OUR ENERGY PRESENT 3

Global Trends and What They Mean

The future is the worst thing about the present.

GUSTAVE FLAUBERT, "Pensées"

ENERGY INDICATORS: CAN THE WORLD BE GRAPHED?

Though we may doubt the virgin birth of U.S. presidents or Russian premiers, there is little question that the power they wield comes back, sooner or later, to matters of energy. Economic vitality, military readiness, and national security all depend on energy realities. No surprise, then, that more than a few organizations have taken on the job of analyzing relevant trends and making forecasts. What *does* seem unexpected, perhaps, is the degree to which these analyses tend to agree, at least to a first approximation. The Energy Information Administration in Washington D.C. (EIA, part of the U.S. Department of Energy), for example, and the International Energy Agency in Paris (IEA, an informational body for the OECD), though they may draw blood over acronym mix-up, nonetheless share bread over how to generally interpret the global energy scene today. No less is this true of reports put out by a host of other disparate entities such as British Petroleum (BP), the Worldwatch Institute, and the World Energy Council.

Why is this so? Consensus exists because analysts rely on similar sources of data that make up established "energy indicators." Such indicators in graphical form are now widely in use, tracking and extrapolating levels of consumption and production (by fuel, region, country, economic sector), supply and demand, import dependence, carbon emissions, and more. How reliable are these measures? It depends on what we expect. Much data comes from official sources, what each country reports about its own energy activity. To a large extent, this is the way it has to be if we are to have frequent (annual) updates, since the task of collecting such data independently is simply too gargantuan (oil alone is imported by over 150 nations). Problems methodological and otherwise certainly exist. Some exporters keep secret all detailed information about their oil/gas reserves and production (see chapter 4); others may have no central agency for gathering data or may suffer wartime conflict or breakdowns in the rule of law. Different systems of units and definitions of "reserves" operate in the larger world too. Without question, those who assemble and analyze energy data need to sometimes perform minor feats of numerical magic, or at least incantations to said effect.

Ultimately, compilations like the very widely employed annuals *World Energy Outlook* by the IEA and BP's *Statistical Review of World Energy* are approximations at best and chart data one or two years old by the time they are published. What emerges is admittedly incomplete—a rather blurry optic on a fast-moving landscape. But it is yeoman's work, and lacking it we would be far more blind and unaware. With a few exceptions, data about the past and present are accepted by experts. Future projections are what attract debate, excitement, and disbelief.

Any set of measures, however, brings its own set of assumptions and therefore caveats. In this case, we should point to a certain bias of scale. Measuring global trends in terms of thermal energy, e.g., tons of oil equivalent or British thermal units (1 Btu roughly equals a single burning match) inevitably highlights energy-rich fuels used by more advanced societies. Traditional sources, like wood and dung, much poorer in Btus, appear far less significant even though they remain the staple for billions of people. Much of this use, along with animal labor, as well as low-tech wind and water power, don't show up at all. Such ancient forms are not part of any market system and can't be tracked, though they are life to one-third of Africa and Asia.

Forecasts, meanwhile, come with a different caution. Projecting today's trends into later decades, even with modification, can make the future seem fixed by the present, as if the world were already hopelessly locked into more of the same. Analysts sometimes refer to the result as a "business-as-usual" or "reference" scenario and offer "alternative" versions that could happen if government policies change or technological breakthroughs occur. In recent years, such alternative scenarios, inspired by climate change, include dramatic shifts, with reductions in fossil fuel consumption. But even so, the overwhelming aggregative dominance of oil, gas, and coal forces discussion to focus here, giving short shrift to topics like nuclear power, renewables, and emerging areas of technology, whose development may have far-reaching consequences. Experts might note this as simple four-letter realism. But the truth is that painting with certain brushes can obscure the grain of reality. No group of graphs or savants foresaw the global economic meltdown in 2008, *annus horribilis* for all forecasts, economic and otherwise.

Do such difficulties weaken the importance of these indicators? No—for two reasons. First, though flawed, they offer an honest approximation of things we want to know; comparing past data with contemporary developments shows that indicators can have real explanatory power (as we will see). Indicators cannot see the future, but they do show where we have been and where existing trends are aiming us (forecasts, scientifically speaking, are not the same as predictions in any case; they provide hypothetical futures that reflect back on choices already made). Second, decision makers in both the public and private sectors rely on such data to help frame policy—no minor fact. In the end, how we measure the world determines, to a significant degree, how we comprehend and seek to change it. Indicators yield silhouettes, the outline of larger patterns, and force us to interpret them. This in itself is worthy of our interest.

WHAT DOES THE WORLD WANT?

How much energy does the world use? By 2007, the globe was consuming on the order of 462 quadrillion Btus (EIA measure), or, in other terms, calling for around 11,200 million tonnes (81 billion bbls) of oil-equivalent (IEA measure) per year (Figure 1).[1] Not surprisingly, no less than 80% came from fossil sources—oil (34%), coal (26%), and natural gas (22%).[2] In bare quantity, fossil energy runs the world, an ineluctable fact. It especially runs the prosperity and lifestyles of advanced and rapidly modernizing nations, from South Korea to Spain.

Consumption is the endpoint of demand, and demand drives the system. As Figure 1 shows, the world's thirst for energy over the last 100 years has been ever-growing. As recently as 1970–2000, despite periods of economic downturn, consumption literally doubled, far outstripping population growth over the same period. Looking at the small inset graph (upper left), we see that since 1900, the world's appetite for energy accelerated strikingly in the late 1940s with postwar economic growth in OECD nations, then began to cool in the 1990s, by which point these economies had matured and shifted away from heavy industry. The large graph, however, suggests that this is merely a kind of pause before consumption takes off again in the 2010s, due this time to economic growth in the developing world. The projections on Figure 1 were made prior to the global economic crisis, whose arrival rendered any belief in unbroken growth (how shall we say?) optimistic. Experts today, however, only shift future rises a few years ahead, after the world recovers.

