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BLACK GOLD, ALBERTA TEA

by Dale Speirs

Will We Freeze In The Dark?

With the price of oil stubbornly refusing to come down as the pundits say it must (although it is still cheaper than a cup of coffee), there is greater interest in what exactly goes on behind the scenes to produce the oil we use. Albertans are better informed than most because we have the good fortune to be sitting on a 200-year supply of oilsands. An American in Illinois may not realize that the gasoline he fueled his SUV with came from thousands of kilometres away as crude oil from Alberta, not Saudi Arabia.

Are we running out of oil? Yes, no, and but. How's that for a definitive answer! Yes, we ran out of $2 per barrel oil in 1974, and $20 per barrel oil in the 1990s. We won't see $40 per barrel oil after this decade. No, we are not going to run out of oil in the next two centuries. But, the oil we get in the future will not be light sweet (low sulphur) crude oil that flows out of the ground by itself. It will be heavy oil from the Athabasca Tar Sands that costs $20 a barrel to steam heat out of the sand. It will be heavy sour (high sulphur) crude from Saudi Arabia that needs to have the sulphur removed before it can be used. And everywhere it will have to be pumped out the hard way.

Defining Definitions.

Every oil deposit varies in viscosity (ease of flowing), sulphur content, water content, and energy value. To make it easier for commodity traders, each deposit is standardized against a benchmark oil. In North America, the benchmark is West Texas Intermediate. In Europe it is North Sea Brent, and in the Middle East it is Ras Tanura. Prices are quoted for those benchmarks in the market. When a North American producer sells the output from a particular conventional oil well, a chemist analyses that oil and determines that it is equivalent to, for example, 0.93 of West Texas Intermediate, so the producer is paid 93% of the WTI price. The Athabasca Tar Sands producers sell their refined oil from them at just below WTI price; the crude bitumen sold as is would be about $40 a barrel.

Spot prices are for immediate delivery today, but the futures market is the important price. Like all other commodities, the oil futures are contracts to physically deliver a certain amount of oil at a specified date. The news media quote the futures price for the next month, but futures can be bought years in advance. Spot prices fluctuate with the seasonal demand or sudden events, but futures are the actual supply of oil. Manufacturers, refineries, and governments buy at the stable futures price, while speculators and businesses needing top-up quantities use the spot price.

The Seven Sisters were initially the seven largest vertically-integrated (oil well to refinery to service station pump) petroleum companies in the world. Because of mergers, there are actually only five sisters today, although the original term is still used. They are ChevronTexaco, ExxonMobil, Royal Dutch/Shell, British Petroleum, and ConocoPhillips. Small petroleum companies are called junior petes, of which there are thousands. Once the Seven Sisters were the largest oil companies in the world. Today, the biggest of them is ExxonMobil, which only ranks 12th in oil reserves. The top oil companies, of which Saudi Aramco is the largest, are state-owned. National oil companies around the world are gradually or have completely taken over because their motive is to produce or buy oil for long-term national security, not report a profit to the shareholders.

The Break Point Is Upon Us.

Sometime in 2006 the world will reach a new high in its oil consumption. We will be using **A Thousand Barrels A Second**, as Peter Tertzakian titles his new book (2006, hardcover, 272 pages). That means we are drinking 86 megabarrels of oil a day, plus, in the same 24-hour period, going through 240 billion cubic feet of natural gas, 14 megatons of coal, and 250 tons of uranium.

Tertzakian begins his book by emphasizing that we are not running out of oil per se, but cheap light oil. The break point of any supply disruption is marked by strong volatility of prices, because no one knows what is what. It is not the first break point in energy the world has experienced. The whale oil industry from the mid-1700s to 1870 produced the only major source of good quality candles. When whales were hunted to the brink of extinction, kerosene lamps stepped in. Kerosene was invented in 1846 by a Canadian named Abraham Gesner, who distilled it from the bitumen deposits of southern Ontario. In 1848, the first commercial well in North America was drilled in Ontario, and a year later the Americans began drilling in Pennsylvania. Up until World War One, coal was used more than oil, but the experiences of the military led to a realization that oil was a superior source of energy. There was a mad scramble in the 1920s and 1930s by North America and Europe to control oil supplies, and the dependency gradually became an addiction. The behaviour of the colonial powers and the Seven Sisters triggered a rise in nationalism among the Arab countries, and the formation of the Organization of Petroleum Exporting Countries (OPEC).

