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I

A Civilization in Trouble

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Deteriorating Oil and Food Security

The twentieth century was the oil century. In 1900, the world produced 150 million barrels of oil. In 2000, it produced 28 billion barrels, an increase of more than 180-fold. This was the century in which oil overtook coal to become the world's leading source of energy.[1]

The fast-growing supply of cheap oil led to an explosive worldwide growth in food production, population, urbanization, and human mobility. In 1900, only 13 percent of us lived in cities. Today half of us do. The world grain harvest quadrupled during the last century. Human mobility exploded as trains, cars, and planes began moving people at a pace and over distances scarcely imaginable when the century began.[2]

Today, we are an oil-based civilization, one that is totally dependent on a resource whose production will soon be falling. Since 1981, the quantity of oil extracted has exceeded new discoveries by an ever-widening margin. In 2006, the world pumped 31 billion barrels of oil but discovered fewer than 9 billion barrels of new oil. World reserves of conventional oil are in a free fall, dropping every year.[3]

Discoveries of conventional oil total roughly 2 trillion barrels, of which 1 trillion have been extracted so far, with another trillion barrels to go. By themselves, however, these numbers miss a central point. As Michael Klare notes, the first trillion barrels was easy oil, "oil that's found on shore or near to shore; oil close to the surface and concentrated in large reservoirs; oil produced in friendly, safe, and welcoming places." The other half, Klare notes, is tough oil, "oil that's buried far offshore or deep underground; oil scattered in small, hard-to-find reservoirs; oil that must be obtained from unfriendly, politically dangerous, or hazardous places."[4]

At some point in the not-so-distant future, world oil production will peak and turn downward. When it does so, it will be a seismic event. The only world we have known is one where oil production is rising. In this new world, where oil production is no longer expanding, one country can get more oil only if another gets less.

We are witnessing a fundamental shift in the relationship between oil and food, one that has been in the making for several decades. From 1950 to 1972, a bushel of wheat could be traded for a barrel of oil on the world market. The price of each during that period was remarkably stable, averaging just under $2 per bushel of wheat and per barrel of oil. Since then, oil prices have climbed. In late 2007, even with the recent run-up in wheat prices, it took eight bushels of wheat to buy one barrel of oil.[5]

Agricultural analysts have long been concerned about the effect of the coming rise in oil prices on food production costs, but now the price gap is so wide that the United States is starting to convert grain into fuel for cars. When the price of oil rises above $60 a barrel, it becomes highly profitable to do this. An estimated 16 percent of the U.S. grain harvest was converted into automotive fuel in 2006. For the 2008 harvest, the figure could be close to 30 percent.[6]

The line between the food and energy economies is becoming blurred as the two begin to merge. As a result, the world price of grain is now moving up toward its oil price equivalent. If the food value of a commodity is less than its fuel value, the market will move it into the energy economy.

The Coming Decline of Oil

When the price of oil climbed above $50 a barrel in late 2004, public attention began to focus on the adequacy of world oil supplies—and specifically on when production would peak and begin to decline. There was no consensus on this issue, but several prominent analysts now believe that the oil peak is imminent.[7]

Various approaches are used to analyze the oil prospect. Oil companies, oil consulting firms, and national governments rely heavily on computer models to project future oil production and prices. As with any such model, the results vary widely, depending on the quality of data and the assumptions fed into them.

Another approach uses the reserves/production relationship to gain a sense of future production trends. This was pioneered in 1956 by the legendary M. King Hubbert, a geologist with Shell Oil and later with the U.S. Geological Survey. Given the nature of oil production, Hubbert theorized that the time lag between the peaking of new discoveries and production was predictable. Noting that the discovery of new reserves in the United States had peaked around 1930, he predicted that U.S. oil production would peak in 1970. He hit it right on the head. As a result of this example and other more recent country experiences, his basic model is now used by many oil analysts.[8]

A third approach separates the world's principal oil-producing countries into three groups: those where production is falling, those where production is still rising, and those that appear to be on the verge of a downturn. Of the leading oil producers, output appears to have peaked in a dozen or so and to still be clearly rising in nine.[9]

Among the post-peak countries are the United States, which peaked at 9.6 million barrels a day in 1970, dropping to 5.1 million barrels a day in 2006, a decline of 47 percent; Venezuela, where production also peaked in 1970; and the two North Sea oil producers, the United Kingdom and Norway, where production peaked in 1999 and 2000, respectively.[10]

The pre-peak countries are dominated by Russia, now the world's biggest oil producer, having eclipsed Saudi Arabia in 2006. Other countries with substantial potential for increasing production are Canada, largely because of its tar sands, and

Kazakhstan, which is developing the large Kashagan oil field in the Caspian Sea. The other pre-peak countries are Algeria, Angola, Brazil, Nigeria, Qatar, and the United Arab Emirates. Libya, which is now producing 1.7 million barrels a day, plans to double its output to over 3 million barrels a day, close to the 3.3 million it produced in 1970.[11]

