Before the Peak: Impacts of Oil Shortages on the Developing World*

by

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Abstract

We explore the generally ignored reality that the petroleum shortage will occur before peak oil, when the rate of growth falls below the rate of growth of demand. This underscores that the shortage will be coming relatively soon, even if ultimate reserves are found to be more than the most current thinking, with concomitant price increases. Indeed, an energy shortage already exists for the half of humanity lacking access to modern energy. Supply constraints for affluent, industrialized consumers will adversely affect energy imports for developing countries and, at the same time, increase international pressure on the developing world's resources for the export market. Many resources that have been deemed sub-commercial in these regions will be re-evaluated in light of higher prices. This will offer some opportunity to earn foreign trade, but at the cost of resources that could be tapped for local development. The Development Community has an opportunity to help those regions achieve energy security, through the development of these resources locally, by enhancing professional capacity and offering technical expertise.

Biographical Note

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Introduction

The notion of an impending oil shortage is quite misunderstood and misrepresented, especially as it is contextualized with the developing world as exporters of the resource, but not as consumers. It has often been discussed as 'running out of oil' and this concept seems to have shaped many people's opinions. It creates the image of depleting the world's petroleum reserves much like water swirling down a large drain -- it is there one second, and utterly gone the next. Petroleum depletion will be nothing like this. Instead, it will be a long process, transitioning from sustained exponential growth, to slower growth, to a broad peak and, probably, a long and slow decline. Petroleum is likely to be a valuable commodity, contributing significantly to energy demands, well into the 22nd century.

Some pundits point out that it was not a shortage of typewriters that led to their demise, but their displacement by a superior technology -- computers. This analogy, while oversimplified, does speak truthfully to the final transition away from petroleum. It will not occur because the last drops of oil have been drawn out of the world's reserves. Petroleum production will someday cease because it is no longer needed in the face of newer, ultimately better energy technologies (and organic chemical feedstocks). But that transition in the relatively distant future is not the real problem. A real crisis looms in the much nearer future when petroleum production is still continuing to grow, but is no longer able to grow as rapidly as the world's demand for it. This will be exacerbated by emerging markets and their growing thirst for this resource.

Additionally, half of humanity still relies on extremely inefficient and dirty firewood to meet nearly all of its energy needs. This is linked to a myriad of health and social problems (UNDP 2005). Indeed, the more a nation depends on firewood for all needs, the more likely the quality of life of her people is substantially reduced.[1] Thus it should be expected that as the industrialized world increases its exploration activities of fields previously deemed sub-commercial for export in developing nations, these nations (as well as development agencies that can assist with the professional and technical capacity to develop those resources) should strongly consider the benefits of utilizing the resource for internal projects. Such internal development projects appear more likely to improve the quality of life for the people, as opposed to accumulating wealth from exports that does not directly translate to the same improvement.

In this paper, we present a brief history of Hubbert's Peak, the likely differences between his observations and predictions of North American fields and World fields, the impacts a global crisis will have on the developing world, and the roles industry and humanitarian aid organizations can play to provide local, cost-effective services to benefit those that still require access to them.

Peak Oil

Geologist, M. King Hubbert launched an ongoing line of inquiry with one of the first and clearly the most famous scientific approaches to predict the future of oil production. He analyzed geologic potential, drilling activity and discovery success ratios in sedimentary basins throughout the world in order to estimate ultimate potential petroleum production for the world and overlaid a smooth, nominally bell-shaped, Gaussian curve on the growth trend of petroleum production consumption. This curve has become the very emblem of the discussions about running out of oil. Books and articles are written about it. They always show a symmetrical rise and fall of petroleum, with a peak -- Hubbert's Peak -- occurring when approximately half the world's oil has been produced. Interestingly, this symmetry is not really a part of Hubbert's original work. His seminal article published in 1949 actually showed asymmetrical trends (Hubbert 1949). In fact, the director of the Hubbert Center notes: "Hubbert wrote virtually nothing about the decline side of his Hubbert Curve… The decline side of the curve does not have to be symmetrical with the ascending side; it is just easier to draw it as such…" (Ivanhoe 1997).

