Hydrogen: American Energy Independence in 15 Years

While Collaterally Solving the Persistent U. S. Problems of Unemployment, Economic Growth, Impending Inflation, and an Unenlightened Foreign Policy

Note for the Electronic Version

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Introduction

This is a common sense approach to achieving total energy independence for the United States of America in fifteen years. If the country pursues this plan, we would achieve fifty percent independence in about ten years. If the full plan were realized, the country's energy use infrastructure would be completely revamped such that it would be poised to carry the economy forward for the rest of the twenty-first century.

To do this will require a national commitment on the scale of our mobilization for World War Two and the creation of an independent agency that would make all decisions on how the nation's resources would be deployed. Those decisions must be made freely on the basis of the best good for the country, sometimes over the vigorous protests and political pressures of individual states and the endless string of special interest groups. The priority order for making these decisions would be: sound science, sound engineering, and sound business, with as little consideration for politics as possible and still have the do the things it must.

The ancillary scientific, social, and economic benefits resulting from this dedicated effort should be even greater than those produced by the space race and could result in a reversal of the current decline to an American ascendancy in the global economy for the foreseeable future. America would secure a significant lead in the science, technology, production, and management of energy production and distribution that would be in demand by every segment of the global economy. It might be possible for foreign trade to reach a semblance of balance. It might be possible for our foreign policy to be driven by beneficial trade rather than energy imperialism.

This country possesses all the resources required for the task. Does it have the vision to see there is no other alternative, the self-reliance to take reality and reshape it, and the American grit to see it through? I say, we've done it before; we can do it again. Where do I sign up?

Understanding Our Energy Crisis

Before we can intelligently fix our problems, we must thoroughly understand them—an approach frequently ignored by American business and almost always ignored by American politics. The rest of the world views this country as a vast land of cowboys carrying guns on our hips just waiting for a chance to whip them from their holsters and fire them at whatever apparitions we happen to be imagining that day. They are not far from wrong when it comes to foreign policy, but that's a shortcoming of a political structure that was designed for the problems and sensibilities of the eighteenth century.

The American people have, by-and-large, been able to grow and change as the circumstances of the world have dictated during the last couple of hundred years. The operating profile of our government has not. However, that operating profile has provided the stability and enough flexibility for us to maintain a position of world dominance for a very long time. But we've lost it.

We've lost it for several reasons. We took our eye off the ball, and in a baseball saturated culture like ours, just about everybody knows what results that produces—no hits. And to make the game really tough, we've made a lot of errors. The game is called: the global economy.

We seeded it. We fostered it. We encouraged it. But when it took off on its own, we seemed to forget that we needed a saleable product that the other countries wanted. Many thought that capital alone was sufficient. Some thought that new technology would always be saleable. Still others thought that sophisticated services or cultural envy were the right product. And all of these answers were sort of right. It should have—it could have worked, but the ball was technology.

The spurt we got from the space race disappeared as we went from creative thinking to maximizing this year's bottom line. As the rest of the world focused on self-improvement through enlightened education programs that improved their own technological capabilities, we languished in the luxuries of today with little investment in the realities of tomorrow.

Not only did the other industrialized nations out long-range plan us, but we helped them out by exporting the slim lead we maintained in technology. We rightfully encouraged multi-nationalism and invested heavily in taking our high-tech production facilities to up-and-coming countries where education made the workers smart enough to do the work but their backward infrastructures still had them working for very low wages. Voila! Instant maximization of this year's bottom line.

When we had given away our spurt of technology and failed to have anything in the oven, our cookie jar was nearing empty. We were suddenly importing more that we exported. Our trade deficit was monumental. Our capital was no longer as attractive and we didn't have as much of it. We were no longer a lucrative place for international investments.

Meanwhile, China, India, and a lot of other countries where most of our technologies were successfully deployed and producing the goods we were buying at a prodigious rate were gaining on our position as the number one user of oil. The oil cartels were holding lots of U.S. dollars that were increasingly less desirable, and the world demand for oil could be projected to have virtually no limit with current energy-use patterns. The cartels throttled-back on production increases and let the price of oil begin to rise, as this somewhat offset the drop in value being experienced by the dollar.

Our current blind faith in market dynamics encouraged driving up the price of oil even further by speculation in what was clearly a terrific long-term commodity. The price of oil jumped sky-high.

