APOLLO 2

SOLAR ENERGY MEETS THE NEW GLOBAL CHALLENGE

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ABSTRACT

Humanity faces imminent and serious global oil shortages.[1] It is urgent that the solar energy community respond aggressively to fulfill its central role in the transition from a transitory fossil-fuel economy to a sustainable solar future. The intention here is to explain and quantify the oil shortfall, to validate the renewable option, and to calculate the rate at which the capacity of the renewable energy industry must accelerate to counteract the predictable oil deficit.

Keywords: Apollo 2, global oil crisis, Acapulco effect, future scenarios, energy payback time, energy profit ratio

INTRODUCTION

Environmentalists and energy professionals share the common understanding that petroleum is an exhaustible resource -- that sooner or later humanity must abandon the use of this remarkable substance as a fuel and devise other means to energize society.

Since the early days of its exploitation, many "experts" have erroneously predicted the imminent collapse of oil supplies, so much so that any new evidence of an impending crisis is likely to be summarily dismissed as false. On the other extreme, there are many "experts" who offer assurances that there is plenty of oil available so long as the marketplace is willing to pay the right price. In the midst of this confusion, even though oil production in certain countries (USA, Russia, Indonesia, etc.) is already in decline, nonetheless the timing and implications of the global "rollover" -- when overall oil production begins to decline once and for all -- remain elusive.

It is reasonable to expect the general population to assume that "they -- the scientists" will take care of things -- that technology will magically emerge when needed, without any interruption of the energy services which have long been taken for granted. However, solar energy professionals are those "scientists" upon whom society will depend for solutions. Considering the essential role of solar energy as humanity prepares for an economy beyond oil, it is crucial that this community of solar professionals become informed of the timing and significance of the coming decline in global oil production. For, if there are 50 years left to address such a dramatic change, then one can comfortably carry on with research and ignore the messy details of the marketplace. If, on the other hand, oil production is about to decline, even as developing countries around the world clamor for more oil in order to emulate the lifestyles of the highly industrialized nations, then the solar industry must become prepared to meet enormous demand, far beyond current expectations.

Based on extensive research and regular correspondence with leading geologists around the world, the author has concluded that oil production will begin to decline inexorably sometime during the first decade of the 21st century.[2] This does not mean that all the oil will be gone by 2010. It means that, if humanity is to meet both the oil shortfall and the growing demand for the services that oil provides, then serious mass production of solar / renewable energy solutions must begin in earnest immediately.

Details and references are cited here to provide sufficient information for readers to draw their own conclusions about the impending peak in oil production. Then, based on the author's conclusion, consideration will be given to the forms of renewable energy which are thermodynamically attractive and the rate of growth which industry must sustain to avert a crisis.

DECLINE OF OIL PRODUCTION

One way to see the impending decline of oil production is through the lens of regional conditions:

- Oil reserves in the Caspian Sea region are unlikely to meet current high expectations. Disputes over oil rights in the region (e.g., Russia vs. Chechnya[3]) will not be settled soon. Pipeline issues will continue to generate unrest in the region and thwart production. After much fanfare over "huge new discoveries," some oil companies have already pulled out due to poor results from exploration.[4]
- Oil production in the North Sea is about to decline.[5] Once relatively efficient, Britain's transportation system has become increasingly dependent on oil over the past 25 years. The British have only 250 barrels per capita remaining, much of which it will be tempting to export to prop up an unsustainable economy.[6]

OBSCURITY OF THE FACTS

If the oil peak is coming so soon, why is this not generally known?