Hubbert's analyses are being carried forward by a host of modern researchers, many of whom seem to view his model almost as an inviolable law of nature, with a focus on a symmetrical shape, and the peak itself as a crisis point (Smil 2005, p. 212). While Hubbert's work was original in presenting a scientific approach to evaluating petroleum's future and in advancing a comprehensible image of how petroleum production will ultimately decline, there are certain aspects of the phenomenon which deserve to be revisited. The current research continuing Hubbert's work neglects to discuss two important factors: the sweeping global petroleum shortage will not occur at the peak, but before it; and half of the world already suffers from an energy shortage. These analyses also neglect to discuss economic and technological factors that will tend to make the decline shallower than the growth side of the curve -- a possibility which Hubert himself did not discount.

Character of the Peak

One of the great strengths of Hubbert's work was to demonstrate the relatively gradual nature of the transition from growth to decline. The climb up to Hubbert's Peak has been controlled by the growth of demand -- a purely marketplace-driven phenomenon. Essentially, oil has been available in excess of demand throughout its history (barring a few price spikes associated with demand growing faster than supply in the very early days and more sustained market disruptions associated with international political conflict, such as those seen in the 1970s). The ready availability of energy allowed for new industries and economic opportunities, which have fuelled exponential growth in energy demand across the globe. Exponential growth in population has contributed as well, but, even in nations currently approaching zero population growth levels, demand for new goods and services derived from energy continues to provide upward pressure on demand for even more energy. Considering that most of the world's inhabitants have yet to reap the benefits of cheap, abundant energy, there will certainly be a need for continued economic and social service growth, with an attendant need for additional energy supplies.

As the path up to the peak begins to level off, it will signal the transition from a demand dominated regime to one controlled by physical limits. During the exponential growth phase of petroleum, surplus production capacity permitted demand to control production rates. This also means that there has been a nominal steady state balance between reserves extracted by production and new reserve additions to offset the extraction. At some point, global reserve additions will fail to keep pace with extraction and the surplus production capacity will dwindle away. Once surplus production capacity is gone, the world will enter into this new phase of production limited by physical constraints.

Numerous authors have (correctly) championed Hubbert's legacy by highlighting that running out of oil in the absolute sense is not the problem. Rather, they argue, it is when the world reaches half of the total recoverable oil, assuming a purely Gaussian-shaped rise and decline. This movement has also been commonly referred to as 'Peak Oil,' depicted (as the solid, Gaussian curve) in Figure 1.[2] One large oversimplification of most of the Peak Oil authors is the presumption of a relatively precipitous decline. We suggest there is considerable evidence to indicate that the decline may be quite shallow, especially as technology and conservation become more important in the recovery (Ebenhack 2006).

Most Peak Oil proponents assume that the decline will be a mirror image of the growth side of the petroleum production curve. Whether or not they personally hold this view as a necessary condition to the phenomenon, public sentiment has overwhelmingly been shaped to believe just that. While symmetry may have been a fairly reasonable simplifying assumption for Hubbert to make in the 1940 and '50s, in modern times there is no good reason to believe that the decline rate will match the growth rate. Indeed, there are number of good reasons to expect the decline to be much more gradual than growth. Most notable among these reasons is price. When a shortage occurs, the clearest and most immediate outcome to expect is an increase in price. If demand moderates quickly, or if alternatives are readily available, the price increase should not be very high.

It is the character of the gradually diminishing growth rate for petroleum, followed by a broad (and doubtless irregular) peak, followed in turn by a long, gradual decline, also represented in Figure 1 (dash-dot curve), that we believe is important. Of course, since the transition will be gradual, not instantaneous, only looking back at it many years later will define clearly the date of the absolute peak. It is easy to picture that crossing the peak and beginning the long decline will generate shortages. Yet, in light of the numerous factors that will continue to drive demand upward, the gradual bending over of the growth side of the curve will represent a shortage. Thus, a long crisis will actually begin at the point of inflection, where the curve begins to bend. By our best estimates, it could begin at least a decade before the peak. This will create a deficit between demand and supply that will represent an economic market failure -- and a global crisis.

Market Failure

Global energy demand has been rising exponentially for more than 100 years. A number of factors will drive continued growth in the global thirst for oil. Not the least of these is the reality that half of humanity has essentially no access to modern energy sources and services. Thus far, global petroleum production has been able to keep pace. Notice also in Figure 1 the departure from exponential demand growth to declining production growth rates before Peak Oil actually occurs. At this point the hypothetical demand curve exceeds the real supply. Economists would refer to this as a 'market failure,' quite aptly.

