CHAPTER 4

In-depth Review: Finite Fuels, Renewables, all Resources

The intent of this chapter is to give a quick overview and update of all energy sources going into 2015. It is difficult to avoid becoming mired in the details of each of these subjects and risk losing sight of the overall basic conflict between the limits of finite fossil fuels (especially oil) and steadily increasing population. This is the foundation for the ultimate crisis that confronts all of civilization. To add to the confusion and complexity about energy there are many differing references, units of measurement, grades, and use-efficiencies for all forms of energy. To keep things as simple as possible; wherever possible, all units will be converted to energy-equivalent barrels of oil.

WORLD ENERGY SUMMARY 2014

Table 4 summarizes the contribution from all primary energy sources. These numbers fluctuate from year to year and there may be minor disagreements, but these will not change the conclusions. See also Figures 3 and 4 for graphics. **Note: nuclear, hydro-electric, solar, and wind are presented at three times their electrical energy equivalents in order to compare directly with equivalent fossil fuels burned at an average of 33% efficiency.** Biofuels are also burned at 33% efficiency. Solar and wind contribute less than one-half percent of total energy but at much closer (comparatively) to 100% efficiency. In other words, it requires only one-third as much electrical output at nearly 100% efficiency to offset fossil fuel combustion. These are examples of the confusion that creeps into any comparison between different forms of energy.

TABLE 4 Comparison of Energy Forms

Energy source	Equivalent billion barrels of oil per year	Percentage
Oil and all liquids	32 *(see also Chapter 1)*	36
Coal	24.5	27
Natural gas (w/o NGL's)	19.5	22
Total fossil fuels	76	84
Nuclear	5	5.6
Total finite (non-renewable)	81	90
Renewables		
Hydro-electric	6	6.6
Solar and wind	0.6	0.7
Biofuels (and everything else)	2.4	2.7
TOTAL	90	100

ALL LIQUID FOSSIL FUELS

Figure 3 shows that world extraction of **conventional** oil continued into 2015 along an "undulating" plateau of about 75 million barrels per day (27 billion barrels per year). Beginning in about 2000, the addition of **non-conventional** oil including tar sands, deep-water, polar, natural gas liquids, condensates, and "tight-oil" made possible by horizontal hydraulic fracturing, increased world output of "all liquids" by another 16 million barrels per day.

These recent additions, especially biofuels, have much poorer energy (and economic) returns on investment EROEI); some as low as 1:1 instead of up to 100:1 with original conventional oil. To include them together is like adding pears to apples, but they are shown this way in Figures 3 and 4. "All liquids" will help extend the oil age a few more years, but totally confuse the public by suggesting unlimited potential for extending industrialized civilization beyond the two-lifetime, oil-age epoch we are now half-way through.

Oil, 2014 update, history, and forecasts

It is nearly impossible to precisely quantify and compare all world energy statistics because of poor data and starting assumptions. There are too many different country, political, and economic viewpoints involved to avoid bias. For instance, Figure 5 shows a more recent International Energy Agency's (IEA) *World Energy Outlook 2012* forecast. This report says, "The world could produce **increasing** amounts of

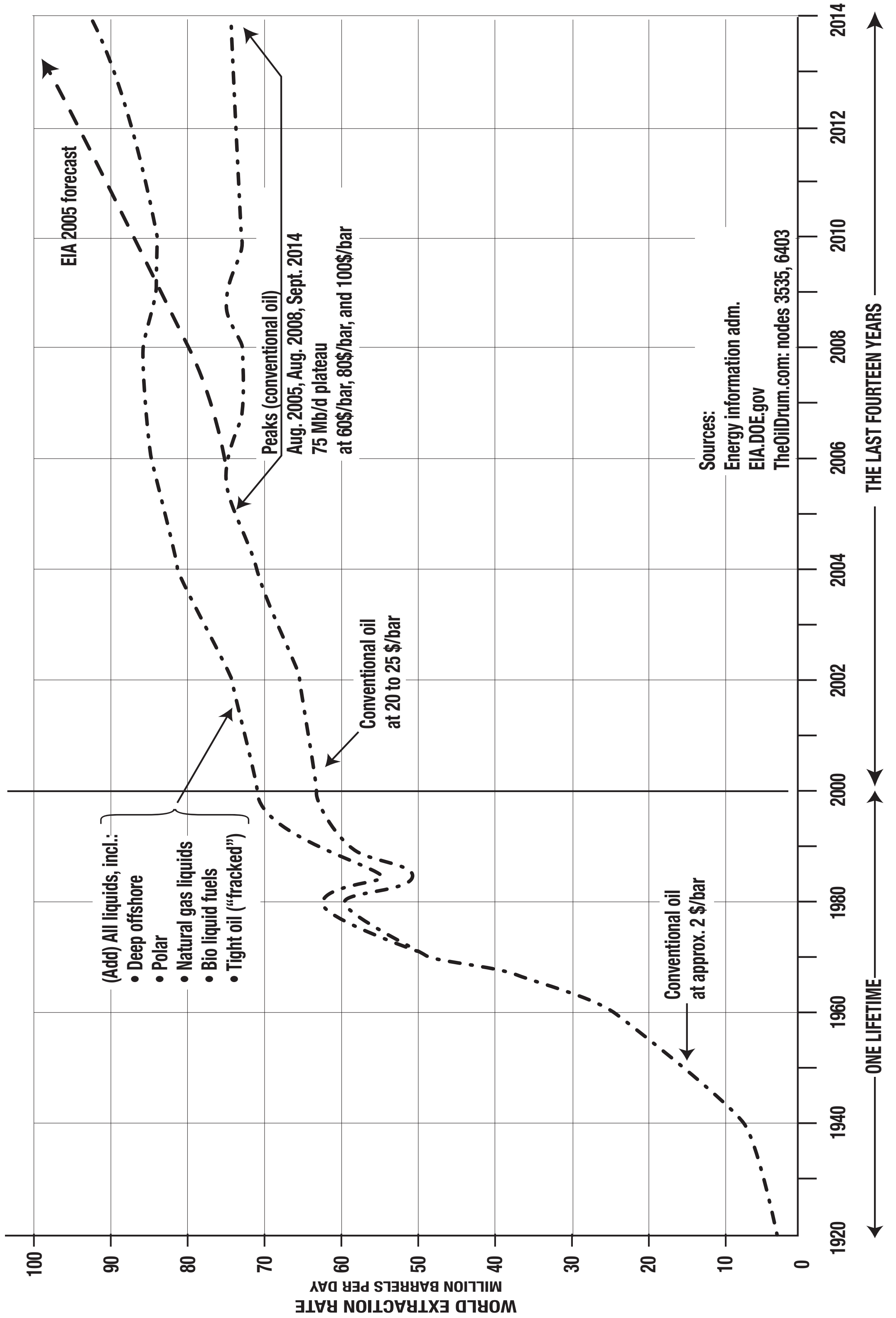

FIGURE 3 Peak oil update (January 2015)

