ALTERNATIVE ENERGY RESOURCES & ENVIRONMENT: A NEW PARADIGM

by

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ABSTRACT

The finite limits of fossil fuels have not been fully realized by the public. Inspite of the fact that dependency on imported oil has become a hard reality than a simple economics of supply and demand, there is a false sense of optimism that somehow the perceived policy changes will alleviate the supply problems and high cost of energy.

The inexpensive and abundant supply of energy has indeed been the foundation of our civilization, as we know today. But this very growth in energy production and consumption is threatening our existing ecological balance. The problems of climatic variations, ozone depletion, acid rain and radioactive fall out, are all of global magnitude and all are related to the production and consumption of energy.

It is therefore imperative that we review the alternative sources of energy, particularly in the light of increasing cost of fossil fuels and try to get out of this paradigm and look beyond the carbon-based energy sources. This will require appropriate incentives for R & D and a need to optimize the energy policies to help open new horizons.

About eighty-five (85) percent of our current energy comes from fossil fuels, i.e. oil, natural gas, and coal[1]. These fossil fuels have played and are still playing a significant role in providing energy supply to this country. Among fossil fuels, oil and natural gas provides about sixty-three (63) percent of all energy used by the United States. Coal's share of the energy market, which was about eighteen (18) percent 15 years ago, has made a marginal growth to twenty-four (24) percent. Thus, in spite of an abundance of coal in this country, it has not made a significant in-road into the energy market because of its inability to penetrate the transportation sector of the industry. As oil is used primarily by motor vehicles, coal – due to its physical nature – has not been able to replace oil in that energy sector, and all attempts at coal liquification and coal gasification still remain in the research and experimental stage[2].

Oil, thus continues to play a very important role in our energy supply. But due to dwindling domestic reserves, more than half of our domestic requirements are imported from other countries. The incentives given by the government during the last two decades to increase domestic oil production have resulted in temporary surges in production, but it soon became apparent to economists and planners that fossil fuels are indeed finite and petroleum reserves are limited. Therefore, a policy that uses general principles of supply and demand for fossil fuels would be myopic, and that dependence on foreign oil is more a matter of hard reality rather than simple economics of supply and demand. Indeed, the U.S. has been importing oil for more than twenty-five years; but it is only since the oil crisis in the seventies that people in other parts of the world have become aware of the United States vulnerability to imported oil. Hence, the oil exporting countries, particularly those in the Middle East, will make every effort to exploit that situation. The price, therefore, that we will pay in the future, for imported oil will be much higher in terms of human life and resources.

This was not realized until the oil crisis hit the door for the first time in early seventies, on a major scale in the U.S. The price hike plus the curtailment of production by the Middle East countries took everybody by surprise, but the oil companies and their respective governments were unable to do anything about it. Therefore, as early as 1973, the need to develop alternative sources of energy was made as one of the main policy issues of the U.S. Government and the other major oil importing countries. The need to become independent in terms of energy resources caught fire both in the private and public circles and in 1973, President Nixon launched the Project Independence[2]. The hysteria to develop alternative sources of energy extended far and wide. Everything was being talked about, from oil shale in Colorado and tar sands to solar energy, energy from the sea and trapping of the heat flow from underneath the surface. But in the fervor, the question alternative to what and for what purpose remained vague and unclear not only in the minds of the public but also the policymakers.

Oil Shale

One of the first attempts was to look in to the feasibility of producing oil from the oil shale in Colorado where huge deposits of the same were known for quite some time. Oil shale is an immature bitumen, i.e., the organic material that has not been "cooked" sufficiently by the nature to produce oil and/or gas. Cooking of the organic materials derived from aquatic microorganisms takes place under the surface when these are buried sufficiently deep in the ocean, by slowly accumulating sediments on top of them when the natural flow of the heat from the interior of the earth cooks them.

Many a times, as in the case of Colorado and in several other parts of the world, these organic rich sediments were never buried deep enough to be cooked properly to be able to generate oil and gas. In due course, due to tectonic movements, these sediments rise above the water and occur as black to greenish-black sediments rich in uncooked organic material, which we call oil shale. To derive oil and/or gas (depending upon the composition of the organic material) from these oil shales we must literally cook them in large retorts or ovens at high temperatures. The amount of oil that eventually squeezes out is small, i.e., usually less than one barrel of oil for every cubic yard of solid rock. The exact amount varies because the concentration of organic material in the rock varies from place to place but as a general rule of thumb, the above figure is a good estimate.