Whatever the surplus of oil may have been in the past, today the exporters operate at about 98% of capacity. This means not just the wells, but the pipelines and refineries. Crude oil by itself is useless; it must be converted into fuel, lubricants, or industrial chemicals. Any downtime anywhere in the chain cuts the market surplus to zero, hence the current instability in prices. Hurricane Katrina did not cause a shortfall in American oil supplies, but it did knock out Gulf Coast refineries and trigger a rise in gasoline prices. It matters not how much oil Nigeria has if the petroleum technicians cannot operate because they are under small arms fire from rebels.

Government leaders everywhere are smarter than their people would believe. When they read the news about oil shortages, they began adding to national strategic reserves. It is expensive to store a billion barrels of oil in an underground reservoir, but still cheaper than the economic chaos that would result from a sudden shortage of oil. The USA discusses its strategic reserves in front of the news media, but countries such as China are very quiet about how much they are storing. This storage also keeps demand and prices high.

History has shown that after each recent oil shock (1973, 1979) the oil supply rebounded, but never to what the peak production was before. Wishful thinkers have a way of forgetting the past, and even now there are a few stubborn pundits who insist that oil will eventually return to US$20 per barrel.

Transitions.

In North America, wood was the exclusive energy source until the early 1800s. About 1845, coal displaced wood as the primary energy source.

Oil became the dominant source during the second decade of the 1900s. Hydroelectricity became noticeable in the late 1800s, but once all the major rivers were dammed, its growth stopped at a small percentage of energy use. Nuclear power first came on line in 1957, but stagnated from the 1970s to early 2000s. As the current electricity demand increases, they are coming back into favour despite the NIMBY (Not In My Back Yard) crowd.

Tertzakian addresses the post-peak production oil world. The fastest energy use transition was wood to coal, which took about 75 years. (Electricity took 30 years but it is a derivative, not a source.) Oil took a century to become bigger than coal. Natural gas has never had more than 30% of the market. Transitions in the energy world are slow because of the huge infrastructure that must be changed. It is unlike consumer electronics, where formats can change in a decade from vinyl to CD, or VHS to DVD.

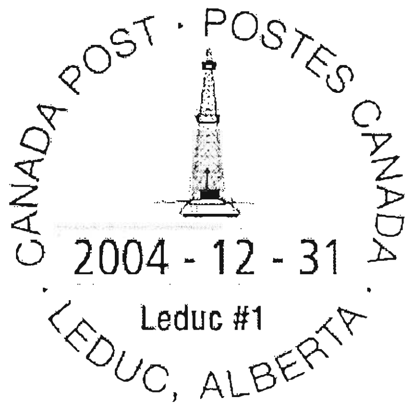
Alberta gets most of its electricity from coal-burning power plants, and relatively little from hydroelectricity. One way to tell that a recent arrival to Alberta is from Ontario is that they talk about their hydro bill instead of their electricity bill. The Tories are opposed to nuclear power plants, strangely, and Alberta has none, unlike Ontario.

The Alternatives.

Wind, tidal, and solar power are not scalable or continuous enough to quickly displace oil and coal, although they will be valuable supplements to the energy mix and should thus be encouraged. The agony of the next transition will be upon us for decades.

Some highly touted future energy sources are actually negative energy sources. That is, they consume more energy than they produce. Hydrogen-powered cars can only be used on a mass scale by expending electricity to split water into hydrogen and oxygen. Hydrogen power thus uses up more energy than it creates. Likewise for battery-powered vehicles. It has been claimed that such water electrolysis or battery recharging can be done on the night shift when electricity demand is lessened. Even on the night shift, electricity is running short of supply. Also, most electricity in North America is generated by coal-fired plants. The only method of generating hydrogen or battery recharging on a mass scale is to build hundreds of nuclear power plants. One can already hear the chanting: "NIMBY!, NIMBY!, NIMBY!".

Hybrid vehicles (gasoline or diesel plus a braking electrical generator) will help but will not make a major difference. Tertzakian comments that just to keep vehicle fuel consumption level in the USA, every single vehicle sold there from now on would have to be a hybrid. European vehicle consumption has been level for the past few decades because of ferocious fuel taxes, and Canada is about halfway between the two because of not quite as ferocious taxes, but Americans are not prepared to accept forced fuel conservation that way.



The greatest challenge is to convince people to make lifestyle changes. Take the bus downtown instead of the car. Turn the air conditioning down. Heat or cool only rooms in use, not the entire building.

