeleton of a successful industrial economy, and a bias towards clean technology industries can create the momentum for such wealth-generating linkages.[12]

[11] See Rosenstein-Rodan (1943) for the classic statement of this position.

H. Insertion in Global Value Chains

A GD pathway offers opportunities for local firms to embed themselves in global value chains and to create their own local supply chains — as witnessed in the domestic value chains being created in China and India for solar cell and wind generator construction, and in Brazil for bioethanol and now biodiesel processing. A GD pathway likewise reduces the prospect that developing countries will be locked in to a single monoculture (*e.g.* resource extraction) given that it is technologically based rather than extraction based, and offers opportunities for local firms.

I. GD Provides a Bias towards Innovation

Finally, a GD pathway creates a bias towards innovation — rather than simply passively accepting and riding on innovations generated elsewhere in resource extraction industries. The focus on technology and technological capabilities acquisition is just what a developing country needs. The bias towards keeping up with renewable technologies as they are developed around the world puts the developing country in good company — and sets it up for waves of technology diffusion (encouraged through public research institutes such as ITRI in Taiwan or EMBRAPA in Brazil) that drive the development trajectory, and prevent it from being 'stuck' at any point or level.

These are all potential advantages that are available to latecomers — provided they develop smart strategies for taking advantage of these opportunities, and for getting around the barriers raised by fossil fuel dependence and 'carbon lock-in,' and are prepared to invest resources in their own development of technical capabilities and innovation. And they are available to countries at all levels of development — from the poorest and least-developed (provided they have state institutions that can act to shunt the economy onto a green trajectory) to those at mid-level where aspirations to become integrated in global value chains are strongest.

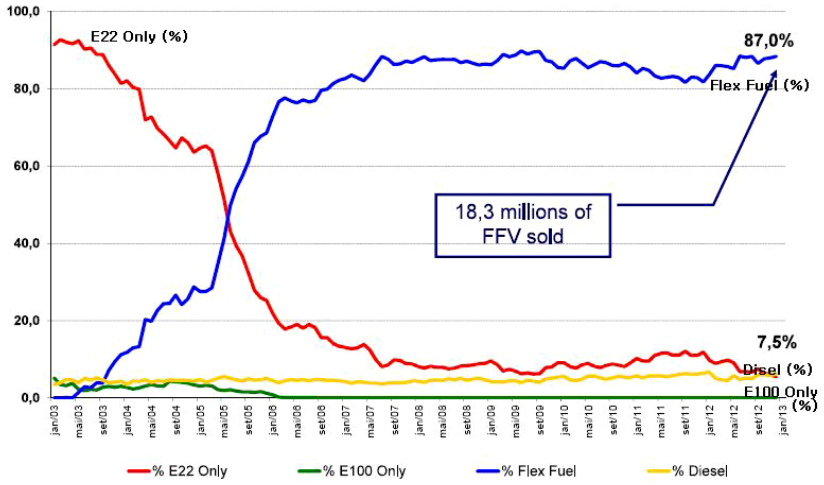
Take the case of Brazil and its very successful biofuel programs as an illustration how developing countries can capture latecomer advan-

[12] I say 'can create' rather than 'does create' because obviously the cross-linkage advantages are secured only by smart policies that seek to create such linkages; in the absence of such policies, critiques such as those by Resnick *et al.* (2012) carry weight.

tages in renewables. Brazil is a developing country that has not faced the problem of fossil fuel dependence. It has been able to build an electric power system based largely on hydropower (which is still being extended, controversially, as witnessed by the latest loans from the BNDeS to the Belo Monte dam); an urban private transport system based largely on home-grown and processed ethanol and (now) biodiesel; and thanks to oil discoveries an export platform for oil and gas that earns export revenues for development across the economy. In these ways Brazil stands as a model for all tropical developing countries — particularly those in Africa like Angola and Mozambique that also have oil, gas and coal deposits and abundant solar and water resources.

