Energy Decline and National GDP in 2050: The Growth of Destitution

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Tags: energy, per capita gdp, population [list all tags]

This is Part 2 of a post by GliderGuider. Paul's website can be found here.

In Part 1 I derived a scenario for the changing global energy supply picture between now and 2050. The conclusion in that article was that due to the rapid decline of oil and natural gas supplies, the total energy available to the world would drop by about 30% in that time. That single figure, however, doesn't tell us much. The picture is dramatically complicated by the fact that the world will be forced to transition from an energy economy largely based on fuels (oil and natural gas) to one based primarily on electricity generated from a variety of sources. In addition, most of the world's population growth in that time will occur in the energy-poor and economically-poor developing world.

In order to gain more insight into how changes in energy will affect different parts of the world, this article will examine the impact of energy declines in specific countries. We will disaggregate the global picture presented in the baseline energy article, and apply those changes to the specific energy circumstances of individual nations. Those energy changes will be translated into their effect on national GDP. The national population changes projected by the UN Medium Fertility Case will be used to translate the national GDP changes into average per capita GDP changes for each country.

The examination of changing per capita GDP, driven by changes in the energy supply and national populations, will help us understand the distribution and extent of wealth and poverty over the next half century.

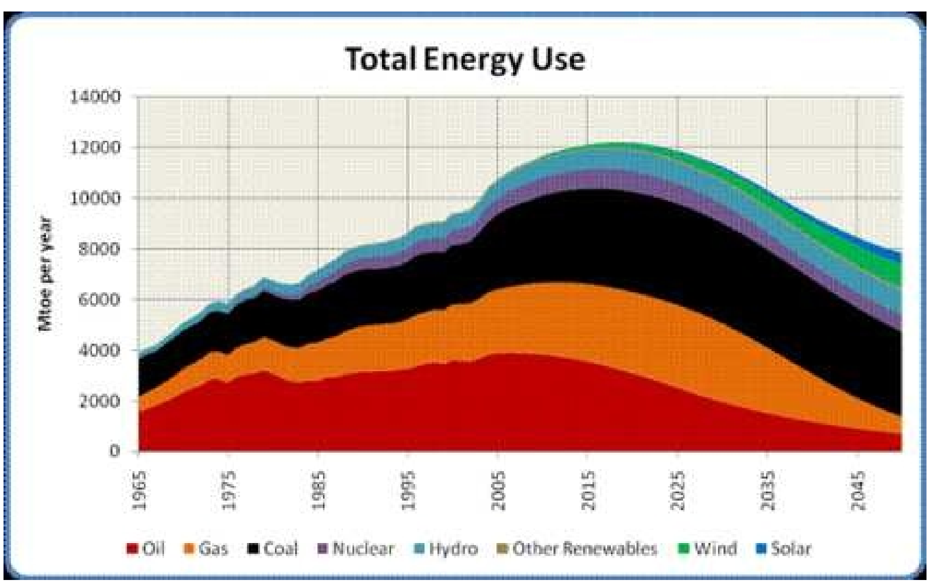

Figure 1: Total Energy Use, 1965 to 2050

Methodology

National Energy Budgets

The analysis in this article is supported by the global model of energy trends referenced above, that defines an individual supply curve for each energy source - oil, gas, coal, hydro, nuclear, solar and wind power.

In order to apply this to individual countries or regions, I started with the national energy consumption figures for 2006 found in the BP statistical Review of World Energy 2007. To establish each country's consumption in 2050 I multiplied their current use of each energy source by its production increase or decline factor derived from the model.

In the case of renewable energy, which is not included in the BP data, I used an ad hoc approach to add some amount of renewable energy to each country's budget. To do this, I took the basic energy budget determined in the first step and increased it by 5%, 10%, 15% or 20%. The assignment of a particular percentage to a given nation was to some extent arbitrary. It was based on their current energy wealth and their current activity in the field of renewable energy. As a result, countries like Denmark and Germany were given 20%, countries like Canada and Australia were assigned 15%, countries like Indonesia, Poland and Portugal gained 10%, and nations and regions like Pakistan, Bangladesh and most of Africa were given 5%,

I recognize that these approaches for both classical and renewable energy ignore probable differences in supply evolution in individual countries - some countries may develop hydro power at a faster rate than the model suggests while others lag behind, for example, and some nations may develop a "Manhattan Project" approach to wind or solar. Given the great degree of uncertainty inherent in this projection, though, I felt that such an approach was good enough to give the reader a feel for the nature and magnitude of the changes we may see over the next forty or fifty years.

National GDP

The standard economist's position on the influence of energy on the economy has been based on a theory developed by Robert Solow in 1956. In Solow's analysis economic growth was driven by two factors, capital and labour, both of which were quantified financially. 70% of the money flow in the world goes to labour as salaries, 30% goes to capital as rent, dividends etc. Solow used the Cobb-Douglas equations to map the growth function of an economy as labour and capital increased. He got nice curves, but unfortunately they under-predict observed economic growth by two thirds.