The U.S. now consumes about 18-19 million barrels of oil per day. The figure varies year to year, but it is obvious that even if we wish to substitute 10% of the present consumption by oil shale then we will have to mine and bake about 1.5 million cubic yards of rock everyday and then after the oil is removed we will have to dump the "dry rock waste" somewhere nearby. The mining and cooking operations would be several times larger than the largest mine in the world. Large retorts (cooking vessels) would have to be built for the purpose. The size of mining operations and the consequences of releasing the solid "waste" as well as the gases in the environment, even for a 10% replacement of conventional oil was considered impractical. Nonetheless, a pilot plant was started in the early seventies by an oil company but neither the government nor the oil company ventured to move ahead in the direction and the project eventually atrophied.

The other alternative of "in-situ" recovery of oil from oil shales buried deep was also attempted. In this process the oil shale was never supposed to be mined, but instead heat was injected in the rock at appropriate intervals. It was perceived that oil would flow out of the rocks and drip on empty spaces underlying the rocks. Attempts made using this technique were also not successful. The heat dissipation was not as predicted and it appeared that the energy efficiency of such a process would be negative, i.e., more energy (in calorific value) will have to be used than the energy actually derived in the process. In addition to the above, the oil crisis, which had caused the oil prices to skyrocket to $34, a barrel seemed to be easing out. There was a feeling that finally the economics of supply and demand was working and that the prices cannot go on rising indefinitely without affecting the prices of other commodities. Two factors became obvious. First, that just about every sector of U.S. economy was highly dependent upon the consumption of energy resources. On the average, in the U.S. we spend in about five calories of energy to produce one calorie of food[3]. Good examples of high energy food items are frozen and canned foods. In other words, if the price of oil went up to $100 a barrel then it is quite likely that price of bread will go up to $10 a loaf from about $1 a loaf. The dependence on energy in our day-to-day life in our industrialized world is profound.

The second factor was the dwindling hard currency reserves in many oil exporting countries. Many of these countries are heavily dependent on the export of oil for practically all of their revenues generated. These two factors started cutting the oil prices from both the producer and the consumer sides. The high price forced people to conserve resulting in about 10% reduction in total oil consumption. This resulted in the apparent global oil glut, which put many OPEC and non-OPEC countries into a situation where they no longer could sell their oil. This had tremendous impact on their revenues and soon a number of them started cutting their prices. Suddenly the seller's market became a buyers market.

The chain reaction was fast. Prices started dropping fast. Several economist in 1980 predicted that the price of oil could go down to $10/barrel within two years. Another panic swept over the oil industry. In addition to the above, the cost projects for the shale oil project kept going up. The cost estimates for Colony project, the largest of all the oil shale projects rose to $6 - $8 billion for 50,000 barrels a day. Exxon had already spent over a billion dollars on the project and was in a very difficult binding situation, but there was no guarantee that the total construction cost would hold to $6 or even $8 billion. Clifton Garvin, Chairman of Exxon, was worried and finally on May 2, 1982, Exxon announced that the Colony shale oil project was being shelved. Other two major companies, Occidental and Unocal, also slowly pulled their additional investments on the project. Even though the three companies, including Exxon, were involved in the research of shale oil development for more than 30 years, it was clear that the era of shale oil had come to an end.

The boom of western Colorado came to a sudden halt and towns like Rifle, Battlement, Mesa, and Parachute became ghost towns like many mining towns in Canada. Exxon's decision was not without precedence. ARCO (Atlantic Richfield), one of the four partners for the Syncrude's tarsands project in Alberta, Canada, had also pulled out of the project in 1975 primarily due to rising cost[4]. Tarsands was another alternative source of energy that oil companies were working on for decades. In fact, of all companies, Sun Oil (Sunoco) was the pioneer producer when it started producing over 60,000 barrels/day of oil from tarsands in mid-sixties. All other major oil companies also had leases around Sun Oil plant in Alberta and in seventies were seriously looking into the feasibility of producing oil from the tarsands.