For the majority of people though, serious change will only come at a major break point. As James Schlesinger remarked about his fellow Americans in 1977, "*We have only two modes: complacency and panic.*"

The Saudi Truth That Dares Not Speak Its Name.

In 2004, the Saudi Arabians claimed to have 461 billion barrels of recoverable crude oil, a 50-year supply for the planet, and to have the capability to produce 20 million barrels a day if needed by the world. In actual fact, they struggle to produce 9 million barrels a day from declining reserves in old fields, and get 90% of their oil from seven fields that have been overproduced for five decades. They claim to have new giant fields waiting to be discovered, but no major fields have been discovered outside the original Eastern Province fields despite intensive wildcatting for decades. They claim to be able to drill for new oil cheaply and easily, but actually have the most expensive drilling programme anywhere on land.

The Saudi government refuses to allow an independent audit of reserves and production, as is standard in North America and Europe, but instead grandly claim they have enough oil to go around for another fifty years, so trust us. This disconnect between press releases and reality has been ignored by the world's governments and news media, or worse yet, they accept the Saudi claims as sufficient truth to plan for the future. As a result, people remain baffled by why the price of oil stays so high, looking to false explanations such as the Iranian nuclear crisis or rebels in Nigeria.

Matthew Simmons has done what no one else bothered to do. He sat down and read through hundreds of scientific papers that gave just the facts about the Saudi Arabian oil fields, most of which were authored by Saudi Aramco geologists. Each paper by itself said little about the overall state of the Saudi oil fields, but together they revealed a disquieting fact. Saudi Arabia will no longer be able to provide a surplus of light sweet crude oil within a decade or so. Indeed, it appears that Saudi production may have peaked several years ago.

Simmons has put this together in a very readable book titled **Twilight In The Desert** (2005, hardcover, 422 pages). He starts with the history of Saudi Arabia, which was born in 1932 when Abdul Aziz ibn Saud finally gained control of the peninsula after 25 years of tribal warfare. The new nation was born in poverty, with no natural resources and suffering from the Great Depression. But both the infidels and Abdul Aziz suspected there might be oil in the land. He granted oil concessions to outlanders who thought they were in control, and found out later that the Arabs were smarter than they looked. Fast-forward to 1973, and the Saudis use their oil as a sword against the Zionists. The oil shock staggered the world and brought in astounding revenues to the Arabs. Only then did it occur to the general public that cheap, abundant oil was not a universal birthright.

We think of Saudis as enjoying an opulent lifestyle, but that is confined to the 2,000 or so royal princes. Saudi Arabia is actually suffering a declining living standard because their population is increasing faster than oil revenues. In 1970, Saudi Arabia had only about six million people. In 2000, they had 22 million people. By 2010, there will be more than 30 million. The average birthrate is about six children per female. The princes who rule the country do not fear external enemies as much as they do riots and public disorder from a populace that needs jobs, electricity, and potable water. By 2003, the kingdom had accumulated $170 billion in debt trying to keep public infrastructure ahead of demand.

Producing The Oil.

When first drilled, an conventional oil field is usually highly pressurized by saline water pushing up from below. The pressure is high enough that the natural gas associated with the field is dissolved into the oil, which lightens it and helps the flow. These three liquids are kept in place by an impermeable rock layer above them. In many places around the world, there are natural empty oil fields whose reserves disappeared millions of years ago because the caprock fractured or was eroded away, releasing the liquids to be dissipated at the surface. The Athabasca Tar Sands are an example of this in progress. They were exposed to the air by the Pleistocene ice sheets that ground away their caprock.

Absent any humans to process the bitumen, then the sands would gradually volatilize their oil to the air and groundwater over the next several millennia and eventually become an empty oil field.

During the initial phase of an oil field's life, the oil rises by itself to the surface, known as primary production. Eventually the pressure drops to the bubble point, where the natural gas bubbles out of the oil and forms a gas layer above the oil and just below the caprock. As pressure continues to fall, it reaches the dew point, where the oil no longer flows by itself and begins to mingle with the saline water. All production stops.

This is when the field enters secondary production. The oil might be pumped out by down-hole electrical pumps, or natural gas previously extracted is re-injected into the field to maintain the pressure, or water is pumped into wells at the edges of the field to sweep the remaining oil towards the main boreholes in the centre. The Saudis are the world leaders in water flooding; they pump in tens of millions of barrels of seawater every day into their fields to keep them pressurized. Secondary production always indicates that the field is mature and past its peak production. 90% of Saudi oil fields have been waterflooded for decades.