The next group are countries that appear to be nearing a period of production decline, including Saudi Arabia, Mexico, and China. The biggest question mark among the major oil producers is Saudi Arabia. Saudi officials claim that the country can produce far more oil. But the Ghawar oil field that has supplied half of Saudi oil output is 50 years old and is believed by many analysts to be in its declining years. With the crown jewel of world oil fields and other older Saudi fields largely depleted, it remains to be seen whether pumping from new fields will be sufficient to more than offset the loss from the old ones. Somewhat ominously, Saudi oil production data for the first eight months of 2007 show output of 8.37 million barrels per day, a 6-percent drop from the 8.93 million barrels per day of 2006. If Saudi Arabia does not move much above its current level, which I suspect may be the case, then peak oil is on our doorstep.[12]

In Mexico, the second-ranking supplier of oil to the United States after Canada, production apparently peaked in 2004 at 3.4 million barrels per day. Geologist Walter Youngquist notes that Cantarell, the country's dominant oil field, is now in steep decline, and this could make Mexico an oil importer by 2015. China, producing slightly more than Mexico, may also be approaching its peak year. The question is, will production actually increase enough in the pre-peak countries to offset the declines under way in the post-peak countries?[13]

Another clue to the oil production prospect is the actions of the major oil companies themselves. Although oil prices have risen well above $50 a barrel, there have not been any dramatic increases in exploration and development. This suggests that the companies agree with the petroleum geologists who say that 95 percent of all the oil in the world has already been discovered. "The whole world has now been seismically searched and picked over," says independent geologist Colin Campbell. "Geological knowledge has improved enormously in the past 30 years and it is almost inconceivable now that major fields

remain to be found." The bottom line is that the oil reserves of major companies are shrinking yearly.[14]

Sadad al-Husseini, former head of exploration and production at Aramco, the Saudi national oil company, pointed out in an interview that new oil output coming online had to be sufficient to cover both estimated annual growth in world demand of 2 million barrels a day and the annual decline in production from older fields of over 4 million barrels a day. "That's like a whole new Saudi Arabia every couple of years," Husseini said. "It's not sustainable."[15]

The geological evidence suggests that world oil production will be peaking sooner rather than later. Matt Simmons, a prominent oil investment banker, says in reference to new oil fields: "We've run out of good projects. This is not a money issue...if these oil companies had fantastic projects, they'd be out there [developing new fields]." Kenneth Deffeyes, a highly respected geologist and former oil industry employee now at Princeton University, said in his 2005 book, *Beyond Oil*, "It is my opinion that the peak will occur in late 2005 or in the first few months of 2006." Walter Youngquist and A.M. Samsam Bakhtiari of the Iranian National Oil Company both projected that oil would peak in 2007.[16]

It is quite possible that Deffeyes, Youngquist, and Bakhtiari are close to the mark. The International Energy Agency (IEA) reports that world oil production in 2005 of 84.39 million barrels per day rose to 85.01 million barrels per day in 2006. For the first nine months in 2007 output averaged 84.75 million barrels per day, slightly less than in 2006. Whether output in the last three months of the year will rise enough to take the annual output above the 2006 level remains to be seen as of this writing. Whether it does or not, there is a clear loss of momentum in production growth that, in the face of rising oil demand, will almost certainly translate into higher oil prices in the near term.[17]

Yet another way of assessing the oil prospect is simply to look at the age of the major oil fields. Of the top 20 fields ever discovered in terms of oil reserves, 18 were discovered between 1917 (Bolivar in Venezuela) and 1968 (Shaybah in Saudi Arabia). The 2 more recent discoveries, Cantarell in Mexico and East Baghdad Field in Iraq, were discovered during the 1970s, but none have come since then. Even Kashagan, the only large find in recent decades, misses making the all-time top 20. With so many of the largest oil fields aging and in decline, offsetting this with new discoveries or stepped-up production at existing fields using more advanced extraction technologies will become increasingly difficult.[18]

If 2006 does turn out to be the historical peak in world oil production, and if the output trend follows a bell-shaped curve, one where the shape of the curve on the ascending and descending sides is more or less symmetrical (as with the classic Hubbert's Peak curve), then we can use the recent historical trend to estimate the likely future trend. In recent decades, politics and prices influenced oil production levels, but we may now be moving into an era of aging oil fields where geology will largely determine production trends.