Brazil developed its bioethanol program through utilizing its own domestic resources (sugar cane plantations fed by rainfall without the need for irrigation) and technology. Through the National Alcohol Program, dating back to the military dictatorship in the 1970s, a market for ethanol was mandated as a means of saving oil imports. Domestic producers were encouraged as well as local suppliers of equipment (such as Dedini) thus creating an entire value chain on the supply side. On the demand side there was initial resistance because cars had to be either ethanol-adapted or conventional, and consumers that switched to ethanol-only vehicles in the 1980s were then burned as the global price of oil fell and ethanol became non-competitive. But in the 2000s Brazil's ethanol program was revived with the strong support of the government, of the national oil company Petrobras, and with the demand-side innovation (developed in Brazil) of flex-fuel vehicles, which could run on ethanol, gasoline or any combination of the two. The rapid rate of penetration of flex-fuel vehicles into the Brazilian automotive sector, since their introduction in 2003, is revealed in Figure 2.

The success of the Brazilian bioethanol program (now being replicated in the case of biodiesel) is not a conventional story of import of product, followed by import of equipment and insertion in global value chains in order to access technology. Rather, Brazil was already a sugar producer at the world frontier in terms of technology and world leader in terms of costs — and was able to carry these initial advantages across to the production of ethanol. Technology for ethanol production was initially imported and rapidly domesticated (leading to formation of domestic equipment suppliers such as Dedini) and then diffused rapidly through the R&D efforts of the national R&D institution, EMBRAPA. This was the body (equivalent to ITRI in Taiwan) that maintained a technological watch on global developments, and utilized advanced technological methods for



Source: Presentation by Henry Joseph (ANFAVEA), Brasilia, March 22 2013. (http://www.globalbioenergy.org/fileadmin/user_upload/gbep/docs/2013_events/GBEP_Bioenergy_Week_Brasilia_18-23_March_2013/4.5_JOSEPH.pdf)

FIGURE 2
UPTAKE OF FLEX-FUEL VEHICLES IN BRAZIL, 2003-2005

researching Brazil's sources of comparative advantage, *e.g.* soils suitable for sugar cane cultivation as revealed by satellite surveillance. But these advantages inherent in Brazil's situation would have been reduced to naught had it not been for strong government support in mandating a steadily increasing market share for domestically produced ethanol, and the role of the national oil company Petrobras in acting as primary distributor of ethanol through pipelines and terminals and fuel outlets across the country. Now Brazil is building an entire value chain for production of first-generation ethanol as well as creating companies to usher in the second generation (in competition as well as collaboration with US and European firms). It bears repeating that its success would be all the greater had a free market for biofuels been allowed to develop. To create such a global free market remains a primary diplomatic goal of Brazil in international forums.

V. Barriers Blocking the Application of Green Development Strategies

The barriers standing in the way of countries adopting a GD pathway, with all its advantages, are numerous. The principal barriers are costs, trade barriers, technological barriers, difficulties in raising finance, and the most difficult of all — the intangible barriers known as 'carbon lock-in' (Unruh 2002).

A. Short-term Cost Barriers

The most immediate barrier is that posed by the cost disadvantage — even when costs are falling rapidly, as in the case of solar PV systems. Short-term cost barriers can be overcome through smart strategies — concentrating initially on renewable energy technologies which are closest to grid parity (onshore wind and solar PV) while keeping abreast of those technologies that are coming within reach of grid parity such as solar thermal power and offshore wind. Smart financing arrangements such as climate bonds (particularly if issued by green banks) enable projects to be aggregated so that economies of scale can be captured, further driving down costs. Smart tax arrangements such as a value-added tax that is recouped by projects with domestic content (technically outside the ambit of the WTO but one that can be argued — following the example of China), the withdrawal of historic subsidies on fossil fuels and the creation of short-term and diminishing subsidies on renewables (such as feed-in tariffs) all help to reduce the gap between renewable options and their least-cost fossil fuel alternatives.

