The Oil Drum
DISCUSSIONS ABOUT ENERGY AND OUR FUTURE

Peak Oil and Reflexivity and Peak Oil

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A good many years ago, I read George Soros' "The Alchemy of Finance", which introduced me to the concept of reflexivity, which in a nutshell is when observers of a phenomenon can't help but impact the phenomenon itself via their 'observing', thus changing the original underlying fundamentals and setting in motion a boom-bust dynamic (i.e. more exaggerated trends in both directions). Since Mr. Soros recently spoke to Congress regarding the oil futures market 'bubble', I thought I'd take a closer look at the concept of reflexivity, both as it relates to oil and commodities in general, as well as its broader implications for efforts in raising awareness of global resource constraints.

> "*The situations that men define as true, become true for them.*" Sociologist William Thomas, 1928

Though Soros applied the idea of reflexivity to financial markets (and had huge success), its origins are in social theory. Social (science) phenomena are influenced by a two-way interaction between perception and facts, thereby making it impossible to ascertain a true stand-alone 'fact'. Thus, reflexivity is basically the ecological/systems concept of 'positive feedback' merged into the social sphere where thinking, acting human agents create circular relationships between cause and effect in real-time. Flanagan (1981) and others have argued that reflexivity complicates all three of the traditional roles that are typically played by a classical science: explanation, prediction and control. For example an anthropologist working in an isolated tribal village may impact the native peoples culture and behaviours in unknown ways- e.g. her observations will not be independent of her participation as an observer. This contrasts to the natural sciences, where one set of facts follows another irrespective of what anybody **thinks**. This is a central example of post hoc ergo propter hoc reasoning that is prevalent in modern Walrasian welfare economics.

In financial markets (which include oil futures), reflexivity occurs when prices themselves influence the fundamentals and that this newly-influenced set of fundamentals then changes expectations, thus influencing prices. This process then continues in a self-reinforcing pattern until it has overshot equilibrium. Because the pattern is self-perpetuating, markets tend towards disequilibrium- where every outcome is uniquely different from the past. (This of course flies in the face of most everything I was taught at the University of Chicago Business School)

Here is what Mr. Soros had to say about reflexivity in a 1994 speech at MIT:

> "I am in fundamental disagreement with the prevailing wisdom. The generally accepted theory is that financial markets tend towards equilibrium, and on the whole, discount the future correctly. I operate using a different theory, according to which financial markets cannot possibly discount the future correctly because they do not merely discount the future; they help to shape it. In certain circumstances, financial markets can affect the so-called fundamentals which they are supposed to reflect. When that happens, markets enter into a state of dynamic disequilibrium and behave quite differently from what would be considered normal by the theory of efficient markets. Such boom/bust sequences do not arise very often, but when they do, they can be very disruptive, exactly because they affect the fundamentals of the economy."

> "The theory holds, in the most general terms, that the way philosophy and natural science have taught us to look at the world is basically inappropriate when we are considering events which have thinking participants. Both philosophy and natural science have gone to great lengths to separate events from the observations which relate to them. Events are facts and observations are true or false, depending on whether or not they correspond to the facts....The separation between fact and statement was probably a greater advance in the field of thinking than the invention of the wheel in the field of transportation.
>
> But exactly because the approach has been so successful, it has been carried too far. Applied to events which have thinking participants, it provides a distorted picture of reality. The key feature of these events is that the participants' thinking affects the situation to which it refers. Facts and thoughts cannot be separated in the same way as they are in natural science or, more exactly, by separating them we introduce a distortion which is not present in natural science, because in natural science thoughts and statements are outside the subject matter, whereas in the social sciences they constitute part of the subject matter. If the study of events is confined to the study of facts, an important element, namely, the participants' thinking, is left out of account. Strange as it may seem, that is exactly what has happened, particularly in economics, which is the most scientific of the social sciences."

Well, economics has been the best path dependent allocation mechanism for a competitive species finding a huge energy subsidy, and as such has developed complicated econometrics and other empirical formulae that appear to be laws. Since energy has always grown, the 'rules' for economics seem like science, but the observations that economists consider to be facts, are based in large part on the specific inputs and history from *this* cultural system.