To some, no doubt, all this spells "runaway train." But we should stop and reconsider. Energy expansion over the past century has brought innumerable advances of a wholly beneficial kind—from electric power (and all this means) to modern transport, from improved education to health care, nutrition, and greater life expectancy. Yes, the potential problem of

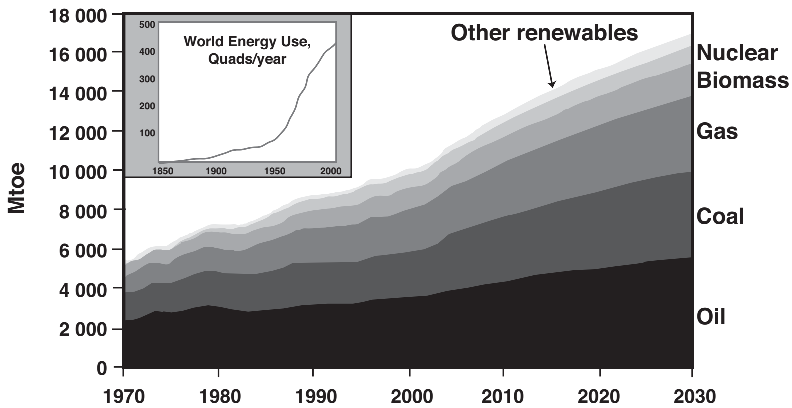


Figure 1. Graphs showing marketed energy use for the world. Inset (upper left) plots world energy consumption in quads (quadrillion Btus) from 1850 to 2000. Main graph shows data for the period 1970–2007, with projections to 2030. These projections were made in 2008, prior to the downturn in energy use related to the global economic crisis. Based on International Energy Agency, World Energy Outlook 2008.

coming resource scarcity must be faced, though this is far from a mere matter of numbers (see chapter 7) and is not at all imminent. Yet impugning the growth in energy use per se makes little sense. Even if the West can make due with less, the greater world needs more. Billions of people still wait to see their lives improved by what modern energy can bring.

Figure 1 confirms that history must be granted its merry inventions. The years 1973 and 1979 saw two major oil shocks, due to the Arab Oil Embargo and the Iranian Revolution, that deepened economic recession in the West, leading to plunges in energy use. Jolts to the global economy also happened in 1991 (Gulf War), in 1997 (Asian financial crisis), and in 2001 (September 11). We know that the economic meltdown of 2008–9 also lowered energy consumption worldwide. Yet, again, it's the long-term picture that matters. Looking at the small graph of Figure 1 again, we note that two world wars and even the Great Depression appear as brief interruptions. An upward slope to 2030 (and beyond) can't be called unrealistic or adolescent.

Beginning in the 2000s, after all, growth in demand was indeed taken over by developing nations (economists call a country "developing" if its GDP per capita is under $10,000). It needs to be said, however, that economies like China are no longer "developing"; they have already come forward on to the global stage; "emergent" seems a better label. As shown in Figure 2, these nations—minus the former Soviet Union and

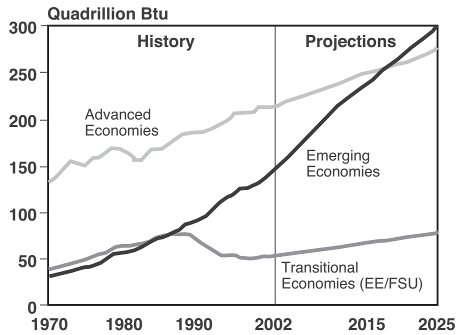


Figure 2. Global marketed energy use, divided by basic type of economy, with projections to 2025. "EE/FSU" refers to Eastern Europe and the Former Soviet Union. Adapted from U.S. Energy Information Administration, International Energy Outlook 2005.

Eastern Europe—have been on track to surpass all advanced countries in energy use by about 2017. In truth, if we include *every* form of use, such as traditional fuel wood, animal dung, and other nonmarketed types, non-Western nations have already surpassed the West. Asia, especially, is where both population and economic growth have been centered. If the world is predicted to have about 1.7 billion more people by 2030, at least 7 (more likely 8) out of every 10 of these new persons will be born there, where modernization has been most rapid.[3]

These are among the reasons that the IEA forecast, even in 2008, that over 80% of new energy demand to 2030 will be in these emerging economies, fully half in China and India alone. Indeed, the IEA continues to say that *all* new demand for oil will come from non-Western states during this period.[4] By 2030, China's GDP/capita could double or even triple; according to the International Monetary Fund, it had already grown from under $1,000 in 2000 to around $5,300 in 2007.[5] Population growth isn't the only key factor here. The U.S., after all, has less than a quarter the people that China does, yet consumes 70% more energy (as of 2008). It is technology and the level of economic development that matter—people using more energy-consuming devices, building and running new industries, abandoning poverty, adopting modern lifestyles. For China, call it a crash program; the world's most populous nation entering not just the Industrial Age, but the Age of Electrification, Motorization, Mass Consumerism and Communication, the Nuclear Age, the Information Age, all at the same time. By 2030, hundreds of millions more might be able to attend school, live in lighted and heated domiciles, buy TVs and refrigerators and cars, see movies and eat in restaurants, participate in all the elements of modernity.

Meanwhile, we said that energy use in the world has risen nearly unabated since World War II. True in the aggregate, this isn't so for every nation. The lowermost curve on Figure 2 reveals the epic decline suffered by all post-Soviet states after collapse of the USSR in 1989–91, with levels still well below their peak even two decades later. This suggests the true struggle endured by these countries, even as the "emerging economies" soared ahead. It helps to understand the scale of devastation by recalling that Western Europe, Japan, and South Korea were all rebuilt and made prosperous within ten to fifteen years after major wars destroyed their cities, infrastructure, and millions of their people.

WHAT RESOURCES?

Figure 1 shows that oil, gas, and coal constitute over 80% of the world's marketed demand for energy services today, and that oil has been foremost among these. Yet note: in the 1970s, oil was a far bigger piece of the whole—half of all energy use—and has declined since then as other resources, especially natural gas and nuclear energy, have grown. Oil's global importance comes from its use in many areas, in industry, in the residential sector (heating oil), and for a number of countries in power generation. But its true dominance is in transport, where it yields fuel for every form of mobility, and where it as yet has no replacement on a world scale.

If oil remains pivotal, what do the indicators say about it? Figure 3a shows who has it; proven conventional reserves (oil that has been found and can be extracted at a profit by drilling) tower in the Middle East over all other regions, though to what precise extent remains debated (see chapter 4). The unshaded portions above North America and South/Central America represent oil sand ("tar sands") deposits, located in Canada and Venezuela. These reserves are huge and now being extracted, yet at a far lower rate and higher economic and environmental cost than conventional oil[6] (thus their ultimate future remains uncertain). East Asia, we might note, has the least oil of any region.

