The green growth economy as an engine of development: The case of China*

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Abstract

Is green growth feasible and possible – or does it remain a contradiction, an impossibly ambitious or (worse) a delusionary goal? If viewed solely from the perspective of the advanced countries, it might indeed seem contradictory. But when considered as a serious goal for an industrializing country, it proves to be an attractive option that delivers economic growth (and with it, rising prosperity) without subjecting the country to the environmental and geopolitical costs associated with black (fossil-fuelled) growth. The case of China is exemplary in demonstrating this, because (1) China is embarked on the biggest industrialization ever before witnessed; (2) China is being forced by circumstance to find an alternative to black (coal-driven) industrialization; and (3) China's model -- best described as one of strategic pursuit of green growth – is delivering economic benefits while also promising to restrain and eventually reduce carbon emissions.

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UNEP *Towards a Green Economy* (2011) (p. 3)

1. Introduction

As the *Green Economy* report issued by the UN Environment Program makes clear, the greening of economies is not generally a drag on growth but a new engine of growth, one that

is focused on the simultaneous achievement of the benefits of growth (new jobs, exports, urbanization) and the benefits of sustainability (e.g. creating renewable energy systems and resource regeneration via the circular economy).[1] In this chapter I probe this assertion and advance the evidence that supports it, with special reference to China.

Western industrialism has achieved miracles, promoting unprecedented levels of prosperity and raising hundreds of millions out of poverty. Industrial capitalism is now diffusing East, where Japan was the first, then the four Tigers (Korea, Taiwan, Singapore and Hong Kong) and now China are all incorporating themselves into the global industrial world. India, Brazil and many others are expecting to follow the same course. But as China, India, and other industrializing giants grow, they are confronted with an inconvenient truth: They cannot rely on the Western industrial development model (fossil-fueled energy systems; resource throughput rather than circularity; generic finance), for reasons to do with extreme spoliation of their own environment and energy security and resource security concerns as much as concerns over global warming.

By necessity, a new approach to environmentally conscious development is already emerging in the East, with China leading the way in building green industry at scale. As opposed to western zero-growth advocates and free-market environmentalists, it can be argued that a more sustainable capitalism is being developed in China – as counterpart to the all-too obvious black developmental model based on coal. This new 'green growth' model of development, being perfected first in China and now being emulated in India, Brazil, South Africa and eventually by industrializing countries elsewhere, as well as by advanced industrial countries such as Germany, looks set to become the new norm in the 21st century. Its core advantages are the energy security and resource security generated. Energy security is based on the fact that all renewables devices are products of manufacturing, and can in-principle be produced anywhere; this relieves anxieties over sourcing fossil fuels from unstable or inaccessible parts of the world. Resource security comes from an industrial system based on closed loops, or circular flows, where minerals can be secured from recycling materials in a system known as 'urban mining' rather than traditional extraction.[2] The two processes complement and reinforce each other – with the shift to a circular economy being the latest manifestation of the movement away from fossil fuels and virgin resource extraction.

In this chapter I develop the argument that a green growth strategy is a logical and reasonable strategy for any industrializing country to pursue, in that it reduces immediate environmental pollution, it costs less than a traditional fossil fuel strategy and linear economy strategy; it enhances energy and resource security by allowing energy and resource extraction to take place within the countries themselves rather than in distant and geopolitically unstable parts of the world; it generates rural as well as urban employment; it is clean and accessible by all. What is there to lose? As industrializing countries pursue the GG strategy (led by China and with India moving to second place and then others like Brazil taking a major position) so they

[1] See UNEP (2011) available at: http://web.unep.org/greeneconomy/resources/green-economy-report; UNEP (2015) provides a follow-up.

[2] See Mathews and Tan (2014; 2016) for articles in *Nature* that make these points. Examples of 'urban mining' activities in Chinese industrial parks such as recirculation of copper in the Suzhou New District are given in the 2016 article. Urban mining promises to become more significant as a source of materials than traditional virgin mining.

discover that they are making moves that resolve their immediate environmental spoliation issues, but also reduce their carbon emissions and waste generation problems. And as these benefits become clear, so the industrializing countries pin more and more of their aspirations on green growth – expanding the market for green goods and driving down their costs in an endless sequence known as circular and cumulative causation (C&CC). This outcome is linked to the fact that renewables devices and industrial symbioses are the products of manufacturing with its attendant learning (experience) curves and the cost reductions that the learning curve delivers.

Green growth as a term is preferred by most of the world's countries engaged in eco-strategies of one kind or another because it is explicitly opposed to 'zero growth'. The OECD made a clever move when it adopted the term GG as describing eco-responsible strategies – as it did in the OECD *Declaration on Green Growth* in 2009 followed up by the major report *Towards Green Growth* issued in 2011. Through these initiatives the OECD emerged as champion of green growth as an alternative to zero growth. The World Bank has followed up, with its report on *Inclusive Green Growth*.[3] Now the term is widely used as a synonym for ecologically responsible industrial development.

When viewed as a serious goal of an industrializing country, green growth proves to be an attractive option that delivers economic growth (and with it, rising prosperity) without subjecting the country to the environmental and geopolitical costs associated with black (fossil-fuelled) growth. The case of China is exemplary, because (1) China is embarked on the biggest industrialization ever before witnessed; (2) China is being forced by circumstance to find an alternative to black (coal-driven) industrialization; and (3) China's model -- best described as one of strategic pursuit of green growth – is delivering economic benefits while also promising to restrain and eventually reduce carbon emissions. Green growth can be viewed as a normative goal, providing a setting within which sound policy choices will be made – such as promoting renewable energies over fossil fuel alternatives, or urban mining as a circular economy initiative rather than searching for virgin resources around the world. The concept of green growth provides the setting where eco-imagination can be allowed to develop, as in proposals to create eco-cities or international renewable power grid interconnections.[4]

Green growth then provides a feasible path forward for industrializing countries – with China demonstrating the strategy most effectively. The green growth strategy is destined to become the development strategy of choice, practiced by all countries that aspire to enhance their wealth and income.

2. Green growth versus sustainable development – what's in a name?

Development discussions ever since the appearance of the Brundtland Report of 1987 and the Rio Earth Summit of 1992 have focused on the concept of 'sustainable development'. The most succinct definition of SD is given in that report, *Our Common Future*: 'sustainable

[3] See OECD (2009; 2011) as well as World Bank (2012). Business opportunities associated with a green shift are spelt out by the Business & Sustainable Development Commission report (BSDC 2017).