Tarsands

Tarsands is a loose term given by people in Canada and the U.S. to heavy oil sands that occur close to the surface in several parts of Alberta, Utah, and Colorado, Venezuela and many other parts of the world. Tarsands differ from the conventional oil in the sense that they are "heavy," i.e., their viscosity is higher (closer to 10-12 API) compared to 30-40 API of the conventional levels and therefore they cannot flow or be pumped. The higher viscosity or "heaviness" comes from the relatively higher number of carbon atoms attached to the molecule. In 1973, Exxon, Atlantic Richfield, Gulf Oil and Cities Service formed a consortium named Syncrude to produce oil from the tar sands in Alberta. After a capital expenditure of $1.9 billions production finally started in 1977, reaching anywhere between 60,000 bbls to 70,000 bbls per day. The cost of production, which was estimated to be around $30/bbl was considered quite high. ARCO pulled out of the consortium even before the production had started. Its share was, subsequently, picked up by the Canadian federal and state governments, because of Syncrude's impact on the local economy. But all other oil companies, including Shell, Amoco and Gulf pulled out or decided not to start on the project. The two plants, Sunoco (Sun Oil) and Syncrude still produce oil from the tar sands in the range of about 150,000 bbls/day but because of the economic and environmental reasons, no other plant has been built in the last 25 years.

The same fate was also for the Coal Gas and Coal Liquification projects. After spending about $10 billion on each one of the projects, the federal government decided to pull out of those experimental projects.

Two small plants produce coal gas, but there has been no program to expand them.

The important thing to note is that even though everybody was talking about alternative sources of energy, we were still within the paradigm of fossil fuels. To a commoner, the objective was to move away from the fossil fuels, but since development and production of energy resources were always in the hands of the oil companies, it was difficult for them to get out of the paradigm of fossil fuels. Thus, in reality, none of the above were alternative sources of energy.

Nuclear Energy

While thinking of alternatives in the 60's and 70's, a thrust was also made towards the development of nuclear energy for peaceful purposes. The importance of end utilization, however, whether the energy produced would be for mass transit or for motor vehicles, was lost somewhere in the euphoria of the availability of clean and abundant energy.

Nuclear energy, for the time, was considered to be the salvation. The nuclear industry put large scale advertisements in major newspapers and journals, stating, "nuclear energy will stop imports of oil from Kuwait and Iraq" (Figure 1). Ironically, just about the same time it came out in the newspapers that the Shoreham's nuclear plant has been raised to the ground after spending five (5) billion dollars to build it. The public was completely dismayed and lost. It was difficult to understand the reality. But the image of clean, safe, and abundant slogan of the nuclear industry was quickly smeared by the inevitable problems faced by the nuclear industry. All the claims made by the nuclear industry slowly and slowly started cracking up. The safety factor dwindled after the Chernobyl accident, and the construction costs soared to meet the new safety requirements. It also resulted in raising the Shoreham plant to the ground after it was built at the cost of $5 billion[5]. The fact that nuclear energy could not replace our dependence on imported oil in the most important transportation sector led eventually to the Gulf War. The news media made everybody aware that the main reason for the liberation of Kuwait was not for moral or geopolitical issues, but for our national security tied to the assured supply of oil. But the biggest problem faced by the nuclear industry has been, and still is, the disposal of nuclear waste. The dumping of nuclear waste in oceans is now banned by the U.S. Government and "not in my backyard" has become a national slogan[6].

All of these factors had a cumulative effect on slowly changing public opinion from optimism to skepticism to an outright negative attitude about nuclear energy. The impact has been so profound that building of additional nuclear reactors have been frozen in this country, in Canada, and in most Western European countries except France. No new plant has been built in the U.S. since 1978[7]. The result has been that utility companies are now going back to coal, which constitutes about 80 percent of our natural resources. Coal resources in this as well as in other countries, though finite, are significant. But projected coal production and consumption by India and China alone could have a profound effect on the carbon dioxide concentration in the atmosphere, resulting in drastic climatic variations with consequences of global magnitude. That global warming by anthropogenic causes is a reality was recently concluded by the Sub-Committee on Global Change Research, U.S. Global Change Research Program

(USGCRP); a committee established by the National Science Foundation. That carbon dioxide plays the most important role in global warming is a reality[8]. The consequences of global warming in terms of a rise in sea level alone, along with the climatic variations worldwide, can be profound.

