Energizing Industrial Development: The Role of the State in 21st Century Greening Strategies

John A. Mathews
Macquarie Graduate School of Management,
Macquarie University

Abstract

Industrial development, as it diffuses globally to encompass the great emerging 21st century powers China, India and Brazil, increasingly has to place energy issues at the core – to move off the fossil fuels that worked in the past but are creating impossible tensions now and to move towards a new green growth model that promises to reduce or eliminate those tensions as it expands. In this paper I review the issues involved in the new 'green industrial strategy' and discuss the institutional state strategies being deployed in China, India, Brazil and South Africa – the BICS countries – to drive the transition that is under way. The argument goes that in the 21st century the developmental state has perforce to be a practitioner of green industrial strategies. The Brazilian model with its threefold involvement of state institutions in developing rolling ten-year plans for renewable energy deployment, targeted investment with local content requirements through the national development bank and promotion of cost reductions through state-mediated reverse auctions, is discussed as a viable strategy.

Keywords: industrialization, strategic planning, sustainable development, public policy, renewable energy, international cooperation, case study

Introduction

There was a time when industrial development and energy were discussed in separate categories. The prevailing orthodoxy, which governed the 'East Asian Miracle' of Japan's industrialization, followed by that of Korea, Taiwan and Singapore, was that integration with the world's fossil-fuel economy represented the optimal path forward. Grow rich with coal and oil, and then diversify – this was the formula. It worked because as a group, the East Asian 'tigers' could not put too much strain on global fossil fuel supplies. But in the 21st century, as giants like China and then India and Brazil and South Africa are moving along the industrialization pathway, their energy choices are becoming critical – for themselves and for the planet.

Let us call these the BICS countries, as opposed to the BRICS – leaving out Russia which is a special case through continued dependence on fossil fuels. The BICS countries have a population numbering 2.7 billion (around a third of world population of 7.3 billion), and at this scale the pathway to industrialization cannot ignore the means through which the process unfolds. If the BICS countries were to follow the 'Business as Usual' pathway, with its strategy of exploiting access to fossil fuels wherever they can be found and are politically/economically available, they would run into serious geopolitical tensions well before the fuels ran out.

The western countries as they industrialized were able to tap resources from around the world, via colonialism and imperialism, while they exploited their own coal and oil reserves without any sense that they might be finite. And carbon emissions with their deleterious planetary climatic impact were not considered a problem. Obviously enough, these conditions do not apply today.

The emerging industrial powers, led by the BICS countries, have to invent a new development model that will enable them to bring ten times as many people to the rising income levels enjoyed by industrialized countries, while having to respect much tighter constraints on resources and fossil fuel usage. Without a 'circuit breaker' this challenge does not add up – the BICS countries would be trying the square the circle. The result would be heightened geopolitical tensions leading to war, revolution and terror, quite apart from ecological damage of unimaginable proportions.

But there is a circuit breaker – and it is green development. Its core is green growth. In their various ways, the BICS countries are all pursuing some variant of green growth alongside the fossil-fuelled and resource profligate model of development. This is their feasible pathway to industrial development. When one reflects on the issues involved, what other pathway is there?

The positive future-oriented scenario is one in which these countries maintain their focus on and commitment to green development, because of their overwhelming national interests in doing so. It is an argument that starts with the interests of

the emerging industrial giants in finding a feasible pathway for completing their industrialization, rather than with international conferences on climate change. The sceptical view is that these countries are doing too little, too late to reverse their previous fossil fuelled trajectory. Our scepticism is reinforced by the carbon lock-in that still prevails in the West. The US for example (pace President Obama's 11th hour efforts) is fixated on its 'energy revolution' involving coal seam gas and shale oil – fossil fuels that have only become accessible in the past decade because of technological developments, and which as high cost businesses now appear to be doomed because of falling oil prices. Japan is still focused on nuclear, despite Fukushima – with all the cost over-runs and delays entailed. And the EU remains divided between the renewable energy optimism of Germany, with its remarkable *Energiewende*, and the fossil fuel/nuclear hard line of the UK, Poland et al.

Moreover the efforts of the BICS countries to promote renewables and low-carbon development are not supported internationally – even with all the rhetoric on carbon reductions emitted under the Kyoto process. In place of promoting diffusion of clean and low-carbon technology, the industrialized countries are actively seeking to impede it through trade sanctions. China for example has been 'punished' for promoting its solar PV industry by other countries, led by the US, the EU and Japan, in imposing counter-tariffs on solar PV imports and causing great disruption to China's PV industry. In India attempts to grow a solar PV industry in emulation of China, utilizing local content requirements, feed-in tariffs, tax breaks and other tools from the industrial strategy toolkit, are also being hindered by trade actions brought to the WTO.

Whether these international trade complications could derail current efforts by the BICS countries to green their industrial development is an important topic to be addressed in this paper. But the case for the success of their greening strategies is overwhelmingly based on the fact that renewables today offer the most cost-effective means of building energy systems. Whereas in previous decades the case that coal could provide the cheapest form of energy (and electric power in particular) was decisive in determining energy strategies, today the situation is reversed, with renewables providing the cheapest option – or being about to do so as the learning curve continues to drive down their costs. This is a truly world-historic change that can transform development possibilities, in the BICS countries and beyond.

Central to these developments and pathways is the role of state agencies and institutions. Price-guided mechanisms will not prove to be sufficiently robust and sufficiently rapid to effect the transition needed, to meet either the needs of the 21st century industrializing giants or of the world as a whole. Indeed, it is the role of public institutions and national governments in driving this new, green phase of world industrialization -- where Brazil, India and China are such key players -- that is proving to be fundamental. The issue is: what strategies are open to states as they seek to guide and shape the unfolding greening process which promises wealth and sustainability?

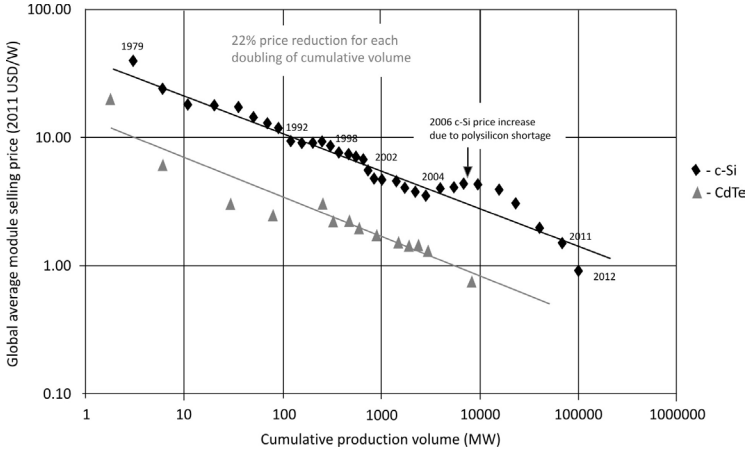
Development strategies in the 21st century: New roles for the state

Energy is not just any other commodity (oil, coal, gas) or any other process (conversion, transmission) or piece of infrastructure (grid, smart grid, high speed rail). It is in fact fundamental to modern industrialization; it lies at the core of the process of modernization that we call industrialization.[1]

Yet energy was conspicuous by its absence in the literature on conventional industrial development strategy. There was capital, and labor and land (e.g. land reform). But where was energy? It was just assumed that energy would be supplied by fossil fuels – as it had been in the west's industrialization. So in the 20th century Japan built a mighty energy system to power its manufacturing system, all based on fossil fuels and then nuclear. Likewise in the cases of Korea and Taiwan and, until recently, Singapore. All are locked into energy systems that prioritize fossil fuels and nuclear – although it is true that Korea is making efforts to liberate itself via its green growth strategy. All were locked into the incumbent energy system; but beyond this, they made leapfrogging progress in 'doing' fossil fuels better than the advanced countries. Singapore for example established itself as an indispensable hub for the oil industry – oil markets (the Singapore oil price index), oil refining, transport and petrochemicals.