A clear departure between an extrapolation of the growth curve and the actual expected production curve will likely occur more than a decade before the peak. There is every reason to believe that this gap will represent a real shortage of energy in the marketplace. Rapidly rising consumption of energy in China and India illustrates the 'energy gap' that already exists. Indeed, there is and has been unmet need for modern energy in the developing world. This need only becomes reflected as demand in the marketplace when the ability to pay grows to an adequate level. And as long as people do not have adequate energy to meet their basic needs reliably, there will always be some unmet demand.

Surely, the marketplace will seek to correct. Shortages will push prices higher. The higher prices will provide incentive for oil companies (both large and small) to expand their exploration efforts. The higher prices will extend the lives of existing fields. Some wells that are closed in or abandoned will be reviewed, reworked, and returned to production under the new, higher prices. Some fields, in which wells have been plugged and abandoned, will be re-drilled. Reserves will be re-adjusted, as prices rise. Note that reserves are calculated for individual fields based on their own production declines and economic limits. These limits represent the points at which revenue from oil sales drops below the operating expenses for the wells or fields. Therefore, any increase in the sales price of the oil automatically lowers these economic limits. Thus, higher prices generate revised reserves estimates, which in turn bring new reserves. This has and will continue to help bolster production rates at the time. Enhanced incentives for exploration will bring new production online, but its impact will take longer to feel. In general, the supply side will see a number of reserve additions that in turn will create a more gradual transition.

The demand curve may be able to respond more quickly, with higher prices suppressing some discretionary consumption. In the most energy consumptive nations, there will be some relatively prompt response. In the United States, for example, there is a significant portion of purely discretionary consumption, which can be (relatively) easy to displace. Using private automobiles for extremely short excursions and personal pleasure would be two conspicuous examples. However, most of the conservation potential will not be realized quickly. New consumer demand for more efficient vehicles will not instantly result in the disappearance of wasteful vehicles from the roadways. There will be an even longer, slower shift in the real estate markets. People will have increased incentive to live closer to their work, but this will not create a sudden migration from expensive outlying suburbs back into decaying urban centres.

Although the rising prices will support more investment in exploration and production technologies, which will add new reserves, these factors will ultimately fail to provide enough production to maintain surplus capacity. Moreover, the reserve additions will result from increased activity, which follows the price increases prompted by shortage.

While some reserve additions will be an immediate result of lowered economic limits, these reserve additions will not add current production, but merely extend the lives of existing fields. Only new drilling and implementation of enhanced recovery projects will add new production -- but neither of these will occur quickly. Therefore, reserve additions resulting from increased prices will not serve to delay the peak, but only to make the decline shallower. There will be some market failure associated with the inability of production to meet demand. The market already fails to provide necessary energy for the needs of the some 3 billion people who lack the ability to pay. Price increases and market failure will only exacerbate this problem.

Overarching Impacts on the Developing World

Taking a broad, global view, for half of humanity the energy shortage is already here. A majority of people in the developing world lack access to modern energy, and rely on firewood and charcoal to meet their essential survival energy needs. This absolutely limits development opportunities. Neither industry, nor medicine, nor education can be built on firewood and charcoal-produced energy. Furthermore, in the face of modern population levels, the firewood and charcoal demands are themselves used unsustainably. In many urban areas in the developing world, wood fuels are not really goods gathered by householders, but are imported to the cities by firewood and charcoal marketers -- by the truckload. This activity can impoverish the local environment, while miring the people in poverty and poor health.

Thus a vicious cycle is promoted, in which poor people must deplete their natural environments to support their most basic energy needs. Without the ability to develop new kinds of enterprises, using different kinds of resources, they have little opportunity to move away from the unsustainable dependence on firewood. The deprivation of the local environments directly impairs the economic activities of agrarian families. The often significant financial burden on them to buy firewood or charcoal, just for cooking, undercuts the economic opportunities of urban households (ESMAP 2006, p. 53).

This destructive cycle, though, is not inevitable. Other energy resources, including fossil fuels, are present in many developing countries. A part of the problem is that the fossil fuels are generally only developed by foreign entities to be exported to the affluent, industrialized world. However, as the industrialized world begins to experience the global energy crisis that already exists, the developing world will once again be a focal point for the extraction of now cost effective fossil resources, while simultaneously impairing current low level imports in these same regions.[3] Thus, major themes that will affect the developing world and its relationships with international entities will be opportunities from untapped fossil resources; promoting energy's role in sustainable development; and expanding capacity and infrastructure for self-reliance and energy security.