Based on this, to project oil production from the peak year 2006 to 2020 we simply go back 14 years, to 1992. Output that year averaged 67 million barrels per day. It then climbed to 85 million barrels per day in 2006, an increase of 18 million barrels per day. If the production decline is symmetrical, then output per day in 2020 would again be 67 million barrels, a drop of 21 percent. Assuming a 1.1 percent annual rate of world population growth from 2006 to 2020, for a total growth of 16 percent, oil supply per person would drop by a staggering 32 percent in just 14 years. In stark contrast to this projection of 67 million barrels per day in 2020, based on the Hubbert's Peak curve, the IEA is projecting world oil output in 2020 at 106 million barrels per day.[19]

If production did peak in 2006 and if future production does follow the Hubbert curve, what are the options? One is to look for oil in even more remote places. Some of the estimated 5 percent of conventional oil not yet discovered may be in the Arctic. With the prospect of an ice-free Arctic Ocean within a few decades, countries bordering the Arctic are beginning to think about oil exploration within the region. Looking for oil in the polar region will raise scores of geopolitical issues, including who controls what parts of the Arctic and what environmental regulations should cover the development of any oil discovered there.

Aside from conventional petroleum, which can easily be

pumped to the surface, vast amounts of oil are stored in tar sands and can be produced from oil shale. The Athabasca tar sand deposits in Alberta, Canada, may total 1.8 trillion barrels. Only about 300 billion barrels of this may be recoverable, however. Venezuela also has a large deposit of extra heavy oil, estimated at 1.2 trillion barrels. Perhaps a third of it can be readily recovered.[20]

Oil shale concentrated in Colorado, Wyoming, and Utah in the United States holds large quantities of kerogen, an organic material that can be converted into oil and gas. In the late 1970s the United States launched a major effort to develop the oil shale on the western slope of the Rocky Mountains in Colorado. When oil prices dropped in 1982, the oil shale industry collapsed. Exxon quickly pulled out of its $5-billion Colorado project, and the remaining companies soon followed suit. Since extracting oil from shale requires several barrels of water for each barrel of oil produced, water scarcity may limit its revival.[21]

The one project that is moving ahead is the tar sands project in Canada's Alberta Province. Launched in the early 1980s, it is now producing 1.4 million barrels of oil a day, enough to meet nearly 7 percent of current U.S. oil needs. This tar sand oil is not cheap, however, and it wreaks environmental havoc on a vast scale.[22]

Producing oil from tar sands is highly carbon-intensive. Heating and extracting the oil from the sands relies on the extensive use of natural gas, production of which has already peaked in North America. As peak oil analyst Richard Heinberg notes, "Currently, two tons of sand must be mined in order to yield one barrel of oil." The net energy yield is low. Walter Youngquist notes, "It takes the equivalent of two out of each three barrels of oil recovered to pay for all the energy and other costs involved in getting the oil from the oil sands."[23]

Thus although these reserves of oil in tar sands and shale may be vast, gearing up for production is a costly, climate-disrupting, time-consuming process. At best, the development of tar sands and oil shale is likely only to slow the coming decline in world oil production.[24]

One of the influences on oil production in the years immediately ahead that is most difficult to measure is the emergence of what I call a "depletion psychology." Once oil companies or oil-exporting countries realize that output is about to peak, they will begin to think seriously about how to stretch out their remaining reserves. As it becomes clear that even a moderate cut in production can double world oil prices, the long-term value of their oil will become much clearer.

The Oil Intensity of Food

Modern agriculture depends heavily on the use of fossil fuels. Most tractors use gasoline or diesel fuel. Irrigation pumps use diesel fuel, natural gas, or coal-fired electricity. Fertilizer production is also energy-intensive. Natural gas is used to synthesize the basic ammonia building block in nitrogen fertilizers. The mining, manufacture, and international transport of phosphates and potash all depend on oil.[25]

Efficiency gains can help reduce agriculture's dependence on oil. In the United States, the combined direct use of gasoline and diesel fuel in farming fell from its historical high of 7.7 billion gallons (29.1 billion liters) in 1973 to 4.2 billion in 2005—a decline of 45 percent. Broadly calculated, the gallons of fuel used per ton of grain produced dropped from 33 in 1973 to 12 in 2005, an impressive decrease of 64 percent.[26]

One reason for this achievement was a shift to minimum- and no-till cultural practices on roughly two fifths of U.S. cropland. But while U.S. agricultural fuel use has been declining, in many developing countries it is rising as the shift from draft animals to tractors continues. A generation ago, for example, cropland in China was tilled largely by draft animals. Today much of the plowing is done with tractors.[27]

Fertilizer accounts for 20 percent of U.S. farm energy use. Worldwide, the figure may be slightly higher. As the world urbanizes, the demand for fertilizer climbs. As people migrate from rural areas to cities, it becomes more difficult to recycle the nutrients in human waste back into the soil, requiring the use of more fertilizer. Beyond this, the growing international food trade can separate producer and consumer by thousands of miles, further disrupting the nutrient cycle. The United States, for example, exports some 80 million tons of grain per year—grain that contains large quantities of basic plant nutrients: nitrogen, phosphorus, and potassium. The ongoing export of

these nutrients would slowly drain the inherent fertility from U.S. cropland if the nutrients were not replaced.[28]