[4] On the proposal for a Global Energy Interconnection, promoted by the State Grid Corporation in China, see Liu Zhenya (2015) or IEC (2016). Such a proposal only makes sense in a setting of green growth.

development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs'. (WCED 1987: Chapter 2) The concept of sustainable development has generated many national development strategies and the sustainable Millennial Development Goals, as well as an enormous literature encompassing different perspectives and arguments over how to promote development that is sustainable, i.e. where development and sustainability can be achieved at the same time, rather than waiting to grow rich first and then clean up afterwards, as would be advocated by the notion of an Environmental Kuznets Curve.[5]

More recently we find that multilateral agencies like the OECD, World Bank and UNEP are starting to favour the term 'green growth' as an alternative to SD. What lies behind this switch – which is clearly more than a mere terminological preference?

The problem, I suggest, is that SD is too vague a concept, and has proven to be susceptible to attack from both the 'left', in the form of zero growth and even 'degrowth' advocates, and from the 'right' in the form of mainstream neoclassical orthodoxy and its adherence to notions like the Environmental Kuznets Curve and natural capital. Current debates pitch 'green growth' against alternatives like 'zero growth' or 'postgrowth' or even 'degrowth'. The latter term was popularized by Serge Latouche (2009), who stirred things up with his impassioned pamphlet calling for an end to growth – without even excepting the emerging industrial giants like China and India. There may well be a straightforward reason why these calls for zero growth or even degrowth have been coming with increasing shrillness. As Pascal Bruckner (2013a; b) put it in well-argued texts, even as the West's global influence is diminishing, its arrogance in seeking to dictate to others on the planet how they should adjust their processes to make them climate-friendly, is rising in its insistence. An article appeared in *Harvard Business Review* in 2009 on the shift towards 'postgrowth' business strategies (Speth 2009).

It is highly probable that the OECD introduced the concept of green growth as a means of marginalizing these competing concepts of zero growth, 'postgrowth' or even 'degrowth' with the latter's connotations of shrinkage of industrial economies. The means for halting growth have been variously sketched – including reducing hours of work, and reduced population. But what an industrializing country wishes to focus on is something different from this – it is promotion of industrial growth. There are continuing attacks on China for its practice of burning coal – without apparent recognition that this was the practice of every preceding industrial power. And yet as I demonstrate in this chapter, China is building a green economy faster than any other country, destined to overtake and supersede the black, coal-fired economy. China's electric generating capacity powered by renewable sources (water, wind and sun) reached over half a trillion watts in 2016, or 34 percent of total capacity, while actual electricity generated from these renewable sources accounted for 25 percent of the total. These trends are discussed in greater detail below.

China is highly pragmatic in its adoption of a green growth economy. The OECD for its part has framed its approach to GG very much in a neoclassical setting. The *Towards Green Growth* (TGG) report lays heavy emphasis on the concept of natural capital, evaluating green policies in terms of their ability to extend or protect natural capital. In this sense it may be viewed as a victory for mainstream neoclassical economic analysis and its equilibrium-based

[5] The Environment Kuznets Curve adapts the Kuznets curve (inverted U) to the case of pollution, seeing it rising with greater levels of income and then falling; see Stern (2004) for a discussion.

analysis of environmental issues in terms of input substitutions – rather than the more straightforward approach to harnessing manufacturing by building renewable energy industries or in moving towards a circular economy where resource efficiency would be enhanced. By contrast with the numerous mentions of natural capital there is only one mention of the Circular Economy – and that is strictly in relation to China and the 12th FYP (implying that the CE is a GG strategy specific to China rather than a general strategy aimed at enhancing resource efficiency).

Perhaps most significantly, newly established Multilateral Development Banks (MDBs) such as the China-ASEAN Asian Infrastructure Investment Bank (AIIB) refers to green growth as a goal in its early Policy notes such as its 'Sustainable Energy for Asia' issues paper. It also refers to itself as a green bank, and is committed to promoting green energy future for Asia as part of a general strategy of green growth.[6] The concept of green growth provides the setting within which such lending policies make abundant good sense.

I submit that the most plausible reason that drives adoption of the concept of GG as preferred term for eco-development is that it is the term that best describes what China is doing. I wish to demonstrate in this chapter that China is clearly embarked on a GG strategy – albeit without using the term explicitly.

3. Why China is pursuing green growth so vigorously

Given that China is determined to raise the living standards of its citizens, it must industrialize – for there is no other path to wealth formation. And so China, together with other industrializing countries, is building the energy and resource pathways needed to support its manufacturing engines. While most emphasis in the literature on development theory is on the labour and capital requirements of industrialization, and how they can be enhanced, a more immediate issue concerns the needed resources and energy inputs. Where are they to be found – and how can resource and energy consumption levels be secured? These are the pressing issues faced by any industrializing country.

The West was able to resolve these issues, through the strategy of replacing organic sources of energy with fossil fuels, and accessing unlimited supplies of resources through the colonial arrangements that could be imposed. But China cannot follow this path, because of both immediate environmental costs and more tellingly because of geopolitical limits. China simply cannot scour the planet to claim its own resources, as if it were a 21st century imperial power. An alternative pathway is therefore needed – or the industrialization process that is under way would have to be abandoned.[7]

There are options that would continue dependence on fossil fuels and resource flows from around the world. These are costly and risky – and getting costlier and riskier. The fossil fuel supplies are uncertain and accessing them is getting more and more uncertain. There are physical limits of course (the famous 'limits to growth'). But of greater relevance and force

[6] See the Issues Note on 'Sustainable Energy for Asia' published by AIIB in October 2016, available at: http://www.aiib.org/uploadfile/2016/1013/20161013092907510.pdf

[7] There is by now a large literature on the greening of China's development and its adoption of a *sui generis* growth strategy; see Hu (2006), Spence (2012), Chevallier (2013), Lin and Xu (2014), Zhang (2015) or Dai et al (2016) for an overview.

are the geopolitical limits – the wars, revolutions and terrorism triggered by becoming over-reliant on unstable countries for resource and fossil fuel supplies. Likewise with resources the flow from virgin sources is getting geopolitically less secure, while waste dumping is creating immediate environmental problems. So because of security issues and growing costs, these options are worst case – even without mentioning climate change.