Untapped Fossil Resources

What makes an oil and gas project commercial or sub-commercial? Of course the answer is economics. What may be less obvious is the role that context plays. The overarching contextual issue is whether an energy development project is situated in the Developed World or the Developing World. This commonly produces two orders of magnitude difference in the minimum threshold for commercial oil and gas discoveries. Consider that the average oil well in the United States barely produces 10 barrels of oil per day, while the average well in Africa produces over 1000 barrels per day. Why? Is it that the US is endowed with many, but small oil and gas accumulations, while the African continent has a very different distribution of very few, very large reservoirs? Not likely. First, it's a matter of being close to consumption centers.[4] Even the markets in the capital cities of developing nations are tiny in comparison to the markets of the affluent, developed nations. The developing world's markets are largely also of limited appeal due to perceptions of political instability, the attendant risk of resources being nationalized, and the likelihood of soft unstable local currencies. Therefore, multinational corporations very rarely have interest in developing oil and gas prospects for local use in these unstable markets. They prospect internationally, with the intention of exporting oil and gas to the large well-developed markets of the industrialized world. The most noteworthy exception to those would be the rapidly growing markets of China and India.

International oil companies bring expatriate workforces to find and produce oil and gas resources for export. The export preference also produces a preference for offshore operations. Offshore drilling and production is much more expensive than onshore, but it eliminates the need for large, (even more) expensive pipeline projects in order to get the product to the coast, where it can be loaded onto tankers. Reliance on expatriate workforces also increases the economic scale. The workers are often paid a substantial 'hardship' bonus. They fly first class, travelling between their corporate office and their overseas assignment. The multinational companies literally build small cities to house their expatriate workforce, their families, their children's teachers, their nurses and doctors, etc. All of these people are extremely well-paid and provided significant vacation and travel benefits. Of course, corporate managers and senior technical experts also travel several times a year to meet with and advise the expatriate staff. A single, brief trip for a single technical expert to consult with the resident staff is likely to cost more than $10 thousand. And where there is major oil and gas development, expatriate workers from support and service companies set up camp as well. Schlumberger is there to log the wells. Halliburton, Baker, and others are probably there as well. The prices they charge for their contract services are also a function of their costs.

So everything about operating in a developing country becomes expensive for the multinational. Consequently, when drilling a single rank wildcat (an exploratory well that is not near any established production), the company wants to get as much information about the area from that single multimillion dollar well as possible. So the geologists and geophysicists recommend the deepest plausible horizon which might contain significant oil or gas and that sets the target depth for the wildcat. Upper-level management does not want to spend $10 million drilling one unsuccessful well and three years later entertain a proposal from their staff to drill another well in the same location, seeking a deeper target. The choice to evaluate the deepest possible horizon naturally means that each exploratory well is very expensive. If it is in fact a rank wildcat in a totally new province, a commercial success necessarily demands building the new camp for a new expatriate workforce and probably developing a new deepwater port or tanker facility.

All of this means that the odds of commercial success for international, rank wildcats are quite low. Some years ago, the success ratio for this high-stakes gamble was commonly considered to be approximately one in 17 -- a little better than the odds of the roulette wheel, but you don't have to bet $10 million on every spin of the roulette wheel. Some authors suggest that exploratory success has grown dramatically thanks to new and improved technologies. It is suggested that such improvements provide the basis for considerable optimism and will serve to forestall any oil shortage indefinitely (Simon 1996, pp162-181; Tippee 1993, p. 129; Deming 2003). This is a highly dubious claim in large part because the relatively depressed petroleum prices of the 20 year period from 1981 to 2001 also curtailed true rank wildcat exploration. The data for improved success ratios are more likely reflecting a shift toward lower risk exploration in proven producing provinces.

Opportunity or Penalty?

As we approach the real crisis point before the peak, higher prices for oil will reinvigorate exploration activities. As companies begin gambling their enhanced profits on higher risk projects, the success ratio can be expected to fall. This will put pressure on unutilized resources in developing nations more than ever before. Of particular concern will be the focus on Africa for these resources. Unlike Latin America and Asia, in which foreign investment focuses on the utilization of cheap labour for industry (and more recently, information technology), foreign investment in Africa is mainly directed at the production of raw materials for export. Mineral extraction, in particular, has been a major source of foreign investment. In fact, much controversy exists around the nature in which mineral extraction occurs.