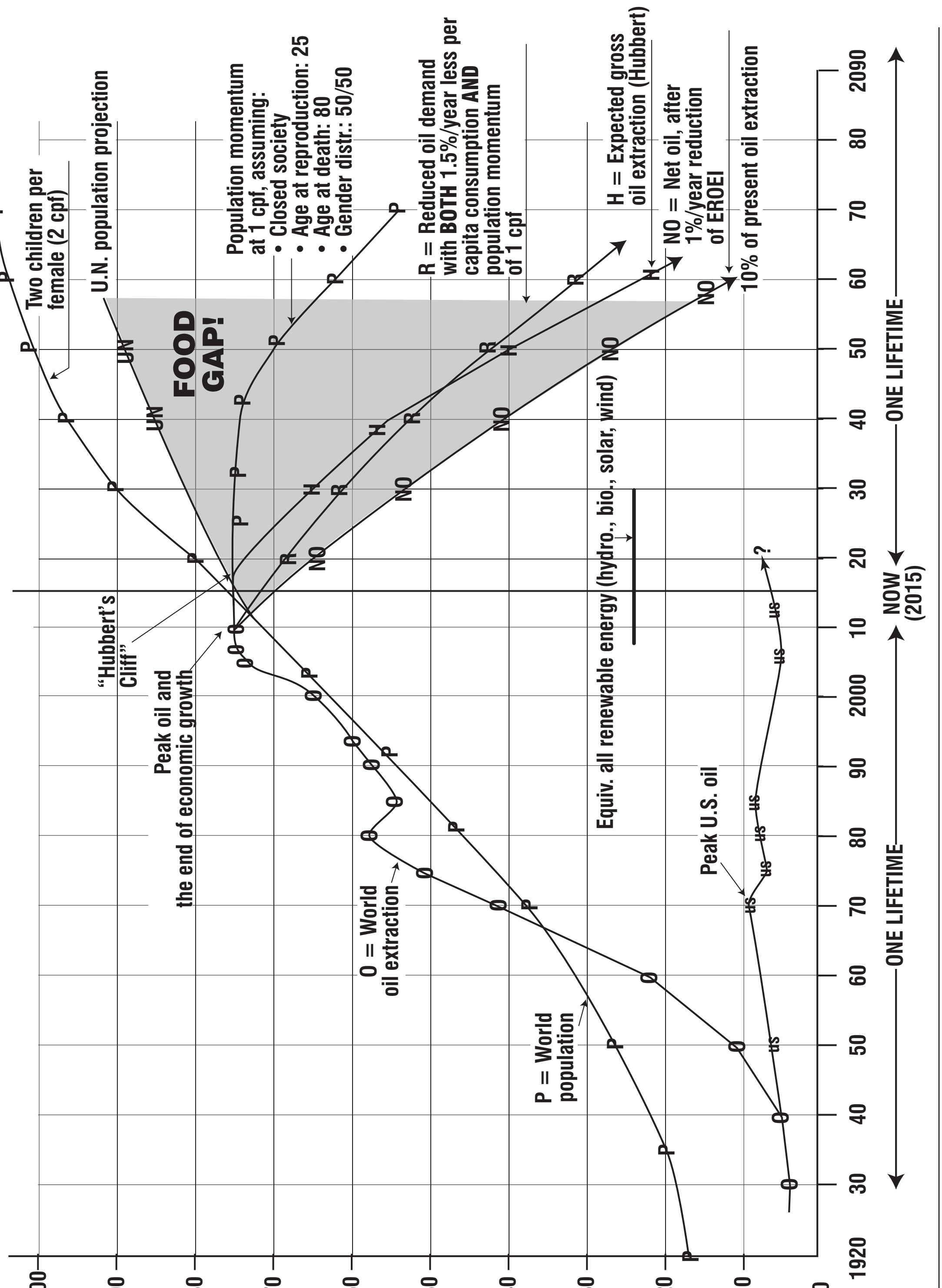

FIGURE 4 World Oil and Population in a Two Lifetime Span

oil through 2035 and meet the world's growing demand for energy as oil." Where does the IEA optimism come from? What happens after 2035?

The top-most curve in Figure 5 (AL) shows the IEA projection for all liquids, including non-conventional like tar sands, polar, deep off-shore oil, natural gas liquids, and condensates to remain essentially level at 33 billion barrels per year (90 mb/d) for the next 20 years. The lower level curve (O) at about 30 billion barrels per year (81 Mb/d) is for conventional oil plus natural gas liquids. **These IEA predictions do not include "yet-to-be-found" liquid hydrocarbons and therefore are flat. The U.S. Energy Information Administration (EIA) projections shown in Figure 6 show a steady increase for all three fossil fuels until 2035.** These EIA forecasts include "yet-to-be-found oil, and apparently refuse to acknowledge the steady decline (beyond peak) of output for more from half of the world's producers.

The two agencies seem to be similar, or are trying to out do each other in confusion and optimism. None of their rosy predictions seem concerned about the concurrent, steady growth of population which, by 2035, will reach about 8.5 billion at the present fertility rate of almost two children per female (2 cpf). (See Figures 4 and 7). **Neither of these agencies offers a clue about the future after 2035** for a continually-expanding population which has become precariously dependent on a fossil-fuel-based food system, and a world all-liquids energy supply of one billion barrels every eleven days. **Sooner or later energy, even in the most-optimistic crystal ball, will no longer be adequate and civilization will have lost another critical twenty years that might have been the last opportunity to stem the tide. By then, a child born today will be an adult.**

Also shown in Figure 5 are, in my opinion, the most realistic and optimistic projections for conventional oil (H = Hubbert's Curve), and a second curve (H+500) showing the effect of an additional 500 billion barrels. This scenario would increase the world total, original, conventional oil endowment to 2.8 trillion barrels, considerably more than the original Hubbert's and Association for Peak Oil (ASPO) predictions of 2.0 trillion barrels. In my methodology, I exclude "all liquids" because it seems incorrect to add more recent types of poor EROEI fuels to the baseline of conventional oil.

"Saudi America"

Also shown at the very bottom of Figure 5 (U.S.) is the glowing IEA 2012 forecast for a boom in U.S. oil. By 2020 and led by "tight oil fracking," U.S. extraction is projected to once-again reach its 1970 Hubbert-predicted peak of 9mb/d This renaissance began in 2010 as an increase of 0.22 billion barrels per year (600,000