- **Subsidies:** The industry is cushioned by massive subsidies.[7] This hides reality from the general populace and protects politicians from challenge.
- **The Oil Industry:** Wall Street's emphasis upon quarterly results forces company executives to focus attention on results within very short time horizons. Furthermore, sharing of strategic information is not encouraged by the corporate culture, so only recently has someone done the cross-industry accounting necessary to develop the hard facts.[8]
- **Oil Prices:** The low global price of oil, a false signal of ample supply, is largely the result of a faustian bargain between the monarchy of Saudi Arabia (the largest supplier) and the USA (the largest consumer). The US government lends money to the monarchy for weapons in exchange for the assurance of cheap oil. The little known consequence is that oil-rich Saudi Arabia is one of the most indebted nations in the world, and its oil field infrastructure is in a woeful state of neglect.[9]
- **OPEC Quota Wars:** in the 1980's, OPEC members reported large exaggerated reserves totaling over 300 Gb (Gigabarrels).[10] Some of those stated reserves represent real oil, but probably over 200 Gb are strictly on paper, about 1/4 of currently published global reserves.
- **"Acapulco effect":** To this day, the impact of a large discovery on the private lives of those involved is such a compelling story for the media that the anecdote prevails over meaningful statistics. (Careful accounting is never a glamorous story.) A discovery of 100 million barrels may buy someone a ticket to a life of leisure in Acapulco but it covers less than 2 days of global consumption.
- **Politics:** Politicians don't want the crisis to occur on their watch. It happened to Jimmy Carter and no USA president since has dared to suggest more than an embarrassingly modest tax on oil. Justifiably, politicians will go out of their way to avoid rioting in the streets. So it is easier to promise cheap prices than to save some oil for their successors in office to bargain with. But the day of reckoning comes. This is not theory -- it happened in 1998 in Indonesia.[11]
- **Solar Industry Weakness:** The solar energy industry perceives itself as weak, and solar professionals do not want to sound the alarm for fear of losing whatever limited credibility the industry has. The voice of those who know the facts is quiet in comparison to the excitement and cacophony of the dot-com culture.
- **Psychological Resistance:** Confronting the demise of an economic era is no more exciting than contemplating one's own death. It is more comfortable to live for the moment. After all, those who could make a difference do not (yet) suffer as their children will. Just the same, a drastic change is likely to happen soon enough to affect most people living today.

FUTURE SCENARIOS

Since fossil fuels affect air quality and arguable contribute to the threat of global warming, some environmentalists are known to say, "Okay, so let's just use up the oil and get it over with; we'll be better off." Unfortunately, along the way to climate stabilization, clean air and sustainable global energy systems, the decline of oil will have dire consequences for humanity, long before global warming has the serious impacts that many predict:

- **The first sign:** Certain economies dependent upon oil will weaken as reserves diminish and production declines. A case in point, Indonesia, having already used up 3/4 of its oil, had energy riots in 1998.[12] As mentioned above, during the first decade of the new century, the North Sea fields will go into steep decline. (Due to the physical challenges, offshore oil gets harder to pump as production tapers off. Furthermore, the dismantling of oil derricks often costs more than $100 million.) "Great" Britain, with 60 million people, will be amongst the first western economies to feel the pain.
- **Air Travel:** As the price of oil rises, air travel, especially for pleasure, will become prohibitively expensive. Island economies based on tourism are likely to be amongst the first to suffer.
- **Another consequence**: Car-pooling will become the norm and one-person commuting will become an anomaly. Investments in road widening will be laughable -- traffic will decline dramatically and rapidly. Innovation in the auto industry will not be able to keep pace with the demand for fuel efficiency -- "There is hardly time for a model change," according to one industry leader.[13]
- **Food shortages:** With more than 7.5 calories of oil embodied in every calorie of food produced by western industrial agriculture[14], entire economies will be challenged -- oil will be rationed and subsidized for food production. This may happen by 2010 and is likely by 2020.[15]

When will it begin to happen?

Rightfully, the solar energy industry does not want to be accused of promoting gloom and doom just in order to sell products. On the other hand, it is irresponsible to ignore danger or withhold information, especially if one has privileged access. Suffering from the decline of oil is not a fiction; it has already been experienced. It happened in the USA in the 1970's, when people were shot in gas lines; it happened in Cuba in the early 1990's, when Russia cut off its highly subsidized oil supply; it happened in Indonesia in 1998, as noted above. If one challenges the social equity of oil for SUV's at the expense of oil for agricultural production, then a shortage of oil is

manifesting itself through the starvation occurring now in parts of Africa and elsewhere.

Considering the lack of awareness and dependency on oil, Western cultures are likely to come to share in this experience of mass starvation. Humanity may face these consequences within only ten years when oil production goes into serious decline.

MEETING THE CHALLENGE

The challenge to reach the moon was called the Apollo project. An aggressive program is proposed to avert a colossal global energy crisis, by employing terrestrial solar energy development, to be called **Apollo 2**. Humanity can meet this challenge, but the challenge is daunting. To illustrate, attention will be given to two renewable technologies, photovoltaics and wind turbines:

- **PV:** To meet only 20% of the oil shortfall by using photovoltaics ("PV"), the PV industry must ramp up 40% per year steadily for 20 years.[16] This rate of growth is extraordinary for any industry. (See figure 1.)

