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PROSPECTS FOR INVESTMENT IN SOLAR ENERGY

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DISCLAIMER

Let me begin by telling you something about the Solar Energy Research Institute, usually known by its acronym, SERI. SERI is a government funded research laboratory, somewhat analogous to Lincoln Laboratories. SERI has been in existence a little over two years and now has over 600 employees. Its responsibility is to research, develop and aid in the commercialization of the various solar technologies. Employees at SERI range from surface physicists working on new types of photovoltaic cells, to chemists working on varieties of algae which will make methane or hydrogen, to economists who are investigating the probable effects of tax incentives, to attorneys who are trying to devise legislation which will guarantee individual access to the sun.

SERI

There are also four regional solar energy centers, one of which is the Northeast Solar Energy Center, located at 70 Memorial Drive in Cambridge. There are about 100 employees there and an excellent library. Their chief mission is the dissemination of information about solar energy.

NESEC

Now, what are the prospects for solar energy? This question can have several intents, depending on the questioner. The Department of Energy wants to know how many quads of energy (that's quadrillions of Btus) can be displaced in the future by solar. The consumer wants to know whether there are reliable manufacturers, whether the costs make solar economical, and what are the prospects for reselling a house with a solar installation.

WHAT ARE PROSPECTS FOR SOLAR?

The investor presumably wants to know whether solar energy is a growth industry. To the question of whether solar is a growth industry, the answer is a resounding "Yes."

IS SOLAR A GROWTH INDUSTRY?

REASONS

I shall give a couple of reasons why solar can be counted on to be a growing industry, and why the uncertainty about that growth is less than the uncertainty about the growth of other energy technologies.

INCREASING PRICE OF RECOVERING FUELS

The primary reason why solar is likely to be a growth industry is widely known. We are running out of oil and gas. Uranium and coal have longer but still finite lifetimes. The problem is not only that the resources will run out in a matter of decades, but that the easier to recover portions of those resources are naturally recovered first. Thus the cost of recovering them becomes progressively greater and greater. This virtually guarantees that the price of these fuels will rise faster than inflation.

<u>ENERGY FUTURE</u>

There are many other problems with the fuels mentioned above. For a good treatment I recommend <u>Energy Future</u>, the book written by a study group from the Harvard Business School, edited by Robert Stobaugh and Daniel Yergin.

FOSSIL FUELS ARE ALSO SOLAR ENERGY

This may be a good place at which to interject that, of course, fossil fuels derive from solar energy. They have been converted from solar energy by a completely natural process—compaction of biomaterials in the earth's crust. Fossil fuels would be renewable, too, if we used them at something less than one-millionth of the rate at which we now use them. The trouble is that this natural process of conversion of solar energy to fossil fuels is too slow and too inefficient. Only the tiniest fraction of the original solar energy is converted to useful fuel. What we refer to as solar energy today means any one of a number of ways of more readily converting incoming solar radiation to useful energy. I shall later describe all of the technologies which fall in this category.

SOLAR IS INCREMENTAL

Another reason why the growth of solar is a very good bet, and also why solar is less vulnerable to uncertainties that afflict other energy sources, is that solar is "incremental." Solar devices come in small units. You don't need to decide whether to build a $2 billion unit or nothing. Solar can grow through the cumulative purchases of many individuals and industries. The growth of solar is sensitive to government policy, but not so sensitive as are nuclear, coal and synthetic fuels. If the government doesn't fund synthetic fuels, there won't be any. But if the government doesn't support solar, it will probably grow anyway, though perhaps somewhat less than it might.

SOLAR WILL BECOME ECONOMICAL AS FUEL PRICES RISE

Hence, solar is bound to become economical as fuel prices rise, and the decision to "go solar" can and will be taken incrementally, rather than by a massive and centrally orchestrated program.

HOW MUCH GROWTH? 6 TO 25 QUADS BY THE YEAR 2000

Once it is established that solar is a growth industry, the next question is, "How much growth?" The Domestic Policy Review of Solar Energy, published by the Department of Energy in February, projected four scenarios for solar in the year 2000. Excluding large hydroelectric installations, which are classed as solar but are now nearly fully developed, the lowest projection was six quads of energy displaced by solar in the year 2000, and the highest was 25 quads displaced. Any of the four scenarios represents a huge annual growth rate in the use of solar energy, compared with today's minuscule amount. These projections imply a solar industry in the year 2000 between 15 and 65 percent as large as today's oil industry.