Since fossil fuels will continue to be a strongly sought after commodity, it would seem obvious that any developing country with substantial fossil reserves should begin exporting them to bring in foreign investment. Indeed, capital is one leverage point that can theoretically be used for development. However, considering the nature in which foreign investment often occurs, specifically in regards to oil and gas development, it raises serious questions about exploitation and corruption, and challenges notions of true foreign investment.

For example, Ferguson suggests that investments in petroleum production are commonly "socially thin" (Ferguson 2006, p. 197). Consider that the Organization for Economic Cooperation and Development (OECD) found that between 1994 and 1996, the five top recipients of foreign investment were countries that fell into the study's "most risky" category (Ferguson 2006, p. 196), including Angola, Congo/Zaire, and Equatorial Guinea. These countries, along with Sudan and Nigeria, are hotbeds of political unrest, yet they continue to receive some of the highest levels of foreign investment.

Furthermore, foreign investment in oil and gas development almost exclusively goes towards production for export, as opposed to domestic use. While contracts may entitle local communities to some royalty use of the produced oil or gas, little accountability exists for foreign companies to follow through. For example, recent violence in Nigeria directed towards oil and gas companies stems from this very dispute. These nations are almost completely dependent on these companies operating within their borders. Nigeria, the highest petroleum producing Sub-Saharan African country, has a per capita GDP of $1,400. However, 95% of foreign exchange earnings, and 20% of GDP comes directly from petroleum exports. Angola's per capita GDP is $3,200 (CIA 2007), however, over two-thirds of the population lives on under $1 dollar a day. Oil accounts for 40% of the GDP and 90% of exports (EIA 2006). "The Angolan government currently receives something on the order of $8 billion of oil revenue each year…Angolans today are among the most desperately poor people on the planet" (Ferguson 2006, p. 198).

In addition to the disparity between oil wealth and standard of living, a serious disconnect exists between the oil companies and the local socio-economic communities. "Today, enclaves of mineral-extracting investment in Africa are usually tightly integrated with the head offices of multinational corporations and metropolitan centres but sharply walled off from their own national societies (often literally walled off with bricks, razor wire, and security guards)" (Ferguson 2006, p. 36). In Angola, fewer than ten thousand nationals work for oil and gas companies. (The petroleum industry is not particularly labour intensive, which exacerbates the limited job creation potential) Additionally, the vast majority of oil production facilities operate offshore.

The correlation between petroleum producing nations and corruption on the African continent challenges the notion that foreign investment in the energy sector for export is always a desirable venture for the local community. In fact, the previous examples, though extreme, may not be as abnormal as many would like to think. Mozambique, for example, has far less corruption compared to the aforementioned nations, and lacks the complete dependency on foreign energy firms. In fact, the enhancement of an energy market would further diversify the Mozambican economy. However, as energy projects in Mozambique move forward, often at the urging of neighbouring countries desperate to import more energy from nearby and accessible resources, past experiences with mineral extraction on the continent may become apparent. And, this is not limited to oil and gas -- electricity can be exported as well. In cases such as the hydroelectricity production and export from the Cahora Bassa dam in Mozambique, they may even purchase their own product back from the importer. Modern energy purchases create balance of trade deficits, while still not providing enough modern energy to reach the majority of the populace. Economics alone will always say to export the goods but this is more than an economic problem. Negative externalities associated with export must be accounted for. If so, it will likely reveal that all of these factors contribute to an energy export penalty akin to the popularly dubbed "oil curse" and likely will support the use of the resources for internal development projects first.

Energy and Sustainable Development

The most pervasive goal of development is some form of that promulgated by the Brundtland Commission for sustainable development, which defines it as: "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development, 1987). It would seem that the very development context of this definition (and of the

Commission itself) has implicit a goal of supporting improved living conditions for the world's less affluent peoples, relating then to a concern for some form of social justice or equity. Unfortunately, the implicit concern for the well-being of the world's poor in this generation is sometimes lost in the focus on sustaining the environment and resources for future generations. We argue that neither justice for future nor present generations can be adequately addressed while ignoring the other. A sustainable world must be one with some reasonable level of equitable access to essential resources - now.

