Stu's Notes #8

Stu's Notes provide selected passages from books that are of interest to Stu. They are primarily direct quotes, though some longer passages are summarized. They do not generally provide a thorough synopsis of the book. Rather, they capture individual facts or opinions of interest, which may or may not be reflective of the overall text.

Title:	**The End of Oil: On the Edge of a Perilous New World**
Author:	Paul Roberts
Publisher:	Houghton Mifflin
Published:	2004
Stu's Notes:	2005 July 12
Summary:	*Clear, comprehensive, balanced, and interesting exploration of oil and energy issues, starting with the peaking of global oil production. Geology, technology, politics, sociology. Inquisitive and intelligent.*
Highlights:	Inflation of stated reserves [p.48-49]
	Conditions for creation of an oil field [p.61-62]
	Inaccuracy of resource projections [p.62]
	Ancient solar energy [p.71]
	"Climate change is the latest and possibly greatest confirmation that our great mastery of energy may be more accurately described as a series of accounting errors." [p.118]
	Throwing charcoal briquettes out the window [p.119]
	Carbon capture and sequestration [p.207-210]
	Efficiency and conservation [p.214-232]
	Half the electricity generated in the US isn't needed to begin with [p.215]
	Car fuel efficiency can be doubled with existing technologies [p.220]
	Consumer purchase decisions that ignore life cycle costs [p.221-222]
	Focus on the energy-related services (outcomes) we want [p.225]

Up to half of all electricity is lost from transmission lines as heat [p.226]

If we want to reduce CO2 emissions and other negative effects of energy use, we must somehow alter the historic trend whereby any gains made through energy efficiency are more than wiped out by a corresponding jump in overall energy consumption [p.232]

Externalized costs [p.274-275]

Recommendations for the way forward [p.307-303]

2: The Last of the Easy Oil

"The classic case came in the late 1980s, when the six big OPEC producers – Kuwait, the United Arab Emirates, Iran, Iraq, Venezuela, and Saudi Arabia – collectively added more than 300 billion barrels to their stated reserves. The move nearly doubled reserve numbers that had been on the books for years and, in one stroke, 'delayed' a peak in world production by nearly a decade. Saudi Arabia alone, owner of the largest oil reserves in the world, raised its estimate from 167 billion barrels to a breathtaking 257 billion barrels, overnight. … The six countries themselves claimed to be correcting for past mistakes: the Western oil companies that founded Middle Eastern oil operations had routinely underreported the size of their reserves. Yet although some correction was in order, it is worth noting that the upward revisions just happened to coincide with a 1985 OPEC edict stipulating that the higher a member's stated reserves, the more oil that country could export and thus the more revenues it could earn." [p.48-49]

USGS believes that 1.0 to 1.5 trillion barrels of oil is yet to be discovered ("undiscovered oil"). But there are few places on earth that haven't been searched. Oil doesn't occur in random locations. You need three geological conditions to get oil:

- Source rock: deeply buried sediments rich in organic matter
- Migration pathway: cracks or porous rock through which the newly formed petroleum can escape to the surface
- Impermeable layer (stone, clay, salt) to trap the petroleum

The three-part package is called a "petroleum system" by geologists.

And the timing has to be right. The source rock needs to be between 10,000 and 13,000 feet below ground (the "kitchen"), to give temperatures of 100°C to 135°C that will boil organic material into petroleum. Rock that's too shallow won't be cooked. Rock that's too deep will be over-cooked (the petroleum will "crack" into gas, or simply be destroyed).

OPEC can produce 3 million barrels/day *above* global demand. Meanwhile, non-OPEC companies have been forced to go after expensive oil ahead of the cheap (OPEC) oil. These factors have hidden any price signals that might otherwise appear as we approach peak. Plus it allows OPEC to sell "cheap" oil for the price of expensive oil.