Yet patterns of consumption, given by Figure 3b, show that Asia's thirst for oil has grown more rapidly than that of any other region, with the Middle East next. Europe has kept its consumption largely flat (controlled) while North America allowed its own to rise steadily until high prices took effect after 2004 and demand cooled. If we turn to production, Figure 3c reveals that the long-term increases in oil use by Asia and the U.S. have been fed mainly by increased flows from the Middle East, with smaller contributions from Europe/Eurasia (the North Sea and Russia) and Africa. Figure 3c has much history in it—note the plunge in Middle East production during the early 1980s (when demand fell after the price spike of 1979–80 and the recession of 1981–82), which was made up by the Soviets (Eurasian production). Soviet supply then slumped after the fall of the USSR, allowing the Middle East, in turn, to regain top

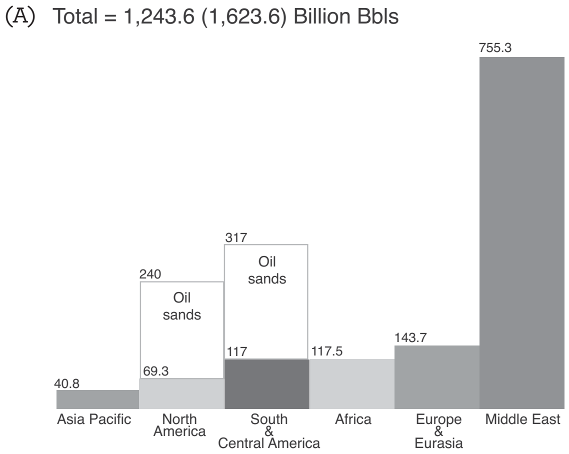
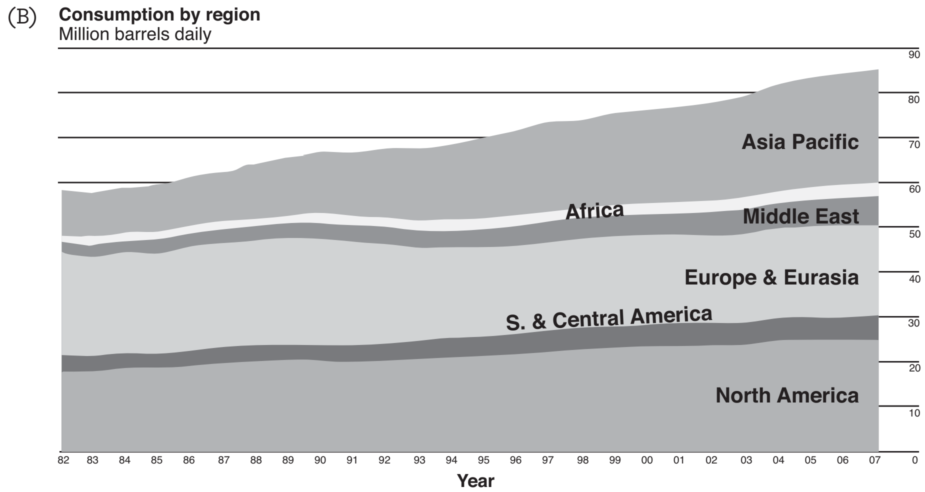
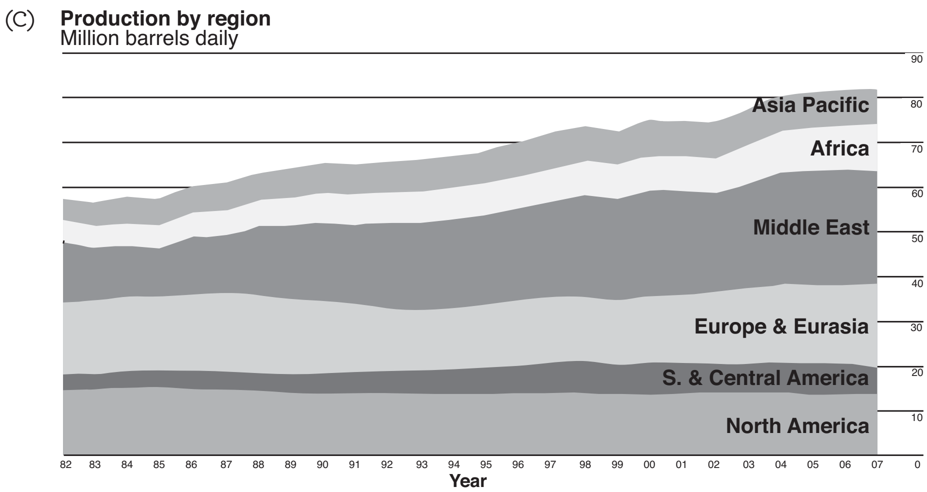


Figure 3. Regional geography of the world's oil. (A) Proven conventional reserves, plus oil sands. Total global reserves, as currently estimated, are given at the top, with this total plus oil sands in parentheses. (B) Global oil consumption, by region. (C) Global oil production, by region. Adapted and modified from BP Annual Statistical Review 2008.





market share through the 1990s. More recently, when we compare Figures 3b and 3c, we see that global production ceased to grow in the 2000s, due to years of little investment in new capacity, even as consumption kept rising—a condition ripe for tight markets and high prices. After 2005, this began to change as a number of exporting nations, particularly Saudi Arabia, launched programs to build more production capability.

The future? Oil's use, as we've said, appears almost certain to expand. How certain? Not at all in the West—here the trends toward more fuel-efficient vehicles and use of biofuels could mean a flattening or even decline in oil consumption overall. But in Asia, the situation is very different. An example: in 2009, Tata Motors, India's largest auto company, rolled out the Tata Nano, a four-door, two-cylinder "People's Car" sedan, offered at a base price of 100,000 rupees, roughly $2,000. At a single stroke, the potential Indian auto market grew by tens of millions, in the midst of global recession. Moreover, the price may be startling to those in the West, but not to Asians—China's QQ3Y Chery and India's own Maruti 800 models were already selling for under $5,000 in 2007. That such cars cannot be exported to the West because of safety standards does not matter. Tata's plans are to ignore rich countries, perhaps altogether, and make the Nano available in Southeast Asia, Latin America, and Africa.[7] What we see here is the logical outgrowth of two realities: pent-up desire for cars (and all they mean), and the ability of non-Western automakers to adapt technology to new cultural-economic settings. Both have the effect of reempowering oil. And China? As noted already, in the 2000s car ownership grew more than fourfold, such that, by late 2009, new vehicle sales exceeded those in the U.S. What if, by 2030, the ownership figure reached a modest 15% of a total 900 million potential drivers? Some projections see the Chinese market growing even faster—to nearly 400 million cars by 2030.[8] This would be *twice* the size of the U.S. fleet today. And if India were to even reach half such a number? Now, these might well be "panic" figures. It is quite possible that authorities in these countries will not simply stand by and watch as their cities fill up and choke on traffic. But even so, Tata's Nano is a sign that carmakers in Asia are ready to do what it takes to create new markets among their own people. Massive increases in the global auto fleet are clearly on the way.

