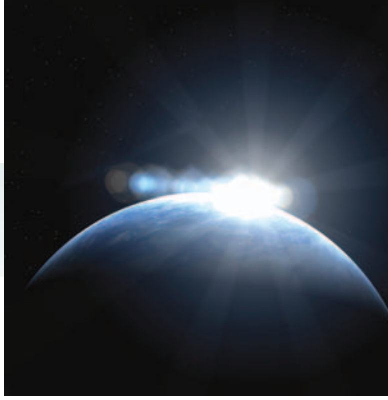

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# A WAKE-UP CALL

The sun is the only energy source that can meet the oil depletion challenge. But solar energy ramp-up must be large-scale and immediate.

By **Francis de Winter** and **Ronald B. Swenson**

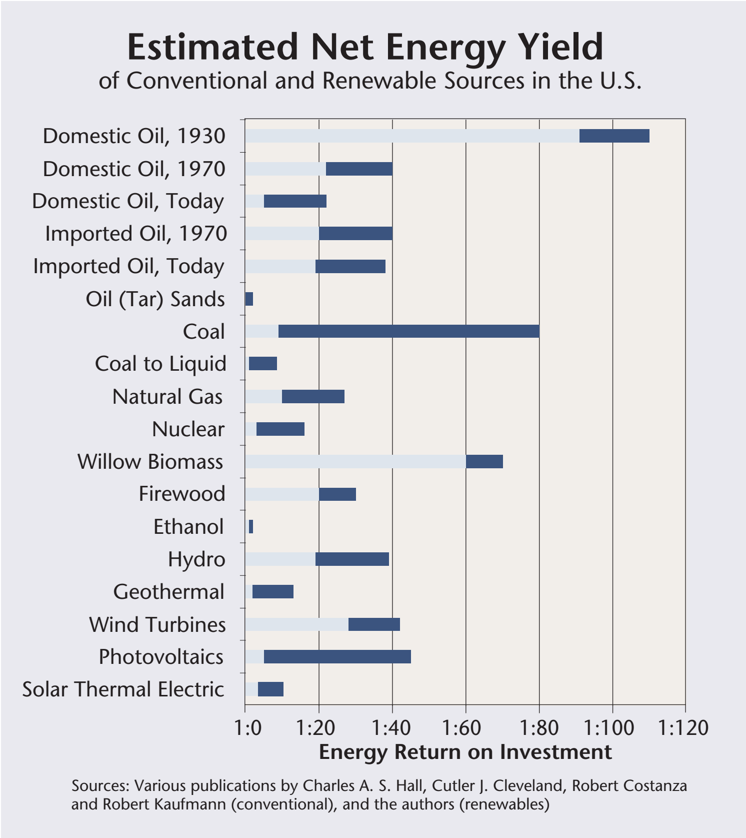
This issue of *SOLAR TODAY* focuses on the Global Hubbert Peak, the point in time when petroleum (and natural gas) will go into unavoidable decline. Here we explore the options available in light of dwindling fossil fuel resources, and we speculate on the scale of solar energy development that will be needed to overcome the expected oil and natural gas shortfall.

Peak oil is an emerging reality. With production already declining in all but a few major oil regions, an energy shortfall is inevitable. As demand for oil continues to grow, this shortfall can only mean disappointment for those around the world who aspire to live more like Americans, consuming their body weight in oil every week (150 pounds on average). Never mind price. Even if price is no object, production will begin to drop and shortages will become increasingly acute. There will be great temptation to exploit high-carbon, non-conventional fossil fuels that could accelerate global warming. To avoid disaster, solar energy must rise, and rapidly, to meet the challenge of oil depletion.

## A Coming Crisis

In 1994 we established contact with leading geologists who were studying oil depletion and created a website, www.oilcrisis.com. Much earlier, one prominent petroleum geophysicist spoke out about the future of oil. In 1956, the late Dr. M. King Hubbert predicted correctly that oil production in the United States would peak around 1970, after which production would decline forever. In the 1960s and 1970s, he predicted that the worldwide "Hubbert Peak" would be reached around the year 2000. The world Hubbert Peak has been postponed a bit because the 1970s energy crisis made us more frugal, but experts agree that it remains imminent. Dr. Farrington Daniels, the founder of our International Solar Energy Society, was associated with Hubbert when he first introduced his peak oil analysis. *(See sidebar, "A Solar Future Long Anticipated.")* Dr. Colin J. Campbell, the most prominent successor of Hubbert, expects the Hubbert Peak in the very near future *(see "The Second Half of the Age of Oil Dawns," page 20)*.






Since the beginning of our short oil era around 1860, world population has increased dramatically. This population growth has been fueled substantially by oil. In the United States, food travels more than 1,000 miles on average, requiring over 10 times the petroleum energy to produce than its solar energy food value (calories). As a practical matter, we are eating mostly petroleum.

Many societies throughout history have faced resource depletion. History tells us that Plato deplored the deforestation in Greece, and that the Greeks started using passive solar orientation in their settlements when they ran out of firewood. Archeologists have found many societies that disintegrated because they depleted their resources with no concern for the future. Some simply abandoned their settlements and moved to fertile land. Others, like the people on Easter Island, could no longer move. They had cut down all their trees and couldn't even make crude boats to fish.

Developed and developing countries alike are addicted to cheap oil. For the United States, depletion is going to be especially difficult. Americans use oil as if it will never run out. The country is designed and built around cars using cheap gasoline. With fossil fuel resources becoming scarce, we have to learn to make do with what we have peacefully or we will have war, depleting humanity's collective resources even further.

What might be the possible early reactions to peak oil?

**Conservation:** Whenever natural disasters or political disruptions shed light on our energy vulnerability, earnest appeals for conservation can be heard. Conservation can be voluntary: I can choose to buy a Toyota Prius and still go to the beach on the weekend. I will use less oil, but my lifestyle will be preserved.

**Deprivation:** As oil supplies continue to dwindle, energy conservation will cease to be voluntary. That may lead to rationing if we make a reasoned response. But if depletion is not managed effectively, *deprivation* will overwhelm efforts to conserve rationally. As shortages impact the industrialized world, trips to the beach will be sparse. Lifestyles will change.

**Conflict:** With oil as an essential foundation of productive modern agriculture and starvation already intense in certain regions, it can be argued that the poor of the world are already deprived, involuntary participants in energy conservation. Energy inequities will continue to grow between the haves and the have-nots, and the struggle over the remaining oil reserves will intensify.

RONALD B. SWENSON

**Peak oil is an emerging reality. To avoid disaster, solar energy must rise to meet the oil depletion challenge.**

Some say the conflict in Iraq is a grab for oil. Whether true or not, how might we avoid conflicts over energy resources?

**Substitution:** We will inevitably have to find other energy sources, substituting new energy for oil and what oil does. Are there solutions close at hand?

## No Answers in Non-Conventional Oil, Nuclear

One place where the peak oil message is being heard is at the margins of the oil, gas and coal industries. As energy prices rise exponentially, researchers are attempting to exploit carbon-intensive, non-conventional fossil fuels to replace transportation fuels. Massive investments have been made to extract tar sands in Alberta; research is ramping up to find a way to convert oil shale in Wyoming and Colorado; and improved technologies are being developed to convert coal to liquids, using the same process that fueled Hitler's desperate army.