Eventually the water rising from below reaches the borehole. Wells producing more than 50% water were once considered dead, and thus shut-in. With the price of oil increasing, many places (and the Saudis particularly) now continue to process such wells up to an extraordinary 85% water cut (basically a water well contaminated by a bit of oil). In recent decades, horizontal drilling has become common, where the drill bit is turned at an angle and follows the strata that contain the oil. This is an expensive process, but the increasing price of oil makes it payable.

At the surface, the fluids from an oil field are shipped via pipeline to a nearby gas/oil separation and processing plant (GOSP). Each GOSP handles a cluster of oil fields and then ships the unrefined liquids via separate pipelines to a refinery. Very small oil fields (strippers) that produce only ten or so barrels a day may not be connected by pipeline but to a storage tank at the wellhead, where every so often a tanker truck comes by to empty it. There are all kinds of variations to this around the world, as every oil field is different.

Hubbert And The Silence Of The Saudis.

In 1970, conventional oil production in the USA peaked, and even the later bounty from Alaska never brought it back up to the previous high. This is known as Hubbert's Peak, after the geologist who predicted it in 1956. Saudi Arabia peaked in the early 1980s, and Alberta conventional oil in 1978.

When an oil field peaks, it does not mean that the oil is all gone (half still remains, actually), only that production will steadily decline no matter what is done.

Alberta, to take a personal example of mine, now gets the majority of its oil from the Athabasca Tar Sands. There is still conventional oil being pumped, among which is the well my family owns. That well has been going since 1953, which is why none of us who get royalties from it are planning to quit our jobs. We could get a phone call tomorrow that the well is now shut-in (as indeed has already happened to the other well in the 1990s). In 1978, Alberta conventional oil production, which began with the Leduc #1 well in 1947, topped out at 1.6 megabarrels a day from 12,151 wells. In 2004, it had declined to 600,000 barrels a day from 30,958 wells. Similar sorts of figures apply to oil production areas elsewhere in North America, if not even worse.

In 1974, after the oil shock, the Saudis stopped releasing field-by-field estimates of their reserves. In 1982, all OPEC nations stopped providing verifiable reserves data. Since then, all estimates of oil reserves supplied by OPEC countries are simply press release figures. "Trust me, effendi, I am the Minister of Petroleum. Why would I lie to you?" Without drilling any new wells, OPEC's reserves suddenly increased in the 1970s and 1980s, as countries deliberately overstated their reserves so they could cheat on their assigned quotas. These figures are taken as gospel by the news media and financial analysts. They are no more reliable than numbers generated randomly by throwing dice.

Simmons developed a work-around by spending two years going through technical reports by Saudi Aramco geologists. Each report was narrow and specific, about one field or one time interval. Simmons compiled these reports together and saw the overall pattern that no one else had noticed. The drilling is now almost entirely horizontal wells in existing fields, and the reports obsess about water cuts in the outflow. All of these are signs of declining output and aging fields slowly declining no matter what is done.

Saudi Aramco is the most advanced computer user in the world, modeling its oil reservoirs in multi-million cell software to predict where to drill next. The data are displayed in 3-D rooms, where each wall and ceiling shows a cross-section of the strata, and geologists can actually walk around inside the display.

Ghawar And All The Others.

Isaac Asimov once described our solar system as "Jupiter plus debris", as a way of emphasizing how that one planet is in a class by itself. The world's conventional oil deposits could be fairly described as "Ghawar plus puddles". Ghawar is the main conventional oil field of Saudi Arabia (and the world, for that matter), with at least 60 billion barrels of light sweet crude oil produced to date, and still going. Its daily output is about 6% of the total world output, and accounts for 60% of Saudi Arabia's production. The next largest oil field, also in Saudi Arabia, has, or had, only one-fifth as much oil. For comparison, Alaska's Prudhoe Bay region, the largest North American conventional oil field, is expected to produce 14 billion barrels before dying.

Ghawar is often referred to as the King of Kings. In each petroleum basin, there is one field larger than all the others by a sizable margin, known as the King. There are one to three Queens, each about one-half to one-fifth the size of the King's reserves. The next rank are the Earls and Lords, five or ten of them, and much smaller than the Queens. At the bottom are a large number of peasants, small oil fields by the hundreds or thousands, many of which are not economical to produce at any price. These are the fields that junior petes concentrate on, since the Seven Sisters can't be bothered with such petty cash.