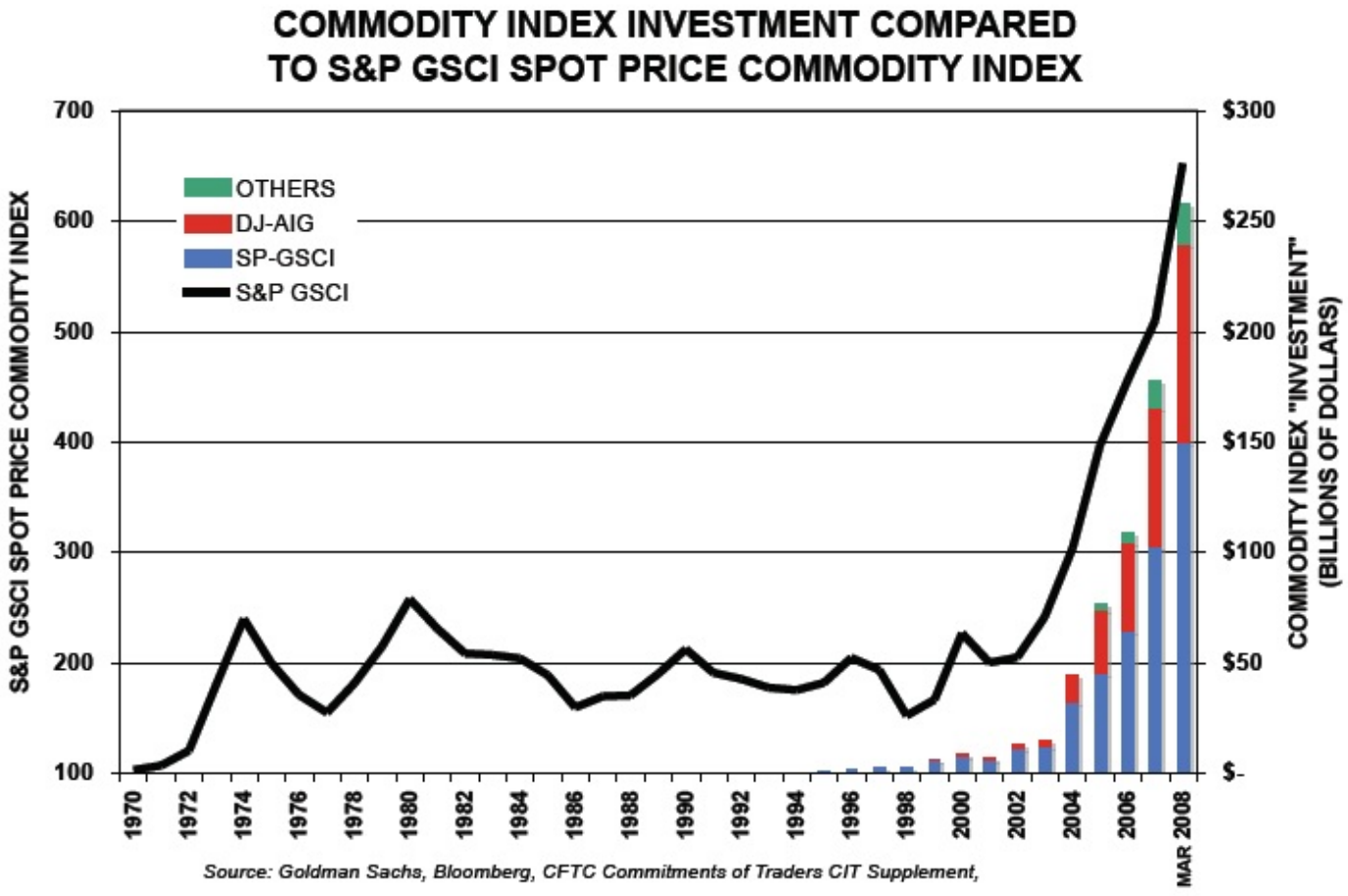
More from Soros:

> "Classical economics was modeled on Newtonian physics. It sought to establish the equilibrium position and it used differential equations to do so. To make this intellectual feat possible, economic theory assumed perfect knowledge on the part of the

> participants. Perfect knowledge meant that the participants' thinking corresponded to the facts and therefore it could be ignored. Unfortunately, reality never quite conformed to the theory. Up to a point, the discrepancies could be dismissed by saying that the equilibrium situation represented the final outcome and the divergence from equilibrium represented temporary noise. But, eventually, the assumption of perfect knowledge became untenable and it was replaced by a methodological device which was invented by my professor at the London School of Economics, Lionel Robbins, who asserted that the task of economics is to study the relationship between supply and demand; therefore it must take supply and demand as given. This methodological device has managed to protect equilibrium theory from the onslaught of reality down to the present day". *from George Soros speech to MIT in 1994*

The upshot of this is that 'facts', as seen from the financial market participants persective, actually change the behaviour of not only the investors, but also the corporations, policymakers, institutions, etc. In studying supply and demand we impact supply and demand.

With this background on the concept of reflexivity, let's take a look at commodity futures markets. In 2004, the total value of futures contracts outstanding for all 25 index commodities amounted to around $180 billion. At that time, that was 240 times smaller than worldwide equity market cap of $44 trillion. Recent estimates of the global derivative markets notional size are northwards of $600 trillion. This compares to US GDP of about $13 trillion, and around $8 trillion of new inflow into investments each year (savings). The total global equity market and debt (bond) markets are around $50 trillion each.



Source: Michael Masters Testimony to Congress, May 20 2008 (pdf)

Commodities have not had a boom since the late 1970s, and until recently have played a minor role in general portfolio asset allocation. Combined with media coverage (e.g. Jim Rogers) and rapid growth in demand and tightening of supply, commodity markets have had explosive moves the last 5 years. Pension funds, sovereign wealth funds, university endowments and other index speculators have been allocating money away from stocks and bonds into commodities. A common way for these entities to invest is to allocate a % of their capital to commodities in general, without taking a particular sector or timeframe, e.g. they buy exposure to commodities via the front months of each major contract and just before they would have to take delivery of the physical, roll into the next closest futures month. There are several major commodity tracking 'indexes' that differ slightly in their respective commodity weightings. The red, green and blue bars in the above graph track the dollars invested in different indexes compared to the black line which is the SP spot commodity index.

This explosion of funds into commodities, combined with fundamentals, has created some hefty price increases in the major commodity groups:

Commodity Futures Price Inreases

March 2003 - March 2008

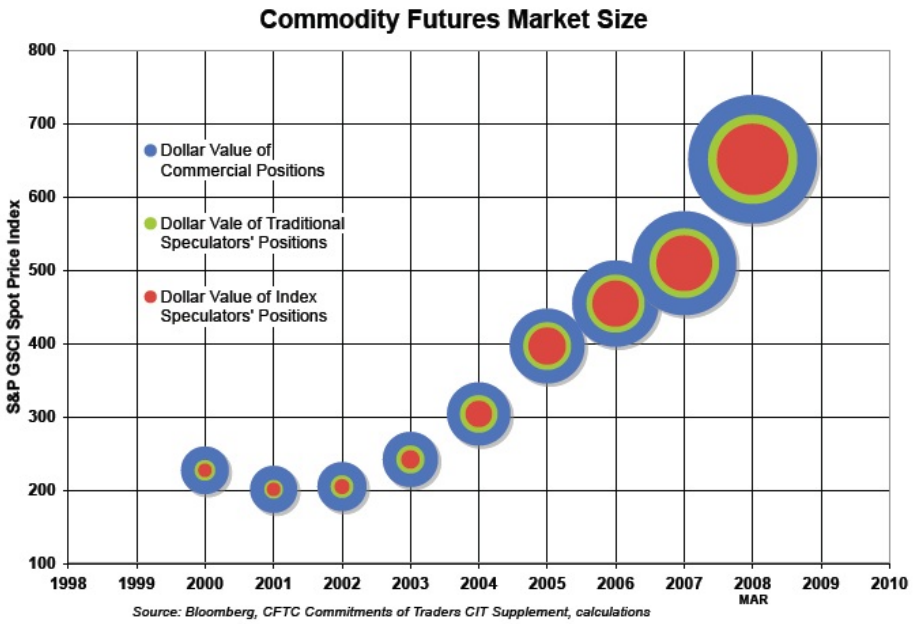
Agricultural	**Cocoa**	+34%
	Coffee	+167%
	Corn	+134%
	Cotton	+40%
	Soybean Oil	+199%
	Soybeans	+143%
	Sugar	+69%
	Wheat	+314%
	Wheat KC	+276%
Livestock	**Feed Cattle**	+34%
	Lean Hogs	+10%
	Live Cattle	+23%
Energy	**Brent Crude Oil**	+213%
	WTI Crude Oil	+191%
	Gasoil	+192%
	Heating Oil	+192%
	Gasoline	+145%
	Natural Gas	+71%
Base Metals	**Aluminum**	+120%
	Lead	+564%
	Nickel	+282%
	Zinc	+225%
	Copper	+413%
Precious Metals	**Gold**	+183%
	Silver	+331%