The administration, it appears has no alternative but to toot the old horn once again. That is because simple inertia makes most oil companies difficult to change away from the existing paradigm. One reason is the current availability of oil globally, at least for the present, even at the substantial increase in the indirect cost of assuming the supply of oil by means of force. But this is also coming to an end soon. The second is the relative importance of finding an oil reserve. For example, a discovery of a field with production capacity of 100,000 bbls/day and at $20/bbls would yield a revenue of at least one (1) billion dollars per year, which would be quite significant for even the largest of the oil companies. But for a country consuming 19 million barrels per day, this discovery would amount to about 0.5% of the national requirement and therefore insignificant. Therefore, importance of any oil field discovery depends upon the viewpoint of a company or the nation.

Future of Fossil Fuels

In 1995, The World Bank made an estimate of the global oil and gas reserves. (Figure 2). Their estimate was that the global oil reserves will last for about 40 years and the natural gas for about 60 years. Of course, this is always vehemently disputed by the oil explorationist whose whole future is dependent upon the belief that we are going to discover more oil and that there is no end to fossil fuels in the foreseeable future. One is not surprised by the denial of the World Bank estimates by many in the oil companies. It is indeed true that we are going to find more oil in other parts of the world and some of the fields discovered may be significant for the companies involved but two things are important. First, when we look at the increases in the rate of consumption of oil and gas in the developing countries, like China, India and Brazil, then it is obvious that any future discovery of oil and gas will be more than off set by the increase in consumption of the same in the developing world.

A second factor is that regardless of the global oil reserve, all estimates indicate that the domestic reserves have declined from 4% of the global reserve ten years ago to about 3.5%[9] and almost all future discoveries are going to be outside the United States. Thus, we have no choice but to be dependent upon imports for running our huge smooth running chariots like SUV's. In that respect, we need to consider (i) as to how long can we afford to send our sons and daughters to other parts of the world to safeguard our assured supply of oil. It would be myopic to assume that the "desert storm" was the last war for the resources or that there will be no more resistance from despots and (ii) the direct and indirect costs, e.g. taxes, getting involved into wars like "desert storm". In addition the environmental impact of burning 18-19 million barrels of oil per day also cannot be ignored. Since the rejection of the Kyoto protocol, the world opinion is overwhelmingly against the U.S. and how long the U.S. can live with this anachronistic attitude is difficult to say. About 89% of the world's cars are in MCDs and therefore, the decision that we make is going to have a profound effect on global environment. It is not the population surge of the third world countries, but the resource consumption and depletion is going to have a lasting and adverse effect on the global environment including our own.

Future of Coal

According to the estimates made by Federal agencies, the United States has enough coal to last for more than two hundred years and for a time during the seventies it was considered that coal will solve all our energy problems. But inspite of the rhetorics, coal's share of the energy market, which was about 18 percent, 15 years ago (in 1978) has made only a marginal growth to 24 percent. Coal has not been able to make a significant inroad into the energy market because of its inability to penetrate the main transportation sector of the industry, which is the automobile. Coal, due to its physical nature, has not been able to replace oil in that energy sector and all attempts at coal liquification and coal gasification have atrophied. The only way coal can increase its share in the energy market, is if we decide to change our lifestyles by changing our mode of transportation from automobiles to mass transit. This of course, would mean a drastic change in our lifestyle. To conclude, coal has a place in the total energy market, but it has not been able to either replace oil or increase their share in the energy market to any significant extent, because of the limitations noted above. To conclude, after reviewing the problems of the fossil fuels there is a need to seriously look at the alternatives is now.

The Era of Alternative Energy

The need to develop alternative sources of energy to meet our domestic requirements, was known to us for more than fifty years, but we never got out of the paradigm of fossil fuels. All the major efforts made were still within the paradigm of fossil fuels. The efforts of the government and industry towards the development of non-carbon based, alternative sources of energy, at best, to date can be described as luke warm (Figure 3). The impetus that is needed to move it from the research to pilot and production stages is lacking for most of them. The reality is that most of them are in a stage where a little impetus will move them on a production stage. This is not happening, because neither the oil producing countries, most of which are ruled by despots nor the consuming countries want to disturb the current balance that exists. But, nobody sees the dark cloud, that's hanging on the horizon. And, when the clouds finally come over the head, it may be too late and the price that we will have to pay in terms of man power and taxes to run our SUV's will be much higher.

We, therefore need to review these resources individually to see where they are now and what it needed. It appears that in the future, not one source will be adequate, rather the country will be dependent upon a basket of energy sources, each coming from a different system and each, providing different needs within our society.