It is falling costs which are the fundamental drivers of the global transition. The most recent analyses find that new solar PV installations are comparable in cost to fossil fuelled power plants, and falling at a rate of 16% for every doubling of capacity. The evidence is provided in Fig. 1.

Figure 1: PV module experience curve, 1976-2013

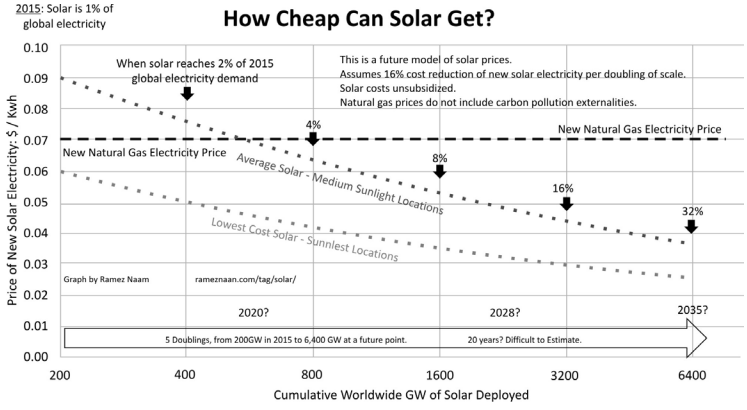


Source : IRENA

[1] See Rodrik (2014) for a recent statement of the case for greening of industrial strategies. My own contributions on these matters are listed in References, including Mathews (2007-2014; Mathews and Reinert 2014; Mathews and Tan 2011-2015; Mathews, Hu and Wu 2015.

As calculated in a recent blog posting by Naam (2015), the cost of solar PV power can be expected to continue its plunge, and to reach well below the costs associated with burning of fossil fuels for electric power by 2020 (Fig. 2).[2] At this point an industrializing country would be well advised to study closely its options regarding energy, and evaluate the costs of going with renewables as opposed to fossil fuels and nuclear.

Figure 2: Future trajectory of solar PV costs



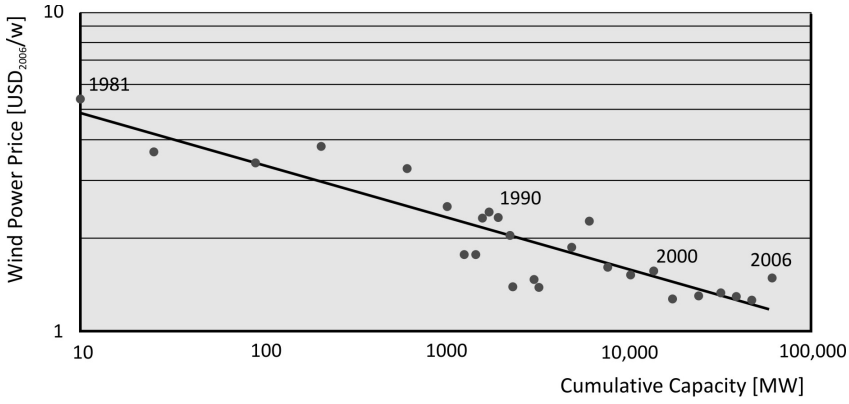
Source: Naam 2015

The chart indicates that the world could pass the 1000 GW mark of solar PV power (the first terawatt) in less than a decade from now, i.e. before 2025. This is entirely plausible. Already China has an official goal of 100 GW by 2020, and India has now matched that goal. There are extensive rooftop solar programs in Europe and the USA, and Japan seems poised to join the process. So the 1 TW mark is actually likely to be passed before 2020 – perhaps in just five years' time. By then the generating cost of new solar PV installations should be somewhere between 4 and 6 cents per kWh (or $40 to $60 per MWh) – cheaper than even the cheapest brown coal. This is how fast the renewables revolution is unfolding.

A similar story can be told for wind power. Consider the learning curve for wind power, which demonstrates a clear cost reduction potential out to 100,000 MW (or 100 GW – a level already achieved by China) – as shown in Fig. 3. The levelized cost of wind power has been falling at a rate of 14% per year as cumulative production experience and scale of market grows.

[2] See Ramez Naam, 'How cheap can solar get? Very cheap indeed', *Energy Post*, 21 August 2015, at: http://www.energypost.eu/cheap-can-solar-get-cheap-indeed/

Figure 3. Learning curve for wind power



Source: FISCHEDICK et al., 2011, p. 847

It is the rapidly falling costs of renewables that is the fundamental feature of the greening process. There can no longer be any doubt that clean and renewable energy technologies are now, or will shortly be, lower in cost than the fossil fuels that they replacing. This amounts to a fundamental sociotechnical shift (Mathews 2013) that will have widespread social, technical and economic repercussions. It challenges countries to revise their developmental strategies and challenges companies to craft new business models that take advantage of the plunging costs of renewables.

There are important reasons for this that go beyond the contingencies of one technology or another. All renewable energy devices – wind turbines, solar PV cells, CSP lenses and mirrors – share the characteristic that they are all the products of manufacturing. And this is what connects renewables fundamentally to industrial strategy. As Hao Tan and I put it in our article published last year in *Nature*:

> ' … unlike oil, coal and gas, the supplies of which are limited and subject to geopolitical tensions, renewable-energy devices can be built anywhere and implemented wherever there is sufficient water, wind and sun.' (2014: 166)

What we meant by this is that manufacturing is the very special process where increasing returns (reducing costs) can be generated: as the scale of production increases, so the unit costs decline. This has been understood by every mass production entrepreneur, from Henry Ford onwards.[3] It is now understood by Chinese, Indian and Brazilian entrepreneurs who are scaling up production of renewables devices and installing them at ever higher capacities, to reduce costs

[3] Between 1909 and 1916, Henry Ford reduced the cost of his Model T Ford from $950 to $360, a 266% drop over seven years. Each year, sales doubled – from just below 6,000 in 1908 to over 800,000 in 1917. The drop in prices was connected directly with the expansion of the market and the sales made by Ford himself.

and drive market expansion. In this way, *renewables are becoming central to the industrialization process*, because they involve manufacturing, learning curves and market expansion linked to cost reduction.

These features are not found in fossil fuel extraction and utilization. On the contrary, all fossil fuel extraction, from coal mining to oil and gas drilling and now right up to extraction of coal seam gas via hydraulic fracturing, involves a relentless process of diminishing returns (or long-run increasing costs). (Fossil fuels are going through a price deflation at the moment, but this is unlikely to continue indefinitely.)

Because renewables devices are always the products of manufacturing, they can in-principle be produced anywhere. This is fundamentally why renewables provide energy security – because a country can build its energy security through building manufacturing systems that can operate independently of the vagaries of supplies (and prices) of fossil fuels. No wonder China, India and Brazil are turning to renewables as fast as is technically and economically possible. And as they do so, they drive down costs even more, and provide further incentives for market expansion and entry by presently under-developed countries into the industrialization process.

This is a virtuous cycle. It was blocked by fossil fuels and their vast infrastructure controlled by the developed world, creating a barrier to industrial development for everyone else. But greening processes unblock the process. That is why it is so fruitful – and why green development is the culmination and likely next chapter in a process of global industrialization.

Let us now review how in their different ways all the BICS countries are participating in this vast energy transition – and through doing so, are raising their income levels to achieve their long-sought goal of becoming middle-income countries.