The $64 trillion question is whether the resources can be delivered to support this and what it will mean for urban air quality and global climate. Indeed, for a planetary fleet of one billion cars, about 30% larger than in 2008, the world would need to produce at least 113 million bbls per day (compared to 85 million bbls/d in 2008) if no changes were made in fuel economy. This is near the most liberal (or, depending on your perspective, fantastic) projections ever made by the IEA for 2020–30.[9] Could it be achieved? No one yet knows for sure (see, however, chapter 13). At some unknown point, production won't be able to grow any further, fuels will then rise in price, and alternatives to gasoline/diesel vehicles will become more and more competitive. Of course, if current fuel efficiency were itself doubled or even tripled (possible using even today's technology), there would be little need for any major increase in oil flows, numerically speaking. Global growth in cars will thus be a dance between economic factors, government policy, and innovation.

What about other resources, beyond oil? Figure 1 indicates that until the early 2000s, natural gas, the least polluting fossil source, was growing rapidly and replacing coal, the most polluting. This remains largely true in the West, where environmental priorities are high. It is not true elsewhere. The rise in energy prices after 2003 made coal even cheaper compared to gas (on a per-Btu basis) than it had been for over twenty years, and thus helped accelerate its use in developing nations. This returns us to China and India, both countries with large domestic coal reserves, which appear intent on using these resources to enhance their own energy self-sufficiency and security. Governments in these countries, it should be said, are not precisely those of England or America in 1850. They know the terrible price in pubic health, and seething public unrest, that unmitigated coal use has brought—fully twenty of the world's thirty most polluted cities in 2008 were famously in China, including the capital Beijing—and have pledged new policies to improve the situation. But pledges are one thing, action another. Cleanup may have been possible in Beijing to welcome the 2008 Olympics, but only by relocating factories and stopping construction, rationing car traffic, and other temporary draconian measures that don't quite comprise a nationwide program. In truth, mixed signals emerge from China over environmental realities. National leaders appear to comprehend the damage that has resulted from breakneck development and have begun many projects to increase energy efficiency and try out various "green" technologies. Yet the rationale for such action seems based more on worries over China's global image, the cost of cleanup and lost GDP, and public unrest. China's economic stimulus spending in 2009 showed a marked leap for "technology and industry" at the noted expense of "sustainable environment."[10] In brief, the country does resemble nineteenth-century America in one respect: economic growth comes foremost as its own justification—higher incomes and a sense of progress translate to legitimacy for the political system and its ruling elite.[11]

We see three other curves on Figure 1, one each for biomass, nuclear power, and renewables. Biomass has been rising mainly due to the growing use of bioenergy, especially biofuels, in advanced and a few emerging economies (Brazil, above all). As for other renewables and nuclear, both have increased, in part, because of the "boom" in worldwide demand for power. What of the future? Figure 1 forecasts major growth in renewables—though these remain a small contributor to global energy use overall—and little change for nuclear power. Yet climate change and oil anxiety have created a new context that could improve the prospects for both these domains. More than a few experts continue to feel that long-term expansion in biofuels is likely and a redesignation of nukes as the "green atom" may be in the offing (see chapter 8).

The "renewable" category on Figure 1 includes hydro, geothermal, solar, wind, and oceanic sources. At present, the great majority of renewable energy (>95%) comes from the first two of these. Hydropower, in fact, accounts for as much as a fifth of all electricity generated in the world. Advanced nations may have developed it to near capacity, but in parts of Asia, Africa, and South America, hydro could be expanded. Plans exist for this to happen, yet there are now serious worries about environmental impacts from dams and in some cases the displacement of people. The trade-offs are nowhere better seen than at the great Three Gorges Dam on the Yangtze River, largest hydropower project in the world (22.5 gigawatts of electricity, enough for about 20 million homes, or several large cities)—a project that will save more than 55 million tons of coal-produced atmospheric carbon a year, yet displace a minimum of 1.3 million people, and possibly, due to growing environmental damage, as many as 4–5 million over time, while also creating huge new emissions of methane, a potent greenhouse gas, from drowned, decaying vegetation. Three Gorges, moreover, is not the last word on hydropower in the country. Chinese officials say it is the anchor to a planned system that includes eleven other mega-stations on the Yangtze. Hydropower, in other words, is no longer a simple renewable source (if it ever was). No less than coal or nuclear, though different in kind, it represents a series of trade-offs.[12]

The true significance of renewables' thin appearance on Figure 1 is twofold: they will not replace oil and coal anytime soon, yet they have enormous room to grow. There is great potential for them to be used locally, on a more distributed (not centralized) basis, something that would not show up big on total consumption figures for a while but would have a profound effect in helping the least developed nations advance out of energy poverty with minimal pollution effects.

WHO OWNS IT? WHO NEEDS IT?

Nature is not a democracy. Nor is it prone to reform. An area less than 7% of the globe, centered on the Persian Gulf, contains 60% of the world's cheap, accessible petroleum and at least 40% of its natural gas. This unchangeable reality brings forth a dark logic, unrelieved by any subtlety. As demand for these sources grows, especially oil, the Gulf will come to command an ever-greater share of global supply. This logic also runs the other way, however. Gulf nations, which remain overwhelmingly reliant on oil and gas exports, are locked into dependence on importers. OPEC wealth is ultimately a function of petroleum demand, thus economic strength or weakness in importing nations.

Figure 1 shows a world in which oil production just keeps rising. Such has been the official line of the EIA, IEA, and other organizations for over a decade, leading up to the economic crisis of 2008. An ailing global economy has imposed a correction on this, stalling demand. Yet, as we have said, any such correction will be temporary. Demand will grow again when economies recover, though perhaps with some changes from the past. Indeed, China's own demand levels have continued to rise, as the financial crisis proved to be of very short duration there. New oil, meanwhile, must be found, extracted, transported, refined, and brought to market. This requires vast levels of investment, thus high-level planning, and also (let us not forget) sociopolitical stability. A few nations have launched such programs—notably Saudi Arabia, whose production capacity went from 7.5 Mbbls/d in 2002 to nearly 11 Mbbls/d by 2009. But Saudi Arabia can't carry the world's oil future by itself. Big growth in production can't be done by a war-torn Iraq or an Iran closed to foreign firms or a Nigeria in the throes of civil war. It won't be done purely by national oil companies (NOCs), which now control 80% of global proven reserves and that, as government monopolies, are often prey to inefficiency, corruption, meddling by political leaders, and diversion of capital to other priorities. And yet, new investment in oil can't be done without these entities either. In short, the world's ability to supply petroleum is ultimately a matter of deliverability—what countries *can* produce—not only of what they have in the ground. Deliverability means politics, economics, and technology all at once (see chapter 7). The political dimension is inescapable. By 2008, as we've said, oil import dependence was 60% for the U.S., 75% in Europe, 90% in Japan, 65% in India, and 50% in China. Figures for natural gas are also high (>50% for Europe, Japan, India, and China). Which highlights a simple truth.