The highly foreign oil dependent U.S. economy could no longer grind along producing goods and services at the same margins of profit. More work left the country, good jobs got harder to find, and inflation's knock on our door is threatening to become a battering ram.

This is the cause of our energy crisis. In a nutshell, it is this: a high technology society producing the most lavish lifestyle on the planet needs lots of energy to exist; we have almost no oil of our own and our economy and lifestyle can't exist without it; and we can't use the coal we do have because it doesn't fit the required functions and we would choke to death on it if we did.

If this sounds serious, it's because it is. Energy independence is a life or death choice for this country, and we're running out of time.

The Bright Side

The subtitle of this book might sound audacious for most of the world's countries, since it would be so out of character, but for Americans it is simply a statement of our proven ability to make bold commitments and stick to them.

We did it the first time in a major way when we cranked up to recover from our devastating civil war. Unfortunately, it came with unbridled capitalism, but we even managed to get that under control, saving its growth and vitality while limiting the abuses of the robber barons before we plunged into the Great War. We did it again when faced with the Great Depression in the 1930s by putting the determination and self-reliance of the American people to work building an infrastructure that led us to world economic dominance and prepared us for the even greater challenge of World War II. We emerged from this challenge as the greatest economic, political, and military power on the planet.

Since that pinnacle, our position has eroded considerably, but we have since risen to outright challenges more than once. We held on to military dominance when we blockaded Cuba. We guaranteed military and economic dominance when we met the technological challenge of the Soviet Union by putting men on the moon in less than ten years. We solidified our political power when we destroyed the Soviets by running them into the ground economically to end the cold war.

We still have the ability, and somewhere buried in our current national ennui, we still have the will. We just have to find it again.

The Dark Side

In fact, we started to work on this problem once before and hardly got out of the gate before loosing interest. President Nixon launched *Project Independence* in 1970, declaring, "Let this be our national goal: At the end of this decade, in the year 1980, the United States will not be dependent on any other country for the energy we need to provide our jobs, to heat our homes, and to keep our transportation moving." Perhaps this was not a perfect plan, but it was a good one. As soon as the world's energy cartels saw that we meant business, they backed down from their production level cuts and price increases that had caused backups at the gas pumps and higher energy prices. They were much too savvy to kill the goose by providing an incentive for American energy independence, so production went back up, prices went back down, and the American public, happy to not look past their noses, forgot about the problem. The goose has continued to lay golden eggs for twenty-five more years.

A Rationale for This Essay

An essay this short cannot be anything other than the concept for such a sweeping plan. But we have to start somewhere if we are going to save the American Dream for at least a few more generations.

With so much planning already done by professionals, it should come as no surprise that this plan contains no basically new ideas that I'm aware of, but it is probably unique in the manner in which it integrates the old and new, the proven and the potential. The "old" goes back to the American innovation of large-scale series production with Henry Ford's early automobiles, and later, the liberty ships and other engines of war for World War II. The "potential" lies with the American dreamers like Burt Rutan who duplicated the success of the first five years of the multi-billion dollar space program from a hangar, in the desert, on a shoestring budget, with an airframe design you could punch holes in with a wooden pencil. But he did it with creativity and genius.

While this plan started out with the scope of achieving energy independence, it quickly became apparent that this goal was not possible without simultaneously solving some other major problems the country faces. This ancillary effect is a lot like that experienced as a result of the technology spurt we received from the space race. In this case, we are not so much the beneficiaries of good planning or leadership, but rather we will gain some much needed changes from our effort to solve the energy problem forced on us by our lack of attention until it had reached a crisis. We'll take whatever we can get, because we need it desperately.

The Long and the Short of It

We will start with the statement that there are NO short-term solutions to U.S. energy independence, nor to regaining technological and economic dominance in the global market. How long would it take, if we made it a national priority? World War II started in 1939 and ended in 1945—less than six years. In 1962, President Kennedy declared the nations intention to ". . . go to the moon in this decade." Neil Armstrong set foot on the moon in 1969—less than seven years and without the impetus of war.

My best guess is that the energy problem would succumb to a ten year program if given a national priority level somewhere between that of World War II and the space program, and if the agency created to manage it were infused with the urgency and independence of the Manhattan project. That is, it would succumb at least to the extent that energy dependence would be reduced to fifty percent of consumption and all the necessary technologies, production capacities, and infrastructure overhauls were by then proven and driving in sophistication and quantity toward total independence by the fifteen year mark.