Fuel Cells

This revolutionary, new technology takes hydrogen and air and converts them into electricity and pure water. It's green friendly – the only end product besides electric power is pure water. And unlike batteries, it does not require hours for recharging. It refuels in seconds.

Experimental fleets of fuel cell buses are already on the streets of Chicago, Vancouver, and Washington D.C. – and they're proving wildly popular. They meet the toughest environmental standards ever devised.

While most auto companies are looking into fuel cell technology, the cost is still high. Vigorous research is needed to bring the cost down, so that it becomes possible to manufacture "zero-emission" vehicles on a mass scale.

Solar Energy

Solar cells directly convert the sun's energy into electricity. Solar cells are thin wafers of specially processed silicone that generate electric current from the sun. One four-inch diameter solar cell produce about one watt of electricity when bright sun is shinning straight down on it. If you live in a climate that is cloudy, most of the time or if your home is shaded by trees, solar energy wouldn't work for you.

High performance solar cell cost too much to produce because they are made out of many silicon wafers, individually sliced from crystalline ingots, treated, and then soldered together into a module. "It's true that solar technology seems to be in a good state right now. Technical advances seem to be rolling in a faster rate, and industry is adopting them as they come along. "But the future health of the industry is dangling". Though the producers are selling their products in niche markets, few companies make money, and some long-term financial backers such as the oil companies decided to get out of this business. There is still reason for hope, because new factors have entered the solar equation. The Chernobyl nuclear power plant disaster has caused European countries such as West Germany and Italy to sink money into solar research. The Japanese government is in support of solar power in the hopes of developing energy self-sufficiency and export profits, and a few years ago, Amoco went to India to set up a solar power plant in Rajasthan desert.

Solar cells are within the reach of commercialization. A little incentive from the government can make a big difference in our availability of solar.

Wind Power

Wind power is an age-old form of power that brings to mind sailing ships being blown by the wind and beautiful picturesque Dutch windmills. The Persians built the first known windmills as early as 250 B.C. Several are still in use today.

Wind power is a clean renewable energy source. Wind turbines hundreds of feet tall, can be seen for several miles along Highway 10, East of San Bernadino and along Hwy. 15, south of San Francisco. It uses both old fashion design and modern technology to harness the wind's energy. Wind is a promising, nonpolluting source of electricity.

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When OPEC (Organization of Petroleum Exporting Countries) tripled the price of oil, petroleum importing countries took a closer look at alternative energy source. In the case of wind energy, spurts of research activity led to some rapid improvements in a centuries-old technology. The interest was short-lived, because the price of oil went down, the government and the companies lost interest in it.

Nevertheless, wind power is far from dead. California now produces more than one percent of the state's electricity with wind power. In Hawaii and Quebec, wind turbines of record size came on-line in 1988. The United Kingdom has announced plans to build three wind-farms covering over 750 to 1,000 acres a piece, in southwestern England and Western Wales. India has embarked on harnessing wind on a large scale.

Wind power can be made, competitive with minor incentives from the government. True, it cannot replace oil in the transportation sector, but it can provide power for cooling, heating and for the industrial use.

Biomass Power

Biomass is a substantial renewable resource that can be used as a fuel for producing electric power and other energy products. Biomass used in today's power plants include wood residues, agricultural residues, and food processing residues such as nut shells. In future, farms cultivating high yield energy crops, such as trees and grasses, will significantly expand our supply of biomass.

Biomass is a proven option for electricity generation. Currently, there is over 7000 megawatts of biomass power capacity installed at more than 350 plants in the U.S., from a diverse range of producers including the pulp and paper industry, electric utilities, and independent power producers.

In the face of intensified competition in the utility sector and low fossil fuel prices, further growth of the U.S. biomass power industry is currently not taking place.

To help expand biomass power production, the U.S. Department of Energy (DOE) is sponsoring efforts to double biomass conversion efficiencies and reduce biomass power costs. At this stage, little incentive from the government can really help boost the industry. When successfully implemented, these efforts will promote industrial and agricultural growth, improve the environment, create jobs, increase U.S. energy security, and provide new export markets.