But such attempts have produced inadequate amounts of net energy. For heat to extract oil from tar sands, natural gas equivalent to one-third of a barrel is used per barrel. This natural gas is in addition to the liquid fuels and electricity needed for mining, refining and environmental remediation. Recognizing rising natural gas prices, advocates are even suggesting nuclear power to replace natural gas for heat in the extraction process.

Nuclear power is also being examined for the extraction of oil shale. This misnamed substance (neither shale nor oil but marlstone and kerogen, an immature hydrocarbon) must be heated under pressure to convert it to oil. One proponent in Colorado envisions a nuclear facility generating more power to heat oil shale *in situ* than all electricity now consumed statewide. Water requirements and environmental impacts could be huge.

As the informed public becomes aware of the impact of greenhouse gases, nuclear power is being promoted again, this time as a carbon-free energy source. But the popular notion that nuclear is carbon-neutral is faulty. High-grade uranium ores have already been exploited, and the mining and refining of lower-grade uranium ores are increasingly fossil-fuel intensive.

If all bets are placed on marginal fossil fuels and nuclear power, the consequences for society will be dire. Perpetuating the automotive fleet, for example, may seem laudable. But propping up the fleet with low-grade fuels could be more dangerous than doing nothing because, as U.S. Rep. Roscoe G. Bartlett suggests in his article (page 27), these marginal sources too will run out, and humanity will be left high and dry.

## Only Solar Energy Can Fill the Gap

Meanwhile, renewable energy technologies are being brushed aside by some peak oil "experts" as too intermittent or diffuse to merit serious attention. Let's examine a few of these objections to a full-scale transformation to renewables.

*"Solar energy, plant biomass and other renewable forms of energy are diffuse forms of energy."*

Direct sunlight is indeed diffuse, but *thin* collectors are a perfect match to *diffuse*. Mirrored surfaces on solar concentrators

### How Will We Fill the Fossil Fuel Gap?

***Solar energy far exceeds all other possible forms of substitution, with none of nuclear energy's safety and waste-disposal challenges.***

***The Energy Challenge***

*13 terawatts (TW) continuous world energy consumption in 2005*

*30 TW projected demand in 2050*

***Projected shortfall = 17 to 20 TW****

ALTERNITY POWER

**The Atlantic County Utilities Authority dedicated the Jersey-Atlantic Wind Farm, supported by solar power, in Atlantic City, N.J., in December.**

NONCARBON RESOURCES

***Hydropower***
4.6 TW global theoretical potential
0.7 TW technically feasible
0.5 TW installed capacity

***Tides/Ocean Currents***
< 2 TW cumulative energy globally

***Biomass***
7 to 10 TW global theoretical potential

***Geothermal***
12 TW globally, of which only a small fraction could be practically extracted

***Wind***
50 TW global theoretical potential
2 to 4 TW economically feasible land usage, plus additional offshore potential

***Nuclear***
10 TW, based on construction of a new 1-gigawatt nuclear fission plant per day for the next 50 years

***Solar***
120,000 TW global theoretical potential
600 TW available incident solar power
60 TW technically feasible generated power based on 10 per cent conversion efficiency
20 TW based on usage of just 0.16 percent of global land area and 10 percent conversion efficiency

*1 TW equals 1 million megawatts (MW). For context, if a large electric power plant generates 1,000 MW of power, it would require 1,000 such power plants to produce 1 TW.

Sources: *Energy and Transportation: Challenges for the Chemical Sciences in the 21st Century* (National Academies Press, 2003) and *Basic Research Needs for Solar Energy Utilization* (2005, U.S. Department of Energy Office of Basic Energy Sciences).



## A Solar Future Long Anticipated

***When Hubbert predicted global peak oil, Farrington Daniels focused on the solution.***

The afternoon of Sept. 15, 1948, was an important date for solar energy, the petroleum industry and the International Solar Energy Society (ISES). The American Association for the Advancement of Science (AAAS) was 100 years old, and AAAS President Edmund Sinnott, Ph.D., invited three prominent speakers for a Symposium on Sources of Energy at the Centennial Celebration in Washington, D.C.:

- **Dr. M. King Hubbert**, a geologist working for Shell Oil, addressed ***oil depletion***, as the "Golden Century of Oil" was getting under way.
- **Dr. Farrington Daniels**, a physical chemist who had been in charge of the Chicago branch of the Manhattan Project and later started the organization that would become ISES, addressed the future of ***solar energy***, while solar energy was still a dream.
- **Dr. Eugene P. Wigner** of Princeton, who would receive the 1963 Nobel Prize in Physics and who had worked on the Manhattan Project for Daniels, addressed the future of ***atomic energy***, about eight years before there were any commercial power reactors.

At this symposium, Hubbert presented his first paper on what would become known as the "Hubbert Curve," the brief period in human history during which petroleum was discovered; adopted by society as its principal energy source; extracted in ever greater quantities; burned with no serious concern for the future; fostered affluence, wars and pollution; became ever harder to find and "produce"; and was destined to decline inexorably — leaving us no choice but to switch to sustainable energy sources.

**Getting to know Hubbert made Daniels aware of oil depletion and the energy deficiencies that solar energy would have to address.**

Even in this first paper, Hubbert warned that the post-oil transition process would be extremely difficult. Neither Daniels nor Wigner had much to offer except hope; solar and atomic energy technologies were still primitive. Despite Daniels' experience in the Manhattan Project (or perhaps because of it), he decided to concentrate on solar energy, forming the society now known as ISES and creating a solar energy program at the University of Wisconsin-Madison that remains famous.

Getting to know Hubbert made Daniels aware of oil depletion and the energy deficiencies that solar energy would have to address. In 1964 Daniels wrote that U.S. oil "production" would peak about five years later, as Hubbert had predicted accurately in 1956, and that worldwide oil scarcity would begin shortly after 2010. As humanity now encounters the Hubbert Peak, the man who established ISES to meet the challenge of oil depletion will inspire members of the solar community in the decades ahead.

are thin. Solar cells are thin, and thin-film cells are even thinner. Furthermore, sunlight is far more evenly distributed around the globe than is oil.

*"Photovoltaic electricity is expensive."*

The *profitability test* is often the result of accumulated political decisions favoring special interests. In economics it is formally assumed that oil and other natural resources have no value until they are "produced" (i.e., extracted), and then the only value assigned to the resources is the cost of extracting them. They are free for the taking, and so we have been paying nothing for the inherent value of oil. Lobbying efforts have provided large subsidies for oil. Externalities are not charged at the gas pump. Preferential tax treatments, highway construction and defense budgets underpin the oil economy.