Renewable energy national strategies: the BICS countries

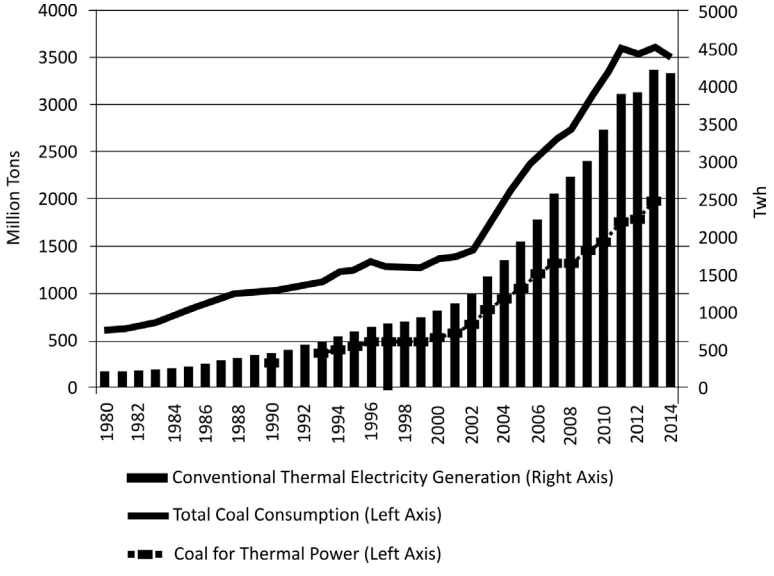
China

In just the past decade China has emerged as the world's renewable energy superpower – building up world class renewable energy industries (wind and solar farms in the vanguard) and renewable power manufacturing industries (wind turbines, solar modules and cells) as well as major infrastructure projects including a strong and smart grid, EV recharging networks and a national high speed rail network. All this as it has continued to expand its coal-fired energy system as engine of its vast manufacturing system – although it is true that China has been curbing its coal consumption over the past two years, not just in relative terms but in terms of

absolute levels. The peaking of China's coal consumption, followed by a peaking in its carbon emissions, could be about to occur much earlier in China than predicted.

Like rising industrial powers before it, China has initially relied on fossil fuels, and coal in particular, to drive its manufacturing engine. The rapid increase in coal consumption, that took off after China joined the WTO in 2001, is clearly seen in Fig. 4.

Figure 4. Chinese thermal power generation and rising coal consumption up to 2014



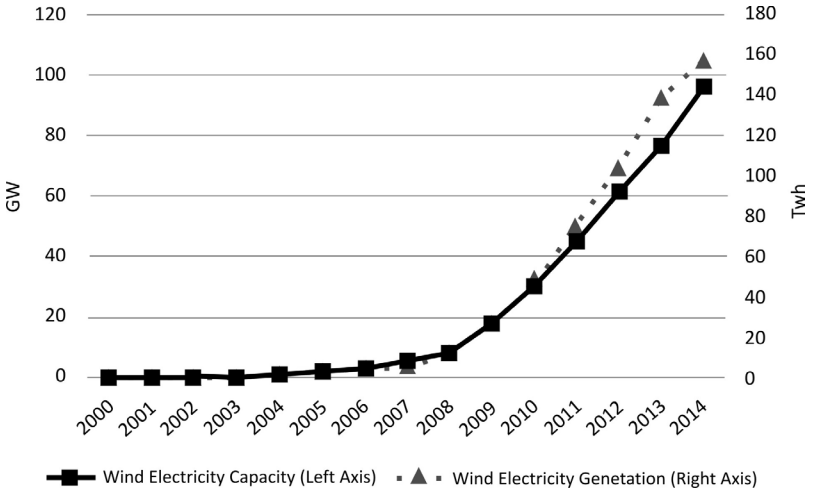
Source: Mathews and Tan (2015)

Fig. 4 also indicates that China is now taking active steps to curb coal consumption – as a step towards remedying the shocking air and water pollution that has struck Chinese cities. This is clearly visible in the flattening of the coal consumption curve after 2013.[4] The complementary actions taken by the Chinese government are that a new green energy system is being created, at a rate of advance that promises to eventually overtake the 'black' coal-fired energy system.[5] The results of actions taken to build a wind power industry are shown in Fig. 5.

[4] For a discussion of China's possible 'Great reversal' in terms of coal consumption, see the article from Hao Tan and myself posted to *Asia Pacific Journal: Japan Focus* on August 26 2015, at: http://japanfocus.org/-Hao-Tan/4365/article.html

[5] On China's expansion of its green power system, see in particular Hu (2006; 2011).

Figure 5. China's wind power generation, 2000-2014



Source: Mathews and Tan (2015)

It is China's building of wind power and solar PV systems at a scale never previously thought possible that is driving the cost reductions that are now making renewables accessible to all – including India, Brazil and South Africa.

China's judicious use of local content requirements was the key to its successful creation of a wind turbine manufacturing system – as widely acknowledged.[6] Some experience was generated by the *Ride the Winds* program of the late 1990s, and the formal LCR provisions were then imposed from 2003, both by the tendering system for nationally approved projects, where the scoring included clear LCR criteria, and by wind farm projects approved by the National Development and Reform Commission (ND&RC) and likewise contained a graduated LCR provision. Following complaints at the WTO by the US, the schemes were discontinued in 2009 – but only after they had done the job of helping Chinese firms to enter all the stages of the wind turbine manufacturing value chain, and ensuring that the leaders like Goldwind, Sinovel and MingYang were on the way to becoming global leaders. China backed these strategies with extensive financing, provided in the form of credit lines to Chinese renewable energy companies by the China Development Bank. In this way it demonstrated once again the power of development financial institutions – something very well understood in Brazil where the BNDES plays such an important role in the development of the Brazilian economy.[7]

[6] See discussions by Kuntze and Moerenhout (2013) and by Gandenberger et al (2015).

[7] See the discussion of the role played by the China Development Bank in Keidel and Burlamaqui (2015) and Sanderson and Forsythe (2013).

India

From a slow start, India is now determined to become a world leader in green energy and green development. It is doing so not just because of concerns over climate change, but for reasons to do with energy and resource security and the building of an energy platform that will supply both domestic markets and export business as well.[8] India is using a full panoply of industrial strategies to achieve these ambitious goals, from market promotion measures including tax breaks and feed-in tariffs to industrial promotion such as local content requirements being attached to foreign direct investments (albeit attracting some opposition at the WTO, particularly from the USA).

The most ambitious program is the National Solar Mission, which in July 2015 was upgraded with a new goal of seeing 100 GW of solar power installed in India by the earlier date of 2019 – where 40 GW would be rooftop solar and 60 GW would be medium- and large-scale grid-connected solar power projects. These are extremely ambitious targets, upgraded from the original target of 20 GW by 2021-22 that had been announced in 2008 and amended in 2010. Indeed it puts India on a par with China in terms of specific solar PV targets, where China has a well-known target for solar PV of 100 GW by 2020 (at the conclusion of the 13th FYP) – although there have been rumours floated in the press that China is about to double its 2020 target for solar to 200 GW as part of the 13th FYP (http://cleantechnica.com/2015/07/26/china-2020-solar-energy-target-200-gigawatts-rumor/).

With the election of the Narendra Modi government in 2014, the stage was set for further detailed promotion of renewables and greening of the Indian economy generally. Modi himself has reiterated the point that his government's central goal will be to ensure 24/7 power for all Indians – and since coal is subject to supply and price fluctuations, the best way of delivering on such a promise is through promotion of renewables. The fresh targets announced are backed by administrative and financial commitments. The July 2014 budget of the Modi government had a provision for a doubling of the tax on coal, which would raise an extra $1.1 billion to fund clean energy projects. Green energy companies were at the same time offered a 10-year tax holiday in order to get themselves firmly established.