As reported in David Strahan's excellent book, "The Last Oil Shock" (pp. 116-123), two physicists, Reiner Kummel and Robert Ayres, independently observed the global economic slowdown following the oil shocks of the 70s and 80s and wondered if the role of energy in the economy was being under-valued. Their analysis convinced them that the price of oil (which was used by Solow in his analysis) underestimated the productive contribution of oil by a factor of ten. In other words, to truly reflect the contribution of oil to the economy, it should be priced about ten times higher. They developed their own economic model that started from Solow's work but incorporated their findings about oil's productive contribution, and found that their predictions matched observed economic growth perfectly.

The models by Kummel and Ayres predict that for every 1% increase in energy inputs you get about a 0.7% increase in GDP on average. The immediate implication is that a reduction of 1% in energy will cause a corresponding 0.7% drop in GDP. So if the world's oil supply were to decline by 30% the global GDP would lose 23% of its value.

Once the national energy budgets were established by the method described in the previous section, I calculated their impact on GDP using the above ratio:a 1% energy change gives a 0.7% change in GDP.

As with the energy budget calculations, there are significant caveats. The ratio observed by Kummel and Ayres is by no means axiomatic. Many factors peculiar to a given country will act on its GDP, driving its performance away from the projections of a simplistic one-number model. On the other hand, the same observation that was made above also applies here: given the inherent uncertainties, this approach should suffice to give the reader a feel for the shape and size of the coming changes.

The other caution applies to oil exporting nations. The future energy budgets and GDP for countries like Saudi Arabia, Canada, Russia etc. are not well addressed by this generalized model. Those nations have more options than do importing nations, since they can choose to retain their oil and gas as described in the Export Land Model (PDF warning). Such actions may reduce the decline in their GDP over the period being considered, though obviously at the expense of importing nations. It is also possible that the deliberate witholding of oil from the world market could trigger military action by desperate and militarily capable importers. Such resource wars would have unpredictable (though necessarily negative) consequences for the energy status and GDP of the otherwise well-endowed target oil producers.

National Population and Per Capita GDP

National population figures for 2006 were obtained from the CIA World Factbook. The figures for 2050 were obtained from a private re-publishing of the projected medium-fertility data from the United Nations Population Fund report of 2001. National GDP figures were also obtained from the CIA World Factbook. To ensure uniform comparisons they are Purchasing Power Parity (PPP) figures from 2006. Per capita GDP is derived by dividing the actual (2006) or projected (2050) national GDP by the actual or projected national populations.

National Results

The full data set for the model is also available in an Excel spreadsheet here.

The data on national population, energy and GDP in 2006 and 2050 that resulted from the research and calculations described in the above section is available in an HTML table here.

Winners and Losers

The research disclosed some of the profound economic and demographic changes that will affect the nations of the world over the next four or five decades. To start getting a sense of these changes, let's first take a look at the top 10 and bottom 10 nations in terms of per capita GDP, in 2006 and 2050. All GDP figures are in 2006 dollars.

The 10 Richest Nations

Table 1: Top 10 in 2006

Country	Population (millions)	Per Capita GDP
Norway	5	$46,435
Republic of Ireland	4	$44,073
USA	301	$43,607
Denmark	6	$36,636

Canada	33	$35,269
Austria	8	$34,610
Finland	5	$33,923
Switzerland	8	$33,618
Japan	127	$33,069
Australia	20	$33,069
Total Population	518	
Average GDP		$39,627

Table 2: Projected Top 10 in 2050

Country	Population (millions)	Per Capita GDP
Norway	5	$48,580
Switzerland	7	$31,634
Japan	105	$29,692
Austria	7	$29,283
Finland	5	$28,886
Denmark	5	$28,320
Germany	73	$26,826
USA	349	$26,720
Taiwan	19	$25,997
France	60	$25,625
Total Population	635	
Average GDP		$27,372

The interesting thing about the winners is that the size of the group has barely changed, and while their GDP has declined, it has not gone down by much. The average per capita GDP has dropped by about 30%, mostly driven by the decline in the United States. While this drop will be noticeable, given the high level of income that exists today it will not be beyond peoples' means to accommodate.

The 10 Poorest Nations

Table 3: Bottom 10 in 2006

Country	Population (millions)	Per Capita GDP
Other Africa	720	$1,889
Uzbekistan	28	$2,005
Bangladesh	150	$2,239
Pakistan	165	$2,656
India	1130	$3,678
Indonesia	235	$4,040
Egypt	80	$4,164
Ecuador	14	$4,458

Philippines	91	$4,940
Other C&S America	60	$5,185
Total Population	2,673	
Average GDP		$3,162

Table 4: Projected Bottom 10 in 2050

Country	Population (millions)	Per Capita GDP
Other Africa	1,436	$582
Uzbekistan	41	$718
Pakistan	345	$787
Bangladesh	212	$794
Other Middle East	229	$1,247
Egypt	115	$1,487
Ecuador	21	$1,736
Other C&S America	108	$1,768
Indonesia	312	$1,896
Algeria	58	$2,077
Total Population	2,877	
Average GDP		$939

It's a very different story for those nations on the bottom of the ladder. While the population of the bottom 10 countries hasn't changed much, their per capita GDP has dropped a whopping 70%. The average income has fallen from $8.50 per day now to $2.50 per day (in today's dollars) in 2050. Also notice the inclusion of Africa's 1.4 billion people in this group. As their average income is so low, probably a full billion people in this group will be trying to live on less than a dollar a day.