Obviously, energy is at the very crux of this issue. At some minimal level, energy is critical to survival itself. Beyond that, it is an essential building block for all kinds of industrial, economic, and social enterprise. Therefore, no development is possible without energy. It would seem tautological that without development, one cannot have sustainable development. Therefore, transitions towards a more sustainable society demand increased access to energy -- modern energy -- for much of the world. At the same time, all that we consume or even desire in affluent, industrialized societies is based on significant energy consumption. Energy that is abundant and cheap. Sustaining the benefits of modern, affluent society will require continued access to abundant energy supplies. Probably, though, it will cease to be cheap energy some time soon. Abundance, then, will also have to be reassessed. What gains are we really getting from the energy we consume?

It is altogether clear that continued exponential growth in energy demand is not physically sustainable. The resources on which the world currently relies (primarily oil, gas, and coal) will begin to decline in the coming few decades. As we have described earlier, shortages will begin at least a decade before the decline. This will drive prices higher and increase competition for the resources. At the same time, the larger unmet demand for energy in the developing world must be addressed. Transitions to more sustainable energy systems can, then, not be viewed as simple transitions to 'renewable' energy. The fossil fuels will and must continue to play a substantial role for some time -- even for many decades after their peak productions have been reached and their declines have begun. There is no alternative energy system ready to take a large market share in the time frame that Peak Oil is likely to dictate. In fact, one of the most serious problems the fossil fuels raise is the sheer magnitude of consumption their abundance has facilitated. This raises the level at which renewable energy production will have to compete.

Environmental arguments are growing louder in their demands for the developing world to develop with only renewable resources and technologies. This problematic viewpoint unfortunately neglects that fossil resources will nevertheless be developed and exported out of these very regions. If so, then we must consider which activity has a smaller environmental footprint: using the resource locally, or exporting it elsewhere to be used anyway. Moreover, it is well documented that all industrialized nations used fossil fuels and concomitant technology to catalyze their own development. With knowledge of best practices, fossils can also catalyze and continually support activities in the developing world, with visions for an evolving energy mix and infrastructure that shift the load away from fossils, once established.

The need to expand capacity

The need for expanding professional capacity and the financing of energy infrastructures to support health, education, and trade industries is a critical step (FEMA 2007). The work of planning contextually appropriate energy mixes is a highly innovative enterprise. Local access to resources must be well defined in each locality. Prevailing and likely future consumer demands must be characterized. Technologies must be evaluated and adapted to the contexts of resources and needs. Transitions must be planned effectively. This sort of work necessitates strongly collaborative work from a broad range of disciplines: engineering, economics, sociology, policy analysis, and probably history as well. Strong cohorts of well-trained, experienced professionals will be essential. We would argue that the best development planning is directed by people with local knowledge and interest.

Energy projects in developing countries are often hampered by lack of trained and experienced local energy professionals. Again, focusing on Africa, relatively few citizens have been trained for professions in energy industries because these countries have few institutions of higher education and those that exist may not offer degrees in all of the energy-related fields. Even those who have received formal training outside of the continent often lack direct industry experience. As pressure mounts to export Africa's rich energy resources to wealthy nations, Africans may be at serious disadvantages when negotiating contracts without the staff needed to verify energy reserves or negotiate favourable terms.

There is then an opportunity for the Development Community to place seasoned energy professionals with energy agencies in the developing world to assist with efforts to develop modern energy services. In a possible scenario, partner agencies might define their needs and develop position descriptions. Clearing house entities might recruit specialists with ten years or more of industry or professional experience to serve abroad for three months to two years as unpaid staff with partner agencies. Volunteers would be placed on projects that are scalable, economically sustainable, locally-controlled, and environmentally conscientious (AHEAD 2007).