China as a pragmatic hegemon must have realized early in its outward-oriented trajectory that its ability to move ahead with a traditional fossil-fuelled pathway would reach these geopolitical limits, cost limits and environmental pollution limits. The serious pursuit of green power and green transport options dates from the middle of the first decade of the 21st century, and could have been triggered by multiple sources including reflection on the price paid by the US for its dependence on Middle East oil supplies. But in China's case the overwhelming problems with urban air pollution created by burning of fossil fuels (coal for power and industry, oil for private transport) would have provided the major impetus for an alternative pathway, together with longer-term considerations over geopolitical limits.

There is an alternative in the form of **green growth** that is available.[8] This involves on the one hand switching from fossil fuels to renewables – with the attraction that renewables devices are products of manufacturing, and hence can be produced domestically. As such the switch to renewables can enhance energy security while reducing costs (particularly the costs of importing fossil fuels) and providing business export platforms. On the other hand it involves regenerating resources from circular flows, rather than relying on imports of virgin resources and build-up of industrial waste. Instead there can be resort to urban mining whereby resources are regenerated from circular flows. Both strategies are currently being pursued in China.[9]

China has stumbled on this green growth solution and is now implementing it as a matter of the highest priority.[10] China is rapidly becoming the world's renewable energy superpower, where the drive may be located as one that seeks energy security and the cleaning of the immediate environment, through the convenient feature that all renewables devices are products of manufacturing. As such they can be utilized entirely within the domestic sphere, without having to resort to insecure oil supplies from the Middle East, Africa or Latin America. China is emerging as world leader in the restructuring of its economy, transforming linear economic flows into circular flows that encourage initiatives such as urban mining. The strategy of building renewables promotes energy security, while the circular economy promotes resource security. These are of far greater significance for China in its pursuit of green growth than preservation of natural capital, with its neoclassical economics overtones.

There is a strong tendency in the West to view climate change as the main problem and the carbon emissions of industrializing countries like China as the principal source of such problems, to be controlled by placing limits on economic growth. This zero-growth option is considered attractive because it places the blame for climate change on an industrializing country rather than on the industrialized countries which actually caused the problem in the first place. And it lends itself to a simplistic solution in the form of zero growth, to be

[8] For scholarly treatments of the green growth option, see for example Aghion et al (2009); Bowen (2012; 2014); Bowen and Hepburn (2014); Hallegatte et al (2012); Lipsey (2016); Lorek and Spangenberg (2014); Schmalensee (2012); Antal and Van Den Bergh (2014) or Vazquez-Brust, Smith and Sarkis (2014).
[9] See Mathews and Tan articles in *Nature* 2014; 2016.
[10] See for example Hu (2006); Lin and Xu (2014), Zhang (2015) or Dai et al (2016).

achieved through severe carbon taxes imposed on carbon emitting activities (such as generating power from burning coal) and through placing limits on resource consumption. This is the real meaning of the endless recitation of China's level of coal consumption, its carbon emissions and its resources consumption.

A green growth strategy provides an alternative – and more effective solution. Because green growth is decoupled from the material base, it enables incomes to rise while keeping material and energy flows under control. Thus it is not growth itself that is the problem – for intensive growth in incomes and ultimately of wealth is possible without growth in fossil fuel and resource consumption. Growth in fossil fuel inputs can be restrained – and ultimately reversed – by adopting the renewables option. Growth in resource inputs can be restrained – and ultimately reversed – by adopting the circular resource flow option. Thus green growth as a strategy enhances energy and resource security, while reducing costs and building export platforms for tomorrow. This is a very different outcome from seeking to change economic behavior by imposing carbon taxes and resource taxes.

The shift in economic behaviour is brought about by investment strategies, where the desired activities are targeted and prioritized by development banks offering finance at discounted rates in the priority activities. It is through the finance system and the role of development banks that green growth is best implemented, rather than through carbon taxes as favoured by neoclassical economics. Carbon taxes and other environmental taxes can work on investment decisions, of course, but they are generally considered as applying to existing economic behaviour and practices. So it is unlikely that a full-blown GG strategy could be implemented by imposition of taxes alone; investment strategy and the role of developmental banks would probably be necessary ingredients.

Thus the feasible strategy that China is pursuing is best described as green growth, implemented by direct intervention of the state in the economy and through the operation of the financial system, particularly through the role played by development banks. This strategy turns out to be effective in greening the energy system and moving towards renewables, with the curbing of carbon emissions a welcome side-effect. It also greens the resource system through shifting the economy to a circular flow basis, again through directing investment flows to the goal of closing industrial loops.

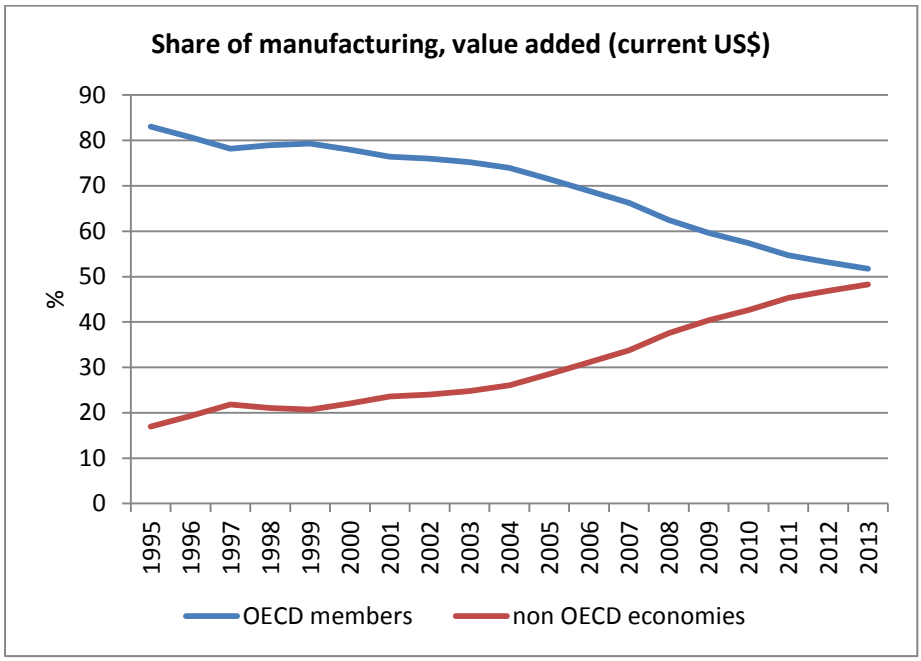
Compared with this green growth approach, as actually practiced by China as a feasible and practicable solution to its industrialization aspirations, the widely discussed policy of seeking to reduce growth to zero – and putting millions out of work in the process – seems crude indeed. And growth does not have to be reduced to zero to accommodate ecological concerns, provided the growth concerned is intensive growth – growth in incomes and wealth, rather than growth in material and energy inputs.