The primary reason for this precipitous drop is that the developing world gets much more of its energy from oil and gas. When those sources start to decline, they have little hydro or coal, and no nuclear power to replace them with. In addition, due to their lack of industrial infrastructure they will find it difficult to install enough renewable energy capacity to offset the decline to any significant degree.

On a national level, two factors seem to determine how well or poorly a country will fare. These factors are its population change (falling is good, rising is bad) and how much coal vs. oil and gas they currently use. Those countries that use a high proportion of coal relative to oil and gas will find their GDP somewhat more stable as time goes by. Countries that use more oil and gas, but less coal, will be more severely affected. This explains the anomalous performance of China: their population is falling and they use a lot of coal. While their coal use is bad news for the global environment, China's GDP will be well protected, dropping only 13% by 2050.

Three Case Studies

To clarify the picture we will now take a closer look at three nations that dominate the economic and energy news these days. We will examine the specifics of their energy use and how that use will evolve until 2050. By translating their energy use into an estimate of their future GDP and then factoring in the changes in their populations, we will derive an estimate of their per capita

GDP in 2050.

United States: a Wounded Giant

Table 5

Year	Energy (Mtoe)							Pop. (x 10^6)	GDP ($Millions)	Per Capita GDP
	Oil	Gas	Coal	Hydro	Nuc.	Renew.	Total			
2006	939	567	567	66	188	0	2,326	301	$13,130,000	$43,607
2050	169	146	599	90	183	178	1,365	349	$9,333,733	$26,720

The energy picture of the USA is dominated by oil and natural gas, and the decline of those sources will determine the nation's future.

Oil

The mathematical calculation of American oil consumption in 2050 indicates a drop of 82%. This results from multiplying the current consumption by the expected global decline in supply, under the assumption that most nations will experience broadly similar reductions given the free market for oil that exists today. Is such an assumption warranted? Let us analyze the situation a bit further.

America currently consumes over 900 million tonnes of oil a year. Of that total, 300 million tonnes are produced domestically and over 600 million tonnes are imported. American domestic oil production has been in decline since 1970, at a constant rate of around 2% per year. If that rate holds for the future, the USA will be producing about 130 million tonnes per year in 2050. In order to meet the calculated figure of 169 million tonnes in 2050, America will have to import about 40 million tonnes of oil compared to 600 million today. I believe that this is a reasonable expectation because of the imminent effect of the "Net Oil Export Problem". Under that scenario it is possible for global oil exports to go to zero quite rapidly, and according to the linked paper by Jeffrey Brown is it possible that this may happen by 2040. Accordingly, projecting American imports of 40 million tonnes per year in 2050 may even be optimistic. It is possible, however, that such a level of imports could be secured by long term contracts or even military force.

Gas

Natural gas production in the USA has been relatively constant for the last 30 years, though this has required drilling ever more holes at an ever-rising cost to maintain the level of supply. Gas imports have risen to about 15% of overall consumption. These indicators point to a coming peak (in my opinion within the next decade), followed by a sharp decline for reasons outlined in my earlier article. The projected drop of 75% would be generated by a loss of imports and a decline in domestic production of 5% per year from 2020. This is in fact less than the average 6% decline rate I used in my earlier article.

Coal, Hydro and Nuclear

These sources follow the global patterns determined in the earlier article. Coal use will be up marginally world-wide in 2050, nuclear power will be down marginally, and hydro use will see a general increase of about 40% over today's values. These changes seem reasonable given the current energy development patterns in the USA.

Renewables

As I said above, I assigned an arbitrary percentage of renewable power to each country based on its industrial capacity and its current level of involvement with renewable energy. That meant that I allotted the USA an additional 15% of their total energy in 2050 to account for wind and solar development.

The Changing Energy Mix

The energy mix of the USA stays quite diverse, though the growing role of coal is clear. Because of their original heavy reliance on oil and gas, the total US energy supply in 2050 declines to about 60% of its present level.