**Humanity's "primary energy production," including all fossil fuels, nuclear power, hydroelectric and renewables, is 13 terawatts. Solar energy has 600 terawatts of terrestrial potential.**

Renewable energy subsidies are beginning to level the playing field. As fossil fuel costs increase, the economics of renewable energy will transform the market. *(See January/February* SOLAR TODAY *for features on the theme, "Solar Energy Cost Breakthrough Ahead?")*

*"The EROI (energy return on investment, or net yield) for fossil fuels tends to be large, while that for solar tends to be low."*

A hundred years ago, oil gushers yielded high net-energy recovery rates, but today solar, hydroelectric and wind power have net energy yields higher than conventional fuels such as oil, gas and coal, and an order of magnitude better than non-conventional fossil fuels. With their inherently high net-energy yields, renewables can be ramped up rapidly. *(See table, "Estimated Net Energy Yield of Conventional and Renewable Sources in the U.S.," page 16.)*

*"Neither solar nor wind power is an immediate, large-scale solution to the energy problem. … Plants, on average, capture only about 0.1 percent of the solar energy reaching the Earth."*

Humanity's "primary energy production," including all fossil fuels, nuclear power, hydroelectric and renewables, is 13 terawatts (equivalent to 13,000 large power plants), less than 1/100 of 1 percent of the 170,000 terawatts continuously delivered to the earth as sunlight. With 600 terawatts of terrestrial potential, solar energy far exceeds all other possible forms of substitution. *(See sidebar, "How Will We Fill the Fossil Fuel Gap?" page 17.)*

Transportation in a post-cheap-oil world poses special challenges. If non-conventional fossil fuels are untenable and

As energy prices rise, researchers attempt to exploit non-conventional fossil fuels to replace transportation fuels. But such attempts have produced inadequate amounts of net energy.

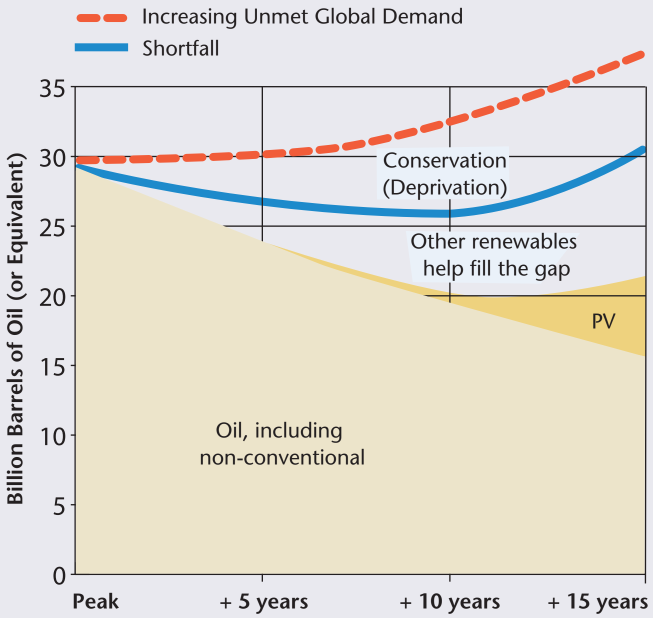
transportation is powered almost exclusively by liquid fuels, it is tempting to propose biomass as a substitute for oil. In the United States, 1 billion tons of biomass are managed each year. To meet all our energy needs, 7 billion tons more would be required. Obviously, electric airplanes or cargo ships are impractical, so biomass will play an important role in our energy future. But liquid fuels exclusively from plant material will be possible for transport at only about one-tenth the present level worldwide. Something has to give.

Considering society's huge investment in the vehicle fleet and these limitations of biofuels, it is difficult to imagine the transformation of transportation to renewable energy sources. To make the shift, the premise that solar energy must be converted into fuel has to be challenged. A direct path from sunlight to electricity can be 10 times as efficient as photosynthesis. Solar energy can't be touched or put into a bottle. Solar is *radiant energy*, not a solid, liquid or gas.

Electricity from renewables is ideally suited for urban transportation. It is nonpolluting and well-suited for fixed guide rail and automated routing of traffic, and an electric vehicle is at least twice as efficient as a gasoline vehicle. We are ready for a good reason to get rid of the internal combustion engine in dense urban areas, where it is about as practical as a campfire in the kitchen. Efficiency in the face of oil depletion is that compelling reason.

Solar technologies continue to improve, and so do electric vehicles. A battery with three times the energy density of lead-acid and a charging time under two minutes is scheduled for introduction in 2007 or 2008. Shanghai has an electromagnetic propulsion maglev train that travels at 270 miles per hour.

## As Oil Supplies Decline, Photovoltaic Capacity Grows




Oil declines at 4% per year
PV increases at 50% per year
Source: Ronald B. Swenson

### Getting Up to Speed: Think Terawatts

According to Campbell and other leading peak oil experts, permanent oil decline will begin during this decade and will likely proceed initially at 2 to 8 percent per year. If oil declines at 4 percent and photovoltaic manufacturing grows at 40 percent per year until 2020, PV would meet less than 20 percent of the oil shortfall without meeting any demand growth. If the PV industry sustains growth averaging 50 percent or more per year, it will contribute significantly. Though such growth is an aggressive goal, it is realistic under a scenario slightly more ambitious than the two-year doubling time projection that Ron Larson presents in this issue's "Chair's Corner" (page 4). As nonsilicon-based solar products quickly become commercialized, this goal is even more feasible. *(See graphic, "As Oil Supplies Decline, Photovoltaic Capacity Grows," left.)* Developing similar growth rates for all renewables, it will be possible for sustainable solutions to realize their potential for oil, gas and coal substitution. The sidebar, "Making the Transition," (page 29), samples some industry proposals.

France converted from zero to nearly 100 percent nuclear power in less than 20 years. Renewable energy technologies have higher net-energy yield than nuclear by far and are faster to install, so it will be possible to ramp up in even less time. If others continue to insist that nuclear power, tar sands or coal-to-liquids are options, the move to renewables will be even more critical as the only pathway that avoids potential nuclear terrorism and curbs global warming.

We must recognize the limits of our fossil fuel reserves and begin to push for rapid growth in solar energy. For the first time in history, all of humanity will share the same problem. This common challenge can help unify us, to recognize the futility of war and to make governments more responsive to our needs. We will need large national and international programs, similar in ambition and spirit to the Apollo "Man on the Moon" program, to reduce our oil consumption and to create alternative energy sources. This transition will provide many good local jobs that cannot possibly be outsourced, and we will need a significant grassroots effort.

If we get it right, we will be able to share a future of clean air and fresh water, viable oceans, thriving forests and peaceful coexistence. We must get it right, and be proud that we are members of the generation entrusted with the task. ●

*Francis de Winter, principal of Francis de Winter & Associates, originated the "heat exchanger factor," used worldwide in solar water heating. He served during four years as chair of the American Solar Energy Society. An ASES fellow, he has received the Charles Greeley Abbot Award and many other honors. Contact de Winter at fdw@ecotopia.com. Ronald B. Swenson is cofounder of ElectroRoof, SolarQuest and Solarevolution, and publisher of OilCrisis.com. A former ASES board member representing the Solar Fuels and Transportation Division, he has published numerous peer-reviewed articles in this field. Contact Swenson at rbs@solarquest.com.*

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# THE **SECOND HALF** OF THE AGE OF OIL **DAWNS**

The question is not when the world will run out of oil and natural gas, but how we will prepare today.