In a given basin, a Queen field is usually discovered first, then the King and other Queens (if more than one, not always a given), and finally step-out drilling locates the small fields. It takes about a decade to fully outline a basin. King and Queen fields are also referred to as elephant fields; none have been found anywhere in the world in the past three decades. The last elephant field found was the Cantarell field of Mexico in 1975, which today produces 60% of Mexico's oil.

Simmons spends considerable time discussing the individual oil fields of Saudi Arabia. This is not as lengthy as it might seem, since there are only twelve fields. Canada and the USA have thousands, albeit, of course, much smaller ones. Many of the papers Simmons examined discuss how to keep the output of Ghawar from declining any further. Problems abound with waterfloods reaching the wellheads, and fracturing in the strata that allowed the waterflood to bypass oil and leave it behind. Ghawar is in advanced middle age, cosseted by Saudi Aramco technicians desperately trying to maintain its output.

Desperate Measures.

The Saudis claim that they can get more oil just by punching holes in the ground, yet they spend billions of dollars trying to maintain production of known fields with advanced technology. They also rely on the short memories of petroleum geologists and the ignorance of journalists by announcing new production from older fields in a way that implies it is a new field, not just secondary or tertiary production.

To their credit, the Saudis have always considered it their responsibility to provide to the world what is known as swing production, the surplus oil needed by the market to guarantee spot market supplies to all who want them without panic buying. The only exception was the oil shock of 1973-74, when the Saudis, fed up with American and European support for Israel during the Yom Kippur War, choked off supplies temporarily to make their point.

Swing production has its price though, because it means that the Saudis are overproducing their fields. An overproduced field is damaged by the accelerated pressure drop, which requires massive waterflooding to maintain pressure, which bypasses oil in useless little patches and pushes water into the well borehole. If the field is rested, the oil will gradually float up past the water into the borehole, but in some cases this could take decades. In Alberta, the government not only prohibits overproduction but also insists that companies underproduce their wells. This is why my family well has been pumping for fifty years. The Arab procedure is to empty the fields quickly of their primary production, and then start on secondary production within a few years of drilling the first well. That is an expensive method of doing business, and often secondary recovery doesn't pay for itself because there is not enough oil within reach to pull out. This is why many Gulf of Mexico wells were permanently shut in after Hurricane Katrina, because the cost of re-establishing those wells is greater than the value of what is left, even for a low-cost junior pete.

Twilight.

All oil fields will eventually peak, which is then followed by a sharp production drop. That does not mean the well stops producing, only that it produces smaller amounts. It may go from 10,000 barrels a day to 200 barrels a day, enough to justify continued production but not major expenses to repair equipment or rejuvenate the field. Often what happens is that after the oil is no longer recoverable, the natural gas sitting on top of it becomes the emphasis, and the well is changed over to a gas well.

1958 Canada postage stamp for centennial of first North American drilled oil well.

Canada and the USA still have lots of extractable conventional oil in thousands of fields. In both countries, that oil will be measured at each borehole in only a few hundred or a few thousand barrels per day. It is not enough to satisfy demand, and as the Arab oil ran out, North America was forced to start using higher-priced unconventional oil.

There is a King of Kings unconventional oilfield on this planet, the Athabasca Tar Sands. But that is not cheap oil. It is $40 per barrel oil minimum, $70 preferred. Further, the production of oil from Athabasca is limited by water supply, since steam is needed to melt the oil out of the sands. Nor will the Tar Sands sate the addiction of North Americans. Even the wildest estimate by the Seven Sisters of the maximum daily production from the Tar Sands is that they will only produce a few percentage points of North American demand in the most optimistic scenario. Oil shale in the western USA is $125 per barrel oil.

The problem will be that there won't be enough oil to go around, and the world will be forced to make massive changes in how it uses energy. Simmons makes the point that the Saudis will be producing oil for generations to come. They just won't be supplying the swing production anymore. No one will. North America will have no choice but to adapt to life in the twilight.

Hubbert's Peak And His Disciples.

"*The good news is that OPEC is no longer in charge of the price of oil. The bad news is that nobody is in charge.*" This remark fairly sums up the current world petroleum situation, and is made by Kenneth Deffeyes in his book **Beyond Oil: The View From Hubbert's Peak** (revised edition 2006, trade paperback). Deffeyes was a student of M. King Hubbert (1903-1989), who, as mentioned earlier in this essay, successfully predicted the peak production of American conventional oil 14 years in advance. In 1968, Hubbert predicted that world conventional oil production would peak in 2000; the actual year was 2003.