While the successful economies of the United States, Canada and Australia are all in former colonies, it is well worth noting that none of these nations represent cases of indigenous peoples gaining independence from the colonial powers, but rather the colonists themselves from the mother country. The developing nations, on the other hand, often experienced flight of the trained, professional personnel, largely comprising the expatriate colonists (The professional positions were almost exclusively held by colonists, with relatively limited numbers of indigenous persons who had been somewhat officially 'assimilated' into the colonial power structure). In some cases, the departing colonial authorities also deliberately sabotaged much of the physical infrastructure, leaving the newly educated minority in the newly independent nations to struggle with rebuilding infrastructure, as well as crafting a nation. Then, as some countries were successful in building a larger base of educated, professionally-trained personnel, they were faced with the difficulty of retaining those workers, who could earn higher salaries by taking their training to affluent, industrialized nations. This phenomenon, broadly dubbed the 'brain drain,' is a serious challenge to building professional capacity. In the case of energy, the problem is exacerbated by issues of scale, since even the indigenous workers who receive professional training and employment opportunities in their own or neighbouring nations will only be exposed to the extremely high scale technologies and operations that typify international energy operations. In order to develop local resources effectively for the small, emerging markets of their own economies, they need to be able to bring 'downward scalable' technologies and methods.[5]

Conclusions

The challenge of the coming global energy transition is probably one of the greatest faced by today's generations. We must plan technologies and policies to move toward decreased reliance on depleting fossil fuel resources, while expanding energy access to the half of humanity currently mired in energy poverty, and while conscientiously reducing the environmental footprint of our global energy acquisition and consumption activities. A lack of informed, deliberate planning will likely transform the set of challenges into a legitimate crisis. No single technology or policy option is sufficient to meet the tripartite set of challenges. We will need an array of technologies and policies that are suited to the entire range of contexts in our diverse world.

At the very heart of the challenge is the transition being forced upon us by the imminent onset of decline in petroleum production rate. Even with an optimistic estimate of the total amount of petroleum that can ultimately be recovered from the Earth, it is clear that the production decline onset will occur considerably before the middle of the 21st-century, probably sometime in its third decade. Transitions toward a more equitable and sustainable global society demand that we understand the dynamics of a petroleum marketplace that will soon be operating in shortage and how this relates to the large share of the world's population that currently lacks access to modern energy.

Thus, what is really needed is deliberate planning of evolving energy mixes that take advantage of the benefits of finite fossil fuel resources, while deliberately and thoughtfully increasing the contribution of non-depletable sources over time. In the case of developing countries, where no large-scale infrastructure for energy consumption exists, it may be feasible to build new, modern energy systems that integrate finite and non-depletable resources from the start. It may be possible to design and deploy systems in which new, locally-produced fossil fuel sources can be designed to backstop variable and lower energy density renewables. In most standalone solar or wind systems, a full half of the capital investment is required for battery storage. The need for storage in turn dictates nominally doubling the installed production capacity, so that during peak production, it can produce enough to charge the batteries and store for the downtimes. Thus, in some cases it could be argued that a hybrid solar or wind with gas or oil system might be as much as four times as cost-effective as a standalone system. This could make many of the alternatives more cost competitive sooner. Of course there are other non-fossil energy sources that can also play the backstop role. Transitions to sustainable systems will be context specific as well as dynamic across the time horizon.

Finally, even if the appropriate capital is spent on development projects, without energy it cannot be of much use. Ask yourself the following questions: What is health care without electricity for refrigeration of medicines and sterilization of surgical tools? What is education without computers for teaching, let alone lights to see? What is industry without energy to deliver goods and services both intra- and extramurally? Soon you reach the only answer possible -- nothing -- and you see that development agencies (government agencies, NGO's, and even oil company charitable foundations) must focus on developing the energy supplies and infrastructure to support real internal development projects.

Notes

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1. Comparing percent traditional biomass use to a nation's quality of life, as measured by the UN human development index, a strong negative correlation exists. That is, the more a nation is dependant on firewood, the more likely their index value will be reduced.

2. Since predicting and reporting an actual date for Peak Oil is troublesome (especially when that date passes by and no peak occurs), we have normalized all analyses and have not set an actual 'Peak Oil' year in our visual representation of the phenomenon.

3. The term 're-import' might more aptly describe this practice of extracting the resource and then re-selling it to the 'host' country.

4. In part, these statistics are a result of the US being a very mature oil and gas province, with most fields being long on decline, but there are factors that make these numbers reflective of the economic scale requirements as well.