The next anticipated move is for the Indian government to announce a National Wind Mission (NWM) to replicate the success so far of the National Solar Mission (NSM). Some reports indicate that the NWM will also set a target of 100 GW wind by 2022, and that it will be backed by comprehensive policy promotion encompassing tax breaks, facilitation in securing land and local permits, as well as promotion of

[8] For discussion of India's greening strategies, see for example Mattoo and Subramanian (2012) or Johnson (2015).

the wind power manufacturing value chain in India (at present largely dominated by Suzlon). The essence of these RE Mission programs (NSM and probable NWM) is that they provide investment certainty and real incentives for developers based on a clear understanding of what manufacturers and wind/solar farm developers need. The projects represent a substantial initiative on the part of the Ministry of New and Renewable Energy (MNRE), itself a major institutional innovation, designed to create fiscal and monetary space for RE development separated from the influence of fossil fuels.[9]

The LCR provisions of the NSM are quite explicit – and no doubt provide a template for what can also be expected under the probable NWM. The NSM was launched by the Singh administration with comprehensive national development goals being made clear (Johnson 2015). Three phases were envisaged, allowing for policy learning along the way. Phase 1 was the pilot phase, with a first batch of bids being commissioned in January 2012 and a second batch in January 2013. Phase 2 was designed to build on the achievements of Phase 1, when a more extensive value chain would be created in India, directly supporting a further 3 GW of solar development and leveraging a further anticipated 6 GW from the private sector. Phase 3 was envisaged as the final scaling-up of the program, with 10 GW being expected to be installed over five years. This aspect has been drastically upgraded to reach the new 100 GW target by 2019.

India has learned from China the power of local content requirements (LCRs) as a tool for domestic industry development. The provisions covering LCRs in the NSM were designed to avoid WTO entanglements, in particular having a state-owned entity being the purchaser of the solar energy generated and thereby being nominally in compliance with the WTO Government Procurement Agreement (GPA). Even the name of the program, namely the NSM Procurement Program, emphasized this aspect and signalled India's strategy if required to defend the program in Geneva. Nevertheless the United States has objected to the LCR provisions on grounds that they create trade barriers to exports of US RE products and technology (which is, after all, their goal). In fact the US has lodged two successive objections and the case is now moving through the WTO procedures. Indian observers were holding out hope that there could be a cooling off or even a settlement reached at the US-Indian Summit of Feb 2015 when President Obama visited the Indian capital with a strong trade retinue; the outcome (if any) has not yet been made public. But it

[9] Current levels of Renewable Energy (RE) capacity in India are (at March 2015): wind power capacity 23.4 GW; solar PV capacity 3.7 GW and total RE capacity 35.8 GW. The ambitious NSM and (probable) NWM targets would have to see an extra 10 GW of solar and 10 GW of wind capacity being added each year between now and 2020. This in itself can be viewed as a major industrialization effort.

is clear that India has not allowed this hiccup to curb further LCR provisions being inserted into Phase 2 batch 2 of the program, and there is open speculation that the anticipated NWM will likewise contain strong LCR provisions. India is clearly serious about building its RE industry and creating manufacturing industries to support both solar and wind power development on a large scale – and it is not about to let some scrapping at the WTO in Geneva block its ambitions.

Brazil

Brazil has been pursuing an industrialization strategy that is lifting tens of millions of its citizens out of poverty.[10] Brazil has been traditionally a green energy source country, with much more emphasis on hydro power than most, and greater emphasis on sustainably grown sugar cane-sourced ethanol as liquid fuel. But in the last five years it has been ramping up its renewable power sources generally, to enhance its energy security – e.g. making the country's industry less prone to brownouts and power rationing because of droughts that reduce hydro capacity (as in the worst drought on record in 2014/2015).

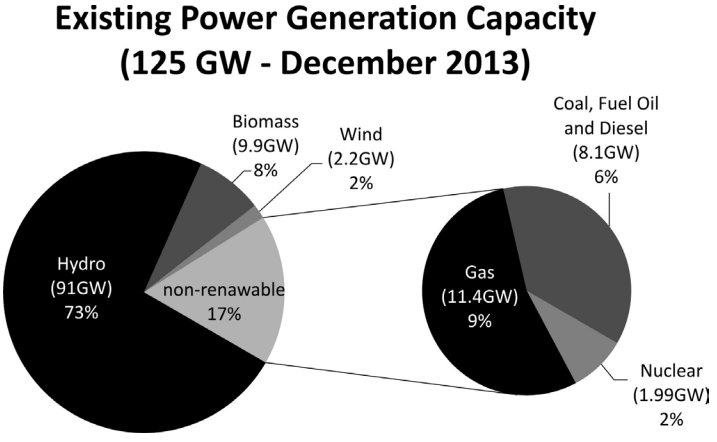
At the same time Brazil has been enhancing its energy security in terms of oil, through its offshore 'pre-salt' oil discoveries and the government's determined efforts to play a role in utilizing the exploitation of these offshore oil deposits to build an offshore oil industry – centered on state-owned Petrobras. Brazil became independent of oil imports in 2006, and since then has become a major oil and gas producer in its own right, earning export dollars and saving vast sums in terms of substitution of imports.

Brazil has one of the largest renewable energy components of its energy system of any country in the world – with renewables accounting for 83% of generating capacity, largely based on hydro (comparable to Norway). Since 2009 it has been ramping up wind and solar PV power as well, so that by 2015 wind power had grown to 6 GW (4.5% of generating capacity) and is expected to reach around 24 GW by 2023 (under the rolling 10-year energy plan maintained by the Ministry of Mines and Energy). Electric generating sources from water, wind and solar (WWS) are expected to grow from 103.2 GW in 2013 to 164 GW by 2023 – meaning that Brazil would be the world's fourth most significant deployer of renewable energy systems on the planet (after China, the US and Germany) and comparable to India. It is anticipated under the 10-year plan that wind will grow at an average of 2 GW per year, to reach 24 GW by 2023 (11% of the total) and solar to reach 3.5 GW (2%), which with hydro reaching 124 GW would mean WWS would account for 164

[10] On Brazil's strategies of industrialization generally, see for example Castro (2008) or Schutte (2012).

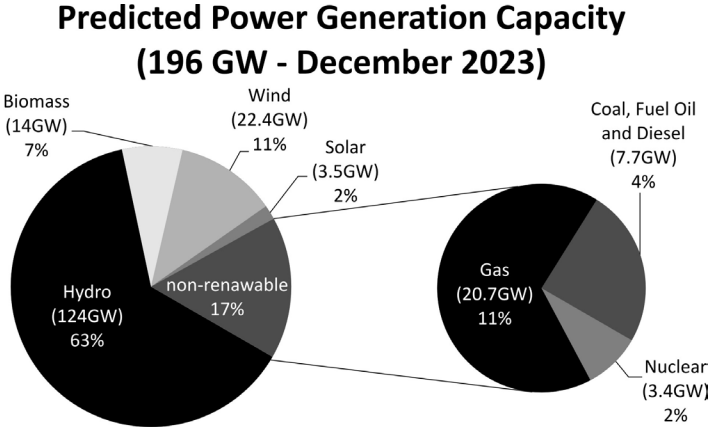
GW by 2023.[11] With biomass contributing 14 GW (7%), the 83% contribution from renewables is expected to be maintained (Figs. 6a and 6b).

Figure 6a. Brazil's existing electric generating capacity (2013)



Source: MME

Figure 6b. Brazil's anticipated electric generating capacity by 2023



Source: MME

Brazil maintains a 10-year rolling target for all energy sources, which in itself is an important institutional innovation and a measure reflecting strong state leadership in the renewable energy sector. The latest version is the 2023 plan, updating the

[11] Note that this projection assumes that hydro sources would grow from a capacity of 91 GW in 2013 to 124 GW by 2023, or a 33 GW increase over 10 years. Given the fact that present dams in Brazil are already highly controversial, and future construction could run up against social as well as environmental limits, particularly in Amazonia, these projections may be unrealistic. See Fearnside (2015) for a critique.

2013 energy mix. This 2023 target has Brazilian wind and solar accounting for 13% of all generation capacity, and hydro accounting for 65% -- i.e. WWS sources accounting for 78% of Brazil's generation capacity, and the balance (thermal, nuclear, and biomass) accounting for 22%.[12]

In June 2015 Brazil and the US issued a joint declaration on climate goals, with Brazil committing to protect forests and ramp up its use of renewable energy. Both Brazil and the US have committed to achieving 20% of their electricity from wind and solar by 2030 – i.e. from non-hydro sources.