Talk of "energy independence" for *any* of these states is horse pucky. No amount of biofuel production, natural gas vehicles, or any other alternative will free us anytime soon from this truth. Major economies everywhere are deeply integrated into the global marketplace of energy, oil and gas above all. Indicators like Figures 1 and 2 tell us that change is needed. But they also show that, for the foreseeable future, *managing* *dependence* is the name of the game. There are options; nations can try to influence supply through diplomacy, reduce demand at home, advance alternatives, or seek some hybrid of these. The first approach, applied by the West for much of the twentieth century, has involved meddling in the politics of petro-states, with (shall we say) mixed results overall. The second two strategies, controlling demand and developing alternatives, have been variably and inconsistently applied since the embargo of '73, yet obviously hold the greatest long-term promise. The U.S. has chosen, above all, the first tactic. "Blood for oil" may be too simple an interpretation, but there is little doubt that America's long-term military presence in the Middle East has been partly aimed at protecting oil flows for itself, its allies, and the global economy as well.[13] We should be mindful, too, that Gulf states do not ordinarily sell to individual countries any longer, but instead to a world market and so cannot easily punish nations of their specific dislike through embargoes. Yet this hardly seems reassuring. It simply means that no one is free of supply insecurities. Again, nations must find ways to deal with such insecurity, to manage and channel it, for it will not disappear.

HOW'S IT BEING USED?

These conflicts reveal what the world is willing to endure for the sake of its fuels. In the abstract, we could say that the politics are messy, the economics volatile, but the science firm. Fossil fuels have enormous practical advantages: they are abundant, affordable, flexible and diverse in their uses, and very rich in energy content (we get a lot of power and work from them per unit weight or volume). There are legitimate technical reasons why a gigantic, multi–trillion dollar system has come to center on their extraction and use. Yet it is exactly this gigantic system, with its depth of long-term investment and familiarity, that presents a challenge to major change. Turning over such a system to new sources will take many years, though the need be urgent.

Emergent and developing states see, after all, that using hydrocarbon fuels makes them richer—the value of their goods and services, their GDP, goes up with the volume and diversity of consumption. The relationship is far from linear. Economic stability and growth depend on much more than Btus. More important are the ways in which energy is specifically utilized. Some indication can be seen in Figure 4, which plots the three main categories of energy service—transportation, power generation, and stationary uses (heating of buildings, industrial operations). Figure 4, in fact, reveals that economic growth has the closest tie to electricity use, which, again, makes perfect sense when we consider how fundamental

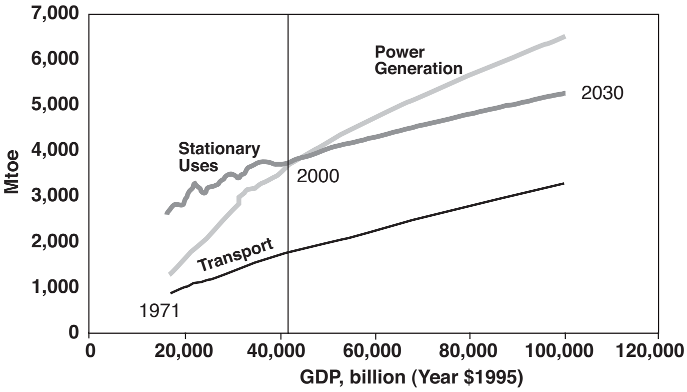


Figure 4. Energy-related services worldwide, as a function of world gross domestic product, measured in billions of 1995 dollars. Historical data is plotted for 1971–2000. Adapted from International Energy Agency, World Energy Outlook 2002.

this energy carrier is to all sectors of a modern society. Developing countries understand this, too. Electrification is their most basic energy goal for advancing their people. No surprise that power generation in non-OECD nations is forecast to exceed that in the OECD before 2015.[14]

Here is another basic question, then: how *efficiently* is the world using what energy resources it has, whether to generate power or make and move its goods? We know that the U.S. is a gigantic waster of energy, the global ogre. We drive too much, live in palatial houses, erect cities like Las Vegas, and call for air conditioning at the first tickle of sweat. Our consumption is nothing if not a measure of squanderer's lust. Right? Well, not entirely. There are two dimensions to consider here—behavior and technology. Compared to the rest of the world, it's true that Americans are energy gluttons by conduct and choice. Our houses use twice as much energy per day as those in Europe and Japan, and our cars get far worse mileage. Yet *technologically*, over time, we have become far more efficient in most areas of use. A refrigerator today needs less than half the electricity it did in 1980. Dishwashers, furnaces, hot water heaters, and dryers, as well as most industrial and manufacturing processes, all consume far less than a generation ago, while often doing more work. On a per–square foot basis, our homes are just as efficient as those in Germany and Japan. How do we know, in the aggregate, that this is true?

The indicator here is called "energy intensity" (EI). It is defined as the amount of energy needed to generate a given unit of GDP, e.g., Btus per dollar (the actual calculation usually involves simply dividing total energy consumption by total GDP). Higher numbers imply a less efficient economy, lower figures a more efficient one—fewer Btus to get the same

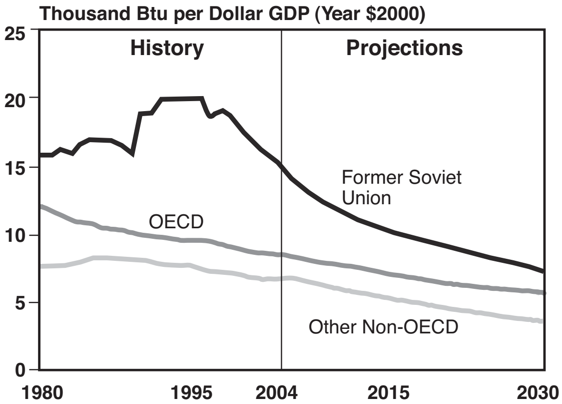


Figure 5. Energy intensity (unit of energy per unit of economic output) for three sets of nations: advanced (OECD), developing (non-OECD), and transitional (Former Soviet Union). Adapted from U.S. Energy Information Administration, International Energy Outlook 2007.

output. On the whole, EI at the national level is a rather blunt indicator that can't account for certain critical factors like geography (northern nations use a lot more energy just for heating), different types of economies (agricultural vs. industrial), or economic evolution (a shift from agricultural to industrial to service economy). EI is useful, however, for comparing patterns over time, as shown by Figure 5.

In advanced nations, EI has fallen continuously since about 1940. These counties have decreased the total amount of heavy industry (e.g., iron and steel-making, shipbuilding), and, since the 1970s, consciously promoted through government policy many improvements in energy use, to get more for less. Overall, EI has dropped about 17% per decade after 1980—meaning that GDP has grown much more rapidly than energy consumption—or, in a different phrasing, economic growth has become less and less dependent on growth in energy use. This marks a major change from the preceding 100 years and shows that the evolution of an economy and hands-on policy can both make a tremendous difference. Why is EI higher in the OECD than in non-OECD nations? People in rich countries use many times more energy per capita, due to lifestyle, technology, and other factors.