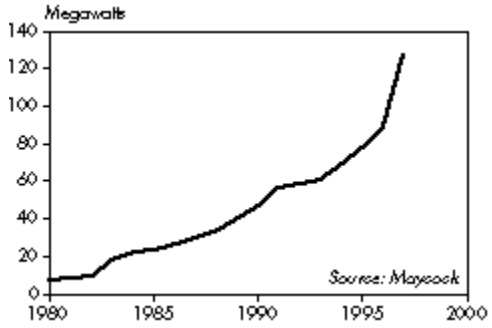

Figure 1
Rising Production of PV

- **Wind:** To meet only 20% of the oil shortfall by using wind energy, the wind turbine industry must ramp up 25% per year steadily for 20 years.[17]

It is through a massive effort on the part of millions of people that global challenges have been met. This happened in modern times, when the first major oil war occurred: World War II involved the struggles of Germany for Russian oil and Japan for Indonesian oil.[18] The next "war" can be a civilized effort against energy deficiencies or it can become another violent war of nation against nation. There is precious little time to mobilize if humanity would choose the lighter path. Such a mobilization would depend upon a radical shift in the mentality of the solar industry, from being apologists for a whimsical technology to leaders in the challenge to avert a global economic and political meltdown

NEXT STEPS

There are several steps to growth in the renewable energy industry that are needed to meet this challenge:

- **Sound the alarm:** Make the danger clear, and do not shirk the responsibility out of fear of being accused of exaggeration;
- **Capture growth:** In emerging economies such as China, India, Mexico, etc., there are increasing pressures for growth of energy infrastructure. Focus investment in such areas, where energy growth will be rapid and extensive;
- **Educate:** youth, the general public, public policy-makers, and decision-makers in business;
- **Invest:** Make significant capital investments in renewable energy production capacity and the installed base of energy-producing hardware. For example, $500 million is a common investment for the manufacturing industry, but to date there has been no such single investment for PV or wind energy manufacturing. An investment of this scale in plant and equipment would dramatically improve the cost of manufacturing;
- **Lobby:** Increase the industry's lobbying strength;
- **Technology:** Advance scientific knowledge, improve industrial processes and improve the energetic performance of energy-producing devices.

CAN IT BE DONE?

It is easy to say that cost-cutting would also accelerate growth. Granted, the solar energy industry is justifiably concerned about reducing the high cost of solar systems. However, in terms of long term potential, cost accounting can be quite misleading. Fossil fuels[7] and nuclear energy are directly and indirectly subsidized, so the cost of renewables is not a fair measure. To get a long term perspective, one must examine the ***energy*** cost of producing energy.

Energy Profit Ratio / Energy Payback Time

In the solar energy community, aperture efficiency is usually given the greatest attention as a measure of energy cost. However, aperture efficiency is only the measure of a device's instantaneous performance, and this can obscure the net energy produced over a lifetime of service. Two similar measures, Energy Profit Ratio ("EPR") and Energy Payback Time ("EPBT"), can give a better picture of the long term effectiveness of any energy technology.

EPR is defined as the energy content of a fuel or device divided by the energy spent producing it. So, an EPR of 1 means that it takes a kilowatt-hour to produce a kilowatt-hour, or a barrel of oil to obtain a barrel of fuel, yielding no net gain. The EPR of a giant oil field in its prime can be in the range of 30-50. On the other hand, tar sands, which are abundant, yield their oil with an energy profit ratio of about ***2***.[19] This poor yield is also accompanied by extensive environmental damage, and clearly contributes proportionately more to greenhouse gases than conventional oil production. Tar sands may have a

place in our future as feedstock for chemicals, but as a major source of energy, they represent a very poor choice for humanity, in spite of the abundant supply.

EPBT is the time it takes to recover the energy invested in making a device. For example, for wind energy systems, EPBTs of two to three months have been claimed.[20] For PV, EPBT's of 8 years on the high side for the older style crystalline panels and roughly 2 years for thin film, ribbon growth and concentrating systems have been claimed, depending upon such factors as the specific PV technology in use and the insolation at the installed location.[21] Using EPBT and an estimate of the useful life of the device in question, an EPR can then be calculated.