4. China's greening: the data

Let us review the evidence supporting the claimed shifts that are the dominant trends today – the shift in manufacturing east, and the green shift away from fossil fuels. They are in fact linked, at a profound level, because it is China that is driving the shift of manufacturing east, and as it does so, it is finding that it has to drive the green shift as well.

The data on the shift of manufacturing to the east is clear and unequivocal. If we abstract from value chains and other miscellaneous features, and focus just on value-added (revenues less costs) then the shift from OECD countries to non-OECD countries (to wit, China) is clear – and the non-OECD countries can be expected already to account for more than 50% of world manufacturing value-added.

Fig 1 Manufacturing moving East



Source: Mathews (2017), with OECD Development Centre as original source.

In fact we have data on China emerging as world's largest manufacturing country. The US-based Manufacturers' Alliance for Productivity and Innovation (MAPI) has analyzed UN data up to the year 2013 and found that China accounted for no less than 23% of world manufacturing value-added in 2013, as compared with just 17% for the US and 8% for Japan. The BRICS countries – Brazil, Russia, India, China and South Africa – accounted for just under 30% of the global manufacturing value-added in 2013, with India accounting for 2% of the total (and growing).[11]

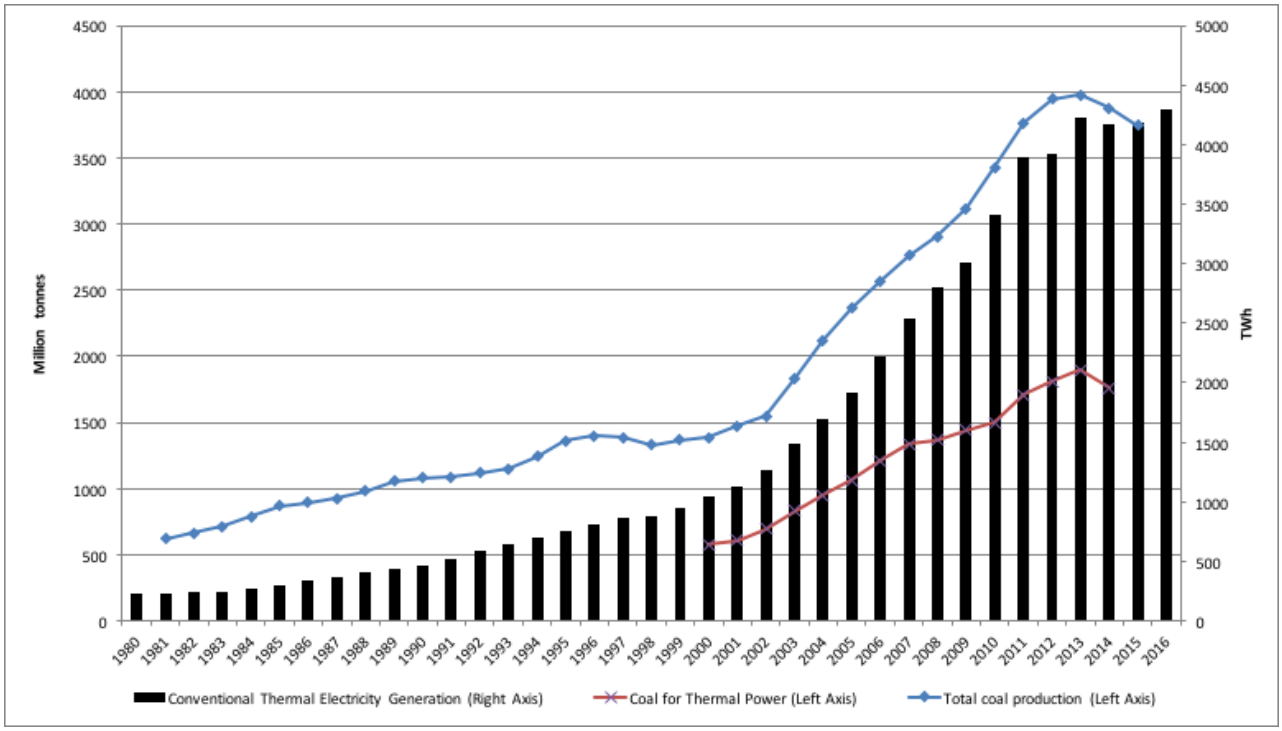
As China and eventually India build their vast manufacturing engines, so they discover the need to power them with energy sources – of which fossil fuels are the obvious and initially favoured candidates. A similar choice has been made by all previous rising industrial powers. But in earlier centuries and decades the choices in favour of coal, oil and gas did not have the immediate environmental problems or geopolitical problems that China's choices face today.

This is where the link with green growth comes in. The green transition that is currently under way is the single most important feature of the current world, along with the rise of China as the world's premier manufacturing power. Indeed the two features or processes are

[11] See the reports on global manufacturing shares at the MAPI website: See: https://www.mapi.net/blog/2015/09/china-solidifies-its-position-world%E2%80%99s-largest-manufacturer

tightly linked, because China's rise is based on the building of a huge energy system to power the manufacturing system, and China has discovered the limits to trying to build this energy system on the basis of fossil fuels. The limits are not so much commodity supply limits of the kind investigated and popularized by the Club of Rome study of 1972 on *Limits to Growth*, but rather geopolitical limits as China finds that its quest for resources and especially fossil fuels around the world runs into problems involving civil wars, revolutions and terrorism. Compelled by these factors, along with the terrible immediate environmental problems created by China's headlong rush to industrial maturity, China is finding that conventional energy and resource strategies ("business as usual") no longer work, and it is instead engaging in an alternative "green growth" strategy that is proving to be very successful. This alternative is driven by reducing costs, market expansion and manufacturing innovation as China becomes a principal global player in installing renewable energy systems (such as wind power and solar photovoltaic cells) and in manufacturing the devices needed to capture the renewable energy sources. China's green and black strategy is easily seen when we look at longitudinal data on electric power generation.