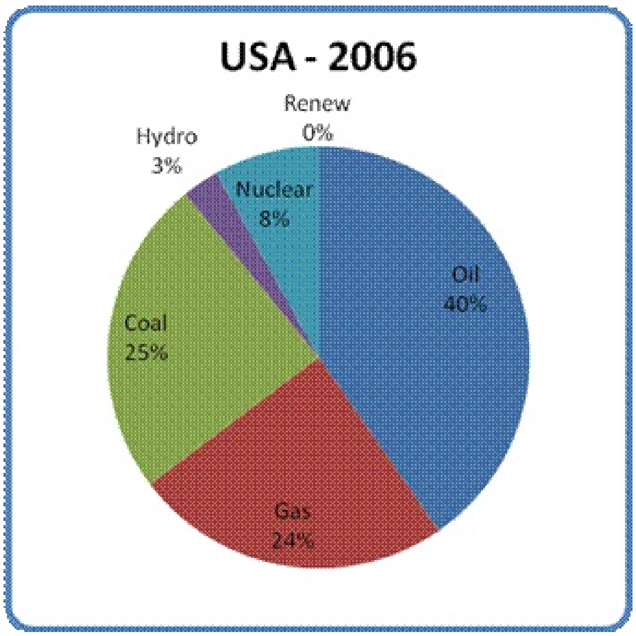

Figure 2: USA Energy Mix in 2006

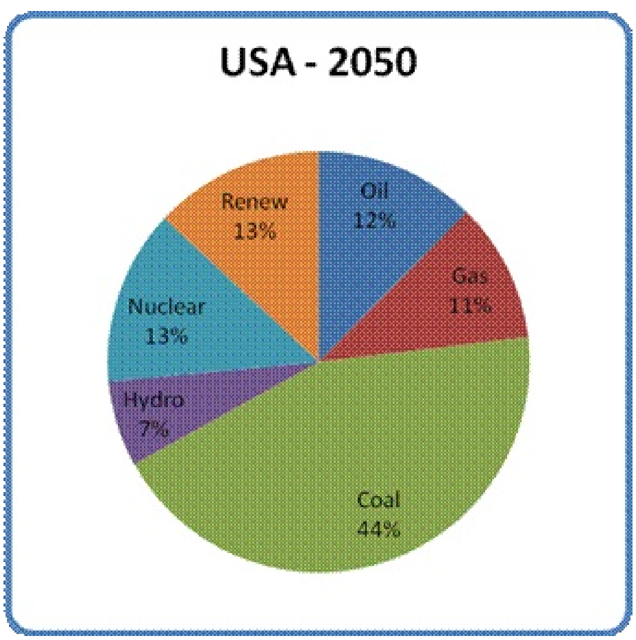

Figure 3: Projected USA Energy Mix in 2050

GDP

Due to the 40% decline in total energy, the American GDP will decline by about 30%. This is determined by applying the 0.7 multiplier determined by Kummel and Ayres to the energy decline.

Population and per capita GDP

According to the UN figures, the American population will have grown by about 16% in 2050. This, combined with the expected 30% drop in GDP, gives a decline of about 40% in per capita GDP in 2050. This would still leave the USA as the 8th wealthiest country in the world in per capita terms, with the second largest GDP (just behind our next case study, China).

China: a Coal-Fired Powerhouse

Table 6

Year	Energy (Mtoe)							Pop. (x 10^6)	GDP ($Millions)	Per Capita GDP
	Oil	Gas	Coal	Hydro	Nuc.	Renew.	Total			
2006	350	50	1,191	94	12	0	1,698	1,322	$10,700,000	$8,094
2050	63	13	1,257	129	12	147	1,621	1,478	$10,362,682	$7,013

China's energy picture is dominated by coal.

Oil

Unlike the USA, Chinese oil production is rising, though slowly (about 1.5% per year). However, their largest oil field, Daqing, has peaked. This makes it quite probable that overall Chinese oil production will go into decline in the next decade. In addition, China became a net importer of oil in 1993 and currently imports about half their requirements. If they, like the USA, lose access to most of their imports over the next 40 years, a decline in domestic production of only 3% per year would bring them to the projected level of oil consumption. As in the case of the USA is is entirely possible that China will try to secure oil supplies outside of normal market channels, so they may end up with a bit more oil than I have projected.

Gas

Natural gas production in China has been rising rapidly in recent years, averaging 15% annual growth since 2000 as China pursues an aggressive program of industrialization. So far their production has kept pace with their usage, but a decline parallel to that of oil is inevitable over the next four decades, especially if they attempt to increase their extraction in concert with their economic growth. The derived global mathematical ratio of 25% by 2050 seems reasonable, though it is also reasonable to assume that China will try and secure foreign gas supplies either though long term contracts or military or economic warfare.

Coal

It is clear that China has placed enormous emphasis on their large endowment of coal. Recent reports indicate that they have plans to build two or three coal-fired power plants per week for at least the next decade. As a result, it's possible that China may exceed the 6% projected net global growth in coal power by 2050. If they do, it could give a large boost to their GDP and vault them well into the global lead. Of course, there is always the question of the environmental damage done by coal, both from the CO_2 production and localized pollution by soot, ash and heavy metals. The extent to which this will restrain China's development of coal power remains to be seen. For now, we will leave the increase in China's coal power output in line with the global model.

Hydro

The development of the Three Gorges Dam has left no doubt that China is serious about developing its hydro potential. The increase of 40% in hydro power postulated by the model seems entirely achievable, especially given China's apparent willingness to sacrifice ecological concerns in favour of industrial development.