Irrigation, another major energy claimant, is requiring more energy worldwide as water tables fall. In the United States, close to 19 percent of farm energy use is for pumping water. And in some states in India where water tables are falling, over half of all electricity is used to pump water from wells. Some trends, such as the shift to no-tillage, are making agriculture less oil-intensive, but rising fertilizer use, the spread of farm mechanization, and falling water tables are having the opposite effect.[29]

Although attention commonly focuses on energy use on the farm, agriculture accounts for only one fifth of the energy used in the U.S. food system. Transport, processing, packaging, marketing, and kitchen preparation of food are responsible for the rest. The U.S. food economy uses as much energy as the entire economy of the United Kingdom.[30]

The 14 percent of energy used in the food system to move goods from farmer to consumer is equal to two thirds of the energy used to produce the food. And an estimated 16 percent of food system energy use is devoted to canning, freezing, and drying food—everything from frozen orange juice concentrate to canned peas.[31]

Food staples such as wheat have traditionally moved over long distances by ship, traveling from the United States to Europe, for example. What is new is the shipment of fresh fruits and vegetables over vast distances by air. Few economic activities are more energy-intensive.[32]

Food miles—the distance that food travels from producer to consumer—have risen with cheap oil. At my local supermarket in downtown Washington, D.C., the fresh grapes in winter typically come by plane from Chile, traveling almost 5,000 miles. One of the most routine long-distance movements of fresh produce is from California to the heavily populated U.S. East Coast. Most of this produce moves by refrigerated trucks. In assessing the future of long-distance produce transport, one writer observed that the days of the 3,000-mile Caesar salad may be numbered.[33]

Packaging is also surprisingly energy-intensive, accounting for 7 percent of food system energy use. It is not uncommon for the energy invested in packaging to exceed that in the food it contains.[34]

The U.S. farmer gets about 20 percent of the consumer food dollar. And for some products, the figure is much lower. As one analyst has observed, "An empty cereal box delivered to the grocery store would cost about the same as a full one."[35]

The most energy-intensive segment of the food chain is the kitchen. Much more energy is used to refrigerate and prepare food in the home than is used to produce it in the first place. The big energy user in the food system is the kitchen refrigerator, not the farm tractor. While oil dominates the production end of the food system, electricity dominates the consumption end. With higher energy prices, the modern food system that evolved when oil was cheap will not survive as it is now structured.[36]

The Changing Food Prospect

The world grain harvest has more than tripled since 1950, climbing from 630 million to 2 billion tons. The most rapid growth came between 1950 and 1973, when the grain harvest doubled. In 23 years, farmers expanded the grain harvest by as much as during the 11,000 preceding years, from the beginning of agriculture until 1950.[37]

The mid-twentieth century marked an abrupt transition point in world agriculture as the frontiers of agricultural settlement largely disappeared. Prior to then, increases in the harvest came largely from expanding the cropped area, as farmers moved from valley to valley and eventually from continent to continent. Yield increases were typically so slow as to be imperceptible within a human life span. In contrast, since 1950 four fifths of the world grain harvest growth has come from raising land productivity, with much of the rise dependent on oil.[38]

Between 1950 and 1990, the systematic application of science to agriculture helped raise grain yields from less than 1.1 tons per hectare to close to 2.5 tons. Grainland productivity worldwide increased 2.1 percent a year. Since 1990, however, the rise has slowed to 1.2 percent a year. By 1990, most of the easy steps to raise grain yields had already been taken.[39]

The growth in land productivity since 1950 was driven by three trends: a near-tripling of the world irrigated area, a 10-fold growth in world fertilizer use, and the rapid dissemination of

high-yielding varieties that centered on hybrid corn in the United States and the high-yielding dwarf wheats and rices in Asia.[40]

While world grain production has expanded continuously, it has slowed in recent decades, falling below the growth in world population after 1984. As a result, grain production per person peaked in 1984 at 342 kilograms, dropping to 302 kilograms in 2006. A 12-percent drop in the grain harvested per person could be expected to lead to a dramatic increase in world hunger, but it did not. The number of hungry people in the world, which was greatly reduced from 1950 to 1984, continued to decline until the late 1990s before turning upward.[41]

The fall in grain production per person did not automatically translate into more hunger because of the enormous growth in the world soybean harvest—from 68 million tons in 1984 to 222 million tons in 2007. The growing use of soybean meal, the high-protein meal left after the oil is extracted, as a supplement to grain in livestock, poultry, and fish rations both substituted for some of the grain used for feed and greatly increased the efficiency with which the grain itself was converted into animal protein. Feed rations containing roughly four fifths grain and one fifth soybean meal are now standard fare in livestock, poultry, and fish feeding. This allowed the global diet to improve even as the grain supply per person was declining.[42]