From another perspective, the plan could and should keep evolving, as energy will always be a growing demand for a society that has embraced technology as its handmaiden and has integrated it into every aspect of its daily life.

The Why and When for Action

Because of the economics, which we will deal with in this essay, and the politics, which we will avoid as much as possible in this essay, the U.S. has been artificially supporting a hydro-carbon based energy economy beginning with the recovery period after World War II, and was undeterred in its support even though the '70s oil crisis made it clear that changes were both needed and inevitable.

A technological society like ours has two basic drivers: energy and intellect. While intellect will gain a much needed boost and reorientation by this plan, intellectual upgrading lies primarily in the domain of education. And while this plan will move us toward the needed technical orientation of education similar to what occurred during the space-race, it is its own grave problem and needs its own plan of rational action beyond the purview of this essay. Energy we will dissect into its many forms and delivery systems to make sense of how to integrate what we already have with what we can do, ultimately putting it into a plan that makes sense.

While intellectual prowess is the source of the blueprints, energy availability and cost is the economic foundation on which the house of industrialization is built. It is impossible to find a manufacturing concept that doesn't have energy costs as a key component of balance sheet expenses even though it usually takes a back seat to the cost of labor. The percentage of expenses that energy makes up of manufacturing seems to decline following the hierarchy from heavy industry (e.g. steel production) to light industry (e.g. electronics), which is basically a hierarchy of raw material utilization to utilization of materials so altered from their raw state as to be indistinguishable from their origins. The percentage also seems to fall as the character of our manufacturing changes from the use of unskilled labor to highly-skilled labor.

While we are currently bemoaning our country's loss of industrial jobs to the less developed nations of the world, we have actually been slowing that natural transition with our subsidy lowered energy costs serving as a small balance to the higher costs of our industrial labor. What will happen to our jobs when the cost of energy in the U.S. continues to grow along with the uncertainty of its availability? There is a real danger of this situation having such a devastating impact on the U.S. economy as to bring about its virtual collapse, but any measure of energy independence we can achieve will improve our chances of avoiding such a collapse and staying in the forefront of the global economy.

At the moment, our foundation is rotting away and our house is teetering. Stopping it from falling over by shoring it up with mere sticks of subsidy (in one form or another), political razzle-dazzle (in every form conceivable), and a myriad of sound-good but do-nothing stop gaps is just going to assure that its eventual toppling *will* be catastrophic. The house is wobbly, but still sound enough for many more years. We need to rebuild the foundation before all is irrevocably lost. We need to do it now.

Who and How Much Is Required

This effort will no doubt take many billions of dollars, probably trillions. If we assume I am correct in guessing that payback will take ten years to merely start, it is clear that industry is not going to do it. The bottom line for this year, much less next year, is too important to those in corporate power structures for it to even be considered. On top of that, the time-line needed to prevent economic chaos requires the maximum cooperation of all American resources, not a commercially competitive dog-fight. What we need is a faux competitive effort like the government employs with the military-industrial complex, where the public is told and generally believes that competition is going on, but where the major contract usually goes to the most qualified or the most in need of work, not the cheapest, and sops of subcontracts are politically distributed to the losing competitors.

That's right, it has to be a government program, complete with all its inherent inefficiencies. No other source is available to commit that kind of money without a payback for that long, and no other source has a chance of properly considering long-term environmental issues. We might wish for something better, but it won't happen. We are stuck with politics, government bungling, and inefficiency—end of this subject.

After vehemently stating that it must be a government program, let me jump right in and say that the program cannot work without the commitment of ALL of the know-how and resources that industry has to offer. This will probably require bait and bash tactics from the government, but we have done it before and we can do it again—the "bait" being gobs of money and the "bash" being threats of cut-off from future participation in the global energy market.

An effort as massive and long-term as this will understandably require vigorous public support. Public education as to the problem is not that complicated and could probably be explained by competent employment of the bully pulpit (something that's been missing of late). For the minority, who cannot ordinarily be roused about any issue beyond tomorrow's sporting event or television's evening line-up, the grave nature of the problem will just have to be used to scare them into support.