Nuclear

Nuclear power may see its strongest growth in China, growth that will be driven by the need for electricity that produces less greenhouse gases and enabled by the willingness of the central government to ignore the personal wishes of its citizens. It is also likely that there will be less public opposition to nuclear power in China than in the West because of the relative weakness of their environmental movement. China currently has 30 reactors planned and 86 proposed, a full third of the world total. It is quite likely that the contribution of nuclear power proposed by the energy model will be too low in China's case. If that turns out to be the case, its contribution could push their GDP decisively past today's level.

Renewables

One area where my model has perhaps been too generous to China is in the penetration of wind and solar. To cover their increasing role I have allotted China an additional 10% of their non-renewable energy budget. However, while China may play a large role in manufacturing such equipment, it seems less likely that they will install it with much enthusiasm. The Chinese system is much more sympathetic to large, centralized power sources and as such more likely to favour increased nuclear power over wind and solar.

In the final analysis the model's pessimism with respect to nuclear power may be balanced by its optimism over wind and solar, with the net result being a wash. Only time will tell.

The Changing Energy Mix

The role of coal in China's energy picture is obvious. As I said above, much of the increase in renewable energy in 2050 could be replaced by nuclear power, with the two sources essentially trading importance. As they are both electrical sources, that realignment would make no difference to the outcome of this particular analysis. The total Chinese energy supply in 2050 is projected to drop by about 5%.

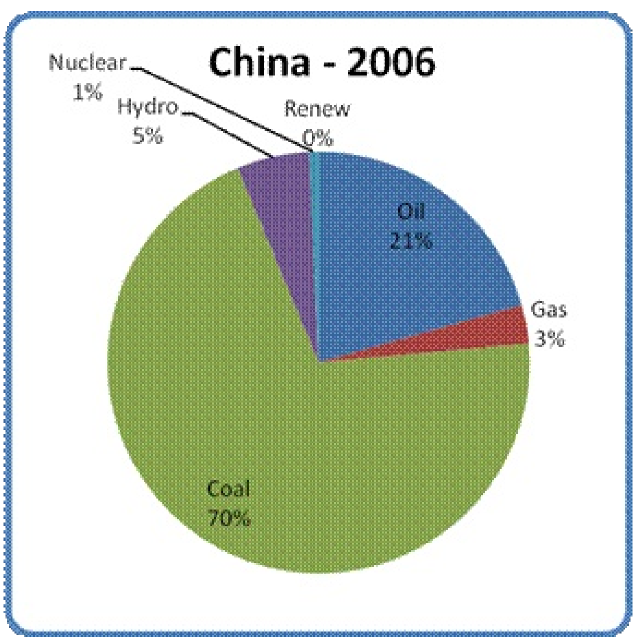

Figure 4: China Energy Mix in 2006

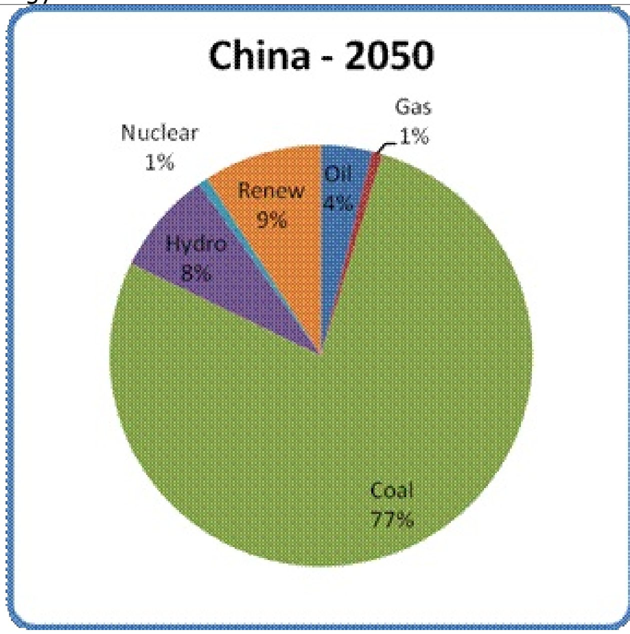

Figure 5: Projected China Energy Mix in 2050

GDP

Due to the 5% decline in total energy, the Chinese GDP will decline by only about 3%, which will still leave them with the world's largest GDP.

Population and per capita GDP

According to the UN figures, the Chinese population will have grown by about 12% in 2050. This, combined with the expected 3% drop in GDP, gives a decline of only about 13% in per capita GDP in 2050.

India: a Nation in Distress

Table 7

Year	Energy (Mtoe)							Pop. (x 10^6)	GDP ($Millions)	Per Capita GDP
	Oil	Gas	Coal	Hydro	Nuc.	Renew.	Total			
2006	120	36	238	25	4	0	423	1,130	$4,156,000	$3,678
2050	22	9	251	35	4	16	336	1,529	$3,559,573	$2,328

For its population, India has a much smaller energy base than the USA or even China.

Oil

India's oil production has been constant for the last decade, though its consumption and imports have been slowly rising. India currently imports about two thirds of its oil requirements. That level of imports leaves it in a very vulnerable position as the international export market dries up. Its domestic production is barely enough to cover the mathematically projected oil consumption in 2050 (20% of current consumption), so any decline in their production could drop India below even the projected 22 million tonnes per year.