Source: Bloomberg Financial Data

Source: Michael Masters Testimony to Congress, May 20 2008 (pdf)

The combination of price increases and more funds allocated to commodities has obviously increased the total size of the 'commodity market'. Notice in the below graphic that the amount of index speculators (red area) as a % of the total has risen over time, again a function of their own

performance, and general commodity price increases:



Source: Michael Masters Testimony to Congress, May 20 2008 (pdf)

Commodities Futures Markets Open Interest

2008	LONG / DEMAND SIDE		
	Physical Hedger	Traditional Speculator	Index Speculator
COCOA	33%	48%	19%
COFFEE	26%	35%	39%
CORN	41%	24%	35%
COTTON	32%	27%	41%
SOYBEAN OIL	46%	22%	32%
SOYBEANS	30%	28%	42%
SUGAR	38%	19%	43%
WHEAT	17%	20%	64%
WHEAT KC	37%	32%	31%
FEED CATTLE	17%	53%	30%
LEAN HOGS	18%	20%	63%
LIVE CATTLE	13%	24%	63%
WTI CRUDE OIL	59%	10%	31%
HEATING OIL	37%	16%	47%
GASOLINE	41%	20%	39%
NATURAL GAS	62%	10%	28%
GOLD	22%	55%	23%
SILVER	27%	46%	28%
AVERAGE	**33%**	**27%**	**39%**

Source: CFTC Commitments of Traders CIT supplement plus calculations

The transfer of 'money' into 'real goods' (or at least paper represntations of them) has been widespread. Commodity-index funds controlled a record 4.51 billion bushels of corn, wheat and soybeans through CBOT futures, equal to half the amount held in U.S. silos as of March 1.

According to Mike Masters, in his Congressional Testimony last week, speculators have now stockpiled, via the futures market, the equivalent of 1.1 billion barrels of petroleum, effectively adding eight times as much oil to their own stockpile as the United States added to the Strategic Petroleum Reserve during the last five years. Since there is a positive feedback mechanism with futures index funds, the demand for futures actually increases as prices go up - the opposite of what one would expect from price-sensitive consumer demand.

There are currently position limits for futures contracts for speculators:

> Position Accountability Levels and Limits
>
> NYMEX Crude Oil Futures - 1,000 U.S. barrels (42,000 gallons): Any one month/all months: 20,000 net futures, but not to exceed 3,000 contracts in the last three days of trading in the spot month.
>
> NYMEX Henry Hub Natural Gas Futures - 10,000 million British thermal units (mmBtu): Any one month/all months: 12,000 net futures, but not to exceed 1,000 in the last three days of trading in the spot month.
>
> NYNEX Heating Oil Futures - 42,000 U.S. gallons (1,000 barrels): 7,000 contracts for all months combined, but not to exceed 1,000 in the last three days of trading in the spot month.
>
> Exemptions
> The Commission and exchanges grant exemptions to their position limits for bona fide hedging, as defined in CFTC Regulation 1.3(z), 17 CFR 1.3(z). A hedge is a derivative transaction or position that represents a substitute for transactions or positions to be taken at a later time in a physical marketing channel. (Source JPMorgan Chase)

