Low Carbon and Economic Growth: Are Both Compatible in Developing Economies?

Posted by nate hagens on August 24, 2011 - 8:15am
Topic: Economics/Finance
Tags: developing economies, economic growth, iier, low carbon economies [list all tags]

At the intersection of global energy depletion and concerns about human impact on the environment lie some serious and oft overlooked issues. Largely gone from our public discourse is the idea that oil is infinite. It is now accepted, even to previous staunch cornucopians, that increasing, or even maintaining oil production will come only at higher costs. The new response to the energy/environmental crisis is to transition to a green economy, replacing our declining stocks of fossil sunlight with new technologies able to harness our current sunlight in its various forms. That these renewable technologies are available, viable and becoming more popular is not in question - however, whether these low carbon strategies can combine with now more expensive fossil fuels to maintain a growth trajectory for both the developed and developing worlds is another question entirely.

I am on the Board and work closely with the Institute for Integrated Economic Research (IIER) - an institution concerned with the transition of human societies following a likely end to global growth. Recently, IIER was commissioned to produce a report sponsored by the British Department for International Development (DFID), addressing the question as to whether it will be possible for emerging economies to simultaneously go green and still grow economically. The answer, which also applies to advanced societies, is that the traditional path of urbanizing and industrializing nations is most likely incompatible with the reduction of carbon emissions, as long as economies don't find someone else to do the "dirty" part of the work.

This "dirty" work is currently to a large extent conducted by China, a country which consumes about 40% of all natural resources and produces about 40% of all industrial outputs, while its own GDP share only amounts to a little more than 10% of the world total. Shifting all the "heavy lifting" away from advanced economies has made it possible for them to become less energy-intensive over time, thus reducing their carbon emissions - while carbon dioxide output has skyrocketed in other places. Unfortunately, this model isn't scalable globally, as in the end, when China tries to copy that Western success story, there won't be another place to go where cheap energy and labor is available.

The report looks at the context of past productivity gains and at the reasons why it won't be possible to extrapolate them into the future, because traditional economics look at past successes by omitting the role of (cheap) energy. It concludes that while it is possible for emerging economies to improve the well-being of their populations without growing greenhouse gas emissions, it won't be feasible to industrialize them in the "green" way everybody hopes for.

Below the fold is a 2-page executive summary and links to the full 66 page report - "Low Carbon and Economic Growth - Key Challenges"(Pdf warning)

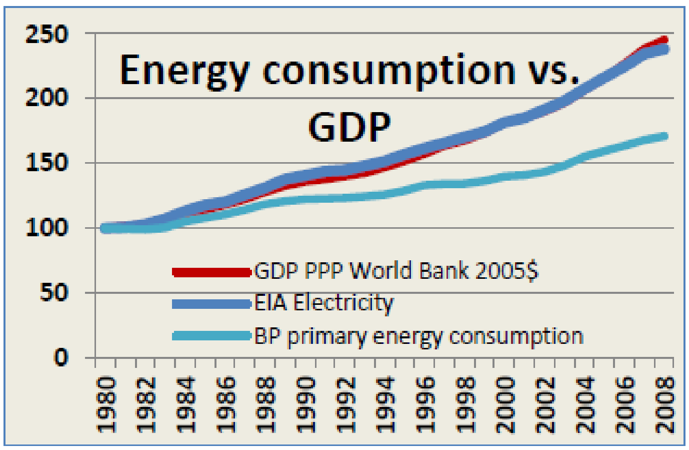
- Economic growth is highly correlated with the availability of low-cost, high-quality energy
- Advanced economies may accomplish some decoupling based on the outsourcing of

heavy industrial activity

- Given the superior characteristics of fossil fuels in terms of cost, density and manageability, renewables will offer only limited potential to replace them as key drivers of industrial output
- While this limits the chances for middle-income economies to reduce emissions, low-income countries have opportunities to grow wealth and well-being without adding large amounts of CO_2

In December 2009, the 15th Annual UN Climate Change Conference ended without a globally binding agreement to reduce greenhouse gas emissions. The outcomes from the 2010 talks in Cancun were equally non-committing. Among the reasons for these failures were concerns of emerging nations such as India and China that limits on carbon-dioxide emissions would impair their ability to further grow their economies. Given the evidence we outline below, they probably have a valid point.