B. Trade barriers

The free trade that has been allowed to underpin the success of the global fossil fuels industries has rarely been transferred across to alternative fuels and renewable energies. In extreme cases, there are tariff barriers that directly impede exports from developing countries — such as the import tariff and production tax credit paid in the US to Iowa corn farmers and ethanol producers until the expiry of the trade barriers in 2012 (after many years campaigning by Brazil). The tariff barriers blocking exports from developing countries to the EU remain in place. Meanwhile a global free market in clean technologies, which would help developing countries looking to import such technologies and eventually

exporting the clean products made with such technologies, is now seen as a feasible option — given the first steps that have been taken by the Asia-Pacific Economic (APEC) countries with the commitment to reduce tariffs on 'environmental goods' to below 5% by 2015 — taken at the Vladivostok summit of APEC in September 2012.

C. Technological Barriers

All development strategies turn on the issue of how to secure access to advanced technologies — whether through foreign direct investment involving multinationals, or insertion in global value chains, or through purchase of equipment. The most sophisticated strategy of all is to secure access to technologies via licensing, through payment of royalties to patent holders. But this is hardly a strategy open to most middle-ranking developing countries, and is certainly beyond the capacities of the poorest countries. But every country can follow the lead of Korea or Taiwan in their creation of public research institutes (which would be better labelled as knowledge diffusion institutes) — such as ITRI in Taiwan or KIET in Korea. In the 21st century we now see Taiwan promoting its solar PV industry actively through the same kind of technology diffusion management strategies, involving ITRI in building technical capabilities to be passed across to the private sector, and through building of patent pools (Mathews, Hu, and Wu 2011). Such strategies are open to emulation by all developing countries.

D. Finance

Finance and capital flows remain the biggest barriers to successful implementation of GD strategies by low-income countries. The efforts by Mozambique to create green sectors to complement its development of black, fossil-fuelled sectors, is clearly hampered by insufficient capital and lack of easy access to finance — even from multilateral banks such as the DBSA. While the Kyoto process wrangles over the funding of a Climate Fund of public monies, the far greater resources of the public and institutional investors (pension funds, insurance and hedge funds) which together manage in excess of **$71 trillion**, remain largely untapped. Yet it is abundantly clear that the switch to clean technologies will only occur once private sector finance is mobilized and convinced of the possibility of favourable returns to be generated by renewable energy and resource recycling industries.

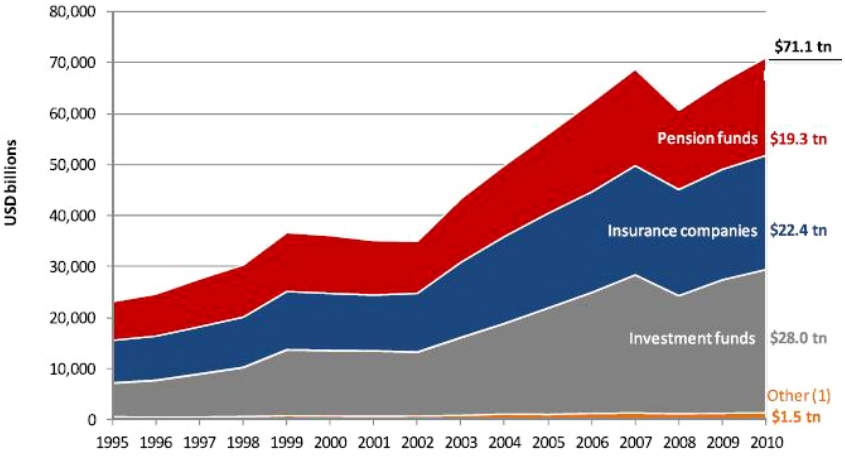
The OECD has addressed the issue of green financing and the role