By **C.J. Campbell, M.A., D.Phil.**

Soaring oil prices have raised concern about the relative supply and demand of the world's premier fuels, having a central place in the modern economy. It has led people to ask, *"Are we running out of oil?"* A sensible short response would be, *"Yes, we started doing that when we produced the first barrel."* The world is not about to run out of oil, but what it does face is the end of the First Half of the Age of Oil. That opened 150 years ago when wells were drilled for oil on the shores of the Caspian and in Pennsylvania. The cheap, convenient and abundant energy it supplied, led to the growth of industry, transport, trade and agriculture. This growth was accompanied by the creation of huge amounts of financial capital, as banks lent more than they had on deposit, confident that *tomorrow's economic expansion* was adequate collateral for *today's debt*. Many people came to think that it was money that made the world go round, when in reality it was an abundant supply of cheap energy, much derived from oil.

**Facing page, A BP Solar array of 5,880 panels in Paulsboro, N.J., provides an adaptive reuse of a former petroleum and specialty chemical storage and distribution facility. The solar field produces 350,000 kilowatt-hours of electricity per year.**

Petroleum geology has made great advances in recent years, such that the conditions under which oil and gas were formed in nature are now well understood. In fact, it transpires that the bulk of the world's current production comes from deposits formed in two brief epochs of extreme global warming 90 million and 150 million years ago. Algae proliferated in the warm sunlit waters, providing the raw material that eventually became oil. It was preserved and trapped in places having the right combination of geological conditions. A glance at the oil map shows that oilfields are clustered in such exceptional places, which are separated by vast barren tracts.

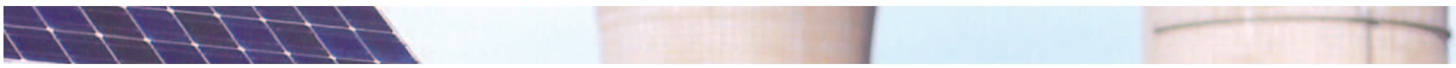
Natural gas was formed in a similar way, save that it was derived from vegetal remains as found in the deltas of tropical rivers. Ordinary oil also broke down into gas if overheated by excessive burial.

Oil and natural gas are clearly finite resources, formed in the geological past, which in turn means that they are subject to depletion. That is not a difficult process to understand, as every beer-drinker knows. The glass starts full and ends empty; the quicker he drinks it, the sooner it is gone; and every bar has a closing time. So, how far along the oil and gas depletion curves are we? The first step in answering this question is to ask how much has been found so far and when it was found, because production has to mirror discovery after a time-lapse.

They sound like simple questions, being just a matter of looking up the data, but as we dig into the details, we find a minefield of confusion, obfuscation and disinformation.

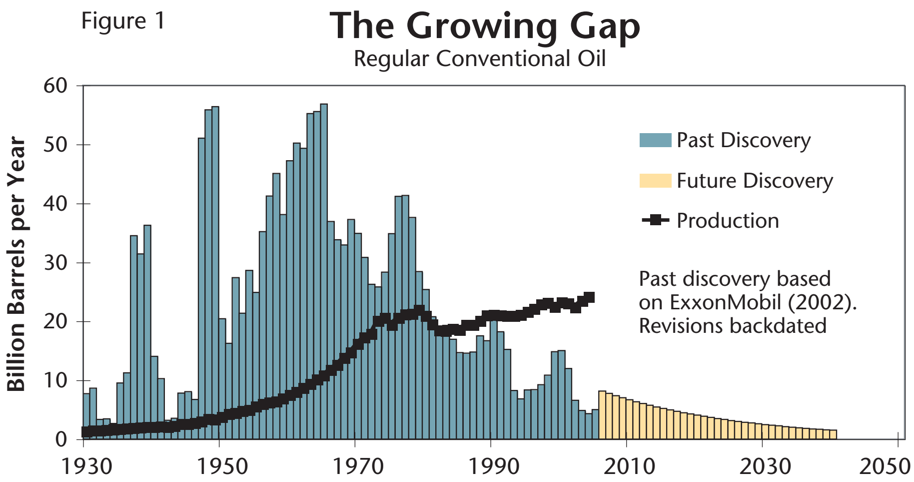
## Assessing the Remaining Reserves

In the past, the word *depletion* was not one the oil companies liked to mention, fearing that it smacked of a dwindling asset that



did not sit well with the stock market, but now some of them do begin to be more forthright. An example is Chevron, whose CEO deserves great credit for his frank presentation *(see www.willyoujoinus.com)*. The official institutions, for their part, tend to continue to publish bland scenarios and half-truths, recognizing that their governments are not yet ready to face bald reality.

Figure 1




In most contexts, the term *reserves* means something sure, but that is not the case for oil. Estimating the size of an oilfield early in its life poses no particular scientific or technical problem. The difficulty lies in the reporting. Oil in the ground is a financial asset to its owners, against which money can be borrowed. Accordingly, the Securities and Exchange Commission (SEC), very properly moved in the early days of U.S. oil production to introduce strict reporting rules. The SEC recognized two main classes: *proved producing reserves* for the expected future production of current wells; and *proved undeveloped reserves* for the expected production of yet-to-be-drilled infill wells.

The rules were designed to prevent fraudulent exaggeration, but smiled on underreporting as laudable prudence. In practice, the major international oil companies reported just as much as they needed to report in order to deliver satisfactory financial results, building up for themselves a useful stock of unreported reserves to tide them over lean discovery years and cover any temporary setback around the world. As a result, they were able to progressively revise their reported reserves upwards, giving a comforting but very misleading impression of steady growth, which was commonly attributed to technology, when in fact it was mainly an artifact of reporting practice. But the luxury of underreporting is fading fast, forcing the major companies to merge and, in some cases, revise downward their reported reserves. In part, this situation reflects the aging of the giant fields holding most of the world's oil — it being clearly easier to underreport a large field than a small one. In any event, the revisions have to be backdated to the original discovery to obtain a valid discovery trend.

The Organization of Petroleum Exporting Countries, for its part, announced enormous overnight reserve increases in the 1980s. At first, these increases seemed to be a correction of the underreporting inherited from the foreign companies before they were nationalized. But it now transpires that they may have started reporting the total found, not the remaining reserves, explaining why the official numbers have barely changed since, despite massive subsequent production. At all events, the dataset is grossly unreliable, with as much as 300 Gb (billion barrels) being in doubt.

Compounding the problem is confusion over what was measured. There are many different categories of oil, each with its own costs, characteristics and, above all, its own depletion profile. Producing oil from a free-flowing Middle East well is not the same as digging up a tar sand in Canada with a shovel, albeit a big one. Some types are cheap, easy and fast to produce, whereas others are the precise opposite. It is, therefore, useful to identify *regular conventional oil*, defining it to exclude oil from coal and shale, bitumen and heavy oil, deepwater and polar oil, as well as the liquids that are extracted from gasfields in specialized plants. Regular conventional oil has supplied most to-date and will dominate all supply far into the future.