The Role of the Government in Biomass Power Development

In 1991, DOE formed the National Biomass Power Program to help establish a sustainable option for meeting the expected 600 gigawatts of new electric generating capacity needed world wide over the next 10 years.[10]

The Biomass Power Program includes such core activities as: working with the biomass power industry to overcome problems in using some forms of biomass in existing boilers; evaluating and developing advanced technologies such as gasification and pyrolysis; assessing the characteristics of biogas produced from various gasification technologies; developing clean-up technology for high temperature biogas; supporting small system demonstrations; analyzing biomass power systems; and sponsoring cost-shared feasibility studies with industry. The Biomass Power Program is also supporting integrated efforts such as the "Energy Partnerships for a Strong Economy" initiative, which includes jointly funded commercial application projects such as the Hawaii Biomass Gasifier Project at the HC&S sugar processing plain in Maui, and the Vermont Biomass Gasifier Project at Burlington Electric's 50 megawatt wood-fired McNeil Station.

As part of the Energy Partnerships initiative, DOE's Biomass Power Program is currently working in collaboration with the United States Department of Agriculture (USDA) and private industry to demonstrate and deploy cost-competitive renewable biomass power systems that spur rural economic development. In order to leverage its efforts and increase its effectiveness, the Biomass Power Program is working cooperatively with a number of DOE programs.

The Biomass Power Program, in collaboration with the Electric Power Research Institute (EPRI) and the DOE Biofuels Systems Program, sponsored feasibility projects, which are cost-shared 50/50 with private industry. Under these projects, industry teams are conducting feasibility studies and developing business plans focusing on the integrated use of energy crops for power production.

In many regions of Asia, India, Africa, Latin America and other developing areas, power demands are frequently in smaller increments and biomass resources are abundant, particularly biomass residues such as bagass (from processing sugar cane), rice hulls, etc. As a result, biomass fuels have become excellent choice for electricity generation in the developing world, and their potential use creates significant export opportunities for U.S. technologies and component manufacturers.

Environmental Benefits

- Biomass fuels produce virtually no sulfur emissions, helping to mitigate acid rain.

- While carbon dioxide is emitted during biomass combustion, an equal amount of carbon dioxide is absorbed from the atmosphere during the biomass growth phase, thus biomass fuels "recycle" atmospheric carbon, minimizing global warming impacts.

- The use of waste biomass reduces the volume of material sent to landfills, extending the life of existing landfills.

- Biomass combustion results in less ash than coal, reducing ash disposal costs and landfill space requirements. The biomass ash can also be used as a soil amendment on farm land.

- Perennial energy crops (grasses and trees) have distinctly lower environmental impacts than conventional farm crops that are replanted annually. Energy crops require less fertilization and herbicides and provide much more vegetative cover throughout the year, providing protection against soil erosion and watershed quality deterioration, as well as improved wildlife cover.

- Biomass energy crops can be a profitable alternative for farmers, which will complement, not compete with, existing crops and thus provide an additional source of income for the agricultural industry. It is envisioned that biomass energy crops will be grown on currently underutilized agricultural land. In addition to rural jobs, expanded biomass power deployment will create high skill, high value job opportunities for utility and power equipment vendors, power plant owners and operations, as well as agricultural equipment vendors.

Geothermal Energy

Geothermal energy comes from the heat in the interior of the earth, which creates geysers and volcanoes. This clean energy source can be tapped to provide heat and electricity, equivalent to billions of barrels of oil. The planet's geothermal potential sources (small-scale) are so great it could provide needed energy for a millennia.

These small sources are hidden below the surface of the earth; their heat energy breaks through the surface at times. It explodes from volcanic craters and steam vents. It bubbles in molten lava. It glows in dark nights. It simmers in high-temperature aquifers and occasionally leaks out in boiling springs. It can even be found in the soil and rocks under your feet.

Geothermal energy is harnessed by sinking exploratory holes, boreholes, and monitoring the temperature range, chemical composition, and flow rate of water. If the findings are promising, engineers and technicians tap the source with drilled wells, then position the pumps, and pump steam to run the generators in a small on-site power plant. In Boise, Idaho, the Moore House, which includes four hundred homes has been using geothermal energy since 1883. Also, nearby was the Mott Mansion built in 1902. The fuel bill for this twenty-eight room house was forty dollars. There is so much geothermal energy, and so many places in the world where it can be harnessed.

CONCLUSION

In addition to these known sources, vigorous research must be pursued to look beyond the horizon for currently unknown alternative sources of energy. That is where we hope to find the real substitute for oil, the source of energy to drive our chariots. It has been man's dream to have his own chariot ever since the invention of the wheel more than 5,000 years ago.