“Thus, despite the widely understood fact that all oil estimates are highly speculative – statistical extrapolations based on data from known oil fields – such forecasting agencies as the USGS, the EIA, and Europe’s International Energy Agency are under intense political pressure to err on the side of wild optimism. And err they do. During the 1990s, for example, a USGS report giving a low figure for oil reserves in the Arctic National Wildlife Refuge was withdrawn under pressure from pro-oil lawmakers in Alaska and rewritten with a more optimistic conclusion.” [p.61-62]

“It would be a huge mistake to base U.S. energy policy on what the USGS thinks about future oil supplies, and the Energy Information Agency has put out such overblown numbers, and done it with such arrogance, that it should be statutorily barred from answering questions about oil”. ~ Anonymous former high-ranking U.S. energy official. [p.62]

3: The Future’s So Bright

Photosynthesis. Solar energy falls on a leaf and causes a water molecule inside to split into oxygen and hydrogen. The solar energy, in essence, attaches itself to the hydrogen atom. This atom is highly unstable and needs to bond with something. It binds with carbon to create a carbohydrate, or sugar. This is why sugars are high-energy compounds: their bonds contain the solar energy brought over by the hydrogen. Sugars, in other words, are a chemical storage for energy from the sun. And hydrogen is the energy carrier. [p.70]

Subsequently, in metabolism, when an animal eats the leaf, the hydrogen splits from the carbon and reunites with oxygen (from the animal’s lungs). In doing so, the hydrogen surrenders its cargo of solar energy. The released carbon combines with oxygen to form carbon dioxide, which is exhaled. [p.70]

From the standpoint of human civilization, the truly amazing thing about hydrogen as an energy carrier is that it can store energy for a very long time. Suppose that our leaf isn’t eaten or burned, but instead falls into a bog and eventually becomes buried at a great depth, and, over millions of years, is pressure-cooked into coal. When we later burn the coal, we reverse the photosynthetic process, producing water and carbon dioxide and releasing this stored – and very old – solar energy. [p.71]

In this way, nature has essentially transformed uncounted trillions of kilowatt-hours of solar energy into highly concentrated and exceedingly useful forms – coal, oil, or gas. Granted, nature’s method of storing solar energy as hydrocarbons is not terribly efficient: the average leaf converts less than 1% of the solar energy it receives into chemical energy in carbohydrate form, and more than 90% of that stored energy is lost during the long process by which carbohydrate is later cooked into coal. Oil and gas are even less efficient: less than a tenth of 1% of the energy contained in the original ocean plankton winds up in the oil or gas we extract from the ground. As a consequence, it takes many hundreds of thousands of watts of solar energy, accumulating over many years, to produce the energy stored in a gallon of gasoline. Still, even grossly inefficient systems can, over hundreds of millions of years, put away a great deal of energy, fortunately for us: if humans hadn’t found such an accessible and concentrated form of energy – if we had been forced to rely on wood or water or wind instead – our industrialized civilization could never have come so far so fast. (from "Buried Losses: The Journey from Plant to Coal") [p.71]

But, disadvantages:

- Finite supply of hydrocarbons

- Noxious emissions ranging from sulphur, which destroys forests, to carbon dioxide, which has serious climactic consequences.

- Pound for pound, carbon carries less stored energy than hydrogen, so high-carbon fuels produce less energy (per unit weight). Coal has roughly 1:1 hydrogen and carbon: lowest energy of the fossil fuels. Oil has 1 carbon : 2 hydrogen and can therefore release more energy. Methane (natural gas) has 1 carbon : 4 hydrogen and therefore releases the most energy. Best of all would be to dispense with the carbon and burn pure hydrogen. Burned in an internal combustion engine, hydrogen produces nearly three times the energy as the same weight of gasoline, and far fewer emissions.

5: Too Hot

"Climate change is the latest and possibly greatest confirmation that our great mastery of energy may be more accurately described as a series of accounting errors." [p.118]

6: Give the People What They Want

Any activity that burns fossil fuel produces carbon, in surprising quantities. Burning a single gallon of gasoline, for example, releases five pounds of carbon – the equivalent of a small bag of charcoal briquettes. This means that most Americans generate a ton of carbon a year, simply by driving their cars. Burning a ton of coal yields nearly a ton of carbon, because coal is nearly pure carbon. [p.119] And footnote: Gerry Stokes, director of the U.S. Joint Global Change Research Institute in Washington. A car that gets 25 miles to the gallon produces carbon emissions the equivalent of throwing a briquette out the window every quarter mile. "Since the average American car drives ten thousand miles a year, that's forty thousand briquettes per car, year in and year out. Imagine the roadside."