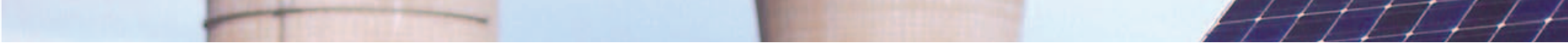
Unraveling all of these confusions, so far as is possible, suggests that the status of depletion for *regular conventional* is as follows (to be generously rounded):

| | | |
|---|---|---|
| Produced to-date (end 2005) | | 968 Gb |
| Future Production | | 882 Gb |
| From known fields | 760 Gb | |
| From new finds | 122 Gb | |
| Total | | 1,850 Gb |

Figure 1 shows the discovery record, using properly backdated industry data published by ExxonMobil *(Longwell, H., "The Future of the Oil and Gas Industry: Past Approaches, New Challenges,"* World Energy*, 5:3 2002: 100-104)*. World discovery has evidently been in decline since 1964, despite a worldwide search always aimed at the biggest and best prospects; despite all the many advances in technology and geological knowledge; and despite a favorable economic regime whereby most of the cost of exploration was offset against taxable income. It means that there is no good reason to expect the downward trend to change direction. The world started using more than it found in 1981, and last year found only about one barrel of *regular conventional oil* for every five or six consumed. Oil has to be found before it can be produced, which means that production in any country, region and eventually the world as a whole has to mirror discovery after a time lapse.

Although the skills of a detective are needed to collect the evidence and analyze it properly, we may be confident that the depletion profile in figure 2 represents a realistic general assessment sufficient for planning purposes.

In short, the Second Half of the Age of Oil now dawns. It will be marked by the decline of oil and all that depends upon it. Gas, which has a rather different depletion profile, will also in due course head into steep decline.

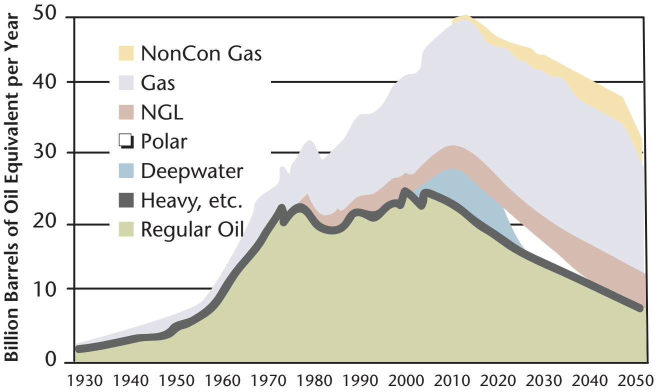


There is an irony about depleting a finite resource:
*The better you are at doing the job, the sooner it ends.*

Figure 2

**Oil and Gas Production Profiles**

2005 Base Case




Note: Regular oil excludes oil from coal, shale, bitumen, heavy, deepwater, polar and gasfield natural gas liquids (NGL).

## Preparing for Declining Supply

Much study and debate has been dedicated to determining the date of peak production, but that really misses the point. It is not an isolated or high peak, but merely the maximum value on a gentle curve. What matters, and matters gravely, is the vision of the long, remorseless and relentless decline that comes into sight on the other side of the peak.

That said, the peak does represent an unprecedented turning-point of magnitude marking the shift from growth to decline. It is very difficult for classical economists to accept this, as the notion that the market must always deliver is deeply entrenched in their thinking. They rightly remind us that the Stone Age did not end for want of stones as man found bronze, iron and steel as better materials for tools and weapons. But the decline of oil arises from natural depletion not from the entry of better substitutes. Many people try to reassure themselves in the belief that new technology or new investment will keep the oil and gas flowing, but there is an irony about depleting a finite resource: *The better you are at doing the job, the sooner it ends*.

The transition to decline threatens to be a time of great international tension. The major consuming countries will vie with each other for access to supply, most of which lies in just five countries bordering the Persian Gulf, one of which has already been invaded.

The conditions that will unfold during the Second Half of the Age of Oil appear dire, and for that very reason deserve serious attention *(see Campbell's 2005 book,* Oil Crisis*, Multi-Science Publishing, ISBN 0906522-39-0, for further discussion)*. It looks as if virtually all companies quoted on the stock exchange are overvalued insofar as their accounts tacitly assume a business-as-usual supply of energy, which is no longer justified. Does this point to a second Great Depression, perhaps accompanied by rampant inflation to remove excess financial capital as debt loses its oil-based collateral? Does it mark the end of economics as presently understood? The world's population expanded six-fold exactly in parallel with oil, posing the awful question of how many people the planet can support without oil.

These are serious questions, and there is certainly no solution in terms of finding enough new oil and gas to prolong the past epoch. But there certainly are responses by which to plan and prepare. It is not difficult to formulate some useful steps:

**1) Evaluate the Real Resource Situation.** In this way, we can avoid being misled by erroneous forecasts promulgated by international organizations that are under political pressures.

**2) Educate Users.** Undertake a massive program of public education, so that everyone may become more energy-conscious and find ways to be less wasteful. Eventually, an efficiency factor could be incorporated into utility and fuel charges to penalize the wasteful and encourage the efficient. The transport system, in particular, demands urgent attention.

**3) Ramp Up Renewable Energy.** Encourage the rapid development of renewable energies from tide, wave, solar, wind and other sources, including the growing of energy crops.

**4) Reconsider Nuclear Energy.** Reevaluate the nuclear option, provided that it can be made safe and the waste-disposal issue can be resolved.

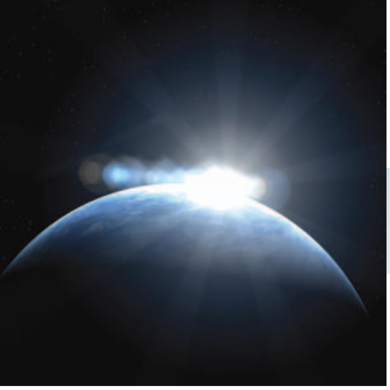
**5) Reduce Imports to Match Depletion Rates.** Arrange for importers to cut their oil imports to match world depletion rates, namely annual production as a percent of what is left, currently standing at 2 to 3 percent.

Of these, perhaps the last item deserves most attention. Such a policy would have the effect of reducing world oil prices by putting demand into balance with supply. The poor countries of the world would be able to afford their minimal needs, and profiteering from shortage would be avoided. The cost of producing oil has not changed materially, so the high prices reflect profiting from shortage, especially by Middle East governments. That in turn gives rise to massive destabilizing financial flows threatening an already fragile system.

Above all, it would force the consumers to face the limits imposed by nature. There are several options for practical implementation, but some form of rationing would seem to be the fairest (e.g., David Fleming's proposed system for tradable energy quotas, described at www.teqs.net). Energy might even develop into a form of currency. Whereas the Kyoto Protocol on climate change requires universal acceptance to work, an Oil Depletion Protocol would not be so dependent, because the countries that adopted its measures would soon find themselves having an enormous competitive advantage over those that continue to live in the past.