Figure 2. China's "black" energy system, 1980-2016: Coal consumption and electricity generation

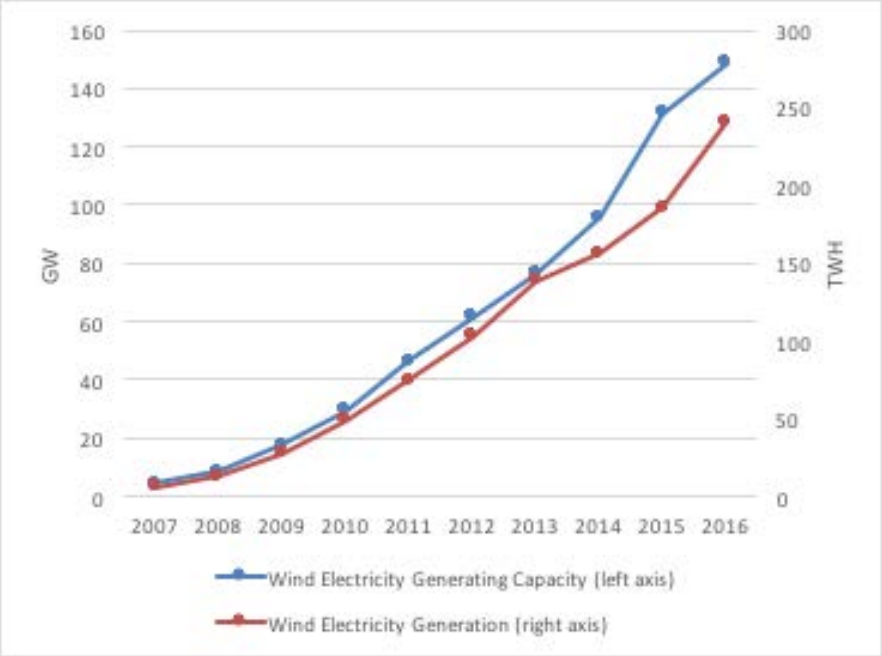


Source: Mathews and Tan (2017). The data for conventional thermal electricity generation is sourced from the China Electricity Council (CEC); the data for total coal production is sourced from the *BP Statistical Review* (2016) 'Statistics of World Energy'; the data for coal consumption for thermal power generation is sourced from the National Bureau of Statistics, China.

The effect of this rapid expansion of fossil fuels input in China is well known – it is unbreathable air and undrinkable water, combined with rising geopolitical tensions as China

(and now India) scour the planet for fuels and resources. But China has stumbled on an effective remedy for these problems – renewable energies and urban mining or recirculation and regeneration of resources. The rapid build-up of wind power (Figure 3) provides one aspect of the green side of China's energy revolution.

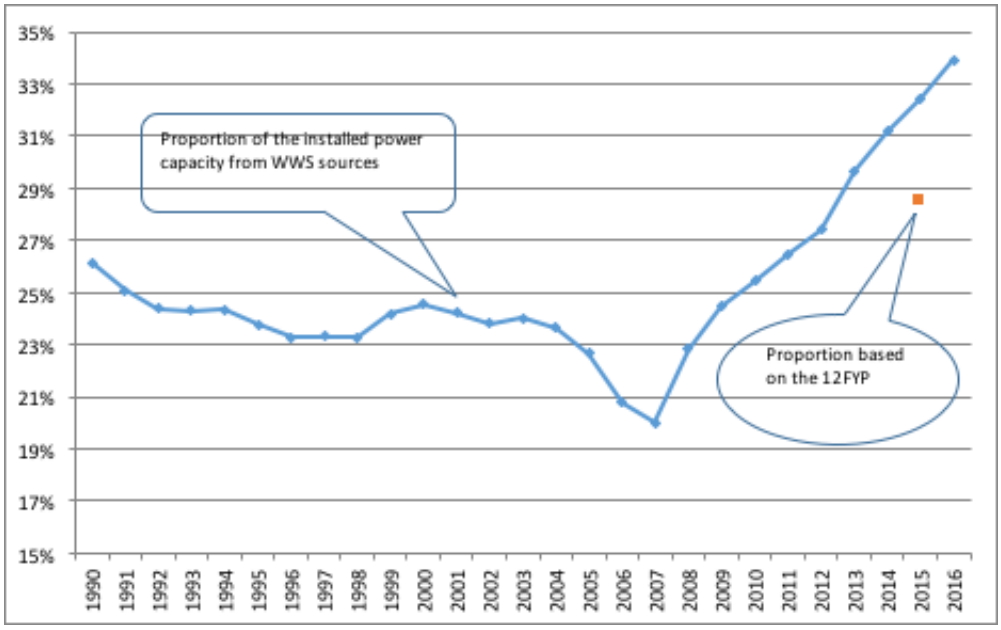
Figure 3. China's "green face": China wind power capacity, 2007-2016



Source: Mathews and Tan (2017), based on primary data from China Electricity Council

The evidence demonstrating this green shift is clear and unequivocal. Consider Figure 4, which shows the rapid increase in proportion of electric power generated from water, wind and sun (WWS) – rising from a low of 20 percent a decade ago to reach 34 percent in 2016 – a 14 percent change in a decade. This is an astonishing rate of change for such a huge system with its vast existing fossil fuel infrastructure.

Figure 4. China: Trends in power sources generated from Water, Wind and Sun, 1990 to 2016



Source: Mathews and Tan (2017), using data sourced from the EIA of the US, data after 2008 is taken from the China Electricity Council

We may break down the renewables sources as hydro (water), wind and solar, calling them WWS, as done by Mathews and Tan (2017), as shown in Table 1. By 2016 the WWS sources together accounted for more than half a trillion watts of generating capacity, or 558 GW, with hydro accounting for 332 GW, wind for 149 GW and solar for 77 GW. While hydro has remained relatively constant over the past decade, the contributions from wind and solar have increased rapidly, as revealed in Table 1.