The role of the state in creating this 21st century energy infrastructure in Brazil has been critical. The Ministry of Mines and Energy has maintained a strong emphasis on building up renewables capacity (with its foundation in manufacturing of wind turbines and solar cells and their value chains) even while supporting the country's existing minerals exploitation and export systems and the emerging offshore oil industry (despite problems of corruption that have surfaced at Petrobras). The series of New Energy Auctions have been responsible for creating wholly new wind power and now solar PV power contracts based on Power Purchase Agreements at costs amongst the lowest in the world.

Brazil has utilized a smart combination of strategies to enable it to catch up in renewables and build its own renewable power industries. These strategies include **guaranteed power purchase agreements** (PPAs) and **power-contract auctions** to boost the market for renewables, as well as the use of indirect local sourcing requirements not imposed through the trading system (where they would attract attention from trading partners, above all the US) but instead indirectly through the financing mechanism, operated by the National Development Bank BNDES. In 2011 the Brazilian (Lula) government took the important initiative of publishing a 10-year plan for energy development, creating targets that have underpinned investment certainty.

BNDES has been central to the renewable energy industry creation. The bank amended its approach to granting loans to the wind power industry in 2012, announcing that developers that utilize BNDES loans to build wind farms would have to source wind turbines and their components locally by the year 2016. In August 2014 BNDES announced similar plans for the solar PV industry. For dominant technology crystalline silicon PV panels, this program would proceed through three

[12] Hydro is expected to grow at an average rate of 3.3 GW per year, expanding from 91 GW in 2013 (73% of capacity) to 124 GW by 2023, and 63% of capacity. Wind is expected to expand at an average rate of 2 GW per year to reach 22.4 GW in 2023, up from 2.2 GW in 2013; while solar is expected to reach 3.5 GW by 2023, up from a negligible amount in 2013, and expanding at an average rate of 350 MW per year. Total WWS capacity in 2013 reached 93.2 GW (hydro 91; wind 2.2; solar PV negligible) while WWS sources are expected to reach 150 GW by 2023 (hydro 124, wind 22.4 and solar PV 3.5 GW).

phases, culminating in all cells being produced locally by 2020. For thin-film solar cells there are two phases with all module assembly having to be carried out in Brazil by 2018.[13] This strategy of attaching LCRs to development bank financing for project developers is a striking and effective aspect of Brazil's strategy – subject to the criticism that it would be better if there were time limits attached to the LCR provisions, ensuring that they do not become protectionist.

South Africa

While South Africa is not in the same league as the BIC countries in terms of its energy transition and its economic potential, there are good reasons for including it in this analysis because it is grouped with Brazil, India and China in Goldman Sachs-inspired analyses of emerging markets, and because it is party to the launch of the BRICS- countries' newly launched infrastructure investment bank (the New Development Bank, launched formally in Shanghai in July 2015: http://in.reuters.com/article/2015/07/21/emerging-brics-bank-idINKCN0PV07Z20150721). Moreover it is seriously addressing renewable energy issues from the perspective of industrial strategy, and utilizing the financing potential of the Development Bank of Southern Africa (DBSA).[14]

South Africa starts from the difficult position that it has traditionally been a highly energy-intensive industrial country with a strong dependence on coal. Its electricity generating system has been highly centralized and coal-fired; moreover the electric power market is dominated by a quasi-monopoly in the form of Eskom, responsible for more than 95% of the electricity generated in South Africa.

Against this backdrop the post-Apartheid ANC government (ascending to power in 1994) has been seeking to set a different direction. There were some false starts in promoting renewables, with the launch of a Renewable Energy Policy White Paper in 2003 that set modest targets for renewables for 2013 – but not including any solar PV or wind power. Next, following the Copenhagen Summit of 2009, the SA government issued a Renewable Energy feed-in tariff (REFITs) policy, but considerable uncertainty surrounded the commitments made and no contracts were actually signed. These could considered learning steps.

In August 2011, following a lengthy national debate, the South African government launched the Renewable Energy Independent Power Producer (REIPP) Procurement

[13] This extremely effective program is also quite transparent. In December 2014 BNDES published its *Perspectives on Investment* report for the next four years (2015 to 2018), outlining where it would be placing priority for investments. http://www.bndes.gov.br/SiteBNDES/bndes/bndes_en/Institucional/Press/Noticias/2014/20141203_estudo.html

[14] On the role of the DBSA, see Mathews and Kidney (2012).

Program, which established a bidding process for renewable energy projects beyond the traditional thermal (coal-fired) generating sector. The new program was designed to encourage the emergence of independent power producers to break the Eskom monopoly, by providing a certain amount of protected market for the renewable sector. The principal target set under the program is for generation of 10 TWh of renewable energy. Complementary targets set under the REIPP included 3.7 GW of renewable energy capacity to be installed by 2016 – including 1.8 GW of onshore wind capacity, 1.5 GW of solar PV capacity and an initial 200 MW of concentrated solar power (CSP). The targets were raised in 2012, when the government called for an extra 3.2 GW of renewables capacity to be added by 2020. While small in comparison with thermal generating in South Africa, and tiny when compared with similar targets in China, India and Brazil, these goals nevertheless represent first steps towards a genuine transformation (greening) of the South African energy sector and pathway towards a new model of industrialization.

In November 2011 the South African government embarked on a public tendering process to accelerate uptake of renewable energy projects, in emulation of similar processes enacted by China, India and Brazil. This called for three rounds of tenders which attracted bids of nearly 4 GW of capacity sweetened by 20-year power purchase agreements (PPAs) with Eskom. The bids came from both domestic and foreign companies, and were backed by serious finance – Chinese bids backed by $2 billion in funding from the Industrial and Commercial Bank of China; US bids backed by $2 billion in funding from the Ex-Im Bank; and African bids backed by a loans facility of $1.1 billion provided by the DBSA, approved in 2012.

The public bidding process has achieved significant cost reductions in renewable energy, but has also enabled the SA government to impose LCRs that have been ratcheted up, from modest requirements in 2012 to 35% in the next round (much of which foreign investors were able to meet through construction costs) and rising to 40% in the most recent round (and 45% for CSP projects). Developers are in practice required to reach a 65% local content threshold in order to build a 'social and economic score' that can win contracts. So far there appears to be no international negative response at the WTO to these LCR provisions, which have a clear industry-building mandate rather than being protectionist. Some foreign countries have also been induced to sign financial assistance packages that clearly pave the way for involvement by their national firms – as in the case of a Danish loan that was followed by Vestas winning contracts. All this represents important activities on the part of the South African state.

In April 2015 the SA Dept of Energy announced the results of its fourth Request for Proposals under the REIPP procurement program (issued July 2014), which

resulted in 13 proposals being selected as preferred bidders, adding up to 1.2 GW of installed capacity and investment of R23 billion (US$ 1.7 billion). That brought total committed private sector investment under the program since 2011 to R168 billion (US$ 12.6 billion). The winning bids averaged R619/MWh (US$46.50/MWh, or 4.6 US cents per kWh) for onshore wind and R786/MWh (US$59/MWh) for solar PV – very much in line with the best results obtained in other parts of the world.[15]

Following initial acceptance of LCRs in Round 1, the bidders for Round 2 were asked to identify components of fulfilling their contracts that would involve local content – with a focus on manufacturing wind turbine blades and towers, PV modules and inverters and metal structures for PV plants. In Round 3 the definition of local content was further clarified, with as much emphasis on production of components along the value chain as on final product.[16]

Wind farms are now proliferating in South Africa, providing enhanced energy security and a growing market for wind turbine products as well as local employment for workers who would otherwise remain unskilled and unemployed. The Cookhouse wind farm for example is the largest built so far in Africa, with 66 2-MW turbines spinning to generate power at 138 MW; it started feeding power into the grid at the end of 2014. The wind farm is partially owned by a Community trust, which channels its profits from the farm to health and education projects. Wind energy costed at less than 5 US cents per kWh means that the farm generates power at around half the cost of coal. Eskom itself founded one of the first wind farms, the Darling farm located in the Western Cape; it was basically a pilot project founded in 2008 and involving just four turbines. Now there are farms like Sere and Dorper, both rated at 100 MW and under construction. (It needs to be pointed out that these 100 MW wind farms, impressive as they are, are only 1% the size and capacity of the giant 10 GW wind farms being built in China.)