"The entire global economy is like a huge machine, steadily turning energy into wealth. … The richest nations use great quantities of energy and do so with stunning sophistication and startling obliviousness: beyond occasional complaints about gasoline prices or the electric bill, the vast majority of Americans and Europeans are no more aware of using energy than they are of breathing air. In the poorest nations, by contrast, energy use is scanty, rudimentary, primitive, and wholly conscious: for the poor, every act of energy consumption is calculated." [p.147]

7: Big Oil Gets Anxious

Solution to the problem of no one wanting a Liquefied Natural Gas terminal: build it in Mexico. [p.165]

In addition to low-value methane, natural gas contains small quantities of so-called natural gas liquids, or NGLs – ethane, butane, and propane, which can be separated and sold for good prices. (Ethane, which is made into plastics and synthetic rubber, is especially valuable.) [p.169]

"Unconventional" oil faces high political hurdles, largely because refining the stuff is so polluting. [p.173] Footnote says: "Tar sands refining is so polluting that Canada recently had to exempt its tar sands operations from its otherwise aggressive policy to reduce CO2 emissions."

Over the long term, switching to a gas economy could create a geopolitical dynamic similar to that of oil. More than half of the total known gas reserves are in just two countries – Iran and Russia – while most of the rest is in Qatar, Nigeria, Algeria, Norway, and Venezuela. [p.185]

8: And Now for Something Completely Different

One of the largest wind farms in the world is 40 miles west of the city of Walla Walla, near the Washington-Oregon border. The Stateline Wind Farm sprawls over 70 square miles and boasts 454 towers. [p.196]

Wind and solar power are dependent on wind and sun, and are therefore not as reliable at any given moment. Utilities can delay a power delivery from a particular wind farm until 30 minutes before the scheduled delivery time. If the necessary wind speed is there, the delivery goes ahead; if not, the utility takes that power from some standby source instead – like a gas- or coal-fired plant or, in the Pacific Northwest, a hydroelectric dam. As a result, wind's unpredictability hasn't been as costly as many sceptics feared: Osborn says that BPA wind power sales miss their scheduled deliveries only 10% of the time. [p.203]

On average, analysts say, wind and solar renewables can provide a maximum of 20% of a region's power. Past that point, either the intermittency factor causes too many power disruptions, or the cost of maintaining so much backup base load becomes too high – a non-starter for utilities trying to avoid blackouts, price increases, or anything else that might attract regulatory attention in the post-Enron era. [p.203]

Gerry Stokes is director of the U.S. Joint Global Change Research Institute. He says the main question about alternative energy is not which renewables technology to focus on or how quickly it can grow, but what to do about the 80% of the market that renewables cannot, on their own, supply. One option is to convert the electricity to hydrogen, to be stored until the time of day when it is needed (or can be sold at the highest rate). But this adds even more to the cost, and neither solar or wind power is economically competitive today. [p.204]

Can “decarbonize” coal, turning it into gas (containing hydrogen, carbon dioxide, carbon monoxide, steam, and trace amounts of other pollutants). All but the hydrogen are then stripped off. Or burn the gas (e.g., to generate electricity) and capture the carbon dioxide. The process is called Integrated Gasification Combined Cycle (IGCC). Hasn't yet been implemented on a large scale. Uses 20% more coal than a non-IGCC plant. Because you've added oxygen (making the CO2), the waste CO2 is three times as heavy and bulky as the original coal. It needs to be hauled away and sequestered (in a manner yet to be determined). Total process would probably add 30-50% to the cost of electricity. But coal is very abundant: nearly a trillion tons on the world; enough to power the entire planet for more than 150 years. Process can also be applied to oil, including tar sands. [p.207-208]

Gerry Stokes: “I really think renewables and fossil fuels with carbon capture and sequestration are the two big dogs in the hunt.” And the UN's Intergovernmental Panel on Climate Change (IPCC) believes that whereas solar, wind, and other renewables, including hydropower, will account for less than 12% of the total energy mix by the end of the century, “clean” coal's share could be as high as 50%. [p.210]

Due to the uncertainties and costs, not everyone is convinced that sequestration is the solution. John Turner (National Renewable Energy Laboratory): “Every dollar we're talking about spending on sequestration should be spent on renewables.” [p.210]

