

Prescription for Sustainable Energy and Preserving Global Climate

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Abstract

The global community faces a challenge as great as any plague or major calamity that has come before: (1) dwindling energy reserves and (2) global warming resulting in potentially devastating climate changes. As a consequence of these threats most of the industrialized nations of the world are addressing these issues with major commitments. However, neither of the major political parties are tackling these two issues scientifically and responsibly.

Tackling these problems will support the greater global community and provide domestic industries the opportunity to develop products to meet these challenges. Finding solutions to these problems will create jobs in the private sector. Our technological leadership positions in electronics and computers, pharmaceuticals, and aerospace have provided us an envied industrial base. We have the potential to establish similar leadership positions in sustainable energy production.

As a retired physicist without any association to energy corporations, I have studied the literature and I am proposing several initiatives to occur at the national and local levels. I strongly believe that some version of these goals will further our position in the global community and provide a needed public service.

Five-year Objectives:

1. Promote the use fuel efficient vehicles for personal transportation and shipping – a potential of 33% savings in carbon dioxide emissions for every effected vehicle;¹
2. Replace, where economically feasible, coal-fired power plants with Combined Cycle Gas Turbine (CCGT) plants– approximately 50% savings in greenhouse gas emissions for every plant replaced;²
3. Promote the development of more energy efficient buildings – approximately 25% savings according to a recent article in Science;³
4. Require all facilities that produce any greenhouse gas (such as methane, soot, and others) to employ reasonable abatement procedures.

Twenty-Five to Fifty Year Objectives:

The goal is to convert nearly the entire nation to using non-carbon, sustainable energy resources. In making this transformation the country will develop leading technology that will create jobs and provide international sales. To achieve this, we should setup research centers and provide special credits to private research to:

1. Develop more cost-effective solar photovoltaic cells,
2. Develop more cost-effective wind turbines,

3. Develop electrical energy bulk storage techniques,
4. Experiment with new designs in nuclear reactors to replace our aging reactors and perhaps expand the use of nuclear power.

Many of the public believe that a switch to a hydrogen economy and/or a biofuels based economy will gracefully allow us to escape the current dilemma. Unfortunately, the problems are more daunting than those alternative energy sources can address.

The solutions to alternative energy production provide an opportunity to build an important industrial business base for the country.

TACKLING GLOBAL WARMING AND ENERGY SHORTAGES

Seriousness of Global Warming

I believe the evidence supporting global warming and its potentially devastating consequences is overwhelming. The warming has been validated by ground temperature measurements over the last several centuries and by inference based on isotope ratios found in air bubbles trapped over a 400,000-year period. The warming itself has the characteristics of the greenhouse effect: nighttime temperatures have risen more than daytime and the vertical temperature profile shows heating in the upper atmosphere. According to the Intergovernmental Panel on Climate Change (IPCC) report the present high atmospheric concentration of carbon dioxide (approximately 379⁴ ppm vs. pre-industrial 280 ppm) has not been exceeded during the last 400,000-years⁵. The carbon dioxide (and other greenhouse gases) unequivocally causes less heat to radiate from the earth into space thereby causing the earth to become warmer. The combustion of fossil fuels during the industrial era has produced this carbon dioxide. Computer models of climates reveal that continued increases in greenhouse gases will result in severe weather changes. Recent weather patterns, ocean levels, and hurricane damage all over the world are showing the evidence of these changes already.

In spite of this overwhelming evidence there are skeptics who claim that global warming is a fantasy and scientists have become panicked over nothing. What is a policy maker suppose to do with such conflicting advice? Without disparaging the integrity or competence of the skeptics, I will simply assert that it is the nature of science that some scientists will question new results. Einstein's historic theories of special and general relativity were not the basis of his noble prize. The prize was awarded for other important contributions, but these major theories were not universally accepted for decades after their discovery. A policy maker must evaluate the preponderance of the evidence and consider the seriousness of ignoring global warming. It will take decades to correct our current practices of generating and using energy so we must react decisively and promptly. In any case, we are faced with dwindling traditional fossil fuels reserves. Without the consideration for global warming, it would be a relatively simple measure to convert to a coal-based energy economy. But coal is the worst emitter of greenhouse gases! So a switch to coal is to deny all this evidence.