The LCR provisions have been successful in creating components firms along the value chain. So far there is one final wind turbine producer, I-WEC, founded by two South African engineers in 2009. I-WEC (standing for Isivunguvungu Wind Energy Converter), offers a state-of-the-art 2.5 MW wind power system, with a design licensed

[15] The process of closing each bid involves negotiation of a Power Purchase Agreement between the bidding IPP and Eskom and finalization of an Implementation Agreement between the IPP and the Department of Energy. The contracted PPA involves a price that lasts for 20 years, indexed to the CPI. Foreign funding accounted for 28% of investment commitments, with local content rising to 65% (from 38% in the first round, 53% in the second and 54% in the third). The Department counts this as an economic success for the program, contributing significantly to SA's industrial development and greening. See South African Dept of Energy presentation on Bid window 4, Preferred Bidders' Announcement under the REIPP Procurement Program, 16 April 2015, at: http://www.ipprenewables.co.za/#page/2183

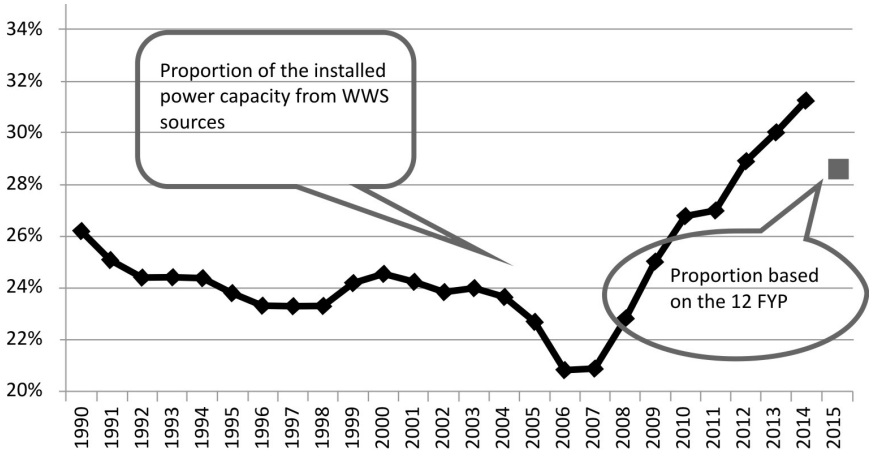
[16] See Moldvay et al (2013) as well as Eberhard et al (2015) for evaluations of these LCR provisions.

from the German wind turbine engineering firm Aerodyn Energiesysteme Gmbh. The company has partnered with the local heavy engineering firm DCD Dorbyl (now a shareholder in I-WEC) to boost its engineering capabilities and with the German wind turbine design company from which I-WEC has licensed its current 2.5 MW turbine. (The same German company has partnered with MingYang in China.) Note that I-WEC claims that its first energy converter already has 70% local content, while some critical components have to be sourced from foreign specialist suppliers.[17]

Global ramifications of integrating renewables into industrial development strategies

Evidently the BICS countries are all embarked on major transformations of their energy sectors with a clear target of raising their dependence on renewable sources, mainly water, wind and solar, and reducing their dependence on fossil fuels (and nuclear – not discussed here). The case of China will have to stand for all four major industrializing powers, in terms of its clear change of direction, as shown in Fig. 7.

Figure 7. Proportion of installed power capacity from renewable sources (hydro, wind and solar) in China: 1990 -2014, and 2015 target based on the 12th FYP



Source: Mathews and Tan 2015

[17] Complementing the wind power projects, South Africa's solar farms feature both solar PV and concentrated solar power projects located in desert areas. The Sishen solar energy facility came online in December 2014, rated at 94.3 MW peak; it can generate 216 GWh electrical energy in a year, from 320,000 solar PV modules. Complementing the solar PV projects are those based on mirrors and lenses – concentrated solar power (CSP) projects. The 100 MW Redstone CSP plant will be the first such facility in Africa, featuring Solar Reserve's molten salt energy storage technology allowing the plant to generate power day and night. Another CSP project is the 100 MW Kathu Solar Park which will be equipped with molten salt storage allowing power to be generated for 4.5 hours after sunset.

What then have been the international ramifications?[18] We have seen that local content requirements (LCR) provisions have been very successful in promoting BICS countries' green industries, and they have correspondingly become the focus of more and more acrimonious trade disputes, thus potentially curbing the global uptake of green technologies. In this way promotion of green industry and trade is coming to be viewed as a relevant 'industrial policy' in the 21st century – and demanding in turn a reform of trade rules to accommodate its specific character.[19]

The rash of current disputes over promotion of green industries and products dates back to the action taken against Ontario's Feed-in-Tariff (FiT) provisions coupled to Local Content Requirements (LCRs), which despite their success in helping to build an effective renewable energy system in the province and reducing carbon emissions, were made the subject of complaint by Japan and deemed WTO-incompatible by an Appeal Board in 2013.[20] There have been actions taken against China's promotion of both its wind turbine industry, through LCRs. and its solar PV industry through local subsidies and tax breaks (in separate actions brought by the US and the EU); and against India's National Solar Mission which was designed to bring India up from being a laggard to being a leader in transitioning to a clean energy future (an action brought by the US). Meanwhile China has itself brought cases at the WTO against US state-level LCRs and local subsidies; the US, in turn, has responded to domestic pressures and imposed anti-dumping and countervailing duties (AD and CVDs) on two occasions against Chinese PV imports, to which China has retaliated by imposing CVDs on US exports of such products as PV cell-making equipment and silicon exports.[21]

According to scholars of trends in world trade, this constitutes a serious outbreak of trade disputes that stem from the imposition of green industrial policies by both advanced and developing states, in a bid to accelerate the uptake of clean energy systems and reduce carbon emissions.[22] The impact is felt by the states targeted by these trade actions, and more widely by the warning sent out to other states that they too will be targeted if they proceed to impose green industrial policies.

Yet it has to be pointed out that if countries are going to seriously tackle the challenge of decarbonizing their energy systems, they will need to employ some

[18] See Gallagher (2014) for discussion.

[19] See Wu and Salzman (2014) and Bigdeli (2014) for reviews of the case law; Rodrik (2014) for the economic significance of the turn to 'green industrial policy'; and Pegels and Luetkenhorst (2014) for an analysis of the related industrial shift in Germany known as the *Energiewende* ('energy transformation').

[20] See WTO, Canada: Measures relating to the Feed-in Tariff program, Implementation notified by respondent, 15 June 2014, at: https://www.wto.org/english/tratop_e/dispu_e/cases_e/ds426_e.htm

[21] See the discussion by Charnovitz and Fischer (2014); Bigdeli (2015); and on Indian implications, Kent and Jha (2014) and Johnson (2014).

[22] See in particular Asmelash (2015); Bigdeli (2014); Rubini (2012); Low, Marceau and Reinaud (2012); Kuntze and Moerenhout (2013); Cosbey and Mavroidis (2014); and Wu and Salzman (2014).

form of green industrial policy, and utilize one or more of the various industrial strategies involving subsidies, low-interest loans, tax breaks and above all FiTs and LCRs which have proven themselves to be powerful means, when employed judiciously, to build new cleantech value chains and producers of cleantech products. It is not a question of allowing newly industrializing countries like China and India to build renewable energy industries that will then destroy such industries in already developed countries. Rather, it is a question of promoting the diffusion of cleantech industries and encouraging the planting of such industries in countries around the world, subject to WTO oversight to ensure that competition remains reasonable and does not become predatory or overly protectionist.[23]

Short of comprehensive reform of world trade rules (unlikely under current conditions) there are promising ways forward. Governments interested in promoting their green interests and expanding trade could make local content requirements a subset of public procurement arrangements for green goods, utilizing government-owned entities for the purpose (as done by India). These arrangements stand a chance of surviving challenge at the WTO, and would have demonstrable ripple effects in the rest of the economy.