A Short Digression on the Nature and Use of Energy

A short digression is needed here to provide a framework for the following discussion. Energy is all around us, seemingly in every conceivable form imaginable, but really either as Big Bang thermodynamics (e.g. momentum and latent heat), the binding forces of matter itself (e.g. fission/fusion), or from combination effects like the weather (momentum, latent heat, and the fusion going on in the sun). It isn't exactly this simple, but it's close enough for this essay.

Man's earliest technologies employed direct utilization of the energy sources like a flowing river, the blowing wind, and the rise and fall of the tides. The energy was extracted from these sources primarily by mechanical devices like water wheels, and wind mills that in turn could be mechanically linked to the device it was powering like grinding wheels and pumps. Man also used the radiant energy of the sun for drying food and staying warm until fire gave us our first use of stored energy, but it took a long time for us to use combustion to provide mechanical power.

With the steam engine we were finally able to use combustibles to power mechanical devices by using the stored energy in those materials. We gravitated quickly to using the combustible materials with the highest concentrations of stored energy from wood to coal to petroleum and gas.

But the uses of this energy for industry were severely limited by the high heat losses of steam in pipes and the mechanical linkages of machinery—enter electricity. While electricity had the inefficiencies of generation, retransformation to mechanical energy by the motor, and transmission loss from the point of generation to the point of use, it was still better than many steam or mechanical linkages required to operate machinery. It also still allowed the use of less expensive prime energy sources like coal and falling water.

With the internal combustion engine came another way of solving the mechanical linkage problem. A higher density though more expensive energy source could now be used with a less expensive and more efficient transmission infrastructure, making it a competitor to steam driven, electrical power plants when mechanical energy at the point of work was the goal. With the automobile addiction, the internal combustion engine then proceeded to change our whole culture, bringing with it our dependency on petroleum.

These two energy-source-to-mechanical-device choices are still with us today, but we have added electronics requirements to the mix, which can only use its energy after its conversion to electricity. Since electronics in all of their various forms have clearly become the primary cultural drivers in the world, any energy independence solution must stay focused on providing electrical energy to the site of its use. The trick is to do this while substituting plentiful and renewable primary energy sources for the dwindling and non-renewable sources we currently use.

The Tripartite Nature of the U.S. Energy Problem

Because of the culture-driven nature of our energy consumption in the U.S., there are really three hardcore parts to the nation's energy problems that have created the current crisis. First, we must find a way to provide cheap, reliable, electric power for the heavy, medium, and light industry we still have and for the multitude of direct consumer uses from lighting, heating, and air-conditioning to communications, computers, and entertainment. The range of uses to which we put electricity is staggering when you try to catalog them, but it is mind boggling when you look at the pace at which we are expanding its scope.

The second part of the energy problem causing the current crisis stems directly from our use of the internal combustion engine. As discussed earlier, the internal combustion engine allows us to put instantly available mechanical power right where it's needed without the massive, power transmission infrastructure required for steam or electricity. It is epitomized in our society by the ubiquitous automobile. While there are some promising new technologies being exploited to use electricity or fossil-fuel/electric hybrid power sources for autos, cost and physics make it difficult for these technologies to totally displace the convenience and power availability inherent in the combustion engine for the foreseeable future.

The third problem we must tackle to find a reasonable solution to the current energy crisis is to solve the first two without further degrading the environment, and if possible, while actually improving the environment, since a solution that doesn't reduce pollution levels in general, and carbon dioxide levels in particular will produce a short-lived solution at best. Being able to drive our cars will be a hollow victory if we can't breathe the air, drink the water, and survive radical climate change.

So any answer or answers to provide the U.S. with energy independence in time to stave off economic decline must be capable of fulfilling the functions now being served by fossil-fuels and electricity, while doing it with less pollution and a smaller carbon footprint.

The Criteria for What We Can Do

So mountains of resources and buckets of money are needed with the cooperation (willing and reluctant) of just about everybody, but again I say, we've done it before, and we can do it again. We need only figure out *what* to do and *how* to do it.

Let's take a look at some of the criteria that a solution to the three parts of the energy problem must meet. We'll start with the environment, since it is the most emotional issue and then tackle electric power generation, since it is at least part of the solution and it might ultimately be the sole solution, if new technologies can make it suitable for replacing the internal combustion engine.