Table 1. Power generation and changes, China, 2015-2016

1. Capacity GW

	2010	2015	2016	Change in 2016 compared with the 2015 level	Change in 2016 % Y on Y	Change % since 2010
Total	966.4	1521.2	1645.8	124.6	8.2%	41.7%
Thermal	709.7	1000.5	1053.9	53.4	5.3%	25.5%
Water	216.1	319.5	332.1	12.6	3.9%	71.9%
Wind	29.6	131.3	148.6	17.3	13.2%	387.9%
Solar	~0.26	42.6	77.4	34.8	81.6%	-
WWS subtotal	245.6	493.5	558.2	64.7	13.1%	102.1%
Nuclear	10.8	27.2	33.6	6.5	23.8%	185.4%

2. Generation (TWh)

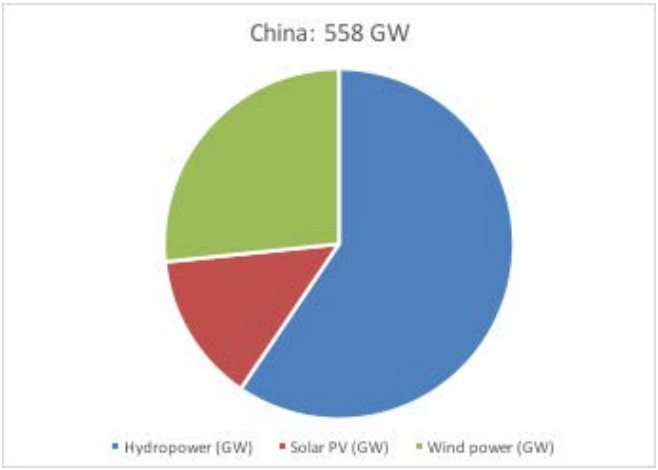
	2010	2015	2016	Change in 2016 compared with the 2015 level	Change in 2016 % Y on Y	Change % since 2010
Total	4227.8	5693.8	5989.7	295.9	5.2%	70.3%
Thermal	3416.6	4186.8	4288.6	101.8	2.4%	48.5%
Water	686.7	1111.7	1180.7	69.0	6.2%	53.7%
Wind	49.4	185.3	241.0	55.7	30.1%	402.5%
Solar	~0.1	38.5	66.2	27.7	71.9%	-
WWS subtotal	736.1	1335.5	1487.9	152.4	11.4%	127.2%
Nuclear	74.7	171.4	213.2	41.8	24.4%	211.5%

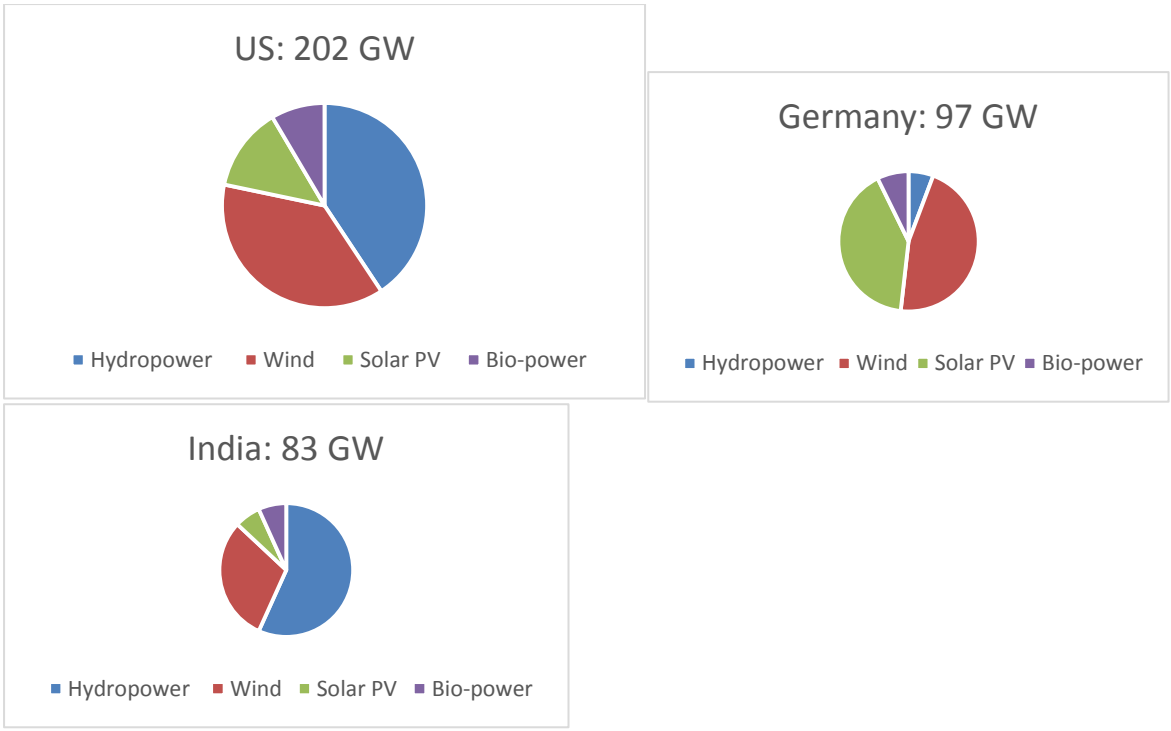
Note: WWS Water (hydro), Wind and Sun

Source: Mathews and Tan (2017)

If we look for evidence that China is actually building more green energy capacity than other countries the data is again clear: China's generating capacity of 558 GW sourced from WWS (water, wind and sun) stands in strong contrast with generation from renewable sources in other industrializing countries, as shown in Fig. 5.

Fig. 5. China's generation capacity from WWS sources compared with other leading industrial countries, 2016





Source: Mathews and Tan (2017). Based on REN21 (2016) *Global Status Report.* Note that the total WWS capacity for China is listed as 558 GW, consistent with Chinese CEC statistics.

These are the data we need to frame a story about China's otherwise inexplicable choice in favour of green growth. China's green shift (what it calls 'ecological civilization' but which equates to green growth) is a response to the strategic desire to industrialize as fast as possible, via the well-tested path of manufacturing, and to the recognition that a conventional path via fossil fuels will not be feasible. But an alternative strategy via renewables and the circular economy (green growth) is a feasible way forward – not because of carbon taxes but through interventions by the strong Chinese state to restructure the Chinese economy along renewable and circular economy lines. This is not to provide a justification for the actions of an authoritarian state, but to suggest that an objective evaluation of its impact is called for. And as China reduces costs for a GG strategy, so the options for other industrializing countries are broadened, without their necessarily having to deploy authoritarian state agencies to capture these opportunities.