And it would be prudent to hold on to our smooth-running chariots by finding alternative sources of energy to run them. The time is right. Let's move ahead to open up new horizons. Horizons that will empower us in our search for new, clean sources of energy will never end.

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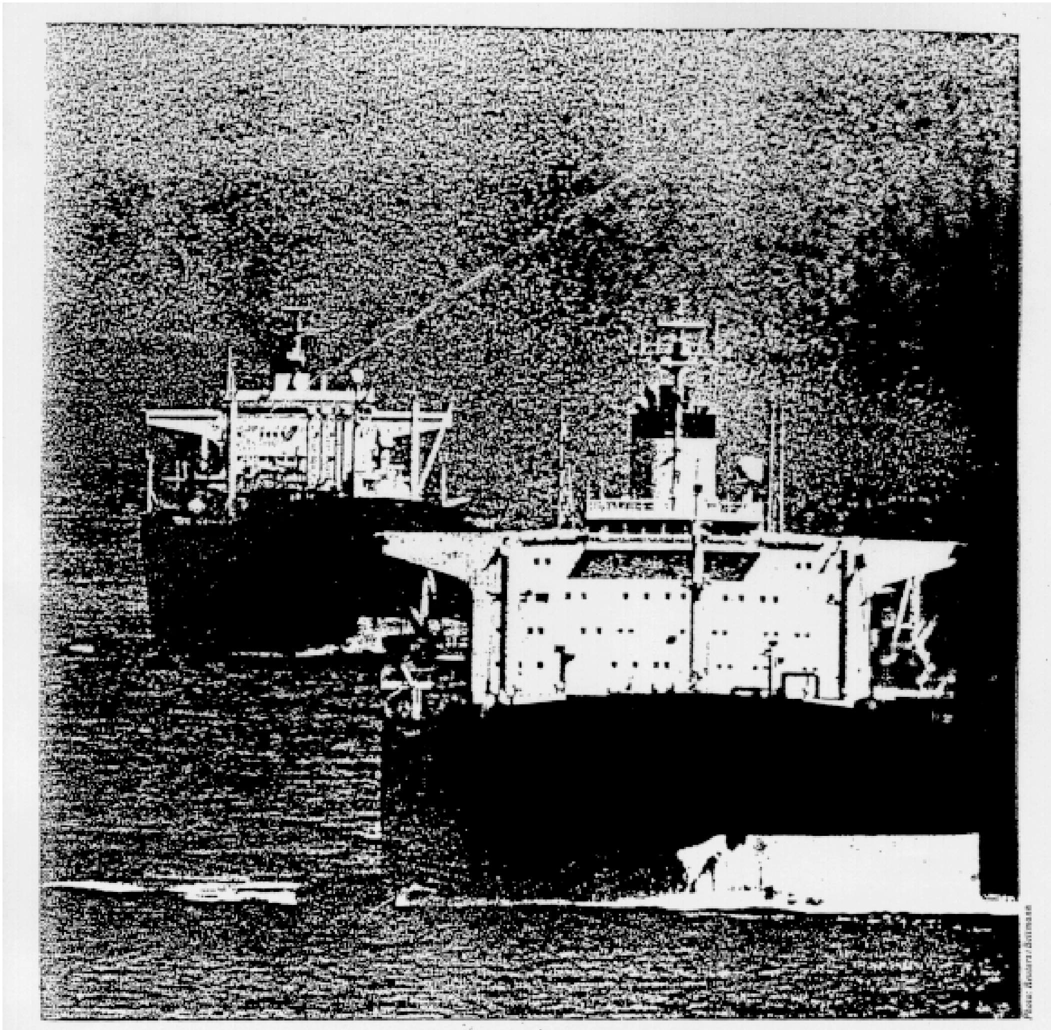

Figure 1. Nuclear-generated electricity saves more oil each day than we used to import from Iraq and Kuwait.