9: Less is More

When the 2000 California power crisis was declared to be over in late 2001, “it wasn't because the new power plants had come on line,” argues Dan Kammen, director of the Renewable and Appropriate Energy Laboratory at the University of California, Berkeley, and an expert on the state's power problems. “It was that consumers immediately cut their power usage by 10% as soon as a crisis was declared.” [p.214]

Less than a quarter of the energy used in the standard stove reaches the food. Half the electricity generated in the US isn't needed to begin with. Barely 15% of the energy in a gallon of gasoline ever reaches the wheels of a car. As Amory Lovins, one of the world's most outspoken efficiency advocates, likes to point out, “just a 2.7 miles-per-gallon gain in the fuel economy of this country's light-vehicle fleet could displace Persian Gulf imports entirely.” [p.215]

Arthur Rosenfeld, California's efficiency czar: “We realized we were discovering, or had blundered into, a huge oil and gas field buried in our cities, factories, and roads, which could be ‘extracted’ at pennies per gallon of gasoline equivalent.” (from Rosenfeld, “The Art of Efficiency”) By making basic improvements to cars and buildings, America could save the energy equivalent of 12 million barrels of oil a day – well over half the nation's total demand – thereby obviating the need for oil imports. And it doesn't mean giving up what we like; efficiency can be largely “transparent” to the consumer. [p.217-218]

Between 1974 and 1986, Western economies, and especially the U.S. economy, made enormous strides in conservation, often, as Rosenfeld had predicted, in the form of efficiency improvements that were largely invisible to consumers. By government mandate, air conditioners were reengineered to use less power, yet they suffered no loss of cooling capacity. New building codes required double-paned windows, better insulation, and more efficient heating systems. New refrigerators used only one-quarter of the power that a pre-1970s model had – a savings that, when multiplied by the number of U.S. households, helped avoid the construction of 40 new power plants. Most dramatic, however, was the improvement in cars. Between 1977 and 1985, despite a booming U.S. economy that grew 27%, oil demand bell by more than one-sixth. [p.218]

In the U.S. power sector alone, we could reduce our electricity rates by 40% and cut CO2 emissions in half by upgrading power plants and transmission systems. Replacing inefficient household furnaces with high-performance models would, within 15 years, reduce gas demand in North America by nearly 25%. And, as we have seen, automotive fuel efficiency could be doubled through technologies that are already in use, thereby saving vast quantities of oil and, in theory, sparing us endless foreign entanglements. [p.220]

Whereas residents of poor nations are acutely aware of every aspect of their energy use, every stick of wood, every gallon of cooking fuel, in modern, wealthy societies, where energy costs are a small fraction of overall expenses, energy is not a hot topic of conversation. … In more affluent cultures, energy has become an invisible commodity, something we vaguely understand to be important on a national and international level, yet no longer fully recognize in our daily lives. [p.221]

Most consumers make purchase decisions on the up-front (capital) cost, rather than life cycle costs. If companies made purchasing decisions like that – looking only at up-front costs and ignoring costs over the life cycle – they would go bankrupt, or at least they would fire the purchasing manager. [p.221-222]

By most estimates, assuming that projections for future energy demand and population growth hold true – and that we maintain our current disdain for energy efficiency – by the year 2100, the world's ten billion people will need something on the order of fifty terawatts of electricity, or around four times what we produce today. [p.223]

Doubling the average fuel economy of American cars added around $300 to the cost of each car. But it also saved drivers anywhere from 300 to 500 gallons of gasoline *a year*. Assuming that the life of a car is ten years, customers ended up spending around a penny or less to save each gallon. [p.224]

As David Goldstein, an efficiency expert at the environmental group Union of Concerned Scientists, told me, "anywhere companies have pursued energy efficiency, they have ended up making money, even if making money wasn't their initial goal." [p.225]

"Customers don't want lumps of coal, raw kilowatt-hours, or barrels of sticky black goo. Rather, they want the services that energy provides: hot showers and cold beer, mobility and comfort, spinning shafts and energized microchips, baked bread and smelted aluminum." The point, Lovins says, is to look at the desired end use and then determine how to achieve it as efficiently as possible. [p.225]

Every dollar spent retrofitting an old office building with more energy-efficient lights, heating and cooling systems, and windows typically nets the owner savings of $1.20 or more – a 20% return on investment that easily beats the Wall Street average, but with far less risk. [p.226]