Hedgers have no position limits but do have reporting requirements. Currently, an index speculator can call up a bank and request exposure to say, $100 million of oil and enter into a swap - the bank then hedges this via the futures markets - in this way the speculator has bypassed the official position limits, skirting the current intent of the rules. There are rumors that due to pressure from hedge funds, politicians, etc. (either in an effort to reduce energy and food prices or reduce the pain on their short positions..;-), that the definition of 'hedger' is going to soon become more restrictive. In theory this would relieve pressure on commodity prices, as the large positions by index speculators would have to be reduced (e.g. sold). However, it is not clear to me that this rule alone would drop oil prices: 1)there exists a large *short* interest in oil that counterbalances the index longs -e.g. some large 'shorts' would have to reduce their positions by covering too, 2)at the end of each calendar month, *someone* is taking delivery and paying these high prices, 3)if speculators were largely responsible for the oil price spike, where would all the stored oil be that they were taking delivery on?

With this brief overview of the commodity markets, let's now revisit the concept of reflexivity.

REFLEXIVITY - TAIL, DOG, WAG?

Back to Mr. Soros:

> "So we can observe three very different conditions in history: the "normal," in which the participants' views and the actual state of affairs tend to converge; and two far-from-equilibrium conditions, one of apparent changelessness, in which thinking and reality are very far apart and show no tendency to converge, and one of revolutionary change in which the actual situation is so novel and unexpected and changing so rapidly that the participants' views cannot keep up with it."

Wheat might be a good example of the 2nd of these three conditions. After breaching an all time high of $6 last summer, wheat continued until it peaked over $12 per bushel (hard red wheat hit $25). Droughts in Australia and Eastern Europe exacerbated a low inventory situation and people were caught off guard - thinking and reality now differed. In 2007 Americans consumed 2.22 bushels of wheat per capita. At 1.3 billion bushels, the wheat futures 'stockpile' by index speculators was enough to supply every American with all the bread, pasta and baked goods they could eat for two years (Masters). Yet despite the large bullish position, indeed perhaps *because* of the large bullish position, wheat futures reversed their asymptotic rise in similar dramatic fashion, with the speculators riding it up and the physical hedgers sending it down. (Sidebar - there is still a massive index speculative position in wheat, despite a nearly 50% selloff, a relevant datapoint to those who believe index speculators are *primarily* to blame for crude oils rise.)

Dec/08 Wheat futures - daily prices

Here was an example of equilibrium overshoot in two directions, eg. large 'runs' both up and down. Speculators were behind, reached, and got out too far ahead of fundamentals in this case. **But what about oil?** I would contend that a 1200% increase in price since 1999 and flat production since 2005 with a growing world economy is consistent with either the 2nd or 3rd of Soros' 3 conditions. Whether we have overshot equilibrium or are in a situation of revolutionary change is still an open question. But let's step back first with a thought experiment.

Imagine that there were no Ken Deffeyes, Matt Simmons or Colin Campbell. Imagine that M. King Hubbert spent his retirement playing Parchesi with his wife and not modeling future oil depletion. Imagine that when the UK hit is second (and final) peak in 1999 that no one noticed, and that market participants didn't pay attention to the subsequent 12 fold increase in oil prices. Imagine we didn't know that the energy return on crude oil had declined from over 100:1, to 30:1 to around 10:1. Imagine that Nigerian rebels and Iraqi freedom fighters couldn't cause daily spikes in crude prices by their actions due to the fragility of supply and demand. Imagine that