Originally domesticated by farmers in central China some 5,000 years ago, the soybean now occupies a dominant position in world agriculture. The growth in soybean production has been meteoric. In both Brazil and Argentina, soybean production took off after 1980. By 2005 the soybean harvest in each country was rivaling or exceeding the grain harvest. By 1990, more U.S. land was planted to soybeans than to wheat.[43]

In the end, however, the world food prospect depends heavily on the expansion of the "big three" grains—wheat, rice, and corn. In seven of the last eight years, world grain production has fallen short of consumption, dropping world carryover stocks of grain to their lowest level in 34 years. The world's farmers—already struggling to expand fast enough to feed 70 million more people each year and to allow billions of low-income consumers to move up the food chain—are now being further challenged by the exploding demand for grain to produce fuel ethanol for cars.[44]

Farmers are facing new constraints as they attempt to meet record growth in the demand for grain. While the irrigated area was growing throughout the last half-century, supplies of irrigation water in this new century are beginning to shrink in some countries as wells go dry and scarce water is diverted to cities. And for the first time, harvests in large countries like China are being reduced by water shortages. This is most evident with wheat, produced mainly in the more arid northern half of China, where water tables are falling and wells are going dry. China's wheat harvest peaked in 1997 at 123 million tons and has now dropped to scarcely 100 million tons, a fall of nearly 20 percent.[45]

The wildcard in the food prospect is climate change. Crop ecologists estimate that for each 1-degree-Celsius rise in temperature above the norm during the growing season, we can expect a 10-percent decline in grain yields. With higher global temperatures, we can expect more extreme weather events, including more-destructive floods and more-intense droughts.[46]

Putting further pressure on farmers is the conversion of cropland to nonfarm uses. This is gaining momentum in many parts of the world, particularly in countries with urban sprawl, such as the United States, and in densely populated, rapidly industrializing countries like China. From the central valley of California to the Yangtze River basin in China, construction of homes, factories, roads, highways, and parking lots is devouring some of the world's most productive farmland.

Cars and People Compete for Crops

For most of the 25 years after 1978, when the crop-based fuel ethanol program was launched in the United States, investment in distilleries was modest, trickling along well below the radar screen. Then oil prices jumped above $60 a barrel in 2005, pushing U.S. gasoline prices to over $3 a gallon. Suddenly investments in corn-based distilleries became hugely profitable, unleashing an investment frenzy. Investment in U.S. ethanol distilleries, once dependent on the ethanol subsidy of 51¢ per gallon, was now driven primarily by surging oil prices. By mid-2007 the capacity of plants under construction slightly exceeded that of all plants built since the crop-based fuel ethanol program began. Stated otherwise, when these plants are completed, the grain used in ethanol production will double.[47]

The United States eclipsed Brazil as the world's leading ethanol producer in 2005. While Brazil uses sugarcane as the feedstock, U.S. distillers use grain—mostly corn. The estimated 81 million tons of the 2007 U.S. corn harvest used to produce 8.3 billion gallons of ethanol represents one fifth of the country's entire grain harvest, but it will supply less than 4 percent of its automotive fuel.[48]

Brazil, the world's largest sugar producer and exporter, is now converting half of its sugarcane harvest into fuel ethanol. With 10 percent of the world's sugar harvest going into ethanol, the price of sugar is rising. Cheap sugar may now be history.[49]

In Europe, the emphasis is on producing biodiesel. In 2006, the European Union (EU) produced 1.2 billion gallons of biodiesel from vegetable oil, mostly in Germany and France, and 417 million gallons of ethanol, most of it distilled from grain in France, Spain, and Germany. To meet its goal of obtaining 10 percent of its automotive fuel from plant-based sources, the EU is increasingly turning to palm oil imported from Indonesia and Malaysia, a trend that is leading to the clearing of rainforests for oil palm plantations. The Netherlands, concerned about the impact this could have, is reconsidering its import of palm oil for biodiesel production.[50]

In Asia, China converted some 4 million tons of grain—mostly corn—into ethanol in 2006. In India, as in Brazil, ethanol is produced largely from sugarcane. Malaysia and Indonesia are investing heavily in oil palm plantations and new biodiesel refineries.[51]

Production of corn, now the world's dominant feed grain as well as the leading ethanol feedstock, overtook wheat roughly a decade ago. In 2006, the world corn harvest exceeded 700 million tons, wheat was just under 600 million tons, and rice was 420 million tons. The "big three" account for 85 percent of the 2-billion-ton world grain harvest.[52]

The U.S. corn production is huge, accounting for 40 percent of the global harvest and two thirds of world corn exports. The corn harvest of Iowa, the leading corn-producing state, exceeds the entire grain harvest of Canada.[53]

Iowa is also the epicenter of ethanol distillery construction. Robert Wisner, Iowa State University economist, reports that the state's demand for corn from processing plants that were operating, under construction, or being planned as of late 2006 totaled 2.7 billion bushels. Yet even in a good year the state harvests only 2.2 billion bushels. As distilleries compete for grain also used to feed livestock and poultry, Iowa could become a corn-deficit state—with no corn to export to the rest of the world.[54]

What happens to the U.S. corn crop is obviously of concern to the entire world. Leading importers like Japan, Egypt, and Mexico will be particularly affected by any reduction in U.S. corn exports.