1. The crucial role of energy in growth: On a global scale, economic growth has always been highly correlated with higher energy consumption. Between 1980 and 2008, to produce one additional unit of GDP, 0.55 additional units of primary (raw) energy inputs were required[i]. When looking at energy that can be directly applied to societies, correlations are even stronger: during the same period, for one unit of GDP, electricity use grew by 0.95 units globally.[ii]



GDP and primary energy use (1980=100)

This strong connection between economic growth and energy consumption is often overlooked. It is based on the key paradigm of the industrial age: a significant portion of the productivity gains of the 19^{th} and 20^{th} century were achieved as greater mechanical energy use released human labour capacity. In industrial societies, one unit of human labour, measured in food intake, was often replaced by 100-1000 units of mechanical energy, mostly delivered from fossil fuels.[iii] This mechanism produced benefits during periods of low energy cost in the form of lower prices for goods, higher wages and profits. When energy prices rise, this same model begins to work against us. IIER research shows that rising manufacturing-related energy prices quickly reverses benefits for wages and profits. Efficiency increases are rarely able to offset those productivity losses, as they – for most process chains – are typically only in the 10-30% range.

2. How advanced economies became more energy-efficient: Whilst apparently advanced economies have been able to post economic growth without growing their energy footprint, a significant portion of 'energy efficiency' gains are related to the outsourcing of heavy industrial activities to emerging economies. For example, in 2007, China produced 41% of all iron and steel and 37.5% of all aluminium globally, while representing only 10.8% of global GDP, leading to significant embedded energy transfers to advanced economies. This reflects overall trends in globalisation as supply chains have been repeatedly reconfigured to exploit the benefits of low-cost labour and energy. When netting out these benefits, a majority of energy and carbon footprint reductions in advanced economies have been due to "energy used elsewhere" from global shifts of energy-intensive processes, and not related to real efficiency improvements[iv].

3. Fossil fuels are key drivers: In order to grow, economies not only require more energy, but the properties of the energy sources used, such as density, cost and manageability, matter a great deal. Today, almost unchanged from 1990, coal, crude oil and natural gas provide approximately 85%[v] of global primary energy.

	Self Sufficiency		GDP$	Global Share			
	Primary Energy	Food calories	Per GJ	GDP	Iron+Steel Production	Aluminum production	Fertilizer production
United States	71%	119%	141 $	21.1%	4%	7.6%	6.1%
China	92%	90-95%	95 $	10.8%	41%	37.5%	32.8%
UK	80%	74%	217 $	3.1%	0.6%	1.1%	< 0.5%

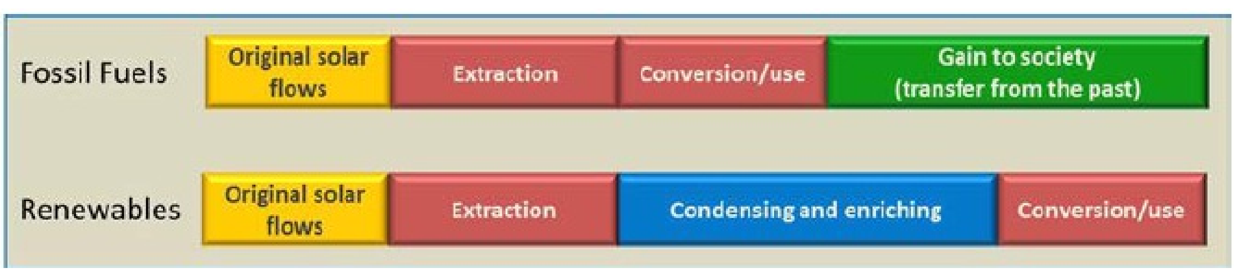
Energy efficiency of economies ($/GJ of primary energy consumption) and other key factors

Low-income countries may grow despite carbon reductions

Fossil fuels are – despite recent price increases – the cheapest and most useful fuels, as long as externalities such as pollution and environmental issues are not factored into their pricing.

The key challenge in replacing coal, oil and gas is that they are formed from historic solar inputs. A barrel of oil contains past solar energy from growing plant biomass, from biotic or abiotic fermentation, and added pressure and heat from geological, solar and geothermal mechanisms applied over millions of years. This process has yielded high density energy sources that are easy to extract, transport, and handle. To accomplish the same, for example with biomass, the required "upgrade" from plant material to a combustible fuel needs additional energetic effort, which adds cost and reduces net benefits. This need for "upgrading" directly translates into higher energy cost for the future[vi].

Furthermore, alternative sources, like nuclear, solar, wind and biomass, are based on significant fossil fuels inputs. If solar panels were produced with energy from solar panels, their price would be prohibitive, compared to today, where 50% of all panels are manufactured in China using coal-based inputs. This makes a true replacement of fossil fuels extremely challenging, unless currently unknown new technologies come into play. Given the "historic energy" embedded in fossil fuels, this is maybe an unrealistic expectation.