Developing nations, then, tell a different story. EI levels worsened into the late 1980s for these countries, as many of them expanded their power and manufacturing industries. Indeed, rises in EI, unfortunately enough, corresponded with the rapid erecting of fossil fuel systems using cheaper, outmoded, polluting technology. By the early '90s, the largest of these nations, China and India, had turned to more labor-intensive light manufacturing and service-related work, lowering their energy use per dollar of output. But then from 2000 on, China changed direction. It began rapidly building itself into an urbanizing industrial power, focused on infrastructure—new roads, railways, skyscrapers, suburbs, airports, power plants, and factories, urging the adoption of coal as a primal energy source, the one fuel China has in great abundance.[15] Between 2000 and 2008, energy consumption in China went up more than 100%—a stunning leap, but fully comprehensible given the country's all-out effort to modernize.

China's impact appears as a reversal in the slope of the EI curve for other non-OECD nations, which carries to about 2008. That flip on Figure 5 tells us that energy policy decisions by major nations can alter, even in a few short years, big historical trends. Note that EI is predicted to fall again; in fact, this had already begun by 2008. The reason? Again, aggressive policy on the part of the Chinese government—officially to reduce EI by 20% between 2006 and 2010, by closing down the most inefficient industries, replacing older power plants with newer coal technology, and financially discouraging poorly built factories (among other measures). Is everything now on a new course, once and for all? Figure 5 warns that any final proclamations are likely to be premature. As noted by the country's deputy minister of the environment, China still has a long way to go, since "to produce goods worth $10,000, we need seven times the resources used by Japan, six times the resources used by the U.S. and—a particular source of embarrassment—almost three times the resources used by India."[16]

The former Soviet Union, meanwhile, presents yet another kind of example. The collapse of the USSR brought a plunge in energy use but an even worse decline in economic output—a falloff in trade, the closing of many factories, even the dissolution of entire industries, all leading to a rise in EI through much of the 1990s. This was reversed by a new period of prosperity in the 2000s, brought by rising oil and gas prices. How much of the decline in EI shown by Figure 5 actually came from improvements in energy use is uncertain. Three factors help explain why EI remains so high: (1) climate (higher energy use per capita); (2) economic structure, which relies heavily on energy-intensive natural resource industries like oil/gas, timber, and metals; and (3) outdated, inefficient technology from the Soviet era. Russia has said it wants to make energy efficiency a capital goal, and certainly much can be done. Yet the realities of climate and a natural resource economy will keep EI at comparatively high levels indefinitely.

One major conclusion we can derive from Figure 5 is that technology can indeed bring big savings in energy when applied consistently toward innovation. A factory running on coal and steam, using machinery from the 1940s, is a predatory dinosaur on resources compared to one operating on natural gas turbines developed in the late 1990s. Similarly, a V-8 SUV (20 mpg) does far more to keep the demand for oil high—and all that this means, geopolitically—than a four-cylinder sedan able to run at 40–45 mpg. Yet efficiency is no Holy Grail for managing demand. There is also, again, the behavioral side of the equation. The past tends to show that energy savings lead over time to increased energy use, the so-called "paradox of plenty." Major successes that lower consumption often bring in their wake market "innovations" that want to exploit that same energy dividend—more efficient homes that fill up with a greater number of appliances and devices; more efficient manufacturing used to generate more output; better fuel economy cars that (in the past at least) are built larger and more powerful. Controlling oil use, more generally, is a complex matter in a country like the U.S.—big, spread out, its towns and cities erected around car use, its economy and lifestyle wedded to the roadway, its culture married to vehicles that increasingly incorporate the comforts of a pleasant living room and office, its consumers breast fed on low prices that don't include the military, medical, and environmental costs of oil use. Energy demand can be brought under real, consistent control only through an array of measures affecting the technology, motives, and choices people make. Awareness and sensibility, not only equipment and price, are the solution.

WHAT'S IT DOING: CARBON EMISSIONS

There are important reasons to think in terms of awareness today. National choices in energy have global consequences, and not just political ones. No matter how efficiently and economically we may be consuming our oil, coal, or yak dung, we are still putting climate-altering gases into the Earth's atmosphere, therefore altering in a manner against our interests the most fundamental "global commons" of all. In the first decade of the twenty-first century, the reality of climate change and its primary cause, the increase of atmospheric greenhouse gases (GHG), especially carbon dioxide, from the burning of fossil fuels, are established science. Climate change now forms an integral part of the world's energy equation. It forces us to dream the dreadful dreams of a less friendly world, but also to view the primary fuels of the modern era a new context (a point taken up in more detail in chapter 15).

Indicators for energy-related emissions, like Figure 6, often take carbon dioxide, the most abundant GHG, as their focus. This figure tells us that the great majority of CO_2 has come from coal and liquid petroleum—power generation and transport—with coal having surpassed oil

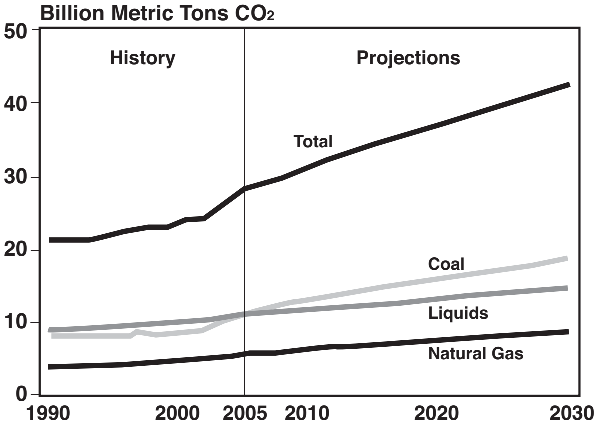


Figure 6. Global energy-related carbon dioxide emissions, 1990–2005, with projections to 2030, based on trends through 2007. Adapted from U.S. Energy Information Administration, International Energy Outlook 2008.

in 2005, worldwide, due to growing use of this fuel in China and India. By 2008, these two nations already exceeded all of the advanced world in coal consumption. Indeed, Figure 7 shows that China alone, after becoming the world's leading emitter in 2007–8, is on course to surpass the rest of the OECD before 2020.