Gas

Natural gas production in India has risen by 25% since 2000 but its imports have recently shown a sharp rise - from 0 in 2003 to 20% of their consumption in 2006. As in the case of China's gas consumption, this is probably due to India's ongoing industrialization. The relatively small amount of natural gas used in India and their relatively healthy level of production means that even if depletion strikes other continental gas exporters India's gas supplies may fare somewhat better than the model indicates.

Coal

Like China, India has placed great reliance on coal as a proportion of their energy supply. It is likely that this dependence will continue in the years and decades to come. As a result, it is possible that India may exceed the expectations of the model to some extent, especially as a growing population demands enough electricity to live a basic life. On the other hand, the resulting ecological damage expected in China would also be expected in India, and might, to some extent slow the growth of coal power. For now, the picture is unclear enough to warrant moving away from the model's projections for coal.

Hydro

India's hydro development is expected to be on par with the global projection. However, in this case the reduction of Himalayan glaciers due to global warming may reduce water flows faster than experienced in other parts of the world. This reduction would slow the development of more hydro power, which would act to offset any gains in the coal sector. As with coal, we will accept the projections for hydro, on the assumption that any shortfall could be broadly balanced by increased generation in other energy sectors.

Nuclear

India is also taking the development of nuclear power seriously, with 19 reactors currently in the planning or proposal stages. There is a possibility for India to outperform the model's projections over the next couple of decades, but this performance should be taken with a grain of salt. A trend towards de-industrialization driven by declining oil and gas supplies may put the brakes on nuclear development after 2025. This trend could manifest not only as a loss of industrial capacity, but also in a loss of the capital required to support such a technologically intensive enterprise.

Renewables

There are significant opportunities for solar power in India, both in small photovoltaic installations and in the use of thermal solar generation. At the moment there isn't much penetration of solar power in India, especially for utility-scale electricity. There has been some installation of point application solar power, for running specific services like pumps, lighting etc. where grid feeds are not available. As a result I have given India a 5% allotment for renewable energy. To put that amount in perspective, it would give renewables a greater role than natural gas by 2050.

The Changing Energy Mix

India uses almost as high a proportion of coal as China, though their total energy supply is only a quarter the size. As time goes on, coal will take on even more of the burden - not so much by choice as by default, as imported oil falls away. It seems unlikely that renewable energy will be able to alleviate much of the 20% drop in energy supplies projected to occur by 2050.

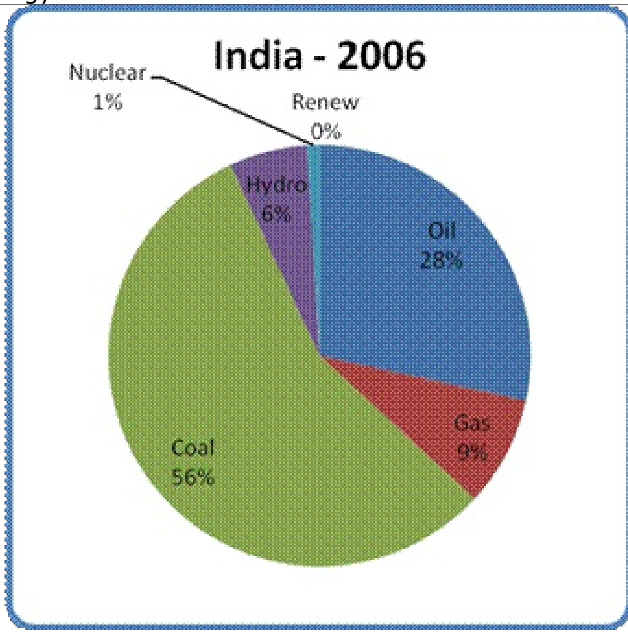

Figure 6: India Energy Mix in 2006

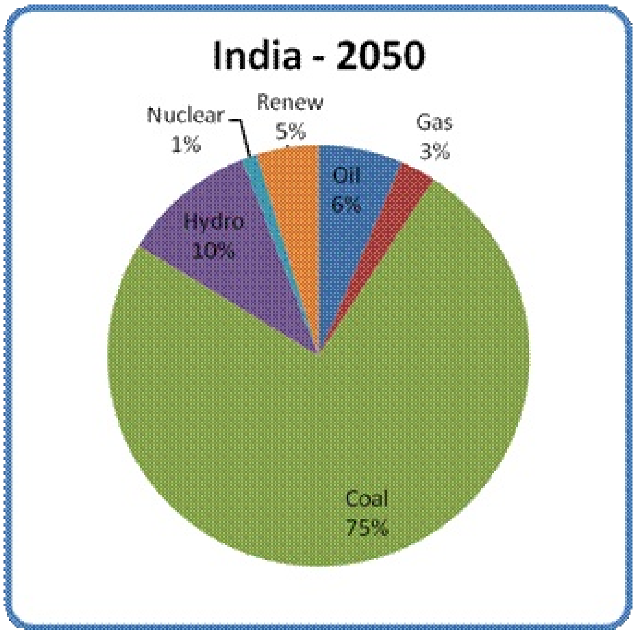

Figure 7: Projected India Energy Mix in 2050

<u>GDP</u>

Due to the 20% decline in total energy, in 2050 the Indian GDP will decline by about 14% in today's dollars.