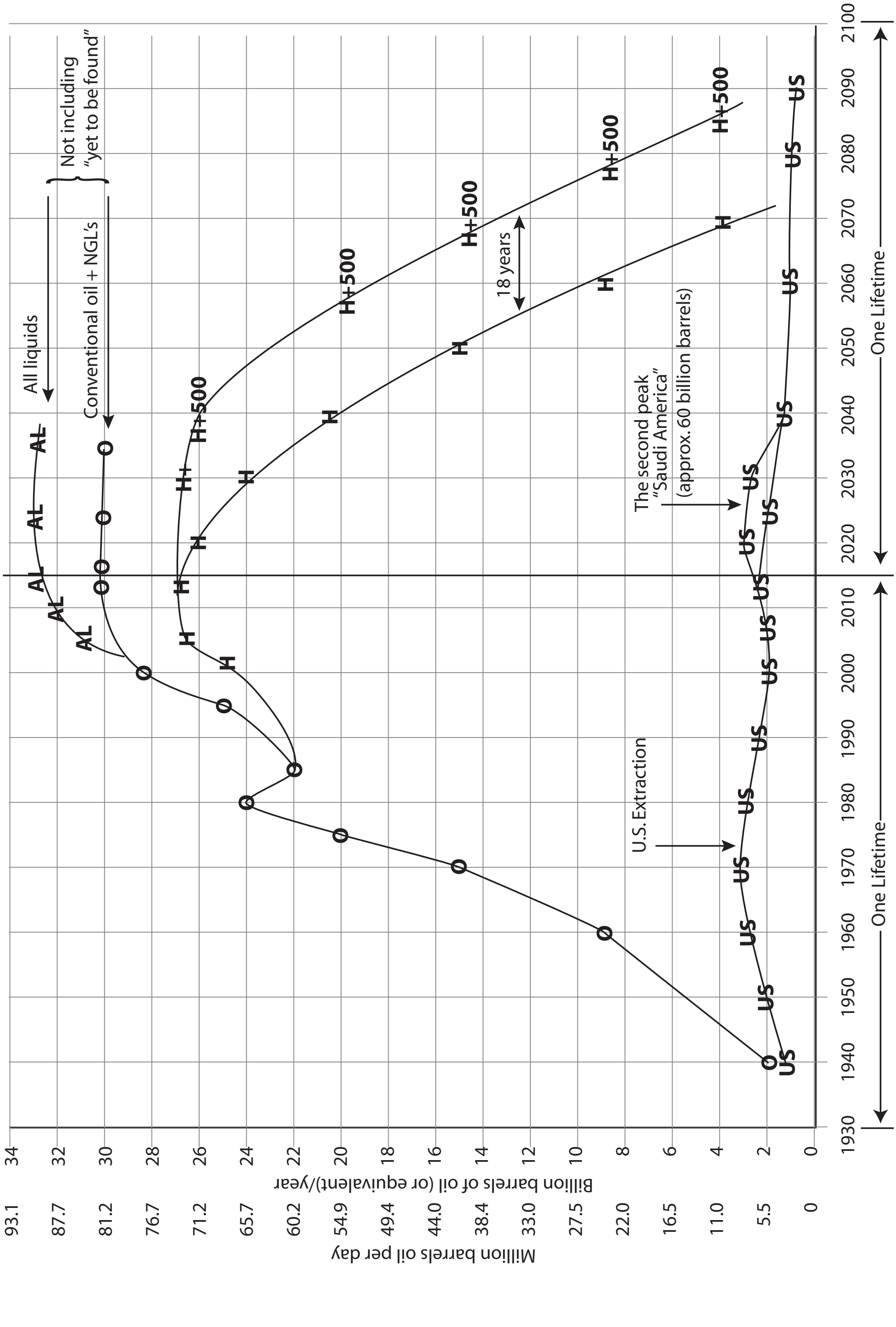

FIGURE 5 2014 Update, World and U.S. Oil barrels/day). It is enticing to simply extrapolate this curve upwards another 1.5 billion barrels per year to a second, "twin peak" of U.S. extraction at 3.5 billion barrels per year, exactly what Americans are using each year now, just for gasoline. If this did come to pass, it would add an additional 25 billion barrels to the 75 billion barrels, the most we could possibly have left in the next thirty years. **The total of 100 billion barrels of remaining U.S. oil is the same as in the most optimistic scenarios in Chapter 2.** This euphoria assumes a massive amount of new infrastructure, new jobs, and predictions of a revitalized U.S. economy.

The additional oil, shown in Figure 5 as a "second peak," would add just over four years at our present, U.S. annual consumption rate of 7 billion barrels per year. This new extra oil would still have to accommodate continued population growth, even at one child per female (see Figure 7). **This surge of American oil, if it does come to pass, would all be over in less than half the lifetime of a child born today leaving twenty-five billion barrels less for their future.** How can anyone deny or argue this simple logic?

Coincidentally, by 2035, I will personally have reached one-hundred years old so probably won't be here to see the outcome. The oil age will have seriously contracted by then. In my opinion, we will know the outcome far sooner, in the next several years, because the predictions for world and U.S. oil extraction are far too optimistic in light of steadily decreasing EROEI and global net export math. (GNE, see below).

Other forecasts

In this amazing age of information, it is possible to go on-line and "google" any subject. "Peak oil" will turn up hundreds of references and forecasts, most within the ranges shown in Figure 5. Typical of most economic pundits, Larry Kudlow ("The Kudlow Report") assures us that "we are becoming energy independent." To this euphoria, I would add: this includes coal and natural gas for a few more years, or as long as we can extract our kid's future energy as fast as we can to maximize immediate profits and continue business as usual. Some analysts are even more optimistic. For happier reading try: *The new Era of Oil Renaissance* (commodities-now.com/13445) or, *The New American Oil Boom* (secureenergy.org).

The summary curves shown in Figure 6 are from an excellent, comprehensive, peer-reviewed paper by G. Maggio and G. Cacciola titled: *When Will Oil, Natural Gas, and Coal Peak?* It was published in the International journal, *Fuel*, and can be found on www.sciencedirect or wikipedia. **This paper projects oil extraction to decline fifty-percent, from a 2015 peak of 30 (82 Mb/d), to15 billion barrels per year (41 Mb/d) by 2050.** This about the same decline as the Hubbert prediction shown