Here we come to the core of this argument. It turns out that green growth is a smart strategy for China because it is based on manufacturing. All the renewables devices are products of manufacturing, and their production can be controlled domestically – enhancing energy security. All the shifts towards a circular economy and urban mining likewise are based on manufacturing value chains. And it is manufacturing that generates increasing returns.

Now the conventional economic account of this green shift is to focus on switching from one energy system to another (or one resource flow to another) as a matter of substitution, where price of one commodity/product versus another is determined in some equilibrium framework. Policy initiatives can be taken in such a framework by cost-moderating instruments like green taxes or market mediated caps on emissions. Apart from the fact that such interventions have proven to be very weak when put into practice, and stand little

chance against the raft of subsidies that have historically supported the fossil fuels system (oil and gas industry, coal industry, power generation industry), these equilibrium-based instruments offer precious little insight into the workings of energy industrial dynamics. But a Schumpeterian perspective will generate far more fruitful insights than the conventional approach. The extraordinary feature of this GG strategy on China's part is that it delivers the very low-carbon emissions results that are sought by other neoclassically designed strategies, like carbon taxes and cap and trade schemes.

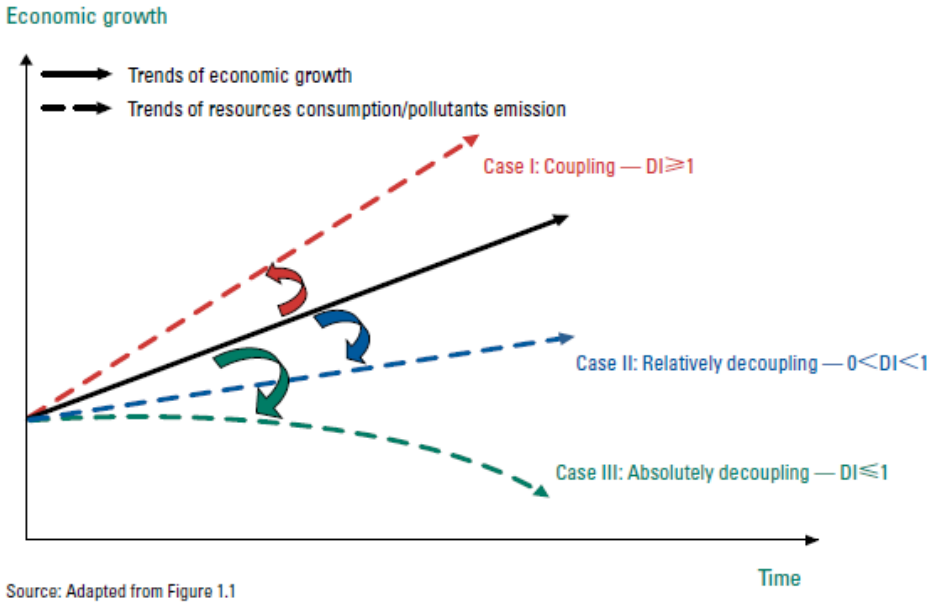
5. Decoupling is the core concept in green growth

The core of the notion of green growth is that growth and enhanced resource efficiency (lower throughput of resources per unit economic output) and enhanced energy security (through manufacture of renewable energy devices) can be achieved while economic incomes, wealth and prosperity rise. Let us refer to a *Decoupling Index* to capture this idea graphically. We can capture the rate of change of resources used per unit rate of change in the economy as such a DI. Normally this Index will have a value exceeding 1 – meaning that the resources consumed will increase faster than the economy grows. This is otherwise known as 'Business as usual' – and it is what spells ruin for an economy like China's because of the increasing geopolitical pressures experienced as it tries to keep running on the resource throughput treadmill. It also spells ruin for the planet if that resource footprint keeps on getting larger. If an economy's resource usage/consumption increases just as fast as the economy is growing, then it is said to have a Decoupling Index equal to 1 – an important tipping point. When the Decoupling Index falls below 1 (but is still positive) this is a situation known as relative decoupling. .This is the situation reached in many OECD countries, where falling resource intensities mean that the countries consume less and less resources to achieve a given level of economic growth. For China the achievement of relative decoupling is a pre-eminent goal, measured in its Five Year Plans with their national targets for resource intensity reduction and energy intensity reduction. These are eminently pragmatic targets for China's planners, of much greater significance than ideas emanating from concepts of natural capital and its preservation. Finally, if the Decoupling Index actually falls into negative territory, then this means that the economy consumes fewer resources as it grows – a situation known as absolute decoupling. No major country has reached this situation as yet. But it is clearly the end goal of any green growth strategy.

The Decoupling Index is introduced in the important UNEP/IRP report of 2011 on 'Decoupling natural resource use and environmental impacts from economic growth'. The report provides a useful chart that explicates the shift in the Decoupling Index very clearly (Fig. 6).

Figure 6. The Decoupling Index and economic growth

Figure 8.2. Scenarios for economic growth and its pressures on environment and resources



Source: Mathews (2017), based on UNEP/IRP report *Decoupling natural resource use and environmental impact from economic growth*, Fig. 8-2.

There are clear policy implications of this analysis, namely that GG strategies should be oriented towards lowering the value of the Decoupling Index – such as through promoting renewable energies as opposed to fossil fuels and promoting the Circular Economy as opposed to linear resource throughput. These are precisely the policy directions that may be observed today in China (and which can be expected in India) and in the funding guidelines of new financial institutions such as the Asian Infrastructure Investment Bank (AIIB), as noted above.