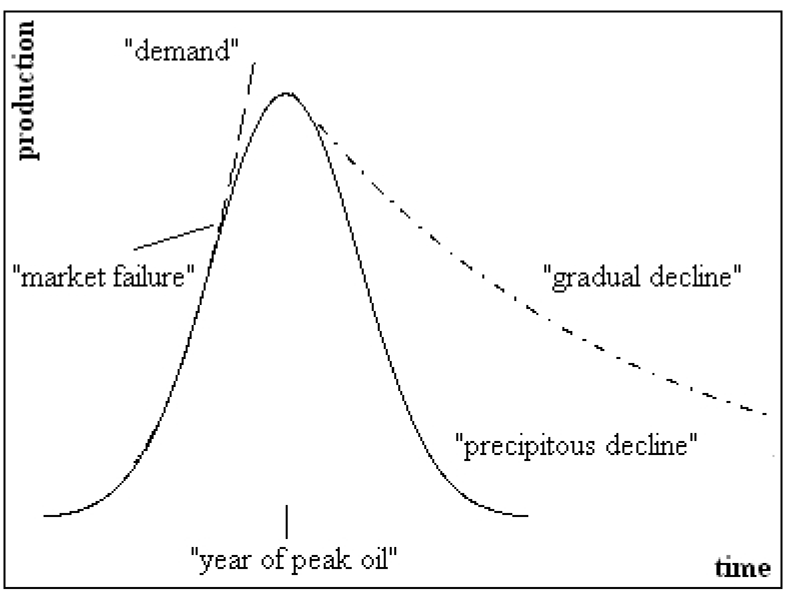
5. Often in the industrialized world, technologies are developed first at the bench scale and then scaled up to the level of a commercial pilot. Only then are they developed to compete fully in the marketplace. The ultimate commercial scale-up is expected to provide improved profitability through economies of scale. In the developing world, however, especially with respect to energy demands and services, 'downward scaleable' technologies and methods may be a much more

valuable endeavour. The irony exists that, because of the export-orientation of international development, the indigenous professional people are only exposed to the very large scale commercial export operations. These require economic investemnts that may be prohibitive to the local economies. It will be necessary to find an adequate scaled-down energy mini-to-micro-enterprise to meet local demand in local demand centres.

Figure Caption and Figure

Figure 1: Representation of the character of the Peak Oil phenomenon. The solid, Gaussian curve, represents the commonly cited representation of M. King Hubbert's production and decline calculations. The dashed curve represents the exponential increase in demand on the growth side of the curve. The dash-dotted curve represents a more likely gradual decline in production spurred on by enhanced exploration and recovery. Market failure occurs when the demand curve and the production curve separate, some time before the actual peak in production. This will be exacerbated by rising global energy demands.

Figure 1:



References

AHEAD Energy Corporation. 2007. *Professional Resources to Optimize Sustainable Solutions*. Rochester: AHEAD.

CIA. 2007. *The World Factbook*. See: https://www.cia.gov/library/publications/the-world-factbook/index.html.

Deming, D. 2003. "Are We Running Out of Oil?", *Policy Backgrounder* 159.

Ebenhack, B.W. 2005. "Clarifying the Limits of Petroleum Production," *AIChE Annual Meeting Proceedings*. New York: AIChE.

EIA. 2006. *Country Analysis Briefs*. See: http://www.eia.doe.gov/emeu/cabs/.

ESMAP. 2006. *Energy Sector Reform and the Pattern of the Poor: Energy Use and Supply, a Four Country Study: Botswana, Ghana, Honduras, and Senegal*. Washington: World Bank.

FEMA. 2007. *Energy Security and Sustainability in Africa*. Nairobi: FEMA.

Ferguson, J. 2006. *Global Shadows: Africa in the Neoliberal World Order*. Durham: Duke University Press.

Hubbert, M.K. 1949. "Energy from Fossil Fuels", *Science*, 109 (2823), 103-109.

Ivanhoe, L. 1997, "King Hubbert Updated", *Hubbert Center Newsletter* 97 (1), 1-1 – 1-4.

Smil, V., 2005. *Energy at the Crossroads: Global Perspectives and Uncertainties*. Cambridge: MIT Press.

Simon, J. 1996. *The Ultimate Resource 2*. Princeton: Princeton University Press.

Tippee, R. 1993. *Where's the Shortage?* Tulsa: PennWell.

UNDP. 2005. *Energizing the Millennium Development Goals: A Guide to Energy's Role in Reducing Poverty*. New York: UNDP.

World Commission on Environment and Development. 1987. *Our Common Future*. Oxford: Oxford University Press.