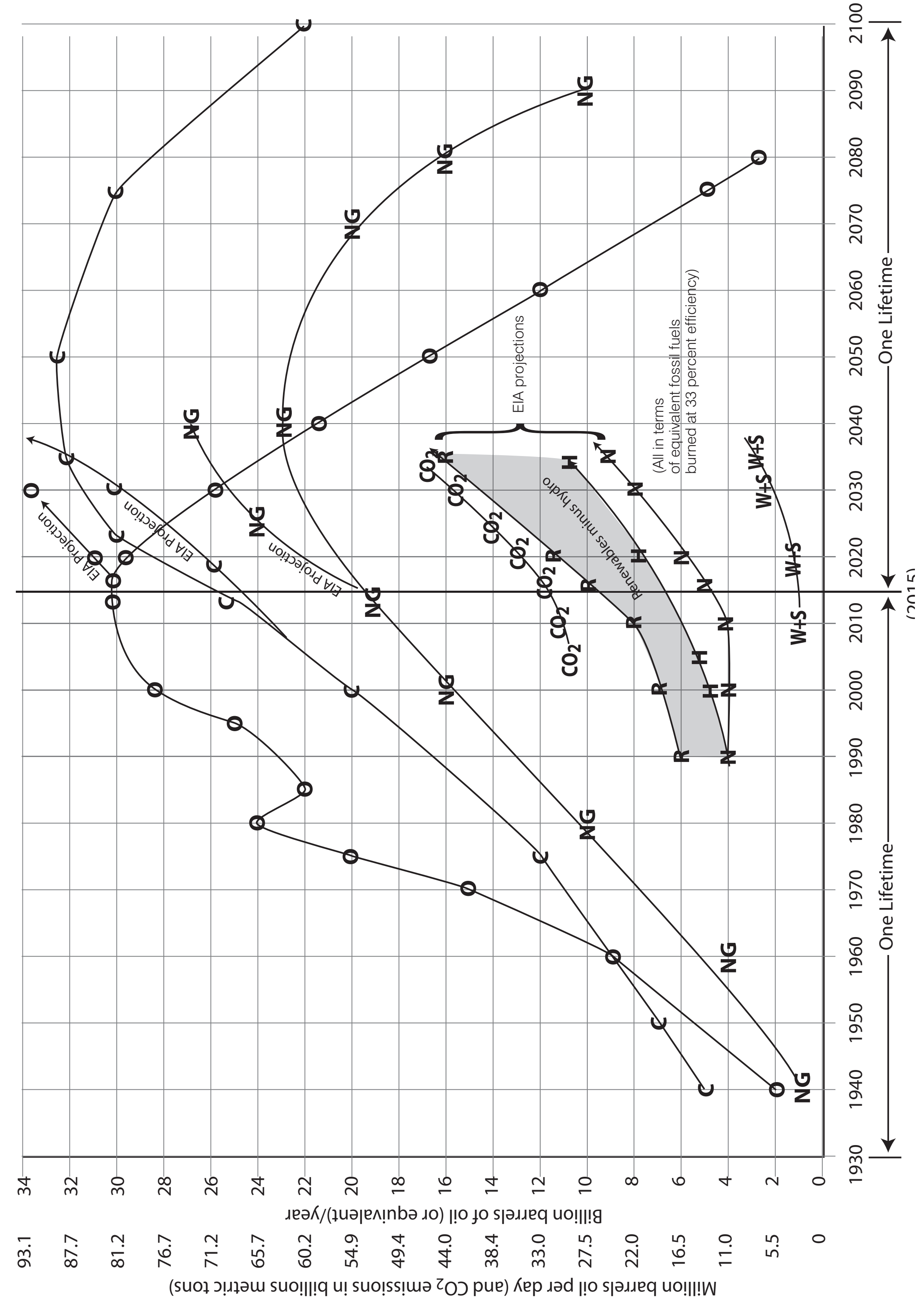

FIGURE 6 When Will Oil, Natural Gas, and Coal Peak?*

* per G. Maggio analysis and EIA projections *(source: World Energy Consumption Outlook)*

by the "H's" in Figures 5 and 7, but with the addition of NGL's. *The Maggio* paper also shows peaking and decline curves for various "ultimate" endowments of all fossil fuels. These are the mid-range reference cases for each fossil fuel.

The initial world-endowment for oil shown in Figure 6 is 2600 billion barrels, just slightly less than my most-optimistic scenario of 2800 billion barrels shown in Figure 5. **The ominous, predicted declines in oil, no matter how optimistic, are blithely ignored as we roll merrily along, pedal to the metal, with steadily increasing numbers of consumers, all looking forward to economic growth, travel, jobs, fuel, and food.** We are comforted by the steady upward trends shown in Figure 6, from the EIA.DOE World Energy Outlook. The optimists are quick to include "yet -to-be-discovered" to make their case.

Global Net Exports (GNE)

We can not leave an update of the oil age without including another very serious, overlooked issue that is not considered in "plateaued" world extraction rates. **There is steadily less net global oil left available for export** from traditional oil-rich countries: like Saudi Arabia, Indonesia, UK, and Venezuela, **after they first satisfy growing internal demand.** As autonomous nations struggle to supply their increasing national oil demands; the overall, world oil export numbers steadily contract, especially so when considered on a per capita basis. The poorly understood phenomenon of GNE underlies and explains much of the political tension and economic distress in the world. For instance, Indonesia was one of the original OPEC countries (and supplied much of Japan's oil in WWII), yet ceased to be an exporter by 2003. The UK pumped out so much of its North Sea endowment during the heady Thatcher era that, after peaking in 1999, it ceased to be an exporter by 2005.

Another excellent example of terminated net exports is Egypt, which recently ceased being an oil-rich exporter in 2010. Two simple exponential curves, one of increasing population, the other of declining oil extraction, quickly intersect. **The results are crowds of unhappy young protesters for whom the oil party just ended. This was the context for the "Arab Spring" and continues to this day throughout much of the world. Geopolitics is nearly always related to oil. Any form of government will be unpopular if it can no longer pacify a growing population with declining energy income.** This is a classic example of "more forks and less pie." Neither a Democracy nor Autocracy can change the numbers and inevitable outcome. Some countries, like the UK, still rich in residual wealth or other resources can weather this growing storm for a while longer, but eventually all must face the decline of oil and an unhappy populace.