Hubbert was a prickly man who had little patience for explaining how he reached his conclusions. Even his friends mentioned that he was difficult to get along with. He published his papers on a take-it-or-leave-it basis. In the 1950s and 1960s, geologists did not use advanced mathematics much, and had trouble understanding Hubbert's equations. In short, he was none too popular in the oil patch, thus explaining why his conclusions were rejected for many years.

Deffeyes devotes the first part of his book to explaining Hubbert's methodology in a reader-friendly manner, and then goes on to discuss alternative energy sources of the near future.

Using both Hubbert's original equations and improved methodology, Deffeyes calculates several ways of determining just how much oil is left. Several independent methods arrive at the same conclusion; the total world supply of recoverable oil (including unconventional) is just over 2 trillion barrels. 94% of all oil that can be recovered has already been discovered, although much of it still has to be pumped or steamed out. As Hubbert pointed out, the peak is the halfway point. There is no new King of Kings in waiting. Even the idle oil fields of Iraq and Nigeria are not going to stop the decline once the fighting is over in those two countries. The Venezuela and Alberta oil sands, although each amounts to a trillion or more barrels of oil, will never be fully recoverable.

The Next Decade.

Deffeyes discusses the next couple of decades as the world tries to find alternative energy sources. It won't be a pretty sight. Tertzakian, in his book reviewed above, handwaved his way past the transition and concentrated on what it will look like on the other side. Deffeyes considers what it will look like now and in the near future.

Natural gas is currently a continental energy source, and for much of its history has been wasted by flaring because it was too cheap to conserve. When natural gas was a few cents per gigajoule, it didn't pay to try to conserve it. Today that is starting to change but not by much. The alternatives to local natural gas are not feasible. Liquified natural gas (LNG) makes up less than 5% of the world market. Like nuclear power plants, few people want to live next to a LNG unloading facility, especially in this age of terrorism. One shoulder-fired missile as an LNG tanker sails into an American port will make a hell of a bang. Gas hydrates from ocean deposits are not as abundant as previously thought, and no one has come up with the technology to extract natural gas from them economically.

The USA, Canada, and Russia have centuries of coal available. The problem is that pollutants can't be removed from solids before burning, the way that sulphur can be stripped out of sour oil and gas. The only way to do this is by stripping the exhausted fumes, and this technology still awaits much improvement. For this reason, coal will be much in the news in the next decade, not because of price or supply problems, but because of carbon dioxide and sulphur emissions.

The oil sands of Alberta and Venezuela can only be extracted by steam-heating. Lack of water, as well as a severe labour shortage, are hampering the Alberta operations. Venezuela is a slow-motion train wreck in progress, as political instability makes it difficult to do business, to the point that people are making book on the odds of a coup or civil war.

Oil shale, like hydrogen-powered cars and fusion reactors, always seems to be on the horizon as the coming thing. The world's leading experts are Estonians, whose only petroleum deposits are oil shales. The USA does have 60% of the world's oil shales, mostly in the Green River Formation of the Rockies. Despite repeated efforts over the years and on-going pilot plant projects, attempts to extract oil from shale have remained uneconomic. The major problem is that the American oil shales happen to be in an arid zone, and there is no economical way to pipe in water. Worse yet, the nearest water sources are all spoken for. Attempting to pipe water from the Colorado River basin would touch off a war with Arizona, California, and Mexico, who have treaty rights to the water. Other problems are high sulphur content and the fact that once the oil is cooked out, the shale expands like popcorn, which means it can't be just dumped back into the mine. Deffeyes concludes that oil shale will not be viable at any future high oil prices until someone comes up with new, as-yet-unborn technology to extract it cheaply.

Non-Petroleum Sources.

Because few people have actually seen Hubbert's famous 1956 paper in which he correctly predicted the USA peak oil production, it is not commonly known that Hubbert was actually writing about nuclear power. The paper, titled "Nuclear Energy And The Fossil Fuels" was written by him because he was thinking about the transition after the oil declined. His conclusion was that fission nuclear reactors would be the only alternative. This message was unpopular then and still is. (Pause for chants of "NIMBY!, NIMBY!, NIMBY!") The last American reactor was commissioned in 1973.