Whether you are a believer or non-believer in global warming and/or climate change, you need only look around you to know that pollution of all sorts is seriously degrading the quality of life in our country (and everywhere else) and probably its span—and that's the immediate effect. The secondary, long-term, and tertiary effects of pollution are usually missed by the general public, since they are not sensational enough for journalistic fervor, but they must also be addressed in the multi-generational problems we are trying to solve.

Let's start with an axiom most can agree on—all potential solutions to the immediate energy crisis have environmental impacts. What we need to determine is which combination of technologies and ameliorations produce the least environmental impact in both the short and long term. All of this is usually a trade-off with cost, and they go on every day in decisions made by the electric power generating companies. For now, suffice it to say that the soaring price of crude oil, in particular, and fossil-fuels in general, has completely changed the economics of utilizing pollutant reducing technologies and incorporating basic changes in design, operating profile, site selection, etc. that can reduce environmental impacts of any sort. This has already resulted in more types and larger quantities of alternative energy sources and generating technologies being seriously considered based solely on their possible contribution to the bottom line.

Of course, some energy sources have a very low level of environmental impact regardless of steps that the current energy economics might allow to ameliorate environmental impact. This gives them a natural edge on “dirtier” potential solutions to the crisis, which we will consider in our more detailed look at potential solutions to both electricity generation and combustible fuel production, but first we will take a survey-level look at the general problem of energy and the environment.

Energy Sources and the Environment

All of the fuels used to power industrialization in the world today produce pollutants in some stage from extraction or creation to actual combustion except for the less than 10% that use some form of kinetic energy as their source like wind and water. Since most of these fuels start out in the ground, let’s start there where its area of impact is usually small, go on to water where nature causes wider distribution, and finally to the air where distribution can be enormous and frequently international.

The largest ground contaminants of energy production are usually related to the immediate area of retrieval from sub-surface sources, like coal, oil, radioactive ores, and even some hydro-thermal sources. Ground contamination can also occur from the malfunction of nuclear power plants, the spilling of oil and petroleum products, and the careless disposal of fly-ash, but they are not regular or normal occurrences. Technologies for avoiding, abating, and cleaning up these types of contamination has been around for decades and should be adequate for the future, if employed rationally.

An oil spill in a river or one that washes up on the shores is highly visible but much easier to deal with than pervasive contaminants that leak into streams and rivers as well as leach into the ground waters. For our hydro-carbon based form of organic life, pure water is the most essential substance on the planet. There is no substitute, and we must ensure that we have it in sufficient quantity or solving the energy problem is of little consequence. Then again, with sufficient inexpensive energy at our disposal we could make all the pure water we needed—a micro example of the chicken-and-egg enigma presented by this envisioned energy program. Water-borne contaminants must be high on the screening list for potential energy source solutions.

Air pollution is the most serious threat from both potential electrical energy production sources and the combustion engine. While we might be able to live with the inconvenience of wearing filter masks when going out of air-conditioned areas, the rest of the flora and fauna on the earth would just die.

Add to that the fact that much of the water-borne pollution we now suffer is a secondary effect from airborne pollutants washed from the air by rain, like the acid rain that is killing our freshwater streams and forests. Air pollutants are also the most visible contaminants we have to deal with and the vast majority of them are produced by burning fossil-fuels for heating, energy production, transportation, and industrial uses. The public will not support energy source solutions that increase air pollution, and public support is essential.

Electric Power Generation Plants and the Environment

Electricity can be produced by many methods. All of these methods break down into just a few general categories: direct conversion, like solar cells; kinetically driven generators, like hydro-turbines and wind-turbines; and heat driven generators, which primarily utilize liquid-to-gas, phase-change turbines, such as fossil-fuel-fired hydro-thermal, solar thermal, and ocean thermal turbines. We will explore the more feasible of these and other specific alternatives as the essay progresses.

It would be nice to say that we could just pick an electric power generating technology with no environmental impact and be done with it, but there aren't any of those. Electric generating technologies that are available and proven are reasonably small polluters if they accept the increased costs and inefficiencies that come with incorporating the latest technologies for pollution abatement. So knowing that we can make current technologies reasonably clean by spending more money (which raises the cost per energy unit produced), what is our most critical environmental criterion for selecting potential energy sources capable of providing America with energy independence? It is site selection.