6. Green growth: intensive vs extensive growth and strategy

Green growth appears to be a contradiction only when growth is viewed in a traditional mainstream sense as extensive growth, involving growth in the scale of physical production – with expanded inputs of resources and expanded physical output. But growth is equally susceptible to an alternative definition as growth in economic performance – involving incomes and wealth – which if decoupled from its physical and energy basis can grow without growth in its physical character. This is what is known as *intensive growth* – and I submit that it is essential to make this distinction if the debate over green growth strategies is to make any progress.[12]

Intensive growth is the product of economic processes of interaction that draw on cluster effects, inter-organizational dynamics and industrial districts resulting in what economists have long termed ‘increasing returns’. They may be generalized as systemic effects, or the result of synergistic effects that make the whole greater than the sum of its parts. If output is

[12] See my 2011 *Futures* paper for a discussion. Unfortunately the OECD report *Towards Green Growth* makes no such distinction between extensive and intensive economic growth. It refers to growth that is capital-intensive, or energy-intensive or carbon-intensive – but not growth that is intensive as opposed to extensive.

represented as a production function, where output Y is depicted as a function of inputs including capital, labour as well as physical resources (generalized as land), then the increase in output resulting from an increase in inputs is represented by a growth equation. By contrast, the existence of intensive growth would be represented by an inequality, where the increase in output would exceed the immediate effect of the increase in inputs. It is clear that in probing these processes we are getting to the very core of what makes an economy work.

As I put it in an article in *Futures* published in 2011,

> It is the difference between intensive and extensive growth that is fundamental. Growth that is measured in increases in GDP is usually extensive growth, associated with increasing flows of materials and energy through the economic system. This is what clearly cannot continue indefinitely – and which indeed must be curbed as a matter of the highest urgency. But intensive growth is a different matter entirely. This refers to a growth in value without change in the flow of resources, through increasing levels of recirculation. … Increasing returns were banished from analysis for reasons solely to do with mathematical tractability of the equations governing supply and demand at equilibrium (there is no convergence with increasing returns); but in capitalist reality, as opposed to its neoclassical fictions, the search for increasing returns govern strategy, and in totality they create the possibilities for intensive growth.[13]

It is concepts like increasing returns, clusters and systemic interactions that characterize the real progress achieved along GG lines by emerging industrial giants like China and India. Increasing returns are generated (and so intensive green growth is accomplished) through the expansion of the green growth sector of the economy -- which can be envisaged as groups of firms making interconnections in the same way that pieces strengthen each other in the ancient board game GO. This remains a vivid illustration of the expansion of the green growth economy within the womb of the old fossil fuel and linear economy.

7. Concluding remarks

Green growth is articulated in this chapter as a sound normative goal for rapidly industrializing countries like China, and as providing the descriptive setting within which policies like expanding the reach of renewable power grids makes abundant sense. No one invented the green growth strategy in itself. There was some discussion of 'eco-development' in the 1970s and 1980s, but this petered out in the West. China has stumbled upon the notion while seeking to allay problems of immediate environmental pollution and energy security issues as well as resource security issues. It was a pragmatic turn on the part of the Chinese leadership. But once the benefits of the green growth strategy started to manifest themselves, the Chinese state (at central and provincial levels) was able to intervene in the economy to restructure it along green growth lines, utilizing green finance as the means to drive investment along new pathways. This has turned out to be a powerful means of reshaping an economy – far more powerful than the carbon taxes and cap and trade schemes so much discussed by neoclassical economists.

Meanwhile the traditional economic establishment puts up heroic resistance to the green growth challenge. Some argue that 'green growth' is a contradiction in terms, and that growth

[13] See Mathews (2011): 8. Eventually, scholars such as Murphy, Shleifer and Vishny (1989) managed to make the synergies involved mathematically tractable.

always means growth in resources and energy consumption that is incompatible with a finite world. This would be a deadly objection – if it were true. But there can be growth in incomes without growth in energy and resource throughput. Indeed this is the real meaning of the notion that there is an economic output produced by economic inputs that generate increasing returns. This is what industrializing countries like China are moving towards as they implement determined green energy and green resources (circular economy) strategies. While some argue that greening growth can create new jobs, mainstream economists insist in response that green policies can have an impact on the composition of investment and employment, but not on their levels (e.g. Schmalensee 2012). This is an assertion not supported by any evidence. The case of China clearly demonstrates the contrary, namely that green investment can create jobs in great numbers -- while the same state-led policy is reducing employment in fossil fuel industries, particularly coal. These are market-mediated policies being implemented in China – but they do not seem to be recognized as such by mainstream economists.[14] Other scholars like Antal and Van Den Bergh (2014) view a GG strategy as being impossibly difficult (based largely on vested interests reasoning) and fall back on zero growth – without considering the impact that this would have on prospects for countries like China and India.

We find economists like Collier and Venables (2012) arguing that green strategies in Africa go against the comparative advantages that African countries are supposed to have in traditional non-green industries. Schmalensee himself argues that 'Africa's shortages of capital, skills, and regulatory capacity make green options relatively expensive, while its natural endowments of fossil fuels make their uses relatively cheap' (2012: S5). This is tantamount to arguing that all the poor need are fossil fuels; or that fossil fuels fulfil a moral obligation on the part of the rich world to the poor world. But a closer look at the same situation reveals that African countries have everything to gain by moving to build their economies around green energy and resource flows. African countries can leapfrog their competitors in Western countries by moving swiftly to adopt solar and wind power while reducing their (sometimes onerous) costs of importing fossil fuels.[15]

By contrast, green growth promises to provide guidance for realistic and feasible industrialization strategies pursued by emerging giants like China and India and to be emulated by emerging economies in Africa, Asia and elsewhere. Green growth is more focused and explicit than the vague goal of 'sustainable development' while being sharply different from the current Western favourites of zero growth and even degrowth. In this chapter I have argued that green growth implies an alternative view of how the economy works, focused more on clusters and industrial districts than on individual firms; on growth as an intensive phenomenon driven by market expansion; on manufacturing as the source of

[14] Schmalensee (2012) queries both demand-side and supply-side policies for stimulating green growth in the US, insisting that they have had perverse outcomes. 'Particularly in recent years, the state requirements have been explicitly intended to create in-state employment. The result of all this has been remarkable growth in both wind and solar electric generation, which has served to increase the cost of electricity – some of which is borne by taxpayers, not ratepayers'[2012: S4] Compare this with the case in China, where state guidance through the 5YPs channels investment towards solar and wind device manufacturing as well as solar and wind power generation. As the market expands so the costs decline, through the effect of the learning curve.

[15] See 'African path to avoid fossil fuel dependency', *Financial Times*, November 10 2016, by Andrew Ward https://www.ft.com/content/c168de08-9f8f-11e6-891e-abe238dee8e2

increasing returns; and on the power of emerging giants like China and India to drive the restructuring of the world's unsustainable energy and resource flows.

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