Trends like those shown on Figures 6 and 7 are being used to argue for big shifts in the global energy system. Nearly all of the advanced world now takes the issue of climate change very seriously, and many states have put official policies into place to reduce emissions. In late 2008, the EU confirmed a so-called 20-20-20 plan to lower energy-related GHGs 20%

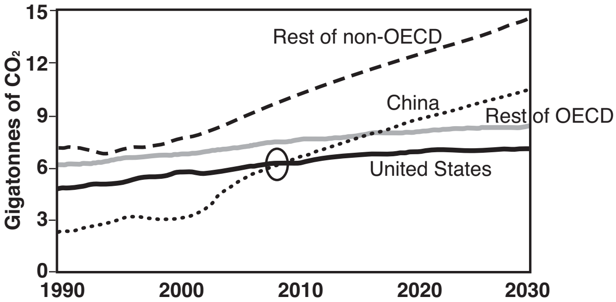


Figure 7. Energy-related carbon dioxide emissions divided out for the U.S., China, the OECD (minus the U.S.), and non-OECD nations (minus China). It is now acknowledged that China surpassed the U.S. in 2007–8. Adapted from Claude Mandil, "The Global Energy Challenge," presentation dated January 22, 2007.

by requiring 20% renewable sources by 2020. President Obama, meanwhile, pledged to reduce emissions in America to 1990 levels by 2020 and then lower them a further 80% by 2050, largely by the use of new energy technology. Such targets, even allowing for "carbon offsets" (carbon-saving projects pursued in the developing world to offset emissions at home) are ambitious—indeed, they express the scale of concern. They do extend well beyond the terms in office of the leaders responsible for them, however. Action by the U.S. will be more than significant, given America's role as a technological leader. But as Figures 6 and, especially, 7 suggest, it would be a mistake to focus solely on a few rich nations in this domain. The long-term future of emissions, like fossil energy use itself, lies elsewhere. Much more will be said about all this in chapter 15.

PRICES: THE PATTERN AND THE PREDICAMENT

Generally speaking, prices in the energy industry refer to oil. This is because petroleum acts as the source for fuels and products used in many areas of an economy—from transport to feedstocks for plastics—and also because until recently the cost of natural gas has often tended to follow, in a general way, the trend of oil (for reasons that remain difficult to adequately explain). Moreover, there is the public to consider, source of demand. Due to the simple reality of giant signs on street corners announcing the price of gasoline and diesel, people are more conscious of cost here than for any other commodity in existence, whether milk or toilet paper, a truth with both political and economic consequences (imagine if the price of electricity and the amount being used were prominently displayed on every household appliance). So what have oil prices done over time?

Figure 8 gives some perspective. For most of the twentieth century, following the wild boom-bust of the late 1800s, oil was not merely cheap but getting cheaper. America, through its home-grown companies, was the world's dominant supplier for nearly a century, till the end of World War II. The U.S. had the ability to fill supply gaps and stabilize prices—or the opposite, by withdrawing petroleum from certain states, using the "oil weapon," as it did against Japan in July of 1941. Everything changed radically in the 1970s due to three developments: (1) a peaking in U.S. production (1970–71); (2) the oil crises of 1973 and 1979, with the takeover of Middle East reserves by national oil companies; and (3) the shift of petroleum onto the New York Mercantile Exchange.

These events essentially marked the loss of market control by a cartel of private oil companies and its transfer to a new cartel of natural resource states, OPEC, and to traders with a vulnerability to short-term psychological influences. OPEC, which tries to influence prices by changing

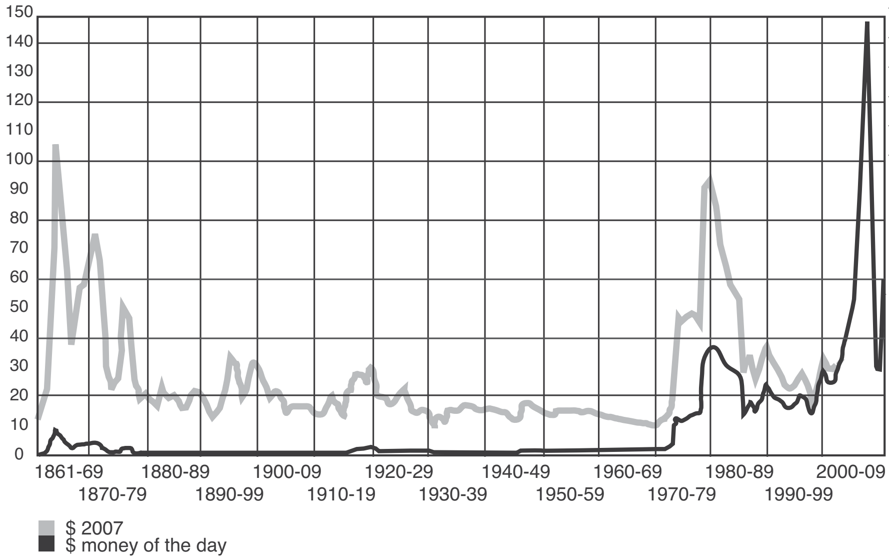


Figure 8. History of crude oil prices during the 150-year lifetime of the modern petroleum industry, through early 2009. Adapted from BP Annual Statistical Review 2008.

supply, and traders, who carry out price setting by open, competitive bidding, have worked at odds ever since. In truth, even in the best of times, OPEC has been only partly effective. It has faced the problems all cartels do: constant squabbling and cheating by members over production limits. A few facts are interesting to note. OPEC was originally formed in 1960 as a response to declining prices caused by import quotas in the U.S., the world's largest oil consumer. These quotas favored oil from North American producers; Venezuela and the Persian Gulf saw the value of their own petroleum fall continuously (see price trend on Figure 8 for 1950–70), leading them to seek greater control by nationalizing reserves and much of production too. Prices finally rose in 1973, when OPEC exercised such new-found power by reducing flows across the board—it was this reduction, not the embargo against the U.S. and the Netherlands specifically (the two countries that had supported Israel most openly in the Yom Kippur War), that brought a quadrupling of world prices in 1973–74. At the time, and again in 1979, shortages in the U.S. were created by ill-advised government price and allocation controls, first imposed in 1971 by President Nixon under a philosophy that saw oil as the critical resource for nearly all economic activity. Such controls work to keep prices artificially low, stimulating consumption, in this case beyond available volumes. Letting prices rise in concert with global supply/demand would have curbed consumption and prevented a shortage, not killed economic vitality. The lifting of price controls by President Reagan in 1980 eliminated these types of shortages. High prices in the 2000s reflected a very different situation.

Indeed, between 2006 and 2008, as shown by Figure 8, the world experienced the greatest price build and collapse of all time (thus far). What happened? In simple terms, global demand, led at first by long-term rising consumption in the U.S. but then by surging economic growth in Asia, caught up to supply. In 2004, a demand spike in China, related to tens of thousands of diesel generators brought out to power factories not served by the country's inadequate electricity grid, took the entire supply system near its limit, with less than 1% spare available. This loss of spare capacity—oil on tap in case of an emergency—became a primary reason for high prices. All through the 1990s, as global consumption rose, OPEC refused to invest in any significant new production. This was done (or rather, not done) for both political and economic reasons—oil was cheap and plentiful in the '90s, discouraging new development—but its effect eventually caught the oil industry by surprise.