Fusion reactors are at least twenty years away from even a working prototype that can generate more energy than it consumes. Deffeyes argues that pure fusion reactors are a dead end, and suggests hybrid fission/fusion reactors. He agrees with Hubbert that ultimately the USA will need to rely on nuclear power for the majority of its base load energy.

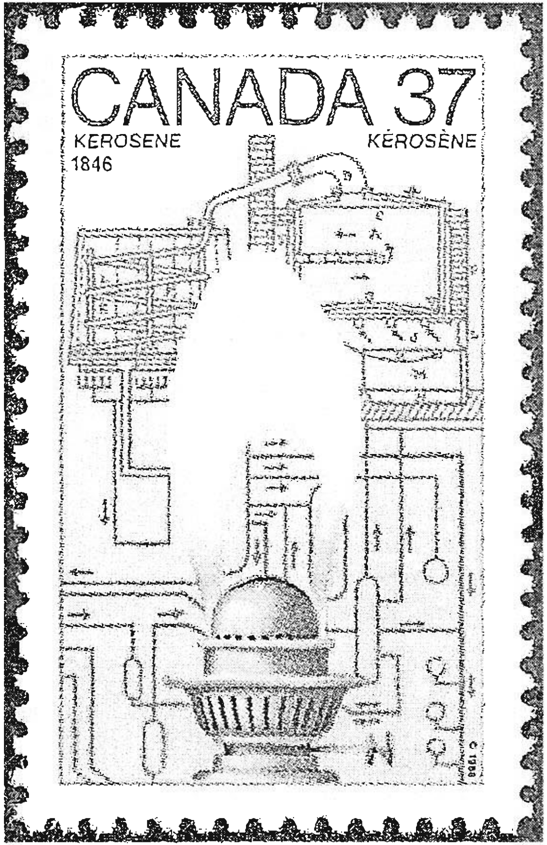
(The base load is the minimum amount of electricity consumed daily, most of which is supplied by nuclear power, hydroelectricity, or coal-fired plants. When peak demand exceeds the base load, gas-fired power plants come on line to take up the slack. Wind, tidal, and solar power are too unreliable to supply the base load but are useful supplements.)

Uranium ore is abundant but the problem with nuclear reactors is, of course, disposal of the wastes. I suspect that ultimately the only way to dispose of the wastes is to dump them into oceanic subduction zones, where tectonic plates are diving down underneath the continents. By the time the wastes resurface millions of years later, they will be inert.

75% of existing oil consumption is for transportation. With this thought in mind, many people are touting hydrogen-powered vehicles, and there are pilot projects thither and yon. The basic problem is that hydrogen only returns 40% of the energy used in manufacturing it. There are no hydrogen wells, and no prospector ever struck it rich digging hydrogen out of the ground. Hydrogen can only be produced commercially by electrolysis, and despite 75 years of commercial production, no one has found a better way. There is also, especially in the USA, legal liability concerns. Hydrogen is difficult to handle under the best of conditions, nevermind someone driving a rust-bucket hydrogen car. Deffeyes does point out one advantage to this; natural selection will quickly eliminate all hydrogen car drivers who smoke.

Since much electricity is produced from coal or natural gas fired power plants, hydrogen car users can't self-righteously claim they are using a clean fuel. Deffeyes recently tried to price out hydrogen production from solar cells, and found out that a 60-watt solar cell costs $1,000. I suspect that hydrogen cars will be on the mass market about the same time as fusion reactors.

Deffeyes concludes his book with thoughts on how to ride out the economic transition. He points out that if he could predict which stocks to buy, he wouldn't be wasting his time writing a book, but does suggest that petroleum-based income trusts would be a good buy.