This is not an issue of “tree-huggers” defending the survival of some obscure insect. Our energy resources are finite and they are likely to be exhausted soon. Global warming will likely have consequences to the overall stability of weather patterns (whose disruption will interfere with agricultural production), relative freedom from severe storm damage, and survival of many flora and fauna. As Margaret Beckett, British Secretary of State for the Environment has said, “We have known for some time that we have to worry about the impacts of climate change on our children’s and grandchildren’s generations. But now we have to worry about ourselves as well.”⁶ The International Climate Change Taskforce (2005) states that continued global temperature increases involve, “The possibilities including reaching climatic tipping points leading for example, to the loss of the West Antarctic and Greenland ice sheets ... and the transformation of the planet’s forests and soils from a net sink of carbon to a net source of carbon.”⁷

Unwise Current Pursuits

There are two extremely disturbing pursuits that are counterproductive to the goals of reducing greenhouse gases and acquiring energy sustainability:

- The current movement to construct new coal-fired plants in India, China, and the United States as described in a recent *Christen Science Monitor* issue⁸ is counterproductive. Coal is the greatest contributor of greenhouse gases of all the fossil fuels. Further investment in major contributors to global warming when there are reasonable alternatives is counterproductive.
- The current craze, which has infected the thinking of both political parties, is that the solution lies in a relatively “simple” switch to a hydrogen-based energy economy. Unfortunately, we can’t mine hydrogen! The sun is almost pure hydrogen, but it is 93 million miles away. A “hydrogen energy economy” still requires a source of energy to produce the hydrogen!
 - According to Matthew L. Wald in *Scientific American*, a hydrogen-fuel cell car actually produces one of the greatest emissions of carbon per mile! His realistic analysis includes all the emissions involved in the production of electricity to produce the hydrogen by hydrolysis, and the hydrogen transportation. Specifically, he calculates that a hydrogen-fuel cell car produces 440 grams per mile vs. 250⁹ grams per mile for a gasoline hybrid cell car.
 - Although other techniques besides hydrolysis might be developed to extract hydrogen from water, they ALL must involve energy to release the hydrogen from its strong attraction to the oxygen in the water molecule.
 - Additionally, we have not solved the problems of safe and compact storage and transportation of hydrogen. Because hydrogen is the lightest and one of the most flammable of all gases, its safe and economical

storage and transportation are formidable challenges, which may never be economically overcome.

- The Bush administration is promoting the production of hydrogen from coal and oil and then sequestering the resulting carbon dioxide. The process is attractive since we have very large coal reserves. However, sequestering carbon dioxide on such a large scale has never been accomplished. Thus, the Administration's single major effort is very risky: it involves the unproven ability to sequester carbon dioxide, the unconfirmed existence of safe and compact storage of hydrogen, and the non-existent technique to distribute hydrogen. It is worthy exploration, but it is not a solution on which to stake our entire carbon-reduction strategy.

Intergovernmental Panel on Climate Change (IPCC) Shortfalls

Although the activities of the Intergovernmental Panel on Climate Change (IPCC) panel are praiseworthy, I believe these recommendations do not go far enough in several aspects. The rational approach is to step-up investment in non-carbon and sustainable energy sources. The latest (2005) recommendation of the IPCC calls for several developments to keep the climate change at only 2°C (3.6°F)¹⁰ above pre-industrial levels. Although these measures reduce the greenhouse emissions per unit of energy produced, many of the measures do not reflect the limited reserves of petroleum. I critique this report as follows:

- The IPCC report recommends proliferation of biofuel technology. However, biofuels produced from starch crops (such as corn and wheat) and cellulose can only make a minor improvement in greenhouse gas emission for unit of energy produced since it takes significant energy to till, plant, fertilize, harvest, and process the crops to produce the fuel. Substantial energy is expended and carbon emissions are produced in performing these functions. Consequently, my reading and analysis of the several research papers^{11, 12, 13} reveals that the efforts to produce biofuels make it impossible to make substantial gains in the reduction of greenhouse gases. Furthermore production of biofuels requires that the current productivity of agricultural land is constant or improves, but this is not likely to be the case given the climate changes that are already taking place. The positive evaluations for biofuels assume credit the cultivation of the feedstock with reducing the carbon dioxide in the atmosphere. The cultivation of feedstock in itself does reduce carbon dioxide, but the argument does not address what alternative options were available for the tillable land. Growing food crops or leaving forests intact also results in growing plants whose metabolism converts carbon dioxide in the atmosphere to plant structures.
- The IPCC report recommends development of Integrated Gasification Combined Cycle (IGCC) coal plants. Although these types of plants are certainly preferred over the standard coal-fired plants, they still produce substantial carbon dioxide emissions. Modern Combined Cycle Gas Turbine (CCGT) plants are more

desirable as they produce only half the greenhouse gases as a coal-fired plant. CCGT or oil-based plants should be built wherever possible.

- The IPCC report does not address the potential for nuclear power to provide clean and renewable energy. Nuclear power certainly has many obstacles, but I don't think it should be excluded at this juncture.
- Finally, the IPCC report focuses on limiting the climate change to 2° C. In its own analysis, the report indicates that their proposed measures – of only allowing the carbon dioxide concentration to build to 400 ppm- will provide an 80% of chance increasing the climate change to 2°C. Or in other words, the recommendations allow a 20% probability of allowing too much generation of greenhouse gases.
- Dr. James Hansen has pointed out that the IPCC analysis has neglected the effects of black carbon aerosols darkening the ice and causing still more warming.¹⁴

Recommendations

Five-Year Goal

I urge our elected representatives to consider the following initiatives or similar ones. If done openly and in union with our immense scientific and engineering expertise, they should garner the necessary political support to succeed:

- Set up several centers of excellence similar to the Sematech – the consortium of industry and government founded in 1987 “to solve common manufacturing [semiconductor] problems by leveraging resources and sharing risks.”¹⁵ At the time of its founding, the United States was in jeopardy of losing its global technology leadership in semiconductors; clearly, we have regained that leadership position. Unfortunately, the United States is behind foreign firms in alternative energy sources. The goals of the Sematech-type centers would be to advance domestic technology alternative energy sources:
 - Improve the cost effectiveness of solar photovoltaic cells (currently British Petroleum is the world leader in this technology),
 - Improve the cost effectiveness of wind turbines (currently the Netherlands leads in this technology),
 - Develop methods for bulk storage of electric energy (such as batteries and inertia storage), and
 - Exploration of new types of nuclear reactors that will be safer.
- Propose national legislation that would provide near-term relief with current technology:
 - Encourage the automobile industry to produce more high-efficient vehicles such as hybrids and encourage the public through various

incentives to purchase the most efficient vehicle that will meet their needs. This recommendation should be considered in the context that according to the EPA the gasoline mileage of cars has decreased from the 1987 value of 22.1 to 20.8 mpg.¹⁶ This decline is due to the public's desire for larger vehicles (such as SUVs) since the actual efficiency of gasoline engines has improved remarkably over this period. Hybrid technology can provide 30% improvement in gas mileage and if the driving population is encouraged to purchase vehicles that are inherently more fuel-efficient since they would be lighter and less accelerative, we can achieve savings of at least 33%.¹⁷ Hybrid technology is new and we will likely see further improvements over the years to come.