<u>Population and per capita GDP</u>

According to the UN figures, the Indian population will have grown by about 35% in 2050. This growth combined with the expected 14% drop in GDP will give India a decline of 37% in per capita GDP in 2050. This decline from $3,700 to $2,300 per person will represent a catastrophic drop below the poverty line for much of the Indian population.

The Big Picture

The easiest way to get a feeling for the global change this all represents is to divide the Earth's population into three groups based on their national per capita GDP (loosely speaking, the poor, the middle class and the rich countries). The bottom group has an income of less than $4,000 per year. The middle group has an income between $4,000 and $15,000 per year, and the top group has an income over $15,000 per year (all numbers in 2006 dollars). Here is how the number of people in each of these groups will change between now and 2050:

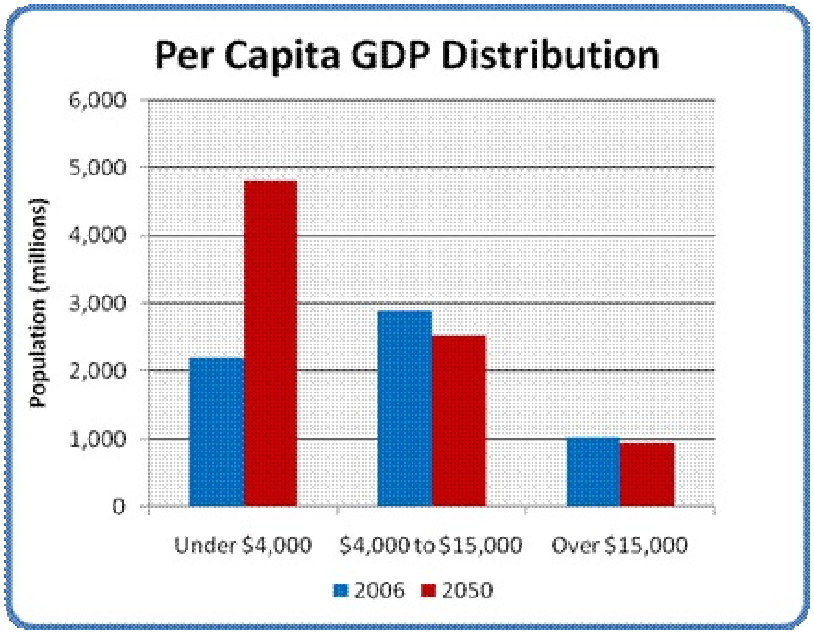

Figure 8: Per Capita GDP Distribution 2006 and 2050

The story here is the same as it was above. In 2050 the size of the upper and middle classes remains almost constant, while the number of poor balloons to two and a half times its current level.. Even worse, the average per capita GDP of the poor group drops from $2,900 today to $1,500 in 2050, a drop of almost 50%. This is due to the burgeoning population of this group sharing the shrinking energy pie. Another significant factor is the movement of a number of large and growing countries from the from the middle class to the poor group.

Who Are The Rich?

The following tables give the countries that comprise the rich nations now and in 2050 - those with average per capita GDP over $15,000 per year.

Table 8: The Rich in 2006

The Rich (2006)			
Country	**Population (millions)**	**GDP (millions)**	**Per Capita GDP**
Norway	5	$213,600	$46,435
Republic of Ireland	4	$180,700	$44,073
USA	301	$13,130,000	$43,607
Denmark	6	$201,500	$36,636
Canada	33	$1,178,000	$35,269
Austria	8	$283,800	$34,610
Finland	5	$176,400	$33,923
Switzerland	8	$255,500	$33,618
Japan	127	$4,213,000	$33,069
Australia	20	$674,600	$33,069

Germany	82	$2,630,000	$31,917
Netherlands	17	$529,100	$31,873
United Kingdom	61	$1,930,000	$31,743
Belgium & L'bourg	11	$342,800	$31,741
Singapore	5	$141,200	$30,696
France	62	$1,891,000	$30,353
Italy	58	$1,756,000	$30,224
Taiwan	23	$680,500	$29,716
Kuwait	2	$55,910	$27,955
Spain	41	$1,109,000	$27,383
New Zealand	4	$106,900	$26,073
South Korea	49	$1,196,000	$24,408
Greece	11	$256,300	$23,953
Czech Republic	10	$224,000	$21,961
Portugal	11	$210,100	$19,821
Slovakia	6	$99,190	$18,035
Hungary	10	$175,200	$17,520
Lithuania	4	$54,900	$15,250
Argentina	40	$608,800	$15,107
Total	1,023	$34,504,000	$33,745