This is why efficiency advocates have long argued that saving energy at the end use is always cheaper than adding more supply. Today, generating a kilowatt of electricity at a power plant costs, on average, just under three cents. By contrast, by the time the electricity has reached the home or business, its cost has climbed to 8.5 cents a kilowatt, owing to operational expenses and waste; up to half of all electricity is lost from transmission lines in the form of heat. [p.226]

Saving energy is also faster than producing energy. … This was a painful, if rarely discussed, lesson of the 1980s. … U.S. policymakers dismissed conservation and chose instead to encourage increased production – especially more power plants and oil wells. Yet by the time many of the supplemental barrels and kilowatts became available, conservation had already "produced" the needed energy. That much of the new oil was now unnecessary contributed to a market glut and the great price collapse of 1986. … "Efficiency had actually captured the market that the suppliers thought was theirs," quips Lovins, clearly relishing the irony. "Efficiency got there first." [p.227]

In reality, when it comes to energy efficiency, the market is far from perfect. Information about energy efficiency is neither widespread nor clear, so most businesses simply are not aware of the potential cost savings. [p.228]

Our infrastructure is designed for low construction cost; not low life cycle cost. Thicker-gauge copper wire would pay for itself in reduced energy loss, in less than five months. … In Los Angeles, the combined effect of so many million dark roofs, as well as dark asphalt roads, forces the city to use up an extra 1,500 megawatts of power cooling itself – the equivalent of one-and-a-half power plants – or about 3% of California's total summertime power load. … Landlords buy (cheap) appliances but tenants buy the electricity they consume. [p.229]

According to the UN IPCC, by the end of the century, more than 30% of our energy demand will be met not by clean technologies, but as a consequence of conservation. … "Of the energy we use today, two-thirds and maybe even three-fourths will be replaced by energy efficiency, and only one-third to one-fourth will be replaced by new supplies and technologies," predicts Lee Lynd, the Dartmouth College biofuels expert. [p.230]

No matter how efficient we become, if we want to reduce CO2 emissions and other negative effects of energy use, we must somehow alter the historic trend whereby any gains made through energy efficiency are more than wiped out by a corresponding jump in overall energy consumption. [p.232]

10: Energy Security

Poorer countries don't have the luxury of paying for clean energy. They need any energy they can get. In China, the emphasis is on cheap coal. Today, China is the second leading emitter of CO2, right behind the United States – despite the fact that China's per capita CO2 emissions are just one-eighth those of the United States. … Between now and 2030, China's CO2 emissions will increase as much as those of the entire rest of the industrialized world. What is truly alarming here is that, despite all the new growth in power usage and in construction of power plants, China's per capita consumption of electricity is still less than a *tenth* of the average for industrialized countries. What this suggests is not only that China still suffers from chronic energy poverty but that, once China starts to lift itself out of that poverty and approach a Western level of energy use, its energy needs will exceed the capacity of any global system that currently exists. [p.248]

11: The Invisible Hand

Companies are not altruistic. They can't build futuristic products that no one wants yet, or they won't be around when people actually do want those products. ("asset inertia") [p.264]

Today, coal-fired power generates more than one-half of all U.S. CO2 emissions, and roughly one-eighth of the world's CO2 emissions. To put it another way, had U.S. utilities been forced to replace those older power plants with, say, gas-fired generating stations, carbon emissions globally would be around 12% lower than they are today. [p.268]

In fact, according to studies by the Electric Power Research Institute (EPRI), if utilities were forced to capture carbon from existing coal-fired plants, technology costs would raise electrical rates to at least 7.5 cents a kilowatt-hour, at which point the older coal plants would simply no longer be worth running. "There is no economical way to control carbon emissions from existing coal plants," says the institute's Kurt Yeager. [p.269]

Past energy transitions were sparked by the arrival of a new fuel that was more cost-effective. That will not be the case this time. [p.271]

Joan Ogden, researcher at the University of California, Davis. Cost breakdowns of competing technologies. Even mass-produced, fuel cells will still cost more than internal combustion engines. Even using life-cycle costs. Because there's no charge for the carbon emission. [p.272-273]