- Encourage, where feasible, the replacement of ALL coal-fired power plants with Combined Cycle Gas Turbine (CCGT) power plants. This will result in a 50% savings in carbon dioxide emissions since coal is the largest greenhouse gas emitter and natural gas is the least greenhouse gas emitter of the fossil fuels.
- Require all industries that emit greenhouse gases and particulates to employ the most effective technology at constraining these gases. Half of the effects of global warming come from non-carbon dioxide gases.
- Upgrading the majority of our buildings to higher energy efficiency will substantially improve the need for energy expenditures. In a recent article in *Science*, S. Pascal and R. Socolow have calculated that such upgrades could reduce emissions of carbon one billion tons per year.¹⁸

Twenty-Five to Fifty Year Goal

We are faced with dwindling oil and gas reserves. The only conventional alternative is coal, but that creates twice the carbon dioxide as the other fossil fuels. Encouraging more coal usage would only exacerbate our global warming problems. Without a “new” discovery, we are faced with only three technologies that are sustainable and non-carbon producing. I am recommending that we implement efforts to coordinate industry and government activities to make these technologies more suitable for wide scale implementation. Refinements of these technologies and deployment of power plants based on them are efforts that will take decades to accomplish, but it will take decades to bring global warming under control. Again, developing a world-class technology in these areas will provide for the needed job growth and provide for exports.

- **Solar-** Solar photovoltaic cell technology has the potential to provide clean, renewable energy, but current photovoltaic technology costs several times the cost of production using current methods. Research and Development along the lines of Sematech should enable the United States to utilize its scientific and

engineering talents at making this technology more economical. Currently foreign firms, BP in particular, are the leaders in producing solar arrays.

- **Wind** – Under high-wind conditions, wind turbines are actually competitive with conventional sources of electricity.¹⁹ The power output of a wind turbine is proportional to the third power of the wind speed. Unfortunately under average wind conditions, wind turbines still lag the economics of conventional electricity production. Again, wind turbine technology leadership is in the hands of foreign firms-primarily the Netherlands.
- **Nuclear** – Nuclear power plants currently provide 20% of the electricity generated in the United States. Better designs should be developed to replace these aging plants and perhaps expand the national capacity for nuclear power generation. The IPCC report explicitly did not address the potential for nuclear power to assist us in reducing greenhouse gases.²⁰ Clearly building more power plants would require developing the necessary technology to ensure a nearly catastrophic-free design and a design that was safe against a terrorist attack. Such developments are problematic and will require one or two decades of development and refinement. Nevertheless, outside of a new discovery of energy, this avenue should be pursued vigorously. In particular an interdisciplinary MIT study has recommended a vigorous program of developing new and safer designs for nuclear power plants.²¹

Conclusion

These problems are serious and they affect almost every aspect of government from foreign relations, regulatory control, and industrial development. Our politicians should to support such initiatives as the McCain-Lieberman Climate Stewart Act, which would bring this country into conformance with the Kyoto Accord.

Objectively one cannot reject the possibility that the recent temperature rises are a statistical fluke and that the industrialized insertion of carbon dioxide is actually offset by some unknown mechanism. Moreover, the business-as-usual practice of switching to coal as our petroleum reserves become exhausted will not worsen the situation.

Clearly, the risk is substantial that this rosy scenario is wrong and corrective, serious measures are warranted at this time. Today Germany must bear the burden of creating two world wars and near-destruction of Judaism. I am concerned that our future generations will bear the burden that the United States ignored the scientific evidence and the requests of the global community and produced more carbon dioxide per capita than any other large industrial country. The result of these emissions caused disruptive climates throughout the world. These disruptions could easily will result in more death and destruction than all the wars of the 20th century.