Countries that already possess the great public asset of a national development bank (like the CDB in China, the BNDES in Brazil and the DBSA in South Africa) have the option of pursuing local content requirements put in practice entirely through the domestic finance system, and by-passing the trade system altogether. Indeed the Brazilian model of building renewable energy industries through judicious use of targeted loans from the national development bank, offering lower interest rates for finance to domestic companies which meet local content requirements (and offering the same rates to foreign firms if they enter into joint ventures in Brazil, where the domestic partner is the one that applies for the green finance), combined with public (reverse) auctions that drive down costs of renewable energy as they enlarge the market, seems to be optimal for emerging/developing/industrializing countries in the second decade of the 21st century.[24]

Concluding remarks

Recognizing that promotion of green industries is already a major component of active state intervention in transforming fossil fueled-economies, and that trade promises to play a major role in the development of green industries around the

[23] The distinction here is that time-limited LCRs are clearly tools to promote new industry formation, not to protect existing industries from overseas competition -- but only become protectionist if they are allowed to run without limit. Brazil's LCRs attached to financing by the BNDES are ambiguous in this regard.

[24] With the proviso that the LCR conditions attached to the loans be time-limited.

world, the scope for a 'grand bargain' between the parties involved would seem to be clear. Yet recognizing that progress on these issues is slow (e.g. the UNFCCC has been hosting talks on developing a global accord on reducing carbon emissions for close on two decades) the prospects for resolution are not encouraging -- yet sentiment on these matters could shift rapidly, particularly if the Paris Conference of the Parties to be staged in December 2015 is successful. A possible line of advance would be for a set of products or processes to be identified as contributing to decarbonization of energy systems, and for which the WTO could provide exemption from the usual constraining rules of free competition. A candidate authority to make such an identification would be the United Nations Framework Convention on Climate Change (UNFCCC), which is calling the world to Paris in December 2015. The purpose of the exemption – the first to be recognized by the WTO since its inception – would be to allow countries to use such exemptions (for a designated period, say five years) and utilize provisions such as LCRs to build their own green industries. This would be a 21st century WTO-compatible green industrial policy.

There is an alternative way around WTO constraints, namely utilization of the provisions on government procurement combined with LCRs for renewable energy and green industry development, as applying to some nominated public entity or entities.[25] There is the Indian precedent, involving a government-owned energy company – but it is complicated by the action being taken against India's green LCRs by the United States.[26] This Indian experience provides a tentative model for other countries, because the public procurement provisions of the WTO are the ones that are least disciplined and subject to WTO case law.[27] The way this could be accomplished is that countries looking to promote their green industries in a forceful manner that is probably WTO-compliant would be advised to (1) create a public entity in the energy space that can act as driver of the green transformation (e.g. a public entity that purchases green electricity); and (2) ensure that the actions of the created

[25] On the international political economy of government procurement measures and the WTO, see Weiss (2005).

[26] One of the arguments used by the Indian government in defending its LCR scheme from the attack by the United States is that it has been administered by a public power producer, the National Thermal Power Corporation (NTPC). Now there are oddities here worth noting. India is utilizing the 'public procurement' defence – and yet it is not a signatory of the WTO Government Procurement Agreement, which nominally regulates public procurement between the parties. And the NTPC is a coal-burning entity, not a renewable power company.

[27] See Thurbon (2014) albeit without specific reference to the GPA. Resort to the public procurement provisions of the WTO as a means around interdiction of LCRs is also canvassed by Kuntze and Moerenhout (2013). Asmelash (2015) makes the point that the only cases brought to the WTO involve renewable energies – while leaving the subsidies paid directly and indirectly to fossil fuels unchallenged.

public entity comply with the provisions of the GPA, and perhaps set out exemptions for goods that are designated as 'green goods' where LCRs might be applied.[28]

In this author's opinion the best strategy of all, and the one that makes optimal use of state action in the 21st century, is the Brazilian threefold approach. First, investment uncertainty is reduced through the government creating and maintaining a rolling ten-year plan for the build-up of the renewables market; even if the individual forecasts turn out to be wrong (which they probably will) the important effect is to create a sense of direction. Second, the services of the state-owned development bank are utilized to provide green financing, with a preference for local content reflected in favourable interest rates, available to domestic firms either acting alone or in JVs with foreign partners (particularly technology partners). Such an arrangement where LCRs are effected entirely through the domestic finance system and not through trade or investment, stands the best chance of surviving any potential attack via the WTO. Third is a state-mediated (reverse) auction system where companies are allowed to bid for renewable energy contracts and costs are forced down through a competitive bidding scheme. This threefold approach combines finance with cost reduction and enhancement of investor certainty in an optimal manner – addressing the triple nexus of **market**, **finance** and **cost**. This approach provides a robust justification of a creative role for the state in the 21st century task of greening the world's industrial systems.

References

Asmelash, H.B. 2015. Energy subsidies and WTO dispute settlement: Why only renewable energy subsidies are challenged, Journal of International Economic Law, 18 (2): 261-285.

Bigdeli, S.Z. 2014. Clash of rationalities: Revisiting the trade and environment debate in light of WTO disputes over green industrial policy, Trade, Law & Development, 6 (1): 177-209.

Charnovitz, S. and Fischer, C. 2015. Canada – renewable energy: Implications for WTO law on green and not-so-green subsidies, *World Trade Review*, 14 (2): 177-210.

Castro, A.B. de 2008. From semi-stagnation to growth in a sino-centric market, *Revista de Economia Política [Brazilian Journal of Political Economy]*, 28 (1): 3-27.

[28] The Government Procurement Agreement of the WTO is a set of principles applying to procurement procedures by national and sub-national public entities. Many of the general principles of the WTO are subject to exemptions concerned with government procurement, provided the country concerned has signed up to the minimum principles outlined in the GPA – principles which are themselves also subject to exemptions. Israel for example is a signatory but specifically exempts many products that are purchased by public entities concerned with health and security matters. See Weiss (2005).

Cosbey, A. and Mavroidis, P.C. 2014. A turquoise mess: Green subsidies, blue industrial policy and renewable energy: The case for redrafting the subsidies agreement of the WTO, *Journal of International Economic Law*, 17: 11-47.

Eberhard, A., Kolker, J. and Leigland, J. 2014. South Africa's Renewable Energy IPP Procurement Program: Success Factors and Lessons. PPIAF/World Bank, available at:http://ppp.worldbank.org/public-private-partnership/library/south-africas-renewable-energy-ipp-procurement-program-success-factors-and-lessons

Fearnside, P.M. 2015. Tropical hydropower in the clean development mechanism: Brazil's Santo Antonio dam as an example of the need for change, *Climatic Change*, 131: 575-589.

Fischedick, M., Schaeffer, R., Adedoyin, A., Akai, M., Bruckner, T., Clarke, L., . . . Ürge-Vorsatz, Diana, Wright, Raymond. (2011). Mitigation Potential and Costs. In O. Edenhofer, R. Pichs-Madruga, Y. Sokona, K. Seyboth, P. Matschoss, S. Kadner, . . . C. von Stechow (Eds.), *IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation. Prepared by Working Group III of the Intergovernmental Panel on Climate Change* (pp. 791–864). Cambridge, United Kingdom and New York, NY, USA.

Gallagher, K.S. 2014. *The Globalization of Clean Energy Technology: Lessons from China.* Cambridge, MA: MIT Press.

Gandenberger, C., Unger, D., Strauch, M. and Bodenheimer, M. 2015. The international transfer of wind power technology to Brazil and China, Paper S07/2015. Karlsruhe, Germany: Fraunhofer ISI.

Hestermeyer, H.P. and Nielsen, L. 2014. The legality of local content measures under WTO law, *Journal of World Trade*, 48 (3): 553-591.

Howse, R. 2010. Climate mitigation subsidies and the WTO legal framework: A policy analysis. Winnipeg, MA: International Institute for Sustainable Development (IISD).