There seem to be some widespread misconceptions to the effect that there are limitations on solar which will hold it to a small contribution. The problem most often cited is the space requirement. Let us talk in ultimate terms for a moment. We currently use a total of about 78 quads of energy in the United States each year. That amount of energy from the sun falls on a segment of the United States about 5000 square miles in area. But not all of that energy could be converted into useful energy for the end user. At a conservatively assumed ten percent conversion rate, we would need 50,000 square miles to provide all of the annual energy requirement in the U.S. That sounds like a lot, but it is about the same as the area covered now by roads. If it was possible to cover that area with roads during the growth of a huge automobile industry, it would be possible to cover it with solar conversion devices, which in their simplest form can be merely plastic films and water. And remember, that area is required to fulfill <u>all</u> of our energy needs. That would mean stupendous growth of the solar industry. A very respectable growth rate will require much less land area than that.

MISCONCEPTIONS: LAND AREA REQUIREMENT

I have seen studies that estimate that the area requirement for energy from coal and even from nuclear, when mining, processing and transportation are taken into consideration, approaches the area requirement for solar. One study by Professor Bockris of Texas A&M took the aggregate area of United States oil fields and found that even after conversion, ten times as much solar energy could be recovered from the same area. These estimates require some rather arbitrary statistics, and I don't vouch for them, but they help

SPACE REQUIREMENT FOR SOLAR COMPARED WITH CONVENTIONAL ENERGY FORMS to show that the area requirement for solar is not prohibitive. Furthermore, the estimates of area required for, say, obtaining energy from coal do not count those areas which may be affected by emissions carried through the air from the site of coal burning.

HIGH CAPITAL REQUIREMENT

A second problem often cited with solar is the high capital requirement. There is no doubt that solar is highly capital intensive, but certainly not much more so than synthetic fuels. And as I mentioned before, solar has the advantage that the capital can be invested in smaller, incremental quantities. Solar modules are useful shortly after being installed, while large nuclear or coal power plants are useless until all of the twelve or so years of paperwork and construction are complete.

ENERGY PAYBACK

One objection to solar I read recently in an otherwise fine paper on energy by an executive of a prominent investment counseling firm was the following. He said that the trouble with solar technologies is that the energy required to make the equipment is so great that it takes ten years of running it to get that energy back. That is simply wrong. He might have been thinking of flat plate photovoltaic arrays, which have been estimated to have a six to eight year energy payback period using current production technology. But most other solar technologies have a considerably shorter energy payback period.

HOW FAST WILL GROWTH BE?

So far I have stated that the solar industry will grow, and that it will grow substantially. Only one question remains for investors, and that is: "When?" How fast will the solar industry grow?

IT VARIES AND DEPENDS

The answer to this question is, "It varies, and it depends." That is to say, the time schedule of growth varies with the particular solar technology, and, like many other things, the rate of growth of solar depends on some unpredictable external events. In the rest of this talk I shall take up each solar technology, define it and discuss its prospects.

SOLAR WILL BE RECOGNIZED AS BIG BUSINESS WITHIN FIVE TO TEN YEARS

Nevertheless, I shall venture a personal opinion which summarizes my answer to the question of how fast solar will grow. I believe that it will become clear to everybody that solar is big business within the next five to ten years. Investment being what it is, if you want to get the jump on the efficient market this suggests that you should think about investment in solar in the next zero to five years.

SOLAR NOT JUST A FEW WHOLLY SOLAR COMPANIES

Investment in solar, you understand, does not mean simply investment in those dozen or so companies the majority of whose business is currently solar. The rest of my comments should make it clear that many large companies are concentrating heavily on solar technologies, and there is a good possibility that in the future a substantial portion of the revenues of now established firms will derive from sales of solar devices and services.

TECHNOLOGIES TO BE DISCUSSED

I shall try to be exhaustive by covering every technology which is classified as solar, plus conservation which is akin to solar. I shall discuss these in the order in which they are likely to be commercialized: conservation, passive solar, biomass, flat plate collectors for water and space heating, wind power, solar ponds, photovoltaics, concentrating collectors for high temperature heat and electricity generation, ocean thermal energy conversion systems, and the solar power satellite.