- ¹ <http://www.fordvehicles.com/suvs/escapehybrid/compare/details/?vehicles=15218|14671|16190>, September 18, 2005. A comparison between the Hybrid Escape and Standard Hybrid on the website reveals a hybrid (city mpg/hwy mpg) vs. standard engine of 33/29 vs. 22/25. The average improvement is 30%. I used this conservative number. However, I further assume that an aware public would select smaller and less accelerative vehicles for another 20% improvement. The net savings is a 33% reduction in gas consumption for equal distances driven. Other more favorable comparisons are possible. Also the Escape is hybrid, which is a converted car, further efficiencies are obtainable with vehicles originally designed to be hybrids such as the Toyota Prius.
- ² Natural gas produces half the greenhouse gases relative to coal for a given unit of energy. I assumed that a natural-gas power plant, particularly a combination cycle gas turbine unit would have at least an equal energy to electricity conversion efficiency.
- ³ Pascal, S. and Socolow, R., *Stabilization Wedges: Solving the Climate Problem for the Next 50 years with Current Technologies*, Science, 13 August 2004 vol 305, page 970
- ⁴ *Meeting the Climate Challenge, Recommendations of the International Climate Change Taskforce*, January 2005, page 4
- ⁵ *Climate Change 2001: Scientific Basis*, Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, ISBN 0521 80767 0, 2001, page 7
- ⁶ Gelban, Ross, Boiling Point, A Member of the Perseus Books Group, New York ISBN 0-465-027161-X, 2004, page 1
- ⁷ Meeting the Climate Challenge, Recommendations of the International Climate Change Taskforce, January 2005, page 3 and 4
- ⁸ Clayton, Mark, New coal plants bury 'Kyoto,' Christen Science Monitor, December 23, 2004 Environment Section
- ⁹ Wald, Matthew L, *Questions about a Hydrogen Economy*, Scientific American May 2004, graph on page 71
- ¹⁰ Meeting the Climate Challenge, Recommendations of the International Climate Change Taskforce, January 2005, page 14
- ¹¹ Shapouri, Hosein, et al, *The Energy Balance of Corn Ethanol*, United States Department of Agriculture, Agricultural Economic Report Number 813, July 2002
- ¹² Graf, Angela, and Koehler, Tom, *Oregon Cellulose-Ethanol Study An evaluation of the potential for ethanol production in Oregon using cellulose-based feedstocks*, Oregon Office of Energy, January 2000
- ¹³ Rilett, John, Ethanol Vehicle Fuel: Energy Balance, GHG Reductions, Supply and Economic Overview, Discussion Paper C3-014 Canadian Climate Change Central, April 15, 2003
- ¹⁴ Hansen, James, *Can we defuse The Global Warming Time Bomb?*, Scientific American, March 2004, detailed downloaded document, " ... IPCC calculation, epitomized by the Wild et al. result, omit the most important physics...the effects of black carbon," page 23
- ¹⁵ <http://www.sematech.org/corporate/history.htm>
- ¹⁶ Light-Duty Automotive Technology and Fuel Trends: 1975 to 2004, EPA Office of Transportation and Air Quality, EPA420-R-04-001, April 2004, table on page ii
- ¹⁷ See item 1
- ¹⁸ Pascal, S. and Socolow, R., *Stabilization Wedges: Solving the Climate Problem for the Next 50 years with Current Technologies*, Science, 13 August 2004 vol 305, page 970
- ¹⁹ Taylor, Andrew, *Interest in Windpower is reignited*, FT.com, April 9 2002; <http://specials.ft.com/energy/FT3JEXPHSZC.html>
- ²⁰ *Meeting the Climate Challenge, Recommendations of the International Climate Change Taskforce*, January 2005, page 17 Footnote "The Taskforce is agreed that renewable energy will have a major role to play and that advanced fossil-fuels technology which can capture and sequester carbon dioxide may also be important. **It has not taken a position on nuclear energy.**" My bold font.
- ²¹ *The Future of Nuclear Power*, An Interdisciplinary MIT Study, ISBN 0-615-12420-8