bandits weren't stealing scarce diesel fuel at night in California. And, imagine if places like theoildrum, or ASPO or energybulletin didn't continually posit data and questions that pushed the envelope of conventional energy wisdom. Consider then only geology. That we use horizontal drilling and nitrogen and water injection, that we are drilling more and more wells all around the world using the latest seismic technology, etc. That the EIA continues to model supply forecasts with demand forecasts, because supply has never really been a constraint in the past....Would oil prices be approaching $130? Would T Boone Pickens be interviewed with a mixture of awe and fear on CNBC? Would there be major military presence in what was formerly the fertile crescent? Would Saudi Shura (Parliamant) be voting to keep more oil in the ground for higher future prices? Probably not. Yesterdays 'facts' are influencing today's perceptions which are influencing tomorrows realities.

$100+ oil DOES change consumption habits, but it also changes humans built in beliefs towards their futures, both individually and as nations. Earlier this week the CEO of TOTAL, one of the worlds largest oil companies, stated that new forms of energy would not be able to compensate for the coming oil and gas depletion. He also stated that new oil reserves cost $80 to procure so $80 would become the new price floor for oil going forward. We don't know that this is *a fact* - but is the opinion of an expert in a position to know more than the average participant. Monsieur de Margerie, via his perceived authority and public pronouncements is therby affecting the fundamentals of the oil industry. Each incremental admission, whether from the IEA, from TOTAL, or from theoildrum.com, shifts the mindsets of participants at the margin, which subsequently changes behaviours.

In 1999 with oil below $10 per barrel, the stock market at all time highs, and resource limit concerns restricted to a handful of cranky environmentalists and Hubbert acolytes, were we at 'equilibrium'? In 2001 with oil at $20? In 2005 with oil at $50? The point is that for a very long time we were not in equilibrium - the pendulum was pulled way to the left and finally let fly in 2000 - the question is, has it now past equilibrium in the other direction? Or have we moved into the third stage, where human collective awareness is accelerating knowledge about and action in the oil sector? More knowledge about finite flow limits changes professionals opinions about the future, which changes investment into refineries, changes long term contracts with exporting nations, changes military strategies, changes hoarding strategies, all of which are reflected in the price moonshot. Soros theory, which I happen to subscribe to, implies we will overshoot in both directions, because gravity and momementum will combine to send the pendulum backwards once market participants have not only caught up, but exceeded the reality of the situation. But Soros (to my knowledge) generally applied this principle to finance, and admitted to Congress he is not an expert in things energy. Reflexivity could of course have larger societal implications beyond *investment* booms and busts.

Nearly two years ago, in this post about the Amaranth blow up, I suggested that price floors and position limits would eventually become a reality because of the sheer size of dollars vs notional energy values. In A Closer Look at Futures, I commented:

> I believe there are 3 different definitions of Peak Oil and they will come in succession.
>
> 1. The point when we have used half of the oil that will ever be extracted.
> 2. The point when we reach maximum sustained production (given that we use high technology like horizontal drilling and water and nitrogen injection, we are likely borrowing from the second half of what was normally a bell shaped curve so this point will come later).
> 3. The point when the meme of finite energy resources takes hold in society.

> For sake of this discussion, lets use the first definition, and assume we are roughly at Peak Oil now. We have used 1 trillion + barrels and have 1 trillion + left. But as discussed previously (exhaustively?), those 1 trillion barrels require a decent amount of energy to locate, harvest, refine, and distribute and this amount of `energy cost' subtracted from the gross is increasing.
>
> Lets assume that the 1 trillion barrels nets out to 650 billion barrels to non-energy society. (Yes I chose this number specifically). Given our current world population, that equates to *100 barrels of net oil remaining for every person on the planet*, (and leaves none for our children, grandchildren or subsequent generations). Any Tom, Dick or Rainwater for $4,000 can financially control 1000 barrels of oil in the futures markets, *or 10 times his or her all time planetary allotment*. Once Peak Oil version #3 is realized, there will be many investors clamoring to financially (or physically) control their 100 barrels, let alone 10,000 or 1,000,000 barrels. Can the futures markets absorb this? Will this make the Hunt Brothers cornering of the silver market seem like childsplay? The world uses 85 million barrels per day - and for a mere $340 million in margin, this entire amount can be controlled via the futures markets. Consider this in contrast to the $7+ Trillion invested or saved annually, and the nearly $100 trillion in stock and bond market assets. Will the market send the right signals? What smart angles will hedge funds take on this?