CONSERVATION

In the near term, conservation--or, as it is sometimes called, energy efficiency-- will have a greater effect on the energy picture than any other energy supply technology and perhaps than all of them put together. It stands to reason that if a commodity has been treated as if it were infinitely abundant, and is suddenly discovered to be limited, simple efforts which were never bothered with before to conserve the commodity will meet with success. There is a crazy idea in circulation, however, that less energy use will harm the economy or our standard of living. The opposite is true. Too much energy use will harm our economy and our standard of living, as it has been doing. It is natural that in the course of events some resources may become less abundant, and other resources may become more abundant. In a normal economic process there will be substitution of the more abundant for the less abundant. For example, microcircuitry has become easier to come by, fossil fuels less so. So we shall substitute computerized controls in the home, automobile and industry for profligate fuel usage. We shall substitute insulation in buildings for the saturation of the building and some of its surroundings with heat. We shall substitute ingenuity in engineering design for overwhelming any problem with massive doses of energy. We may describe this as the substitution of "energy brains for energy brawn." And lest it be forgotten, most of these energy efficiencies require new ways of doing or designing things, new industries, new opportunities for investment. The time for energy efficiency measures is ripe and has been for a few years, and the time to invest is now.

PASSIVE SOLAR

"Passive solar" means the design of buildings to best take advantage of solar radiation. This means primarily the use of glass with well designed eaves for shading on south facing walls, and thermal mass to store the heat gathered from the sun during the day for night-time use. Passive solar design of buildings is estimated to cost even less in some cases than conventional building design. There is little question that passive solar is economical. Nevertheless, conventional building practices and existing building codes sometimes pose a barrier to passive solar. These barriers will be overcome with time. Meanwhile, some passive solar housing developments are already being built, and more will come soon.

BIOMASS

The term "biomass conversion" means the creation of liquid or gaseous fuels from municipal or agricultural wastes or manure, or from algae or crops grown expressly for the purpose. Wood is also usually included in the category of biomass. Fuels obtainable economically at present are alcohol and methane. The conversion of municipal and agricultural wastes makes sense even at the present time, and I would expect rapid growth of this industry even within the next five years. There are successful commercial ventures already. Biogas of Colorado has been selling methane, and some people I know are just now going into the business of manufacturing anaerobic digestors, which convert biomass to gas. I expect their business to be a great success.

FLAT PLATE COLLECTORS

Flat plate solar collectors have been the most prominent of the solar technologies, but as this talk shows they are just the tip of the iceberg. Solar hot water heaters are borderline economical today in many parts of the country. They will surely become more so as fuel prices rise. The growth of sales depends on measures to defray the capital expenditure required and on assurances of the reliability and maintainability of the devices. Tax incentives and the availability of loans for solar collectors will defray the capital expenditure. Assurances of reliability and maintainability will come with the maturity of the technology and the business. It would be a help in this area if utilities could become middle men in the sale, installation and maintenance of solar collectors. There is strong consumerist sentiment against the involvement of the utilities, but several utilities are pursuing this line of action.

WIND POWER

Wind power is classified as solar because winds are caused largely by the differential warming of the earth by the sun. Wind power has come a long way since the windmills of the early 1900's when millions were in use on the prairies. New aerodynamic designs make wind machines three or four times as efficient as the old ones, yet with less material. Wind machines will be sold about equally to two markets: large machines will be sold to utilities for central electric generation, and smaller machines will be sold to residences, businesses and industry for on-site generation. Penetration of wind power in the utility market is about to proceed rapidly. Utilities in California have bought or are buying experimental units in pilot programs which are expected to expand into much larger wind power programs in the future. Hawaiian Electric has agreed to purchase electricity from wind power generators. If ten percent penetration of wind power can be achieved in the utilities, that would mean sales of about 10,000 $1 million wind turbines, or about $10 billion over perhaps the next 20 years. These wind turbines are and will be manufactured by such companies as Boeing, General

Electric, Bendix, Westinghouse and Hamilton Standard. At the same time, smaller wind machines are being manufactured by a variety of manufacturers some of whom are already realizing good returns. U.S. Wind Power in Burlington has agreed to sell wind-electric power to the California Water Resources Board for 3.5¢ per kilowatt-hour. A company called Enertech in Vermont is selling, I am told, a considerable number of small wind machines for individual households. It is difficult to understand in conventional terms the popularity of these machines at the present time, but my guess is that people are experimenting with energy independence, practicing for when it will be economically incumbent upon them to have the ability to generate their own power.