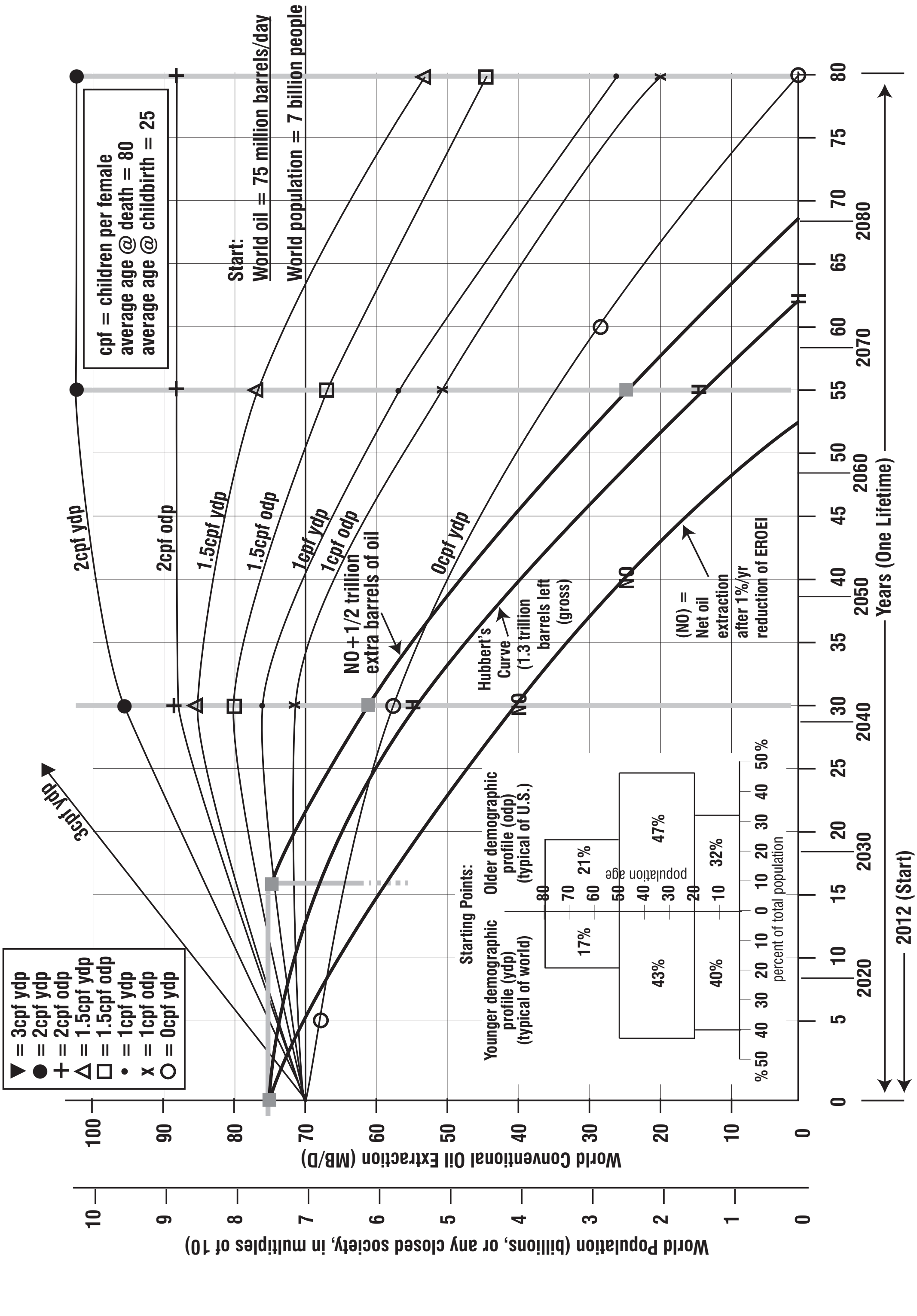

FIGURE 7 World Extraction and Population (beginning in 2012)

A complete explanation of the phenomenon of GNE has been developed by Jeff Brown of ASPO-USA(.org). Using the same methodology that predicted the end of oil exportation for Indonesia, the UK, and Egypt, Jeff projects that "Saudi Arabia will cease to be a net exporter in 2031" (ASPO-USA correspondence 4/11/2012). Coincidentally, this is about the same end of time frame as the IEA and EIA projections to 2035 as shown in Figures 5 and 6. There are no more optimistic projections of an oil age beyond then, one generation from now.

The U.S. has long since ceased being a net exporter of oil. The projected second domestic "oil boom" from an extraction rate of 5, back to 9 Mb/d, even if comes to pass for a few years, will not reach our present (with no concern for increasing population) consumption rate of nineteen million barrels per day.

To summarize, it is inevitable that the ratio of diminishing oil availability for export, to that left to satisfy the increasing demands of importing nations, will rapidly decline as more exporting countries divert their remaining endowment to keep their own people happy. Yet, there are still a few politicians advocating that we export some of our "Saudi America" oil for short term profit, even as we continue to import the difference between our 19 Mb/d consumption and 10 Mb/d extraction.

NATURAL GAS

Natural gas **can never** replace oil as the fundamental finite fuel for modern civilization. Despite rosy statements by "experts" like T. Boone Pickens, **natural gas is not a large-scale transportation fuel.** Consider the basic physics: All forms of motive power (except for dilute, sporadic, wind or direct on-board solar) **require that the energy source (fuel) be stored, and carried along for the ride, until the next refueling opportunity**. Weight, energy-density, and volume of the fuel, or any other on-board energy storage system (like a battery, bale of hay, or back pack of food) are critical. The movement of anything of significant mass, especially a truck or an airplane, requires considerable energy to do the work (force times distance). This is why liquid fossil fuels are used for 90% of motive power and coal is a poor second choice (see Chapter 7, "Gas Rationing" for more discussion). Compressed natural gas (CNG) is minimally used around the world for short-distance cars and trucks; **but this is only possible where the supply and infrastructure are readily available for handling a highly flammable fuel at 3000 psi.** CNG should not be confused with heavier, natural gas liquids (NGL), primarily propane, at 300 psi. Propane is heavier with three carbon atoms, instead of one, per molecule like CNG, and is a most desirable by-product of the current natural gas boom. The recent surge in NGL's is a primary reason for the temporary remission of the oil-age, but at best, propane can add up to seven million barrels per day of additional liquid fuel (about nine percent of world conventional oil extraction). A propane-based transportation system would be highly dangerous and require entirely new infrastructure and vehicles. Airplanes and 18-wheelers would not fit into this paradigm.

Oil, with more than six carbon atoms per molecule, is heavier. It has an energy density at normal atmospheric conditions of about 18,000 btu per pound, and, because it is a room-temperature liquid, one cubic foot (or about eight gallons) has almost one-million btu of convenient energy at atmospheric pressure. The container doesn't even need a super-tight cover. Natural gas (primarily as methane with one carbon per molecule) has only one thousand btu of energy per cubic foot at atmospheric pressure of 14.7 psi. At atmospheric conditions, almost six-thousand cubic feet of natural gas are required to equal the energy in one 42-gallon barrel of liquid hydrocarbon fuel, like gasoline or diesel. If the natural gas is compressed at 3000 psi, or super-cooled to a liquid at –160°C (both require great energy input and extremely complex and dangerous storage), the volumetric energy density of natural gas is increased from 1,000 to about 200,000 btu per cubic foot, **still only about one-fifth the energy density of liquid petroleum fuels.**

Low energy density is why natural gas is called a "stranded" resource. It is limited to low-pressure overland pipeline distribution, or must be cryogenically cooled to a liquified natural gas (LNG) with a very expensive and complex infrastructure for intercontinental shipment.

To convert and transport natural gas as a LNG requires (energy lost) about twenty-five percent of the energy in the gas. As with oil, there are politicians who promote the infrastructure and export of LNG to exploit the three-fold cost difference between surplus "fracked" gas in the U.S. and the price other countries are willing to pay.

Any talk of CNG at 3000 psi for motive power infers short distances, extreme danger, frequent filling with complex equipment, and very heavy, expensive fuel tanks. The only available CNG passenger vehicle is the Honda Civic which has a heavy, chrome-moly fuel tank that requires a substantial part of trunk space, and is rated at eight gallons of gasoline equivalent (GGE). For this inconvenience, the Honda customer is expected to pay a premium of $8,000. A quick Google search will provide copious further information and glowing publicity about CNG vehicles. Instead, try: Bernstein.com, see *"Why we don't see natural gas vehicles putting a dent in gasoline* *demand"* (1/4/13). Despite T. Boone Pickens' glowing prophesies, the time, investment, and energy required for a meaningful transition to a CNG transportation system are far too much to supercede the oil age. Would you take a plane trip on a high-pressure fuel tank with wings?

Another proposed alternative is to chemically convert the "stranded" surplus of natural gas to a liquid fuel called gas to liquid (GTL). Like coal-to-liquids (CTL) described below, the technology has been around for years but is extremely expensive and energy inefficient. **Recently, the Shell corporation spent nineteen billion dollars to build, by far, the world's largest GTL facility in natural gas-rich Qatar.** (Ref.: "Shell's Pearl proves its worth, but it's early days yet for gas-to-liquids," europeanenergyreview.edu/artikel3846). This city-sized operation has a capacity of 250,000 barrels per day, almost equal to all other world-wide GTL pilot plants, and proposals, combined, **and about three percent of present US gasoline consumption**. The investment costs, and intellectual secrets involved, are significant, certainly enough to discourage further enthusiasm.