Then there is the refining side. Even had large amounts of new oil been developed by OPEC, little could have been done with it all, since refineries were nearly maxed out too—U.S. firms, for example, responding to the low-price era of the 1980s and '90s, built no new plants, preferring to maximize efficiency at existing facilities and close a number of weak performers. Another important element was the trading community. As prices began to rise, after 2003, an array of new financial investors moved into the market, seeing in oil an asset whose value outshone stocks, bonds, real estate, and other traditional investments. A weakening dollar (to which oil prices are pegged) and a continuing series of uncertainties related to Iran's nuclear program, the Iraq war, attacks on pipelines in Nigeria, and more, added a "fear premium," as investors bid up the price from worry over supply disruption. All of this conspired to bring oil to an all-time high of $147 a barrel—a dizzying level, no longer strictly connected to supply/demand fundamentals.

The bubble having burst, prices went into free-fall with arrival of the financial crisis in late 2008. Announced production cuts by OPEC, totaling over 4 Mbbls/d, did nothing to brake the fall early on, as oil held in inventories around the world grew. By Christmas, prices were below $35, and the most breathtaking rise and descent in history had been fulfilled. By summer 2009, the production cuts began to take effect, and prices rose back to around $65–$70—still quite high by historical standards (see Figure 8), but now viewed as "cheap" by a world so recently shaken by numbers more than double this level.

Such is a simple analysis and chronology. Yet it helps clarify a few realities. One of these is that OPEC, as a cartel, isn't wholly effective at controlling prices. Another reality is that investors, who do control the price more directly, can't be trusted to act rationally—or rather, they are subject to different rationalities at different times, fear at certain moments and euphoria at others, so that, in a more uncertain world and a tight market, psychology plays an even larger role. A third point would be a repeat of something we've noted several times already: supply depends on countries and companies investing in future production.

These might appear simple facts, and to a degree they are. Yet complications are always nearby. From OPEC's viewpoint, investing in new production when prices are low or moderate is less a matter of insurance than risk—without any guarantee of future demand, there's no way to know whether capital can be recovered. Meanwhile, the Saudis and friends find that importers themselves are now investing heavily, in *alternatives* to petroleum, new vehicle technologies, talk about the evils of "foreign oil," the need to decarbonize. To OPEC, all this tells a tale of yet more risk to the outlook for demand.[17] The oil market, in short, can be defined as a waltz of codependence, with exporters and importers often stepping on each others' feet.

It once was said that everything economic hinged on oil prices. A sharp rise here was presumed to be deadly everywhere, bringing inflation, unemployment, and more. Yet from the events of 2008, it seems fairly certain that the first true oil shock in thirty years can't be held entirely responsible for problems in the global financial system, including the high-risk mortgage lending, inaccurate credit ratings, hedge fund policies, credit default swaps, and lack of government oversight that led to the ensuing economic meltdown. Though there are always some who would find a way to blame oil for all, more than a few economists now feel that the recessions of the 1970s and early 1980s, too, came from a range of factors—decline in rust belt industry, poor monetary policy, and wage and price controls, among others.[18] The coincidence of high oil prices and hard times is not accidental; expensive fuels add a burden to consumer and industry spending. Over time, however, the total negative effect of more expensive oil in advanced nations has declined—price spikes in 1991 (Gulf War) and 2001 (post-9/11) caused barely a ripple in Western economies, and robust growth continued during the most recent "shock" even at prices above $90. This should tell us something. Oil may be not quite as critical to a modern economy as once thought, especially since other energy sources have grown over time and taken domain away from petroleum. But it could also mean something else, something quite different—that oil has been cheaper, relative to other major economic inputs, than even imagined and that the ceiling for what defines "cheap" has risen over time, along with levels of wealth and income. Demand, after all, did not really fall in any significant fashion after 2000 until gasoline prices in the U.S. had more than doubled, to over $3/gal. What would oil at $200 or even $300 bring? We may not wish to find out anytime soon, yet those who forecast doomsday or the demise of modern transport might pause to reconsider.

NOT THE END

Indicators of the type shown here testify to many of the energy trends publicly discussed today and in the years ahead. I have given a small sampling of the most significant of these indicators, and also the types of interpretation applied to them. Much more will emerge in the chapters that follow. But for now, the reader will appreciate a few truths.

Uncertainty, change, and dynamism are the legacy of today. And one of the reasons is interconnection. The world economy has grown threefold since 1990, with resources more traded than they have ever been and more so with every passing year. There are decided benefits to this new globalized era. Thomas McLarty, chief of staff to President Clinton, put the truth of this in wonderfully evocative terms:

> When a Brazilian brews her morning coffee today, she is likely to use electricity from a power plant in Uruguay that runs on natural gas from Argentina provided by a Chilean company. She drives to work in a Ford fueled with Venezuelan gasoline, and her Canadian-owned factory may soon be powered by a 2,000-mile natural gas pipeline from Bolivia.[19]

Thus, the friendly side to the new energy order. Indeed, more should be said here, even briefly. Major infrastructure that crosses national borders—be it pipelines or wind farms—can urge countries to better cooperate with one another. An excellent example is the 1,100-mile Baku-Tbilisi-Ceyhan (BTC) pipeline, built between 2002 and 2005, now a major route for new oil from the landlocked Caspian Sea to the Mediterranean, passing through the capitals of Azerbaijan and Georgia. Meticulous planning, including assessment of environmental and social impacts, and patient diplomacy knit this delicate project together, bringing these two volatile states, plus Turkey, into a cooperative effort that drew nearly 70% of its $3.9 billion financing from foreign investment. The project is not without its difficult politics, to be sure. It was built to avoid using either Iran or Russia as a main transport corridor, a fact that likely played some kind of role in Russia's recent invasion of Georgia. Yet here too, the pipeline's existence also acted as insurance, as it created links with Europe and the U.S., putting real limits on the Kremlin's ultimate options, unlike in Chechnya.

There are always complexities to reflect upon. Energy interconnection also means that a contractor in the U.S. can buy crude originally from the Kirkuk field in northern Iraq, shipped via the Kirkuk-Ceyhan branch pipeline, then transported by Norwegian tanker to a refinery in South Korea, and sent as diesel and aviation gasoline back to Iraq, for use in Humvees and helicopters. Globalization in energy therefore means new possibilities for productive connection and for shared vulnerabilities, both at the same time. Think of a spider web; touch one part, and every part trembles. In no small way, the trends and themes we see today—roaring demand in Asia, supply control in the Middle East, anxious importers in Europe, climate concerns everywhere—directly reflect such connections. Understanding these linkages, and what they portend, defines a required basis for advancing a better energy future.