SOLAR PONDS

Solar ponds would be farther up on this list if only there had been more development of them in this country. There has been a fair amount of research on them in Israel but relatively little here. Yet there is in the U.S. one commercial solar pond, at Miamisburg, Ohio. A solar pond is a pond of water which has built-in measures to prevent the loss of whatever heat is gained from solar radiation. The great advantages of solar ponds are that they are very simple and cheap to build, and they have inherently such a massive amount of thermal storage that they can collect solar radiation in summer and still have enough left to provide heat to buildings in winter. Solar ponds will be applied to the heating of groups of houses or large buildings, and to low temperature industrial process heat.

PHOTOVOLTAICS

Photovoltaic conversion is a wild card. The idea of efficiently converting sunlight directly to electricity with a reliable little semiconductor cell is tremendously appealing. The problem is, the photovoltaic cell is costly and energy-intensive to manufacture. The future of photovoltaic cells depends on the ability of manufacturers to streamline and reduce the cost of the production process. As has been highly publicized, many firms are working on doing this, including subsidiaries of several major oil companies. If they are successful, photovoltaics may become a very big industry indeed. If they are not successful, it may go nowhere, except for certain remote applications and for space vehicles, for which it is already used.

CONCENTRATING COLLECTORS

For producing high temperature heat the technique is to concentrate the solar radiation using parabolic dish or trough collectors or a field of mirrors, called "heliostats," all focused on a central point. Because this technology requires materials-intensive components designed to very strict specifications, and elaborate control systems to keep the collectors focused on the sun, cost is a problem with this technology. But this is primarily an engineering challenge with no major technology breakthroughs needed. There have been several installations built, for high temperature industrial process heat applications and for generating electricity from steam, but most have been heavily subsidized or sponsored by the Department of Energy. Nevertheless, with the relentless rise in fuel costs this technology, too, will become economical, though probably not within the five to ten year time frame.

OCEAN THERMAL ENERGY CONVERSION

Ocean thermal energy conversion means utilizing the temperature differential between surface and deep ocean waters to generate electricity. The technology is proven, and a small plant operates producing net electrical output off the coast of Hawaii. If feasible, this technology could tap a vast resource. However, there are many significant uncertainties which will take a long time to resolve, such as problems with materials corrosion and biofouling and whether the units will pose a danger to the stability of the ocean ecology. If this technology can make a significant contribution, it will not be for a long time.

SOLAR POWER SATELLITE

The solar power satellite is in roughly the same category as nuclear fusion. It is not yet definitely known whether net energy output can be obtained, and it is not yet known whether it is acceptably safe. The idea of the solar power satellite, as is widely known from its coverage in the news media, is to orbit a vast array of photovoltaic cells at such an altitude above the earth that the unit always remains above the same point on earth and is continuously exposed to direct sunlight. The solar energy captured by the photovoltaic array is beamed to earth with microwaves or lasers. The concept is fascinating, but it will be a while before we know whether or not it is feasible, and if it is, it will be a long time before it can be put into operation.

From the foregoing it is apparent that there are many varieties of solar technologies, and there will be many ways to invest in the future of solar energy. There is almost no doubt that several of the solar industries will grow very rapidly.

PURPOSE OF INVESTMENT

Let us step back for a moment now and reflect on what the purpose of investment is. The purpose of investment is to improve the future. That has been the purpose of delaying immediate consumption ever since mankind left the primitive stage. It has been argued that the purpose of investment is to satisfy an individual's personal greed. But that surely does not apply to institutional investors. The institutional investor typically invests the funds of a multitude of pension or profit sharing fund beneficiaries, on behalf of a company owned by a multitude of stockholders. If you manage pieces of the pension funds of, say, AT&T and General Motors, your constituency numbers in the millions. You are virtually investing on behalf of society at large. Therefore it would behoove you to invest in such a way as to improve the future. Investment in conservation and solar energy will improve the future, and it will with a high degree of certainty provide excellent returns to the investor in the long run.