Nevertheless, the recent excitement over "fracked" natural gas is "fueled" and typified by a August 15, 2012 article in the "Wall Street Journal," *The U.S. Natural Gas Boom Will Transform The World,* and subtitled: *North America's massive resources are going to shift market power away from OPEC and Russia and to consuming nations.* **Then, this feature immediately segues from natural gas to the North Dakota oil Bakken/Three Rivers oil boom presently producing about 600,000 barrels per day of oil, including highly-flammable condensate.** This "boom" presently amounts to about eleven percent of total U.S. oil production, about three percent of U.S. consumption, and less than one percent of world extraction as shown in Figures 3 and 7; hardly enough to "transform the world" or, as stated further in the above reference: "A United States hopelessly dependent on imported oil and natural gas is a thing of the past." Many energy experts now predict that North America will have the capacity to be a net exporter of oil and natural gas by the end of this decade. This is an example of gross disinformation from the media, and certainly enough to confuse and placate the public. Refer back to Figure 2 to see how many years our present lifestyle will last without import or export of oil.

For a more pessimistic example of recent discussions about "Energy Independence", visit the website alternativeinsight.com. In a Q&A session, the host, James Stafford (editor at oilprice.com) asks energy expert, Chris Martenson (author, *The Crash Course*): "Should the U.S. export natural gas?" Answer: "Fossil fuels. They're a one-time gift. You get to extract them and burn them exactly once. That is whatever you choose to do with them is what gets done. They perform work for us. So we really should be focused on what sort of work we want those fossil fuels to do for us. There are, right now, about a dozen proposals to liquify and export US natural gas, and a study just came out this past week, commissioned by the EIA, saying that's a good idea. Wrong, it's a terrible idea. Fully 25% or more of the energy contained within the natural gas is expended just in the process of liquefying it. That's what you get to do with 25% of the units of work. You get to turn the gas into a liquid and nothing else. We should be using every possible unit of work that we extract from the ground contained within that natural gas to do something useful. If it were mine to say, we'd be using that energy to rebuild our nation's crumbling infrastructure; we'd have a 30-year plan for exactly what we want our country to look like and how we're going to use our natural gas to get there. So when the natural gas runs out, and it will someday, we'll at least have a resilient well-built country that can run on alternative energy sources."

To this conversation, I would add: it certainly appears that greed (the "Selfish Gene"), as manifested by short-term profit motive, completely dominates public and political discourse with no consideration whatsoever for what's left for our children. This is exactly the same attitude that entices us to buy the things we want today and put the charges (plus interest) on our credit card. **This system only works when the continued growth of resources can support concurrent, continued economic growth to pay the bills plus interest to investor (banks) who really add nothing of substance.** On a longer term national level, we expect that continued energy-fueled economic growth will allow an increased population to pay back today's increased borrowing. Currently there are over a trillion dollars of student loans, almost a trillion dollars of credit card debt, and nine-hundred billion dollars of auto loans outstanding in a country that is eighteen trillion dollars in debt. Declining energy, beginning with oil does not support this traditional way of thinking. **Trivia fact: a trillion dollars is a seventy-mile-high stack of $1,000 bills.**

How much natural gas is left?

This is another of those difficult questions. When I first ventured into energy activism about ten years ago, the future of natural gas was even more suspect than for oil. There were sporadic shortages (remember Enron?) and wholesale market prices were pushing fifteen dollars per thousand cubic feet (with natural gas, each cubic foot has about one-thousand btu, so one-thousand cubic feet has one-million btu of energy, about the same as nine gallons of gasoline, or one-fifth the energy in a barrel of oil). The U.S. was already importing LNG through four ports. Julian Darley wrote the book, *"High Noon for Natural Gas."*

Then, horizontal hydraulic fracturing ("fracking") completely changed the picture. In the last five years, there has been much euphoria and the resultant glut has kept the price struggling to exceed three dollars per cubic foot. Keep in mind natural gas (like electricity) is very difficult to store and has to be used immediately when produced. There must be a pipeline (like an electrical transmission line) directly connecting the source and user.

With that background, Figure 6 shows the *Maggio* contemporary reference source for natural gas in the same units as oil and coal. Peak world extraction is projected to peak in 2040 at an annual, oil-equivalent rate of twenty-three billion barrels a year. This predicted peak is later than oil but ten years earlier than coal. Any attempt to more accurately predict and ensure the future of natural gas requires a higher price to offset the short life of "fracked" wells where the extraction rate can quickly drop to one-half after the first year. For a recent comprehensive analysis: enews.net/energywire/2013/02/11. **But remember again, (and again!) the peak for all three fossil fuels is well short of one-half the lifetime of a child born today.** At least natural gas is the cleanest fuel and will have less environmental impact. More on that subject as we get into coal.

KING COAL

As with natural gas, our modern-day economy and lifestyle cannot possibly continue, as-is, by shifting energy dependency from oil to coal. True, coal can and has been used as a transportation fuel. In the mid-nineteenth century, easy-mobility as a key feature of the industrial age, began with coal. It was carried on-board and used at very low efficiency of around ten percent, along with lots of water, for high-pressure steam motive power in ships and locomotives. Modern-day consumption of coal is primarily in power plants for the production of electricity, about seventy-percent of China's total energy, and twenty-five percent in the U.S. Our contemporary electrical system can continue beyond the near-future demise of the oil age by using a mix of natural gas, coal, nuclear and hydro. But all except hydro are finite fuels and none can support transportation and agricultural energy requirements without batteries, power wires, or third rails for mass transit. As with natural gas, there is no place for airplanes in this discussion.

Also, coal has always been fundamental to the industrial age as the primary energy input for smelting ore or scrap into every conceivable size and shape of cast iron, steel and other metals. Think of every giant skyscraper as a testament to cheap energy. All modern cities built their skyline, interconnecting rail, and ocean-going infrastructure in the age of coal and steel. But each city also owes just as much to electricity, natural gas, and oil to keep it running.

The technology for converting coal to a liquid fuel (CTL) has been around for years as exemplified by Hitler to fuel his WWII efforts as an alternative to Germany's meager petroleum endowment. Currently, there are still small CTL pilot plants around the world, especially in China; but the conversion efficiency is only about fifty-percent and the pollution is terrible. The CTL alternative could not possibly outweigh the hurdles of time, capital, and energy input required to supercede the oil age. Besides coal, itself, is a finite fuel and extensive conversion to a transportation fuel, including electricity, would only hasten depletion.

How much coal is left?

The optimists infer we have "hundreds of years left." They simply divide seemingly infinite reserves by the present consumption rate. To better answer the question, I will defer to two reports: the world-respected Energy Watch Group (EWG) comprehensive report (final version28032007), and the G. Maggio report: "When will oil natural gas, and coal peak?" shown in Figure 6. Both these reports are in good agreement and show vast reserves of coal with an average oil energy-equivalence of one ton of coal equaling about three and one-half barrels of oil.