Despite the challenges, we may hope at the end of the day that a new benign age will unfold, as people again come to live in communities with a better respect for themselves, their neighbors and the environment in which nature has ordained them to live. Leading happier and simpler lives, mainly in rural circumstances, they may look back and realize that oil, and the excessive free energy it released from fossil sunshine, had been more of a curse than a blessing. ●

*C.J. Campbell is the chairman and founder of the Association for the Study of Peak Oil and Gas (ASPO), which is expanding throughout the world. He started his career in the oil industry as an exploration geologist, ending up as an executive vice-president. His career took him to many countries, giving him a breadth of experience on which his views are based. He is the author of five books on oil depletion as well as many scientific and other publications, being now in demand for radio and TV. Contact him at aspotwo@eircom.net.*



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# IMAGINE

Picture a world where peace, health and prosperity reign. It's no utopian vision, but one built on renewable energy.

By **Thomas J. Starrs**

Imagine the United States a century from now, as a society that produces virtually all of its energy from clean, domestic, renewable energy resources. What does it look like, and how is it different from the one we live in today?

In 2106, there are those who bemoan the loss of cheap oil, who long for the days when a gallon of gasoline cost less than a gallon of milk. But access to cheap oil came at a steep price: the price of dependence on countries that were politically unreliable and economically unstable; the price of climate disruption and its economic and environmental costs; perhaps even the price of our principles, as we spoke of promoting democracy while propping up tyrannical monarchies and other oppressive regimes.

For those of us with no stake in a continued reliance on fossil fuels, however, the 22nd century holds enormous promise for world economies, national security and the personal health and economic well-being of our children and children's children.

The stark contrast between this new century and the last is apparent in many aspects of our lives.

## Exchanging Resource Conflicts for Security, Jobs and Health

*It is more economically stable.* The incredible volatility associated with the Oil Era — particularly with its waning years — is now a thing of the past. Energy prices are predictable and stable, because the energy is derived from the natural flows of the sun, wind and rain. Even transportation — the sector of the economy that found it hardest to wean itself from the petroleum diet — has made the transition. Pedestrian-friendly cities and economies built around locally produced products have drastically reduced reliance on transportation, but what public transportation and shipping fleets remain are powered by liquid fuels derived from dedicated biomass feedstocks and by hydrogen derived from renewable electricity.

*It is more secure.* The stranglehold that the Middle East and former Soviet states had on the industrial economies of the world during the late 20th and early 21st century is broken. The dramatic growth in energy efficiency and renewable energy that started late in the 20th century was sustained for decades. The countries that had been highly dependent on oil and gas imports — including the United States, the European Union and much of Asia — can promote political ideals without the hypocrisy of having to prop up tyrannical, antidemocratic governments simply because they controlled access to strategic energy resources. For the world's military powers, it has meant huge reductions in spending, as the Oil Wars of the early 21st century gave way to the peaceful and profitable transfer of new energy technologies. Progress toward demilitarization was threatened briefly by proposals to increase reliance on nuclear energy, but the inherent risk of nuclear weapons proliferation resulted in the adoption of a global ban on nuclear power by mid-century. In short, conflict has given way to collaboration and competition, and the big winners are the countries that focused on research, innovation and manufacturing to support the new energy paradigm.

*It is more democratic and egalitarian.* The means of production for this new, sustainable energy era are quite evenly distributed across the world, both in terms of available resources and the technologies used to harness those resources. Of course, some of the world's renewable resources are geographically concentrated, such as the geothermal energy reserves around the Pacific Rim's Ring of Fire. But others are virtually ubiquitous — particularly solar energy, which is dispersed with cosmological consistency across the earth's surface. The universal availability and affordability of renewable energy resources has brought greater economic parity within and among societies, drastically reducing world poverty

NREL

In the renewable energy-based society of 2106, forest and stream health has improved, and wildlife populations are rebounding from early-century lows.

A future based on renewable energy holds enormous promise for world economies, national security and the personal health and economic well-being of our children and children's children.

> The effect of the transition on communities and commerce will be dramatic.

and hunger. Solar water pumping and solar-powered disinfection alone have added substantially to life expectancies in what had been called the developing world; and universal access to cyberspace — the distributed information and communication networks that superseded the Internet — has eliminated disparities in access to education, research and other knowledge.

The big change in the new century, however, is that the U.S. and other governments have developed trade alliances based on the transfer of energy technologies used to harness local energy resources, rather than the shipment of the resources themselves, as was the nearly universal practice during the Oil Era. Instead of importing oil, countries now import the blueprints for improved photovoltaic manufacturing facilities or design specifications for a wind turbine blade that is optimized for local wind conditions. One implication of this profound shift: The manufacturing of the equipment and the deployment of the products uses much more local labor than the import of energy commodities ever did.

*It is more affluent.* The nations that were largely dependent on oil imports have stopped hemorrhaging money overseas. The United States alone was sending about a quarter of a *trillion* dollars abroad every year to pay for oil imports early in the 21st century. Now those dollars stay at home and get recirculated in the national economy. And because the energy economy is now tied to locally available renewable resources, jobs in those industries are hard to outsource. The agricultural sector has been rejuvenated, with farming communities busily tending to rows of wind turbines as well as rows of corn.

*It is cleaner, healthier and more environmentally benign.* In the prior century, electricity generation was the world's largest source of industrial pollution. Now, most electricity generation is emissions-free. The remainder, based on biofuels, uses advanced catalytic controls to eliminate virtually all pollutants and requires reforestation or replanting to ensure carbon-neutrality. The building sector's heating and cooling loads have been radically reduced through improvements in design, materials and orientation. Homes use virtually no external energy, since on-site solar energy supplies all necessary daylighting, hot water, space heating and electricity. Even the transportation sector has virtually eliminated air pollution, through the shift to biofuels and hydrogen. The retirement of most hydrocarbon technologies stabilized the level of carbon dioxide, one of the principal greenhouse gases, by mid-century. The level has been dropping slowly in the decades since. The health benefits of this transition have astonished the medical community, as the incidence of respiratory diseases such as asthma and emphysema has plummeted. The term "smog" has become archaic, since the air quality in most cities rivals that of the surrounding countryside. And speaking of the countryside, forest and stream health has improved, and wildlife populations are rebounding from early-century lows.

## Transitioning from Ruin to Renaissance

Perhaps this description makes the 22nd century seem idyllic and utopian. But some harsh realities underlie this transition.