Declining EPR for Oil

As oil fields go into decline, their EPRs also decline. Translated into energy terms, enhanced oil recovery means low EPR's, below 10 and typically no better than 3. As a field declines, eventually so much energy is used in coaxing oil out of the ground that net yields become insignificant. This transformation can be seen, for example, in the case of Louisiana oil fields, where an overall EPR of 30-40 in the 1960's and 1970's declined to less than 10 by 1990.[22, 23]

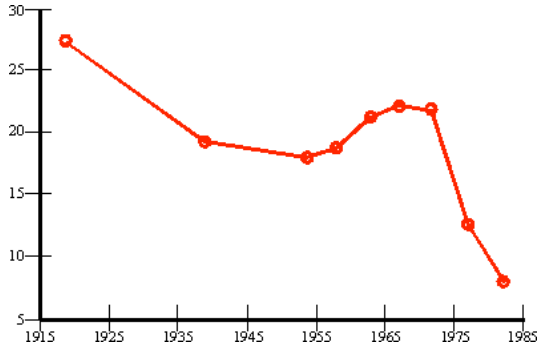

Figure 2
Declining EPR for Oil

Improving EPR for Renewables

Meanwhile, as the overall EPR for oil has declined, the EPR for wind energy and PV has continued to improve. In the 1970's, when PV production was very modest, it is likely that more energy was consumed by workers while commuting than was ever delivered by the panels they produced. Now, assuming a useful life of 30 years, older PV technology has had EPRs in the range of 4, and newer PV systems promise to yield EPRs above 15, better than declining oil fields still in production. Similarly, wind energy systems give clear indications of EPRs exceeding 50, comparable to oilfields in their prime. This means that energy investments in renewables now perform as well as or better than comparable energy investments to exploit oil. In other words, a barrel of oil invested in making a wind generator or a PV panel makes more sense in terms of net energy gain than investing it in pumping and drilling for oil. The implications for broad adoption of renewables are profound.

WILL RENEWABLES BE ADEQUATE?

This question can be raised with respect to many sectors of the economy, but nowhere will the impact of oil shortages be felt more profoundly than in agriculture and transportation. If solar and wind energy technologies are largely geared to producing electricity, how can they possibly meet demands in agriculture and transportation where high energy density fuels are so critical? It seems evident that for agriculture and heavy freight hauling, alternative fuels will be synthesized until other solutions emerge. But for urban transportation, electricity is profoundly more attractive than fossil fuels. While it may take 25 years or more to convert from the present use of highly polluting fossil-fueled automobiles in urban areas, conversion to electric-powered mass transit and autonomous electric vehicles is inevitable. Fifty years from now, a gas-guzzling car on urban streets will seem as incongruous as a campfire in a modern kitchen. It might be fun for urbanites to sit around a campfire at night when camping, but it would be very unpleasant on a regular basis. Similarly, once electric vehicles have a significant presence in the fleet, fossil-fueled cars will begin to seem out of place.

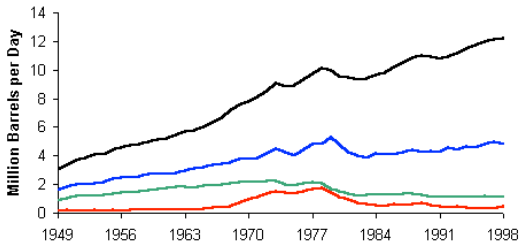

Figure 3
USA Oil Consumption by Sector
Cumulative from top: Transport, Industry, Buildings, Electricity

In agriculture, ocean shipping and air travel, humanity faces serious adjustments. It is none too soon to begin seeking renewable energy solutions in these realms. An example of an alternative to air travel is the revitalization of commercial sailing where kites have been proposed to propel large cargo ships.[24]

CONCLUSIONS

Renewable energy technologies hold great promise to meet humanity's energy needs. However, to avert global economic disaster due to the imminent decline in oil production, the renewable energy industry must ramp up aggressively over the next twenty years. To become cost effective in this effort, the industry must give priority to technologies that have attractive Energy Profit Ratios. Such technologies exist, and astute investors will increasingly make decisions in favor of technologies with high energy yields.

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