that institutional investors from the private sector might play, in a spate of recent reports. In the report *Towards Green Growth* (OECD 2011), a review of financing efforts targeted at promoting green growth concluded that funds expended so far (around $11 billion) were simply a 'drop in the bucket' compared with the 'hundreds of billions that would be needed'. The report pointed to the capital markets controlled by institutional investors and the need for 'green bonds' that would appeal to such a market. The OECD issued a second report in 2011, specifically on the role played by institutional investors, where green bonds were again endorsed as a means of channelling large sums to the green economy sectors.[13] The point of financing such green initiatives from the bond markets is that issuing banks can package a portfolio of projects into a bond at the scale required to attract serious private investors such as pension funds and insurance companies (institutional investors). Until such scaling, or aggregation, is accomplished, the financing of green initiatives — particularly those being developed in the poorest countries — will remain at a substandard level, and fail to tap into the vast sums that are in reality available.

Perhaps the strongest statement from the OECD in favour of targeting the bond markets and institutional investors to drive investments in green infrastructure, in both developed and developing countries, is found in the working paper issued by the Finance, Insurance and Private Pensions Department in August 2012 (Kaminker and Stewart 2012). Here the scale of investment in renewables in the decade 2010 to 2020 is estimated at $6.3 trillion (*i.e.* well beyond anything envisaged through public funds), while the size of the potential investment pool is definitively estimated at $71.1 trillion in 2010, and growing rapidly, drawing from investment funds, insurance companies and pension funds (Fig. 3). In this paper sustained attention is given to the barriers standing in the way of the deployment of such funds at scale in accelerating the uptake of renewable energies and clean technologies around the world.

So a big 'policy issue' to be confronted in developing countries as they grapple with green growth matters is how to fashion their projects in such a way that they will scale up and attract interest from large institutional investors, who will provide the key to low-cost funding —

[13] In the 2011 report the role of pension funds in investing in new vehicles or instruments targeted at green projects was canvassed (Della Croce, R., Kaminker, C., and Stewart, F. 2011). On the general issues involved, see Mathews and Kidney (2010, 2012)



Source: Kaminker and Stewart (2012), Fig. 2

FIGURE 3

INVESTMENT POOL MADE UP OF INSTITUTIONAL INVESTORS, 1995-2010

bringing the renewable energy projects within the reach of even the poorest countries. As the Della Croce report notes, such initiatives have to be taken with the greatest caution, and with the full support of existing development banks, multilateral development banks, and multilateral insurance agencies such as the Multilateral Insurance Guarantee Agency (MIGA) of the World Bank.

E. Industrial Inertia — Carbon Lock-in

The biggest barrier of all is that posed by the accumulated infrastructure, practices, policies and standards that favour the fossil-fuelled industrial sectors — the complex of issues that has aptly been called 'carbon lock-in' (Unruh 2002). Without active intervention by strong, policy-guided government ministries, the industrial infrastructure (hard and soft) of the fossil-fuel system will prevail. Without active intervention to break such locked-in structures and processes, it will be impossible to move to a new, green development trajectory. This is why favored policies such as carbon taxes and carbon markets (*e.g.* cap and trade schemes) are illusory; for most developing countries they would have zero impact. (Think of Mozambique with minimal heavy industrial activities other than fossil fuel extraction and export — what use is a carbon tax in such

a situation?) In such situations it is determined government intervention to set new norms, standards and market penetration levels — as actively practised by China with its 12^{th} Five Year Plan and accompanying regulations; by Brazil with its market norms for adoption of biofuels; and India with its market norms under the Jawaharlal Nehru National Solar Mission.

It is **strategy**, as developed and implemented by a strong state guiding hand, that enables countries to surmount/evade these barriers and reap the potential advantages associated with green development.[14] Nobody hands countries development achievements on a plate — despite the evidence of countless aid agencies claiming to do so. What they are in fact doing is perpetuating dependence — whereas real development is about industrial restructuring and devising ways for a country to build industries that are inserted in global value chains and are part of the global economy.

Thus Brazil's biofuels strategy has been to build a domestic resource base and value chain for every aspect of biofuels processing, including provision of adequate distribution capacities through mobilizing the services of the country's national oil company, Petrobras. Further attention is now being paid to building of infrastructure (such as pipeline developments) to accommodate the anticipated expansion in the country's biofuels industry with the creation of an American hemispheric free market in biofuels.