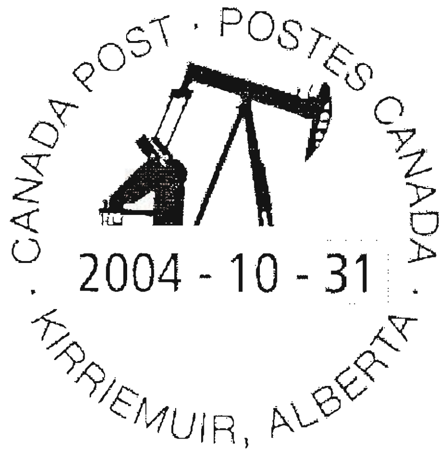


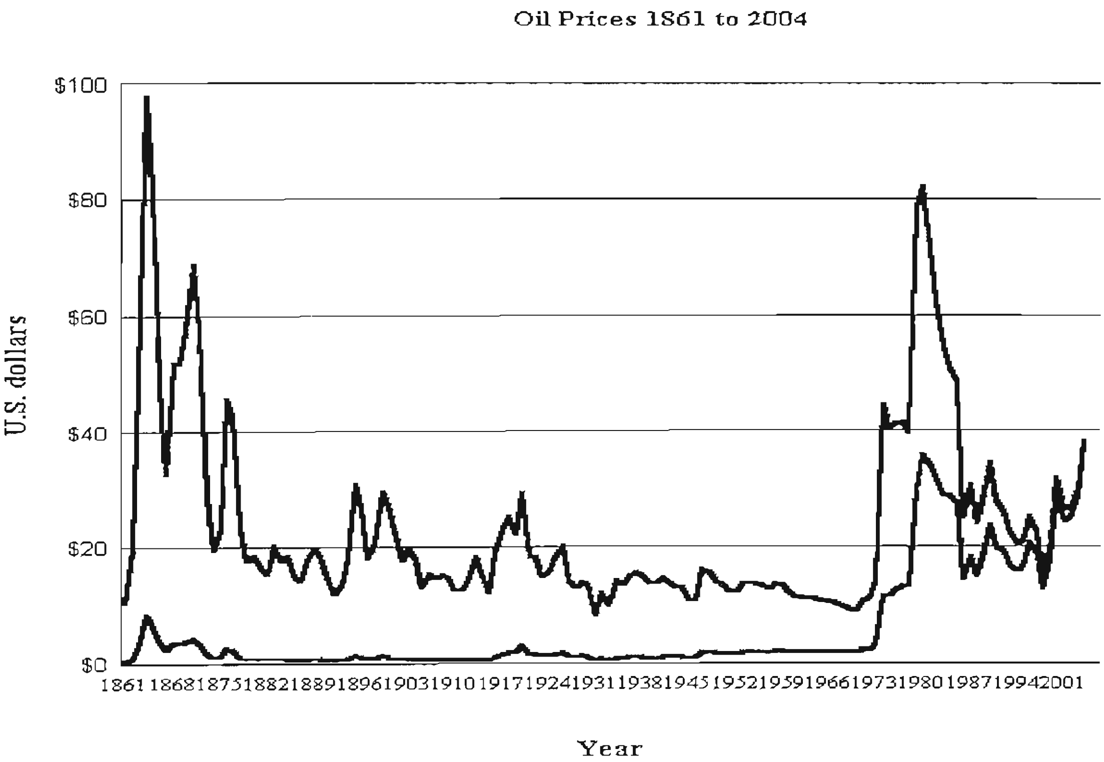
SEEN IN THE LITERATURE

noticed by Dale Speirs

Hill, J., et al (2006) **Environmental, economic, and energetic costs and benefits of biodiesel and ethanol biofuels.** PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES USA 103:11206-11210

"*To be a viable alternative, a biofuel should provide a net energy gain, have environmental benefits, be economically competitive, and be producible in large quantities without reducing food supplies. We use these criteria to evaluate, through life-cycle accounting, ethanol from corn grain and biodiesel from soybeans. Ethanol yields 25% more energy than the energy invested in its production, whereas biodiesel yields 93% more. Compared with ethanol, biodiesel releases just 1.0%, 8.3%, and 13% of the agricultural nitrogen, phosphorus, and pesticide pollutants, respectively, per net energy gain. Relative to the fossil fuels they displace, greenhouse gas emissions are reduced 12% by the production and combustion of ethanol and 41% by biodiesel. Biodiesel also releases less air pollutants per net energy gain than ethanol. These advantages of biodiesel over ethanol come from lower agricultural inputs and more efficient conversion of feedstocks to fuel. Neither biofuel can replace much petroleum without impacting food supplies. Even dedicating all U.S. corn and soybean production to biofuels would meet only 12% of gasoline demand and 6% of diesel demand. Until recent increases in petroleum prices, high production costs made biofuels unprofitable without subsidies. Biodiesel provides sufficient environmental advantages to merit subsidy. Transportation biofuels such as synfuel hydrocarbons or cellulosic ethanol, if produced from low-input biomass grown on agriculturally marginal land or from waste biomass, could provide much greater supplies and environmental benefits than food-based biofuels.*"





Top line is 2004 dollars. Bottom line is money of the day.

Data are from: British Petroleum (2006) "Statistical Review Of World Energy 2005"