Hu, A. 2006. Green development: The inevitable choice for China (Part 1), *China Dialogue*, available at: http://www.chinadialogue.net/article/show/single/en/134

Hu, A. 2011. *China in 2020: A New Type of Superpower*. Washington, DC: Brookings Institution Press.

IRENA 2014. *REmap 2030: A renewable energy roadmap – China*. International Renewable Energy Agency. http://irena.org/remap/

Johnson, O. 2014. Promoting green industrial development through local content requirements: India's National Solar Mission, *Climate Policy*, DOI: http://dx.doi.org/10.1080/14693062.2014.992296

Keidel, A. and Burlamaqui, L. 2015. China Development Bank's strategy and its implications for Brazil. In L. Burlamaqui, R. Sobreira and M. Vianna (eds), *The Present and the Future of Development Financial Institutions: Theory and History*. Rio de Janeiro: Multidisciplinary Institute for Development and Strategies (MINDS).

Kent, A. and Jha, V. 2014. Keeping up with the changing climate: The WTO's evolutive approach in response to the trade and climate conundrum, *The Journal of World Investment & Trade*, 15: 245-271.

Krishna-Hensel, Sai Felicia 2012. *New Security Frontiers: Critical Energy and the Resource Challenge*. Ashgate Publishing.

Kuntze, J.-C. and Moerenhout, T. 2013. *Local content requirements and the renewable energy industry: A good match?* Geneva: International Centre for Trade and Sustainable Development/Seoul: Global Green Growth Institute.

Lewis, J.I. 2013. *Green Innovation in China: China's Wind Power Industry and the Global Transition to a Low-Carbon Economy*. New York, NY: Columbia University Press.

Low, P., Marceau, G. and Reinaud, J. 2012. The interface between the trade and climate regimes: Scoping the issues, *Journal of World Trade,* 46*,* 485-544.

Mathews, J.A. 2007. Can renewable energies be turned to a source of advantage by developing countries? *Revue de l'Energie*, 576 (Mar-Apr): 96-105.

Mathews, J.A. 2008. Energizing industrial development, *Transnational Corporations*, 17 (3): 59-84.

Mathews, J.A. 2009. China, India and Brazil: Tiger technologies, dragon multinationals and the building of national systems of economic learning, *Asian Business & Management*, 8 (1): 5-32.

Mathews, J.A. 2011. Naturalizing capitalism: The next Great Transformation, *Futures*, 43: 868-879.

Mathews, J.A. 2012. Green growth strategies: Korea's initiatives, *Futures*, 44: 761-769.

Mathews, J.A. 2013a. The renewable energies technology surge: A new techno-economic paradigm in the making? *Futures*, 46: 10-22.

Mathews, J.A. 2013b. Greening of development strategies, *Seoul Journal of Economics*, 26 (2): 147-172.

Mathews, J.A. 2014. *Greening of Capitalism: How Asia is Driving the Next Great Transformation*. Redwood City, CA: Stanford University Press.

Mathews, J.A. and Kidney, S. 2012. Financing climate-friendly energy development through bonds, *Development Southern Africa*, 29 (2): 337-349.

Mathews, J.A. and Reinert, E. 2014. Renewables, manufacturing and green growth: Energy strategies based on capturing increasing returns, *Futures*, 61: 13-22.

Mathews, J.A. and Tan, H. 2011. Progress towards a circular economy in China: The drivers (and inhibitors) of eco-industrial initiatives, *Journal of Industrial Ecology*, 15 (3): 435-457.

Mathews, J.A. and Tan, H. 2013. The transformation of the electric power sector in China, *Energy Policy*, 52: 170-180.

Mathews, J.A. and Tan, H. 2014a. Manufacture renewables to build energy security, *Nature*, Vol 513, (Issue 7517): 166-168.

Mathews, J.A. and Tan, H. 2014b. A ten trillion watt 'Big Push' to decarbonize the world's electric power, *Journal of Sustainable Energy Engineering***,** .2: 87-100.

Mathews, J.A. and Tan, H. 2015. *China's Renewable Energy Revolution*. London, UK: Palgrave Pivot (Macmillan).

Mathews, J.A., Hu, M.-C. and Wu, C.-W. 2011. Fast-follower industrial dynamics: The case of Taiwan's solar PV industry, *Industry and Innovation*, 18 (2): 177-202.

Mathews, J.A., Hu, M.-C. and Wu, C.-Y. 2015. Are the land and other resources required for total substitution of fossil fuel power systems impossibly large? Evidence from concentrating solar power and China, *Renewable and Sustainable Energy Reviews*, 46: 275-281.

Mattoo, A. and Subramanian, A. 2012. *Greenprint: A New Approach to Cooperation on Climate Change.* Washington, DC: Center for Global Development.

Moldvay, J., Hamann, R. and Fay, J. 2013. Assessing opportunities and constraints related to different models for supplying wind turbines to the South African wind energy industry, *Development Southern Africa*, 30 (3): 315-331.

Naam, R. 2015. How cheap can solar get? Very cheap indeed, *EnergyPost*, 21 August 2015, at: http://www.energypost.eu/cheap-can-solar-get-cheap-indeed/

OECD 2011. *Towards Green Growth*. Paris: OECD. Available at: http://www.oecd.org/dataoecd/37/34/48224539.pdf

Pegels, A. and Luetkenhorst, W. 2914. Is Germany's transition a case of successful green industrial policy? Contrasting wind and solar PV, *Energy Policy*, 74: 522-534.

Rodrik, D. 2004. Industrial policies for the 21st century. Cambridge, MA: John F. Kennedy School of Government, Harvard University.

Rodrik, D. 2014. Green industrial policy, *Oxford Review of Economic Policy*, 30 (3): 469-491.

Rubini, L. 2012. *Ain't wastin' time no more*: Subsidies for renewable energy, the SCM agreement, policy space, and law reform, *Journal of International Economic Law*, 15 (2): 525-579.

Sanderson, H. and Forsythe, M. 2013. *China's Superbank. Debt, Oil and Influence: How China Development Bank is Rewriting the Rules of Finance*. New York: Wiley/Bloomberg Press.

Schutte, G.R. 2012. Neo-developmentalism and the search for a new international insertion, *Brazilian Journal of Strategy and International Relations*, 1 (2): 59-93.

Schwarzer, J. 2013. Industrial policy for a green economy. Winnipeg, Manitoba: International Institute for Sustainable Development. Available at: http://www.iisd.org/publications/industrial-policy-green-economy

Simmons, Z.C. 2014. Subsidizing solar: The case for an environmental goods and services carve-out from the global subsidies regime, *UCLA Journal of Environmental Law & Policy*, 32 (2): 422-484.

Stephenson, S. 2013. Addressing local content requirements in a sustainable energy trade agreement. International Centre for Trade and Sustainable Development, Geneva.

THURBON, E. 2015. The abandonment of procurement-linked strategic activism in Australia: Standing still with room to move, *Australian Journal of International Affairs*, DOI:10.1080/10357718.2015.1048780

UNIDO-GGGI 2015. *Global Green Growth: Clean Energy Industrial Investments and Expanding Job Opportunities*. Vienna: United Nations Industrial Development Organization; Seoul: Global Green Growth Institute.

WEISS, L. 2005. Global governance, national strategies: How industrialized states make room to move under the WTO, *Review of International Political Economy*, 12 (5): 723-749.

WILKE, M. 2011. Feed-in tariffs for renewable energy and WTO subsidy rules: An initial legal review. Issue paper No. 4. Geneva: International Centre for Trade and Sustainable Development.

WU, M. and SALZMAN, J. 2014. The next generation of trade and environment conflicts: The rise of green industrial policy, *Northwestern University Law Review*, 108 (2): 401-474.

John A. Mathews

Professor in Management, Marketing & Strategic Management and Innovation at Macquirie Graduate School of Management, in Australia.
Contact: john.mathews@mgsm.edu.au