As the share of the U.S. grain harvest going to ethanol distilleries escalates, it is driving up food prices worldwide. In September 2007, the price of corn was nearly double that of two years earlier. Wheat prices had more than doubled, reaching historic highs. Soybean prices were up by more than half.[55]

The countries initially hit by rising food prices were those where corn is a staple food. In Mexico, one of more than 20 countries with a corn-based diet, the price of tortillas in early 2007 was up by 60 percent. Angry Mexicans in crowds of up to 75,000 took to the streets in protest, forcing the government to institute price controls on tortillas. In the summer of 2007, Italian consumers organized pasta boycotts to protest soaring prices. Meanwhile, the British were worrying about rising bread prices.[56]

From an agricultural vantage point, the world's appetite for crop-based fuels is insatiable. The grain required to fill an SUV's 25-gallon tank with ethanol just once will feed one person for a whole year. If the entire U.S. grain harvest were to be converted to ethanol, it would satisfy at most 18 percent of U.S. automotive fuel needs.[57]

Historically the food and energy economies were separate. But with so many ethanol distilleries now being built to convert grain into fuel, the two are merging. In this new situation the world price of grain is moving up toward its oil-equivalent value. If the fuel value of grain exceeds its food value, the market will simply move the commodity into the energy economy. If the price of oil jumps to $100 a barrel, the price of grain will follow it upward. If oil goes to $120, grain will follow. The price of grain is now keyed to the price of oil.

The emerging competition between the owners of the

world's 860 million automobiles and the 2 billion poorest people is uncharted territory for humanity. Suddenly the world is facing a moral and political issue that has no precedent: Should we use grain to fuel cars or to feed people? The average income of the world's automobile owners is roughly $30,000 a year; the 2 billion poorest people earn on average less than $3,000 a year. The market says, Let's fuel the cars.[58]

The risk is that rising grain prices will lead to chaos in world grain markets and to food riots in low- and middle-income countries that import grain. One likely consequence is more failing states as governments that are unable to provide food security lose legitimacy. The resulting political instability could disrupt global economic progress. At that point, it would not be merely the price of food but the Nikkei Index and the Dow Jones Industrials that would be affected by the massive diversion of grain to the production of automotive fuel.

Although there are no alternatives to food for people, there are alternatives to using food-based fuels. For example, the 4 percent of U.S. automotive fuel currently supplied from ethanol could be achieved several times over—and at a fraction of the cost—simply by raising auto fuel-efficiency standards by 20 percent.[59]

Another way to reduce the fuel needed for cars is to shift to highly efficient gas-electric hybrid plug-in cars. (See Chapter 12.) This would allow motorists to do short-distance driving, such as the daily commute, with electricity. If wind-rich countries such as the United States, China, and those in Europe invest heavily in wind farms to feed cheap electricity into the grid, cars could run primarily on wind energy—and at the gasoline equivalent of less than $1 a gallon.[60]

While it makes little sense to use food crops to fuel cars if it drives up food prices, there is the option of producing automotive fuel from fast-growing trees, switchgrass, prairie grass mixtures, or other cellulosic materials, which can be grown on wasteland. The technologies to convert these cellulosic materials into ethanol exist, but the cost of producing cellulosic ethanol is still more than double that of grain-based ethanol. More research is needed.[61]

Another option that is fast gaining attention is the use of wasteland to produce jatropha. This four-foot woody shrub bears inedible golf ball–sized fruit with seeds containing oil that can be turned into biodiesel. In addition to being a drought-resistant, low-maintenance shrub with a 50-year lifespan, jatropha requires little fertilizer or water.[62]

The Indian State Railway has planted 7.5 million jatropha plants along rail lines in that country and uses the oil in its diesel-powered locomotives. The government has identified 11 million hectares of wasteland that can be used for this shrub. One of the early enthusiasts, O. P. Singh, a horticulturalist for India's Ministry of Railways, says that one day "every house will have jatropha."[63]

Jatropha diesel can be produced for $43 per barrel, a price comparable to that of sugarcane-based ethanol but well below that of other biofuels. Companies that process vegetable oils are offering farmers in India long-term, fixed-price contracts for their harvest of jatropha seeds. A U.K. biodiesel company, D1 Oils, has already planted 150,000 hectares of jatropha in Swaziland, Zambia, and South Africa. A Dutch firm, BioKing, is developing plantings in Senegal. China is also considering large-scale production of jatropha.[64]