Benefits of fossil fuels over renewables - past energy inputs

4. What low carbon translates to: To establish a low-carbon economy will require us to work against the key trend that has driven wealth creation during the 19th and 20th century – the replacement of small amounts of expensive human labour by large quantities of low-cost fossil fuels. Renewable energy sources do provide energy, but very likely only with reduced benefits, given their higher extraction and conversion effort and thus higher cost. The same is true for cleaner fossil fuel uses. For example, carbon sequestration might reduce generation efficiency by approximately 24% and lead to cost increases of up to 82% over regular coal based electricity[vii].

5. The challenge - growing economies: Our research indicates that mid-level income countries (like China and India) have only limited opportunity to continue a growth trajectory without significantly adding to their carbon footprint, unless they too find other places to outsource their industrial production – which seems unlikely and would not yield a net reduction in global emissions. This reality is likely to be the main driving force behind the reluctance of China and India to accept clear carbon limits, as this – almost certainly – would impose almost impenetrable ceilings on their growth expectations[viii].

A closer look at China corroborates this view. China procures more than 90% of its energy from oil, natural gas and coal. It operates with a much lower energy cost vis-à-vis OECD countries (3-4 cents/kWh of industrial electricity in China vs. 6-11ct/kWh in most OECD countries)[ix]. This advantage is driven by a number of factors, but the most important is the predominance of coal in China's electricity mix, which can be exploited at low cost. This advantage is further enhanced by lower labour cost and different environmental standards in mining and power generation. Without the use of coal-based electricity, China's significant competitive advantage would shrink, removing an important driver of its recent growth.

6. The opportunity – low-income economies: In poorer countries, we see a much higher potential to combine low carbon and welfare-improving efforts. In many cases, the benefits of industrialisation are not widespread and the transition from human to mechanical labour hasn't fully taken place yet. At the same time, many low-income countries are dependent on patchily available crude oil, currently the most costly fossil fuel per unit of delivered energy. In 2009, Africa (excluding Egypt, Algeria and South Africa) consumed 60.3% of its primary energy from oil, compared to a 35.5% share of oil globally[x].

This opens a window of opportunity for quality-of-life improvement from relatively low-yielding sustainable technology solutions. These are not likely to be high-tech, but instead simpler approaches based on enhancing locally available resources to transform solar flows into usable energy and other benefits. Examples might be simple solar power systems, water purification solutions, the growing and processing of oil seeds from marginal, non-arable land for biofuels[xi], and improvements in agricultural technology that secure higher yields[xii].

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[i] World Bank (GDP PPP), EIA (primary energy)

[ii] U.S. Energy Information Agency (EIA)

[iii] Cleveland, Kaufmann, Stern. 2000. Aggregation and the role of energy in the economy, Ecological Economics, 32(2): 301-317. Cleveland, Costanza, Hall, Kaufmann (31 August 1984) Science 225 (4665), 890., IIER research

[iv] Guan, Peters, Weber, Hubacek (2009). "Journey to world top emitter – an analysis of the driving forces of China's recent CO2 emissions surge." Geophysical Research Letters. 36, L04709, IIER analysis (unpublished)

[v] U.S. Energy Information Agency (EIA)

[vi] Pimentel, David. 2008. Biofuels, solar and wind as renewable energy systems: benefits and risks. [Dordrecht, Netherlands]: Springer.

[vii] Hamilton, Herzog, Parsons, Cost and U.S. public policy for new coal power plants with carbon capture and sequestration, Energy Procedia, Volume 1, Issue 1, Greenhouse Gas Control Technologies 9, Proceedings of the 9th International Conference on Greenhouse Gas Control Technologies (GHGT-9), 16-20 November 2008, Washington DC, USA, February 2009, Pages 4487-4494, ISSN 1876-6102, DOI: 10.1016/j.egypro. 2009.02.266. Cost and U.S. public policy for new coal power plants with carbon capture and sequestration

[viii] Climate Change—the Chinese Challenge

[ix] Industrial Countries' Power Cost Comparison

[x] BP Statistical Review of World Energy 2010

[xi] Biofuels from Marginal lands: Some insights for India; Achten, Maes, Aerts, Verchot, Trabucco, Mathijs, Singh, Muys, Jatropha: From global hype to local opportunity, Journal of Arid Environments, Volume 74, Issue 1, January 2010, Pages 164-165, ISSN 0140-1963, DOI: 10.1016/ j.jaridenv.2009.08.010

[xii] Rockstrom, Kaumbutho, Mwalley, Nzabi, Temesgen, Mawenya, Barron, Mutua, Damgaard-Larsen, Conservation farming strategies in East and Southern Africa: Yields and rain water productivity from on-farm action research, Soil and Tillage Research, Volume 103, Issue 1, April 2009, Pages 23-32, ISSN 0167-1987, DOI: 10.1016/j.still.2008.09.013.

The link to the full report is here.