VI. The Case Against a Green Development Strategy

Finally, what are the arguments against such a well-conceived GD strategy? Resnick *et al.* (2012) can be taken as typical. They claim that GG strategies can be simply 'flavor of the month' and offer superficial advantages, which are outweighed by longer-term costs, particularly in terms of burdens for the poor. That might be the case for poorly designed and poorly executed strategies — but claims can be made against such poorly administered policies, whatever philosophy they are based on.

Resnick *et al.* argue that, whatever the rhetoric, GD strategies generally reduce solely to a strategy for reducing carbon emissions — mainly to the benefit of the countries which created the problem in the first place.

[14] This is a point of view that economists rarely agree with. For a clear statement of the economist's views with regard to green development, see Lee (2012).

It is difficult to sustain this argument in the face of China's GD strategy, which is quite clearly oriented towards building a new industrial system based on clean technologies alongside of, and gradually replacing, the black energy system that has provided the motive power for China's industrial revolution to date. Low carbon emissions are the fortunate (very fortunate!) side-effect of this national development strategy. And the same argument can be mounted for the strategies being pursued by India and Brazil, albeit following China's lead with a decade or so lag. So the GD strategy as outlined above is to be judged not on whether it reduces carbon emissions (which it should do, as a side-effect) but on whether it enhances a country's development potential.

Secondly, Resnick *et al.* argue that the medium-term effect of pursuing GD strategies single-mindedly is indistinguishable from earlier experiences with 'structural adjustment' strategies, imposed by the IMF, in that they are both concerned with superficial changes to industrial structures and less with development potential. Again this may well be true of corporate rhetoric calling for more favourable investment treatment of multinationals (as in South Africa's minerals sector) but it is hardly an adequate description of the fundamental restructuring and aspirations to build export platforms for the future associated with the green development strategies pursued by China, India and Brazil, and evident in the green growth strategies pursued by Korea.[15] The argument of this paper is that GD strategies need to be judged in terms of their strong-willed implementation and not on their weakest examples.

VII. Concluding remarks

In this paper I have argued that China is the game-changer that has raised the profile of green development from a curiosity (of interest at the margins) to a world-competitive new industry capable of powering a giant economy along a development trajectory that will 'scale' to the needed dimensions, without costing the earth. The green development model that China is fashioning, which is already being emulated in some ways by Brazil and India, offers the best hope for sustainable development to the next wave of countries following the BICs, including developing countries in Africa, Latin America, Asia and the Middle East. It is China, the pragmatic super-power, that is also developing its black, coal-

[15] On Korea's green growth strategies, see Mathews (2012) and the OECD reports by Jones and Yoo (2011) and by Kang *et al.* (2012).

fired energy system as fast as its development of renewables. This would make for a pessimistic assessment, were it not for the fact that green industries are self-sustaining and grow through logistic (S-shaped) industrial dynamics, in a circular and cumulative fashion? while resource pressures and rising costs spell an early end for industries built on fossil fuels. There is of course no guarantee that China and the BICs and then other developing countries can swing fast enough behind such a green development model in time to keep carbon emissions and resource spoliation within acceptable limits.

The debate amongst EDCs and their representatives has focused on whether EDCs need 'green growth' and whether it is likely to become yet another 'gimmick'. But the achievements in countries like China, Korea, India, Brazil and now diffusing to many other EDCs as well stand as testimony to the fact that countries can actually improve their development prospects by building green industries. The real issue is to overcome pessimism by returning to the roots of what is meant by 'development' as a restructuring of industry and the creation of new industries that did not previously exist. These industries can be green or they can be black. This paper has argued that EDCs have everything to gain by building new industries that enhance their economic prospects while contributing to a green agenda, and everything to lose by continuing to foster the black development pathway that reinforces carbon lock-in.

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