The World Beyond Peak Oil

Few countries are planning for a reduction in oil use. Indeed, the projections by both the International Energy Agency and the U.S. Department of Energy expect world oil consumption to go from roughly 85 million barrels or so a day at present to close to 120 million barrels a day by 2030. How did they come up with these rosy forecasts? Apparently they focused primarily on demand and then simply assumed that the needed supply would be forthcoming. To use the words of Thomas Wheeler, editor of the *Alternative Press Review*, many analysts and leaders are simply "oblivious to the flashing red light on the earth's fuel gauge."[65]

Even though peak oil may be imminent, most countries are counting on much higher oil consumption in the decades ahead. Indeed, they are building automobile assembly plants, roads, highways, parking lots, and suburban housing developments as though cheap oil will last forever. Thousands of large jet airliners are being delivered with the expectation that air travel and freight will expand indefinitely. Yet in a world of falling oil production, no country can use more oil unless another uses less.[66]

Darrin Qualman, Director of Research for the National Farmer's Union of Canada says, "The problem isn't simply Peak Oil. . . . The problem is the combination of Peak Oil and an economic system in which . . . 'no one is in control.' Ours is a system where it is no one's job to look past next year's profits, to take stock of how this year's production might affect next decade's weather, ...where we become ever more dependent on energy despite the fact that no one is keeping an eye on the fuel gauge."[67]

Some segments of the global economy will be affected more than others simply because some are more oil-intensive. Among these are the automobile, food, and airline industries. Stresses within the U.S. auto industry are already evident. General Motors and Ford, both trapped in a heavy reliance on sales of gas-hogging sport utility vehicles, have seen investment analysts reduce their corporate bonds to junk bond status.[68]

Modern cities are another product of the oil age. From the first cities, which took shape in Mesopotamia some 6,000 years ago, until 1900, urbanization was, with a few exceptions, a slow, barely perceptible process. When the last century began, there were only a few cities with a million people. Today there are more than 400 such cities, and 20 mega-cities have 10 million or more residents.[69]

The metabolism of cities depends on concentrating vast amounts of food, water, and materials and then dispersing the resulting garbage and human waste. This takes vast amounts of energy. With the limited range and capacity of horse-drawn wagons, it was difficult to create large cities. Trucks running on cheap oil changed all that.

As cities grow ever larger and as nearby landfills reach capacity, garbage must be hauled longer distances to disposal sites. With oil prices rising and available landfills receding ever further from the city, garbage disposal becomes increasingly oil-dependent. At some point, many throwaway products may be priced out of existence.

Cities will be affected by the coming decline in oil production, but it is the suburbs that will take the big hit. People living in poorly designed suburbs, in the sprawl of housing developments, are often isolated geographically from their jobs and shops, forced to use a car even to get a loaf of bread.

Suburbs have created a commuter culture, with the daily roundtrip commute taking, on average, close to an hour a day in the United States. Although Europe's cities were largely mature before the onslaught of the automobile, those in the United States, a much younger country, were shaped by the car. While city limits are rather clearly defined in Europe, and while Europeans only reluctantly convert productive farmland into housing developments, Americans have few qualms about this because of a residual frontier mentality and because cropland was long seen as a surplus commodity.[70]

This unsightly, aesthetically incongruous sprawl of suburbs and strip malls is not limited to the United States. It is found in Latin America, in Southeast Asia, and increasingly in China. Flying from Shanghai to Beijing provides a good view of the sprawl of buildings, including homes and factories, that is following new roads and highways. This is in sharp contrast to the tightly built villages that shaped residential land use for millennia in China.

Shopping malls and huge discount stores, symbolized in the public mind by Wal-Mart, were all subsidized by artificially cheap oil. Isolated by high oil prices, sprawling suburbs may prove to be ecologically and economically unsustainable. Thomas Wheeler observes, "There will eventually be a great scramble to get out of the suburbs as the world oil crisis deepens and the property values of suburban homes plummet."[71]

The food sector will be affected in two ways. Food will become more costly as higher oil prices drive up production and transport costs. As oil costs rise, diets will be altered as people move down the food chain and as they consume more local, seasonally produced food. Diets will thus become more closely attuned to local products and more seasonal in nature.

Air transport, both passenger travel and freight, will suffer as jet fuel prices climb, simply because fuel is the biggest airline operating expense. Although industry projections show air passenger travel growing by some 5 percent a year for the next decade, this seems highly unlikely. Cheap airfares may soon become history.[72]

Air freight may be hit even harder, perhaps leading at some point to an absolute decline. One of the early casualties of rising fuel costs could be the use of jumbo jets to transport fresh

produce from the southern hemisphere to industrial countries during the northern winter. The price of fresh produce out of season may simply become prohibitive.