This changes if you work in the externalized costs (health, climate, etc. total $2,006 for internal combustion engine or $225 to $736 for a fuel cell car running hydrogen made from natural gas). … Ogden estimates that even an advanced car with an advanced internal-combustion engine incurs another $1,571 for the cost of keeping the U.S. Fifth Fleet in the Middle East, along with other military expenditures associated with protecting oil supplies, whereas a fuel cell car incurs no such expense. [p.274-275]

12: Digging in Our Heels

The world map of energy politics is dominated by five major players, each with its own agenda and, more to the point, its own role in the building of the next energy economy:

1. **Developing world (mostly Africa, Asia, South America).** Includes tiny impoverished nations and emerging giants (China, India). Focused on least-cost solutions, short-term objectives. They regard policies to reduce carbon emissions as undercutting their own efforts to escape energy poverty and to

modernize. Will need financial assistance from wealthy nations if they are to adopt policies such as CO2 reduction.

2. **Europe.** Leaders in climate policy and alternative energy, due to decades of dependence on imported energy. Europe has stopped waiting for the United States to join in on climate policy and is implementing programs to reduce emissions on its own, though it has little hope of bringing developing nations aboard without American assistance.

3. **Energy producers (countries and corporations).** Mainly invested in a hydrocarbon energy economy – oil, gas, and coal. Heavily biased to retaining dominance of hydrocarbons, and they have political influence.

4. **Advocates.** Environmentalists, peak oilers, UN IPCC, etc. Lack economic power; rely on persuasion. Use of stunts and exaggeration gets attention, but can be negative.

5. **United States.** Top consumer; top CO2 producer. World energy cop. Extremely influential (e.g., giant U.S. car market could be catalyst for a cleaner auto industry). But heavily invested in the hydrocarbon energy economy. [p.284-289]

13: How Do We Get There?

Geopolitics of Energy in 2015. Annual conference of energy, international relations, CIA. Examined four scenarios in 2002:

1. Environmental disaster galvanizes public opinion, allowing for aggressive environmental policies. By 2020, world is using 13M barrels/day less than trend.

2. Technology breakthroughs in supply and efficiency lead to substantial declines in energy intensity worldwide.

3. Conventional oil peak sometime between 2010 and 2015. Prices rise to $40 barrel (!). Global economy pushed towards recession.

4. U.S. defeat of Saddam Hussein has backfired, leading to alienation of many in Arab world and overthrow of Saudi Arabia, Kuwait, and other "relatively friendly Arab governments by nationalist Islamic regimes." New governments reduce supply. Terrorists attack oil shipments. Prices go to $50/barrel (!) for five years, thereby setting the stage for the end to a modern energy economy based on oil. [p.307-308]

The last American energy revolution came only in response to crisis – the 1974 Arab oil embargo – and since then, U.S. energy policy has become even more fractured and obsessed with supply. [p.309]

This is why, for many energy experts, true change in the global energy system is virtually impossible, except in response to some serious shock. In this somewhat pessimistic view, the question is not whether the world can avoid some kind of energy-related disaster, but whether our response will be reactionary and short-term, or constructive and long-term. [p.309-310]

Likely shock would be upheaval in the Middle East (e.g., succession battle upon the death of the aging Saudi crown prince). If Saudi Arabia tilted toward fundamentalism, pressure for military intervention would be large. As one foreign policy analyst who works closely with the CIA told me, "there is simply no way the United States would allow an Osama bin Laden to control the world's largest oil reserves." Yet any intervention would further fuel Islamic rage. [p.310]

The optimistic scenario:

1. Assume smaller shocks come gradually, before the main one.

2. Assume American people don't want any more oil wars.

3. Assume that a series of price spikes and blackouts have convinced American people that energy is too important to be left entirely to the private sector.

4. Assume that "energy security" and "volatility" have become nightly news topics.

5. Assume that data on climate change have become irrefutable.

6. Assume a few big states go it alone on vehicle emission standards, carbon tax or cap-and-trade system, decentralized energy production.

Then, U.S. lawmakers might be willing to risk a more progressive and interventionist energy policy. Core of long-term goals:

- Staying within a hundred-year carbon budget

- Moving toward a hydrogen economy

- A transitional phase to arrest the worst of the current energy trends, while giving us flexibility in eventually creating a new energy system [p.313]

Three near-term objectives:

- Expand natural gas imports

- Carbon tax

- Dramatically improved automotive fuel efficiency [p.313]