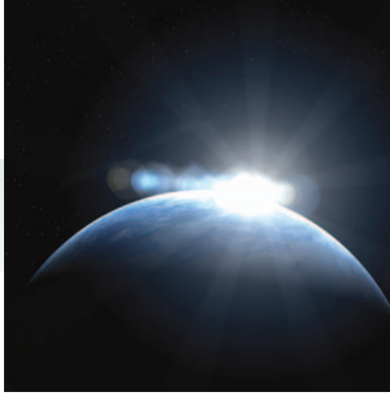
First of all, the intervening years — during which the transition was made — were painful, even devastating. Global warming's early victims included the low-lying Pacific Island nations and the Florida Keys, both of which were inundated by mid-century as rising sea levels took their toll. The Floridians lost their homes; the Pacific Islanders lost their countries. The United States, last among the industrialized countries to abandon the Oil Era, paid the price for having the most energy-intensive economy among countries in the Organization for Economic Cooperation and Development: Its economy shuddered, and nearly collapsed, as rising energy prices made its products uncompetitive and obsolete, since global markets rewarded the countries that had made the transition early, squeezing the most out of each unit of energy they used. And then there were the Oil Wars. …

Second, although the transition to renewable fuels has been completed and energy is abundant, some fuels are much more expensive. The effect on communities and commerce has been dramatic. Cities have reorganized around their urban centers, with dense communities surrounded by greenbelts used for agricultural production. Suburbs, which lost their attraction as the cost of commuting skyrocketed, have become the new slums. Air travel is expensive and exotic, available only to the most affluent. The result is that families tend to be less mobile, and businesses focus on building relationships with materials suppliers and customers closer to home. At the same time, communications networks have expanded, further enabling the flow of information globally, even as the flow of people and materials has slowed.

This communications revolution has reinforced perhaps the most fundamental shift in the global economy, which is that the greater exchange of information and ideas more than offsets the reductions in exchange of resources and other materials. No longer is it common for goods manufactured in China to be sold in the United States, but ideas and technologies developed in China are marketed to the United States — and vice versa. The result has been a renaissance of ideas, with global affluence rooted in entrepreneurship and innovation, rather than in the ownership and control of natural resources. With this renaissance has come world peace and prosperity, based on equitable resource allocation, abundant supplies of food and water, and record improvements in health and mortality.

This new paradigm has also revitalized the U.S. economy, which lagged behind the rest of the industrialized world in weaning itself from fossil fuel resources, but which rose like the Phoenix from the ashes of the Oil Era and emerged as a leading global innovator and developer of new energy technologies and systems. For 22nd-century Americans, life has never been better or more hopeful. ●

*Thomas J. Starrs is the immediate past chair of the American Solar Energy Society board and is vice president for marketing and sales at the Bonneville Environmental Foundation. He can be reached by e-mail at tomstarrs@b-e-f.org.*



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# TRANSITIONING TO A NEW PARADIGM

Now is the time to establish a strategic plan to address the inevitable end of cheap oil.

By **Roscoe G. Bartlett**

Oil runs our economy. Oil runs our military. Oil makes and transports the food that we eat. That's why it makes no sense for our country to wait for global peak oil to impose a radical and permanent end of cheap oil.

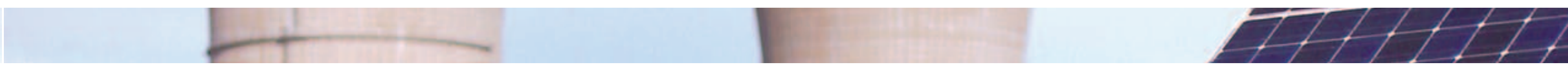
Oil production reached a maximum, or peak, in the United States in 1970. It has declined every year since. Oil production has also peaked in 33 of 48 major oil-producing countries. Many experts predict that global peak oil is imminent. Chinese government officials have projected global peak oil in 2012. The Department of Energy's Energy Information Administration estimates global peak oil won't occur until 2037. Only the timing of global peak oil is in dispute among energy experts, but the year won't be known until after it has occurred. Energy advisor Robert L. Hirsch in his recent *World Oil* article cautions that peak oil was not apparent in the 48 continental United States, Great Britain or Norway one year in advance *(see http://worldoil.com/magazine/MAGAZINE_DETAIL.asp?ART_ID=2696&MONTH_YEAR=Oct-2005)*. A 1999 National Petroleum Council report failed to predict the apparent 2005 peak in North American natural gas production.

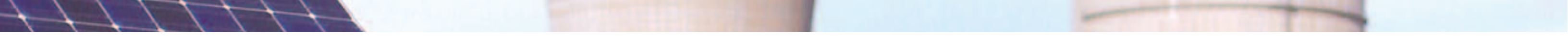
From 2003 to 2004, the average increase in oil consumption in Belarus, Kuwait, China and Singapore was 15.9 percent. With worldwide demand increasing, what effect would a decline in oil supply from global peak oil have on oil prices? The National Commission on Energy Policy and Securing America's Future Energy issued a report on Sept. 6 titled, "Oil Shockwave" *(access the report at www.energycommission.org)*. The commission estimated a 4 percent sustained shortfall in global oil supply would raise the price of oil above $160 per barrel.

## Our Spiraling Energy Appetite

Our country is much like a young couple whose grandparents died and left them a big inheritance. They have established a lifestyle where 85 percent of all the money they spend comes from their grandparents' inheritance, and only 15 percent comes from their earnings. They realize at the rate they are spending the inheritance it will run out long before they retire. Obviously, they are going to have to spend less money, earn more money or do both.

That is a good analogy for energy use in our country. Eighty-five percent of the energy we use comes from natural gas, oil and coal. Only 15 percent comes from other sources. A bit more than half of that 15 percent, 8 percent, comes from nuclear. Global peak oil will impose a transition from today's 85/15 ratio to generating a major proportion of our energy from renewable sources such as solar, wind and agricultural sources.







These renewable sources contribute trifling amounts of current U.S. energy use. Since the year 2000, solar and wind power have increased approximately 30 percent per year. At that rate, solar doubles in about two-and-a-half years. It is four times bigger in five years. So, how much has solar grown in five years? In 2000, it was 0.07 percent of total U.S. energy use. That is less than one-tenth of 1 percent of the energy Americans consume. In five years, solar has grown to 0.28 percent. It is now a little over one-fourth of 1 percent. If solar and wind continue to grow at the same rate, they would increase four times, to more than 1 percent of our energy use by around 2009.

According to a recent report, a 4 percent sustained shortfall in global oil supply would raise the price of oil above $160 per barrel.

Agricultural sources currently contribute 1 percent of total U.S. energy use. How much more can they contribute? When the oil era began about 100 years ago, world population was 1 billion. Now, it is nearly 7 billion. We're barely able to feed the world. If we use food crops like corn or sugarcane for energy, how will we feed the world? If we take other organic material considered waste such as beet pulp, corn stover, soybean stalks or switch grass to make energy, we will take away the organic material that creates topsoil. How will we maintain the topsoil to grow the crops to feed the world? The U.S. population is increasing by nearly 30 million persons every decade. These are all limitations to expanding energy production from agricultural sources.

## It Takes Energy to Make Energy

How much energy does it take to get 1 barrel of oil? You have got to discover it. You have to pump it out. You have to transport it and refine it. You have to transport the refined products to gas stations or customers. These processes consume an average of 0.23 Btu (British thermal units) of fossil energy inputs to produce one net Btu of refined product.

Almost half of the energy input to make a bushel of corn comes from nitrogen fertilizer. Essentially the only source of nitrogen fertilizer today is natural gas. When natural gas is gone, we are going to have to find another big energy source to produce nitrogen fertilizer. In a real sense, the food we eat is gas and oil.

## Register Your Support

Your voice matters. Contact your elected representatives and urge them to support efforts for vast improvements in energy productivity to enable transition to domestically available, pollution-free renewable energy. Access Project Vote Smart to search by zip code for your elected representatives in the U.S. House, U.S. Senate, and state house, senate, and executive offices: www.vote-smart.org.