Table 9: The Rich in 2050

The Rich (2050)			
Country	**Population (millions)**	**GDP (millions)**	**Per Capita GDP**
Norway	5	$231,143	$48,580
Switzerland	7	$213,373	$31,634
Japan	105	$3,115,347	$29,692
Austria	7	$207,734	$29,283
Finland	5	$141,486	$28,886
Denmark	5	$135,740	$28,320
Germany	73	$1,966,411	$26,826
USA	349	$9,333,733	$26,720
Taiwan	19	$491,347	$25,997
France	60	$1,534,492	$25,625
Italy	41	$1,009,096	$24,494
Spain	30	$714,144	$23,627
Czech Republic	8	$184,491	$23,565
Canada	42	$963,140	$22,763
United Kingdom	57	$1,273,956	$22,481
Belgium & L'bourg	9	$207,336	$22,057

Republic of Ireland	5	$99,343	$21,092
Australia	26	$529,660	$20,561
Greece	8	$166,303	$20,200
Netherlands	14	$280,913	$19,844
New Zealand	5	$87,506	$16,674
Portugal	8	$132,346	$16,265
South Korea	51	$823,141	$16,053
Slovakia	5	$76,489	$15,817
Singapore	4	$62,020	$15,447
Total	949	$23,980,687	$25,280

As you can see, the world's rich nations fare quite well in 2050 under this scenario. The number of countries in "the club" drops by four, their population numbers shrink a little, and the per capita GDP of the group declines by 25%. Despite this, the rich nations are not going to escape the coming energy realignment unscathed. The impacts they feel will be due to their heavy reliance on oil as a transportation fuel, and on the central importance of transportation to the modern industrial enterprise. These effects will be addressed in a later article. For now, the messages are that energy decline per se is not a lethal threat to the economies of the world's wealthy countries, and that they will have far more options for dealing with energy changes than do the poor countries.

Who Are The Poor?

The following tables give the countries that comprise the world's poor nations now and in 2050 - those with average per capita GDP under $4,000 per year.

Table 7: The Poor in 2006

The Poor (2006)			
Country	**Population (millions)**	**GDP (millions)**	**Per Capita GDP**
Other Africa	720	$1,360,000	$1,889
Uzbekistan	28	$55,750	$2,005
Bangladesh	150	$336,700	$2,239
Pakistan	165	$437,500	$2,656
India	1,130	$4,156,000	$3,678
Total	2,193	$6,345,950	$2,894

Table 10: The Poor in 2050

The Poor (2050)			
Country	**Population (millions)**	**GDP (millions)**	**Per Capita GDP**
Other Africa	1,436	$835,649	$582
Uzbekistan	41	$29,129	$718
Pakistan	345	$271,788	$787
Bangladesh	212	$168,749	$794
Other Middle East	229	$285,425	$1,247

Egypt	115	$170,754	$1,487
Ecuador	21	$36,781	$1,736
Other C&S America	108	$190,978	$1,768
Indonesia	312	$591,254	$1,896
Algeria	58	$119,915	$2,077
Philippines	131	$301,390	$2,303
India	1,529	$3,559,573	$2,328
Iran	115	$290,784	$2,530
Turkmenistan	8	$20,405	$2,645
Venezuela	42	$126,989	$3,013
Azerbaijan	10	$30,072	$3,013
Saudi Arabia	54	$167,110	$3,068
Peru	42	$136,631	$3,231
Total	4,808	$7,333,377	$1,525

In sharp contrast to the outcomes expected for the rich countries, poor nations face a decidedly bleak future in 2050. The number of poor nations or regions jumps from 5 to 18. The total population of the group more than doubles while the average per capita GDP for the group drops by half. Given the level of human misery that exists in the poor nations today, this is a decidedly ominous forecast.

Current statistics from The World Bank indicate that over a billion people today live on a single dollar a day - half of the population I listed above as comprising the poor of 2006. The growth in that population, coupled with the drop in per capita GDP, implies that well over twice that number will be desperately poor in 2050 - perhaps as many as 3 billion. According to the same source, about half the world's population today lives on less than $2 a day. If the scenario developed in this article is close to being true, that number could double by 2050. That demographic and economic earthquake could leave 6 billion people - almost the size of today's entire global population - trying to survive on such a pittance.

Conclusion

The conclusion is straightforward. By 2050 well over half the world's population will be desperately, abjectly poor, and even the rich will find themselves living in constrained circumstances as their average per capita income drops by 25%. Just at the time when foreign aid is most desperately needed, the nations that will be called on to supply it will be find themselves less able to deliver. The implications for life and death in the poverty-stricken regions are dire indeed.

So far, these articles have examined only the impact of energy and demographics on the global economic picture. Complicating factors which have not yet been addressed include: geopolitical upheavals (primarily economic migrations and the threat of increased resource wars); the effect of impoverishment on the food supply of the growing ranks of the destitute; and the underlying drumbeat of ecological damage heralded by the droughts and floods of climate change, the loss of soil fertility and ground water supplies and the death of the oceans. The prospects for the Earth's poor are not likely to improve as we progress though this analysis.