About twenty-five percent of the world's coal has been mined to date. The EWG report projects a similar near-term increase in production as Maggio, but with an earlier peak in 2025 due to environmental concerns. **Neither report discusses how much of the remaining reserves can be mined and shipped without oil-energy input as diesel fuel to do the work. Both reports predict a peak and contraction of the coal age in less than the lifetime of a child born today.**

Another contemporary, peer-reviewed paper by T. Patzek and G. Croft is titled by the controversial statement: *World's Peak Coal Moment Has Arrived* (nytimes.com /70121). Clearly, there are hundreds of billions of tons of coal left; and the world, led by China at four-billion tons per year, is presently mining and consuming about seven billion tons per year. This is the equivalent energy of about 24 billion barrels of oil assuming median energy-quality for the different grades of coal.

POLLUTION, CLIMATE CHANGE, AND GLOBAL WARMING

One thing is certain in the coal discussion. Because of its high carbon content **plus all the other pollutants like lead, mercury, sulfur, and arsenic,** a post-oil age dependent on increasing energy proportion from coal will not be a healthy place.

We are quickly moving toward a run-away, 450 ppm CO_2 climate, well past the idealistic limit of 350 ppm**. Clearly, after the end of our two-lifetime oil party, the environmental hazards of attempting a coal-age sequel will most-certainly change life as we knew it.** Any talk of carbon sequestration is just that ... talk. It's not being done, anywhere. The Chinese are building a new coal-fired plant every week and donning gas masks in Beijing. It's difficult to get excited about any type of "going green" efforts for a sustainable future when coal-fired utilities totally dominate the steady deterioration of our environment. There are myriad new books that delve deeply into environmental issues. One broad summary of related essays is, *Fleeing Vesuvius, Overcoming the Risks of Economic and Environmental Collapse* (new society Publishers, 2011). Unfortunately, even in this book, the ever-present backdrop of continued population growth is absent.

As a footnote, Britain was totally dependent on coal at the turn of the twentieth century just after Stanley Jevons correctly warned that increased efficiency would only lead to even greater consumption and hasten depletion (Jevon's Paradox). This is when the steam engine-powered pump ushered in the industrial age and allowed miners to dig deeper for the remaining coal. Fortunately, the oil age rescued England from "peak coal" and terrible London smog just as the UK supply peaked at about the time of WWI.

Figure 6 also shows the EIA predicted growth of CO_2 emissions that are coincident with their projected fossil fuel increases through 2035. **The world's total CO_2 projected increase is forty percent from 31,305 million metric tons in 2010 to 43,220 million metric tons in 2035.** There is an extremely vociferous counter movement that still argues that greenhouse gasses are not a problem, nor is global warming a modern phenomenon or anthropogenic (caused by man). I can't understand why so many want to debunk what is claimed to be the most serious problem facing humankind. If you want to jump into the middle of this cat-fight, just contrast www.350.org with www.icecap.us, or www.wattsupwiththat.com. If that's not enough, listen to the Rob Hopkins interview with Michael Mann (*The Hockey Stick Wars,* www.transitionculture.org).

The EIA and DOE have a very disturbing pattern of predicting growth of everything, including CO_2 emissions, until 2035 and then leaving us hanging with no concern whatsoever of "what next." Spend some time on eia.gov until you are buried in statistics, projections, and dissimilar units of energy with seemingly no concern for the overall concept of "finite" resources or the future after 2035. See additional EIA discussion on p. 51, "EIA Dreamland." On the contrary, the DOD is very concerned about the future of its navy in light of peak oil, climate change, an open arctic, and rising ocean level. Read: "Full Green Ahead," *Mother Jones*, March-April, 2013.

Another recent, very disturbing and directly-related (to climate change) report can be found on AMEG.me. This analysis of the rapid decline of arctic sea ice is the work of the Arctic Methane Emergency Group and was just released in December, 2012. To quote the group's chairman, John Nissen, "It's all about the arctic sea ice … Abrupt climate change is upon us … Food prices will go through the roof … complete summer collapse is expected by 2015 …putting us in a state of planetary emergency today." This is another example of ubiquitous environmentalism. If those liberal, "enviros," "tree-hugging-greenies," whatever; would just give free-market capitalism a free rein, all will be ok. We can live life to the fullest today including continued growth and prosperity with no consideration for the quadruple crises: energy, population, ecological devastation, and economic collapse staring us in the face. See: robbwiller.org, *"The Moral Roots of Environmental Attitudes."* I have long been of the opinion that energy, specifically peak oil, will be the most urgent and critical of the four, but obviously, all are inextricably combined and must be considered together, **especially since 2012 was the hottest year on record until superceded by 2014. Again, as admonished throughout my humble effort, nothing at all will happen unless you help make it happen! Please get involved. Reread Chapter 3.** Back to the energy update:

FINITE NUCLEAR

Uranium, as used for nuclear fission, provides about thirteen percent of world electricity, and six percent of total energy, but it is also a finite fuel. A quick "Google-U" search shows a third peak of extraction rate at 120,000 metric tons (2200 pounds) expected about 2050. This compares to a current consumption rate of 70,000 metric tons with fifty-percent of the ore coming from Australia and Kazakhstan. There seems to be plenty left, and there are many optimistic theories for improved reactors, alternative radioactive fuels, and "unlimited" reserves at lower concentrations. There is a wide disparity in use of nuclear power among nations. France relies on nuclear for seventy-eight percent of its electricity, the U.S. only twenty-percent. The total contribution of nuclear power for energy is shown in line "N" Figure 6 in terms of equivalent billions of barrels of oil per year. In addition, the catastrophic accidents of Chernobyl and Fukushima along with the threat of terrorism and monumental start-up costs have soured public acceptance for nuclear as a major electrical-energy source. A recent study predicts unprecedented disaster for all of western Europe if there is a nuclear plant blow-up in France (see: www.eurosafe-forum.org).

All of the above considered, it is doubtful if nuclear will ever exceed its present world-wide energy contribution of six percent. But, like natural gas, nuclear, including liquid fluoride thorium reactors (LFTR), and hydro could help as a bridge, "base-load" energy source in a sporadic wind and solar-electric future. This is significant because it will take a long time and considerable capital for an energy-transition to wean ourselves off fossil fuels, cope with climate change; and most importantly, reverse population growth with a proportionate need for food.

EIA DREAMLAND

Also shown in Figure 6 are recent energy forecasts by the U.S. Energy Information Administration (EIA) World energy consumption profile (Wikipedia.org/world-energy-consumption-outlook, August, 2012, and EIA.gov/international energy outlook). The four projections show continued linear growth, from 2012 to 2035, for all four finite-fuel energy sources (including "yet to be discovered").

This same statistical wing of the U.S. DOE predicted flat-lined, short-term retail prices for all three fossil fuels plus nuclear electricity. For instance, retail gasoline was projected in 2012 to drift downward to $3.34/gallon by July, 2014. Now, in hindsight, we see that gasoline climbed back to the $4.00 gallon range in February 2013, and then plummeted to below $2.00 by January 2015. Apparently, the EIA thinking is that steadily increasing oil availability and continued world recession will combine to stabilize prices even in the face of growing population and high-energy lifestyles. In the commodity markets, basic underlying movements of supply and demand can be rapidly magnified by speculation and the physical limits of storage of the commodity itself.