During the century of cheap oil, a vast automobile infrastructure was built in industrial countries, and its maintenance now requires large amounts of energy. The United States, for example, has 2.6 million miles of paved roads, covered mostly with asphalt, and 1.4 million miles of unpaved roads to maintain even if world oil production is falling.[73]

National political leaders seem reluctant to face the coming downturn in oil and to plan for it even though it will become one of the great fault lines in world economic history. Trends now taken for granted, such as rapid urbanization and globalization, could be slowed almost overnight as oil becomes scarce and costly. Economic historians writing about this period may routinely distinguish between before peak oil (BPO) and after peak oil (APO).

Developing countries will be hit doubly hard as still-expanding populations collide with a shrinking oil supply to steadily reduce oil use per person. Without a rapid restructuring of the energy economy, such a decline could quickly translate into a fall in living standards, with those of the poorest falling below survival levels. If the United States, which burns more gasoline than the next 20 countries combined, can sharply reduce its use of oil, this could buy the world time for a smoother transition to the post-petroleum era.[74]

The peaking of world oil production raises questions more difficult than any since civilization began. Will world population growth survive a continuing decline in world oil production? How will a shrinking oil supply be allocated among countries? By the market? By negotiated international agreements? By war? Can civilization itself survive the stresses associated with falling oil production at a time when food prices are rising and the stresses from climate change are mounting? And the list goes on.

Food Insecurity and Failing States

During the concluding half of the last century, the world was making steady progress in reducing hunger, but during the transition into the new century, the tide began to turn. In February

2007, James Morris, head of the U.N. World Food Programme (WFP), announced that 18,000 children are now dying each day from hunger and related causes. For perspective, this loss of young lives in one day is almost five times U.S. combat deaths in Iraq through four years of fighting. Although these huge numbers of dying children may be an abstraction, each represents a young life ended far too soon.[75]

There are many ways of measuring hunger. The U.N. Food and Agriculture Organization (FAO) calculates the number of hungry people based on food intake. FAO data say the long-term trend in reducing hunger is encouraging, but not the recent trend. The number of people in developing countries who are hungry and malnourished, which declined from 960 million in 1970 to 800 million in 1996, has turned upward, reaching 830 million in 2003.[76]

Projections by Ford Runge and Benjamin Senauer of the University of Minnesota four years ago showed the number of hungry and malnourished people decreasing to 625 million by 2025. But an update of these projections in early 2007 that took into account the effect of the massive diversion of grain to ethanol distilleries on world food prices shows the number of hungry people climbing instead of decreasing—to 1.2 billion by 2025.[77]

One of the manifestations of a sharp rise in grain prices is a correspondingly sharp drop in food assistance. Since the budgets of food aid agencies are set a year or more ahead, a rise in food prices shrinks food assistance. For example, the United States, by far the largest food aid donor, saw the price of a ton of food aid in 2007 climb to $611, up from $363 per ton in 2004. In the absence of supplemental appropriations, food aid will drop by 40 percent. Key recipients, like Ethiopia, Afghanistan, and the Sudan, will be hit hard.[78]

Working together, the FAO and WFP each year release an assessment of crop and food conditions that lists the countries in dire need of food assistance. In May 2007, a total of 33 countries with a combined population of 763 million were on this list. Of these, 17 were in need of external food assistance because of recent civil strife and conflict. Many of these countries are on the top 20 list of failing states, including Afghanistan, Burundi, Côte d'Ivoire, the Democratic Republic of the Congo, Guinea, Pakistan, Somalia, Sudan, and Zimbabwe. The bottom line is that political insecurity and food insecurity often go hand-in-hand.[79]

The countries on WFP's food emergency lists are mostly societies trapped between lowered mortality and continuing high-levels of fertility. In this situation, which leads to state failure if permitted to continue indefinitely, agricultural development is often interrupted by a decline in personal security that makes it difficult to maintain technical support for farmers and to sustain timely flows of seed and fertilizer.

With failing states and declining personal security, it is difficult even to operate food relief programs. WFP head James Morris, discussing the food relief operation in early 2007 in Sudan's Darfur region, where violence and insecurity are rampant, says, "Our convoys are attacked almost daily. We had a driver killed there at the end of last year. Our convoys coming through Chad from Libya are always at risk." In failed and failing states, food relief, however sorely needed, is not always assured. And sometimes even though people are starving, it is simply not possible to reach them with food.[80]

There are many threats to future food security, including falling water tables and rising temperatures, but the most immediate threat may be the diversion of an ever-larger share of the U.S. grain harvest into the production of fuel for cars. Only the U.S. government can intervene to restrict this diversion and avoid life-threatening rises in world grain prices.