Isn't this what we would expect in a finite world as people wake up to real resource constraints? What is a dollar, or yen, or euro worth, really? Though Soros' ideas about reflexivity were applied to the financial arena - perhaps we the observers, are impacting the real time experiment of resource constraints in the same vein. Though geologic limits to flow rates are an ostensible signal, the real dilemmas of Peak Oil are all socioeconomic. We are beginning to realize that societies need to be 'intact' with reasonably equal distribution and allocation if the entire system is to continue it's current trajectory. But oil depletion will likely first be a tax on the middle class and poor, accelerating political pressure on things likely to exacerbate the long term situation (e.g. cutting gas taxes, scaling ethanol, giving tax rebates to help economy, etc.) On top of that are myriad human elements that are very difficult to predict. Hoarding behavior is an autocatalytic process which begets other behavioral changes once set in motion. 'Not drilling' or 'not producing' oil and gas at a certain price could also be considered hoarding behaviour. "Virtual hoarding" via futures contracts can also occur to a certain extent. On the one hand accelerated knowledge about geologic limits acts as a needed tax on finite high quality fossil fuels, which spurs investment into alternatives and quickens conservation and consumption behavioral change. On the other hand, once the cat is out of the bag, there is a greater chance of unintended consequences, as the owners of paper money might start to look at it differently. Reflexivity indeed....

SOME PREDICTIONS

Here is my 'participant' part of the equation of Peak Oil. These are not facts, but my opinions:

1)There will be extreme volatility in next 5 years in oil and gas prices. Not only day to day, but year to year. Awareness of possible flow constraints is now upon us, rightly or wrongly. This combined with the tiny size of energy commodity markets compared to investable dollars will engender large position sizes that inevitably will fall victim to the fear/greed/leverage trifecta. Attention to the oil sector guarantees increased volatility. Accelerating oil depletion of older wells and skyrocketing reserve replacement costs guarantees higher highs and higher lows...

2)The Peak Oil community (e.g. those who generally understand that oil production is either peaking now or will peak soon) will begin to bifurcate into two relatively disparate camps - a)the supply-side camp that understands the urgency but will try and address energy and resource shortage via technology, more drilling and alternatives and b)the demand-side camp who will see that no matter what the energy source, a new paradigm of how we live our lives/structure our institutions will be the only full answer to the twin problems of peak fossil fuels and a growing population. Conversations between these two camps will become increasingly disparate and tense. Supply and demand solutions will not be mutually exclusive, but some people recognize that our ends are constrained as well as our means.

3)There will be an eventual slowing and ultimately a cessation of speculation in energy markets by non-producers. This is tantamount to a change in capitalism so I don't say it lightly, but already only 6% of world oil reserves are owned by public companies - the amount of dollars NOW dwarfs the amount of notional physical resources - if printing presses are turned on while resources deplete this disparity will continue to grow. At some point people like you and I won't be allowed to buy oil futures, which is only a short step away from nationalization of the energy industry (which is the case in most countries already).

Conversations and thoughts like these are meant to raise the bar of discourse on energy topics so when real policy discussions take place, either locally or regionally, people will speak a common language. There is a fine line in peak oil outreach - more awareness is needed to accelerate renewable infrastructure and kick-start efficiency and conservation measures - yet too much awareness might cause supply disruptions (hoarding) and make it difficult for oil companies to extend the time horizon that we have access to a large baseline of production, etc. As an editor on this site, I hope we are efforting positive change, but realize many of our readers are likely tuning in to know the latest details in order to improve their own situation, financial or otherwise. One of my concerns is when the pendulum swings back the other direction, and we head towards one of those 'higher lows', that the urgency of both supply and demand response will be lost. Both oil prices and energy stocks will overshoot on the downside and we will lose sight of the long term situation. These are high stakes.