To reemphasize a basic theme of this book, and as shown in Figure 1, the American motoring public is, by far, the dominant customer bloc for oil. As Americans steadily, and inequitably, go broke, the market price for oil and gasoline is dragged down ("demand destruction") to the delicate balance-overlap (if any) between declining, remaining wealth available to buy, and the diminishing number of suppliers (including U.S. and non-conventional) ready and able to produce at the reduced market price level.

CONCLUSION

To end this brief overview of finite energies, one thing remains evident: All finite sources will surely peak, and significantly decline, in the next one-half lifetime of a child born today. Renewables cannot possibly climb to higher than

ten percent of oil alone and certainly not to ten-percent of all today's energy. What then? It appears certain, and typical of human nature, that short-term greed will trump long-term planning**. Oil is the most important fuel as it is fundamental for ninety percent of modern transportation, nearly all of agriculture, and the support of the production of all other energy sources.** Meanwhile, population just keeps on growing. The reversion to dependency on coal as a critical pillar of our future is unnerving. Emissions and climate change will continue to increase, meaning even less food for increasing numbers. As with past failed societies, weather will be blamed for the crash rather than population which always increased when times were good. The cleaner energy sources like natural gas and nuclear can help maintain an electrical-powered world, but neither can offset the demise of oil for travel, construction, transportation, and large-scale-agriculture (see Appendix A).

Also, it is important to remember that the end of the fossil fuel age will also be the end of thousands of other products we take for granted, use daily, and are completely dependent on for hydrocarbon feed stocks. The end of the age of travel will also be the end of the age of plastic. There is nothing we can do about this. A tiny bit of bio fuels, bio lubricants, and bio plastics will only compete with precious food, especially without inexpensive energy input from oil. This composite of dire reality could be partially, and immediately, mitigated by equitable coupon-rationing of gasoline, our most-wasted fuel. Does Chapter 7 now make more sense?

RENEWABLE ENERGY SOURCES

Beyond the ephemeral age of finite energy sources, which presently supply over ninety-percent of the world's total energy, renewables, specifically solar, wind, hydropower and biofuels are our only hope for a future with any semblance to the life-style we take for granted today. **Finite sources** (except for nuclear) represent stored energy from eons of ancient sunlight. **The renewable sources are severely limited because, instead of millions of years of accumulation and convenient storage, they are dependent on current dilute and sporadic solar energy.** All renewable energy sources are shown as line "R" in Figure 6. Other sources of energy like tidal flow from the gravitation of the moon, and geo-thermal heat from deep in the earth, although renewable, are so limited as to be non-issues. Before the industrial (fossil fuel) age, renewable energies supported all living species. Growth was limited by current solar input and minimal storage capacity like a dam for hydro power or a tree for bio fuels.

Hydro power

Thermal energy from the sun transports water vapor from the oceans to higher, colder regions. There it condenses, collects, and flows downhill thus converting potential energy collected and stored in dams, into kinetic energy to turn water wheels or turbines. Simple enough, but limited by the height, area, and topography of land surface required for collection before it flows back to the oceans or evaporates on route. Except for still-undeveloped potential in a few remaining mountainous areas, these constraints plus massive capital investment and regional disruption like the Three Gorges dam in China, limit hydro power to its present contribution of about seven percent of the world's energy. Also, it is only a source of electricity. It's an excellent electrical energy source for mass transportation only in developed mountainous regions like the Alps or Scandinavia.

Hydro power, as potential energy stored in a dam, resolves the energy storage problem and is excellent for backing-up intermittent wind or solar. Pumped storage uses temporary excess power to pump water uphill to a storage reservoir. This stored energy could also be used as needed to meet intermittent demand. Pumped storage can be very efficient and, on a regional basis, is one of the best ways to balance varying inputs and demands.

But, water flow is also impacted by climate change, which has further reduced hydro's contribution to America's energy mix in the last decades. Back in the 1930s, hydropower was the largest source of electricity in the U.S. Now it is a minor player at about fifteen percent of electricity and has been relatively flat since the mid-1990s because the best sites are in use, and water flow is declining.

Renewable bio fuels, wind, and solar

As shown in the table at the beginning of this chapter and Figure 6, **all renewable fuels minus hydro contribute not more than three and one-half percent of total world energy**. This is the equivalent energy of three billion barrels of oil per year. As shown at the very bottom of Figure 6, wind and solar (W+S) together contribute less than one-percent of the world's energy today. This leaves less than three-percent from renewable bio fuels some of which, like ethanol and bio diesel, are also included as a small percentage of all-liquid fuels. Also included in the "everything else" category are laboratory or pilot-plant scale (and very poor EROEI) energy sources like algae, tidal power, and cellulosic ethanol, which do nothing but mislead and divert public attention from the imminent crisis of finite oil.

Traditional biofuels, like wood, would not even come close to keeping today's population warm, especially with diminishing liquid fuel energy-input for harvest and delivery. Also, dependency on biofuels in any form must always respect the regrowth time for sustainable harvest and return of nutrients to their source. Otherwise, it's Easter Island all over again**. All non-renewable energy sources together, including hydro power, can never exceed more than ten percent of today's world energy consumption.** They are only different forms of daily solar energy with the same limitations of dilute sporadic solar input, poor EROEI, and difficult storage.

But, we might ask, how did colonial Americans survive and proliferate with only an axe and a horse or ox? They even had time to clear the forests, have ten kids, and build the stone walls like those that surround our beautiful old farm in Maine. (The "three-holer" in the barn, hand water pump, horse-powered hay-wagon unloader, and spring water system are still here.) The best answer for their success is that early farmers, although quickly increasing in numbers, were still well below the carrying capacity of their prolific, immediate surroundings. The sparsely-settled country was teeming with fish and game. **Very hard work cleared the fertile land. Farms were built with two and four-legged muscle power.** Life was hard and short (for many). It is my dream that we, as a nation, could gradually return to a similar sustainable life style along with a stabilized, dependable climate; but with far fewer people than we have today. Adding to my limited optimism is the opportunity we have to benefit from a modern electrified lifestyle as described in Chapter 5.

NON-ENERGY, NON-RENEWABLE RESOURCES

Starting back in the iron and copper ages and progressing forward from spear heads and plows to windmills and guns, **it is obvious that the progress of humanity was completely dependent on finite metal resources.** With only wood and charcoal, and no fossil fuels for mining, smelting, and fabrication, there probably would have been enough metal ores to last for thousands of years. Now, however, every non-fuel, under-the-ground, finite resource is being rapidly depleted and the reserves of some are more critical than oil. **It may well be that no advanced civilization can exist very long on a finite planet because all finite (by definition) non-renewable resources will eventually be depleted.** Exactly like finite fuels, the competition between growing population and diminishing non-fuel finite resources is first economically defined (price), and then usually becomes belligerent as scarcity separates the wealthy from the masses. The best book about all non-renewable resources is Chris Clugsten's *Scarcity, Humanity's Final Chapter* (see Chapter 11 for review).