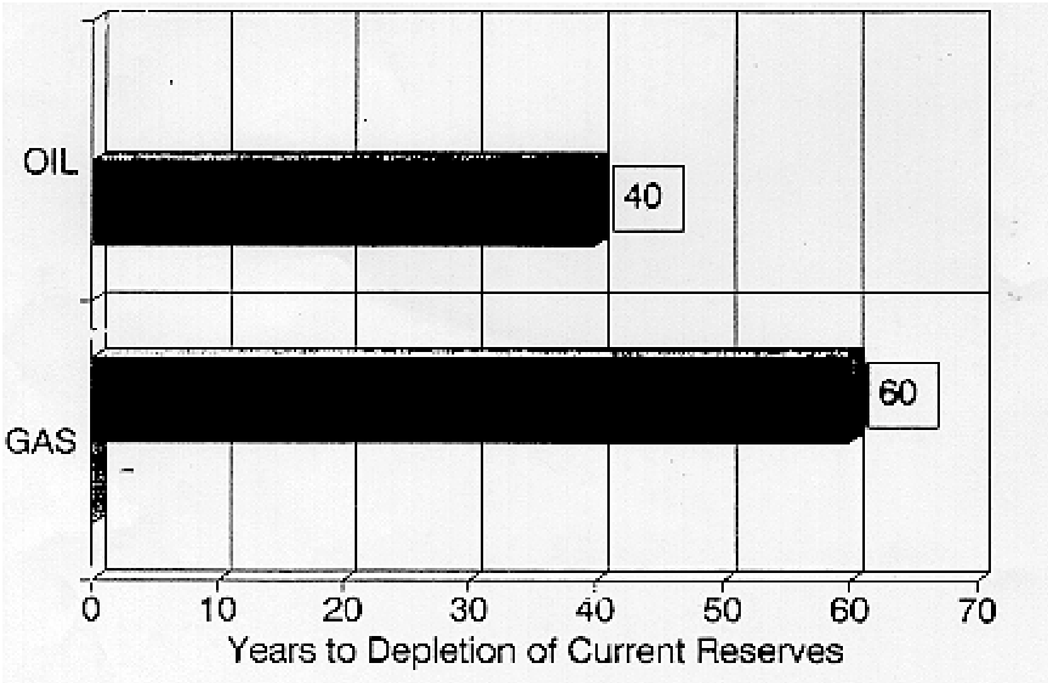

FIGURE 2. World Oil and Gas Balance, Production – Reserve Ratio

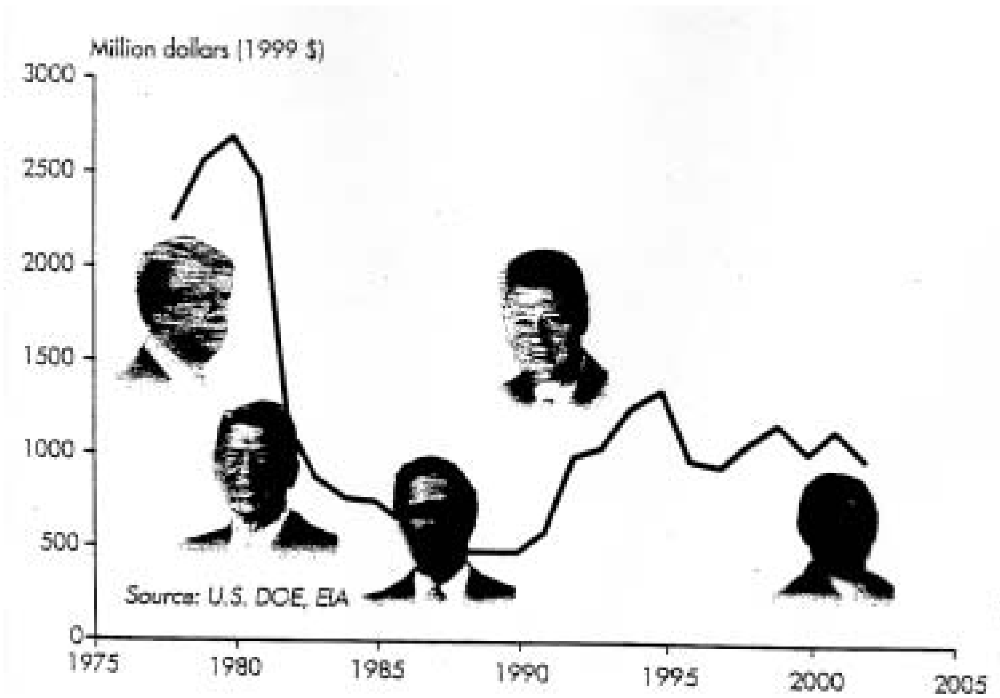

Figure 3. U. S. Government R&D Spending on Renewable Energy and Conservation, 1978-2002, (World Watch).