The energy density in 1 barrel of oil is the equivalent of 12 people working full time for one year. A barrel of oil yields 42 gallons (159 liters) of gasoline. Think about how far 1 gallon (3.8 liters) of gas takes your car. How long would it take you to pull your car that far? That is an example of energy density. It also demonstrates that global peak oil poses the greatest threat to the transportation sector. There are no ready liquid fuels substitutes of comparable quantity and energy density to oil for use in transportation.

## A Call for a New Paradigm

Until now most of the focus has been on how to "fill the gap." That is, how can we find enough other energy sources to continue to meet growing demand? The Department of Energy's February 2005 commissioned report, "Peaking of World Oil Production: Impacts, Mitigation and Risk Management," concluded that a crash program to manufacture current available liquid fuel alternatives at the maximum rate would have to be initiated 20 years before global peak oil to avoid significant supply shortfalls. *(Access www.energybulletin.net/4638.html.)*

It might seem possible to "fill the gap" in the short term. However, in the long term, it will be impossible. For one thing, doing so will hasten the exhaustion of other finite resources. That will make the inevitable transition to renewable sources more difficult and more painful.

For instance, there are 250 years of coal in the United States under current use rates. If that consumption rate is increased by 2 percent per year, coal reserves are reduced to 85 years. If coal is converted to a liquid fuel for transportation, the reserves are reduced to 50 years.

That is why I propose a new paradigm. We need to recognize that "filling the gap" is futile. We will have competing demands for limited resources of time, capital and energy. The challenge we face is a transition to an economy in which we have reduced our energy needs to a level that can easily and affordably be met with sustainable energy resources.

First, and most urgently, we must raise awareness about the impending crisis from global peak oil. Congressman Tom Udall (D-N.M.) and I have formed a Peak Oil Caucus and introduced H. Res. 507, a bill that states that "the United States, in collaboration with other international allies, should establish an energy project with the magnitude, creativity, and sense of urgency that was incorporated in the 'Man on the Moon' project to address the inevitable challenges of 'Peak Oil.'" Congressman Udall and I testified at the first hearing about peak oil held by the Subcommittee on Energy and Air Quality of the House Energy and Commerce Committee on Dec. 7.

With sound information, proactive planning and preparation we can overcome the challenges of peak oil. If we do not prepare, we will still transition to other sources as oil and other fossil fuel reserves are exhausted. However, if we wait for global peak oil to force the transition, we face a really bumpy ride.

*Congressman Roscoe Bartlett is a seven-term representative of the Sixth District of Maryland. He has discussed peak oil extensively in a series of 14 special order speeches and hosted an energy conference on Sept. 26. Transcripts, including charts, are posted on Congressman Bartlett's website at www.bartlett.house.gov.*

# Making the Transition

A sampling of excerpts from **proposed roadmaps** for getting to a sustainable energy paradigm.

*Compiled By* SOLAR TODAY *Staff*


### *Common Sense: Making the Transition to a Sustainable Energy Economy*

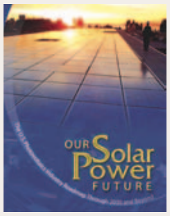
American Solar Energy Society
www.ases.org/print_catalog/ases_reports/PS_Common_Sense.pdf

*"What ASES is proposing is possible and could be implemented by [Congress] over the next two years. Many of the recommendations, such as a national Renewable Energy Standard (RES) and a Renewable Fuel Standard (RFS), reflect proposed legislation that has been debated but not acted on for nearly a decade. … ASES' principal recommendation, however, is that the political leadership of the country at federal, state and local levels act now to begin the transition to a clean domestic energy standard."*

### *Renewable Energy in America: The Policies for Phase II*

American Council On Renewable Energy
www.acore.org/download/phaseII_forum_summary.pdf

*"Public policy leadership in Phase II [must] come from state and local governments, but also, there must be federal leadership to facilitate the spectrum of strategies, policies, and programs. Indeed, the shift from Phase I — a clean and neat funding of RD&D through traditional government funding mechanisms — to Phase II, where policy must accommodate the breadth of differences across a huge nation, will be a great challenge, and worth our best efforts."*



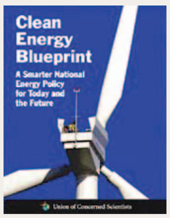

### *Our Solar Power Future: The U.S. Photovoltaics Industry Roadmap Through 2030 and Beyond*

Solar Energy Industries Association
www.seia.org/roadmap.pdf

*"[W]e propose a roadmap that tailors R&D programs to create market solutions, enhances pollution prevention approaches to focus on clean alternatives, ensures customer choice, and provides targeted incentives that seed the market without destroying it. Based on experience in the United States, Japan, and Europe, the actions we propose represent the best and most effective options to achieve these targets."*

### *Clean Energy Blueprint: A Smarter National Energy Policy for Today and the Future*

Union of Concerned Scientists with the American Council for an Energy-Efficient Economy and the Tellus Institute
www.ucsusa.org/clean_energy/renewable_energy/page.cfm?pageID=44




*"UCS and its co-authors analyzed a set of policies that includes standards and incentives to increase investment in clean energy by consumers and the electricity sector and to help overcome existing market barriers that currently slow investment. … The analysis reported here examines the following 10 renewable energy and energy efficiency policies [including] renewable portfolio standard; public benefits fund; net metering; production tax credit; increased R&D funding; [and] improved efficiency standards."*

## Partners for Change

***A sample of U.S. organizations whose mission is to address the peak oil challenge.***

The Community Solution
**www.communitysolution.org**

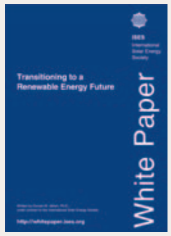
Post Carbon Institute
**www.postcarbon.org**

Association for the Study of Peak Oil & Gas – USA
**www.aspo-usa.org**

Access a more complete listing of organizations focused on creating a sustainable energy future at www.solartoday.org/2006/mar_apr06/roadmaps.htm.

### *Transitioning to a Renewable Energy Future*

International Solar Energy Society
www.whitepaper.ises.org




*"Governments need to set, assure and achieve goals to accomplish simultaneously aggressive efficiency and renewable energy objectives. The implementation mechanisms for achieving these goals must be a packaged set of mutually supportive and self-consistent policies. The best policy is a mix of policies, combining long term renewable energy and electricity standards and goals with direct incentive and energy production payments, loan assistance, tax credits, development of tradable market instruments, removal of existing barriers, government leadership by example, and user education."*

### *A Responsible Energy Plan for America*

Natural Resources Defense Council
www.nrdc.org/air/energy/rep/rep.pdf

*"The cornerstone of NRDC's plan to secure America's energy future is increased energy efficiency. Not only is energy efficiency free of environmental impacts, but it is also by far the cheapest way of meeting our energy needs. The efficiency improvements we recommend do not rely on pie-in-the-sky, undeveloped technologies, but on readily available and cost-effective processes that allow us to gain more productivity out of less energy."* ●