Since the days of Tesla and Edison, electric generating power plants have been sited close to urban and industrial centers because physics doesn't favor anything else. Electrical power transmission is too inefficient (line resistance) to allow remote sighting unless the power source is cheap enough to overcome the losses of power between source and destination. That's why Tesla's alternating current put Edison's direct current out of business—it allowed an easy step-up of voltage for transmission at the power plant and an easy step-down of voltage for safe usage in the user's neighborhood. The higher you pump up the voltage the more efficient the transmission, but that has its physical limits too. Ongoing research in high-temperature, super-conducting materials might make some miraculous breakthrough that would change this situation, but betting our future on it happening soon, if ever, seems risky.

The billowing smokestacks of power plants in or just outside of our cities were tolerable when the usage was small, the convenience of electricity was novel, and there weren't so many people to serve. It is no longer tolerable. The air pollution from transportation systems alone in major metropolitan areas is more than we can accept.

A factor that adds considerably to site selection's first position on the environmental criterion list is public perception. As much as I hate the fact, most people would have little or no objection to additional power plants being built a long way from their neighborhood. Out-of-sight, out-of-mind is a strong inducement for careful sight selection because public support is essential. This is particularly important if the sites are for nuclear power plants, where the press can dredge up all kinds of fear to feed the public.

The largest factor, however, is simply that some areas are better able to deal with inevitable pollutants than others, be they from normal operation or from accidental discharges of whatever nature. The first environmental consideration must be for public safety from contaminants, the second must be for damage to the ecosystem, and the third must be for ease of containment and cleanup.

Fortunately, America is a very large country, and we have many such places that fit most of these requirements. They are the deserts and the high plains areas. This is not to say that these areas don't have ecosystems that would be damaged by just siting the power plants there or by the pollution they might produce, but that the impact would be smaller in these remote areas than any other place. Remember, there will always be environmental impact, it's just a matter of how much and how damaging it will be.

Particulate fallout from power generating plants in arid and semi-arid areas could be physically removed and stored, if necessary, with much greater efficiency than in an urban or forested area. The scarcity of rivers and streams would make containment of pollutants much easier than in areas of high rainfall and natural drainage topography. Finally, and almost serendipitously, these areas are remote because they are undesirable (by most) for habitation and are not economically feasible for farming.

The Current Big Three of Electric Power Generation Technologies

Over the years, three technologies for producing electric power have dominated the power industry in the U.S. The simplicity of the technology and the availability of free fuel certainly got the attention of industrial capitalists of late 19th and early 20th century America, so the cheap labor available from the immigrating masses and depression-numbed citizens was utilized to build huge dams wherever there was an abundant source of flowing water.

While the kinetic energy of water was free, the same cheap labor and disregard for human life and the environment made coal not too far from free, so we built pollution belching power plants near or in our cities where the demand for electricity was the greatest. And when the cost of labor rose along with concern for the environment, we switched many of the plants to natural gas and cheap foreign oil. This fossil-fuel technology still makes up more than 70% of our electrical energy production.

After World War II we had this wonderful technology developed for mass destruction, and we were determined to find a way to capitalize on the seemingly limitless and ridiculously cheap energy it seemed to offer. We did this by building the nuclear power plants that now dot our country.

Remember that these three technologies are in abundant use primarily because of their dependability, fuel requirement availability, and cost to the consumer. With the rising price and diminishing availability of oil, some of the alternative sources examined by our more visionary scientists and engineers seem destined to find a niche in the production of electrical power in the U.S. independent of any comprehensive plan like this essay proposes. Having identified the big three, we need to say a little more about them.

Hydro-electric Power Plants

Most of these were built a long time ago and whatever environmental damage was produced by the construction of dams and power-line right-of-ways has been generally absorbed or shuffled to a new equilibrium by Mother Nature. Only the manner in which water releases are made from these dams has much potential for environmental impact due to normal operations. Of course, catastrophic structural failures of the dams would produce devastating environmental impacts, but they are highly unlikely to occur from natural causes. Terrorism is another topic.

Unfortunately, we have pretty much tapped out all the good sources of water to power such plants with reasonable efficiency. Again, this is mostly due to electrical power transmission inefficiencies, since the primary energy source of kinetic energy stored in the water by the earth's natural weather cycles is free. Add to this the fact that it is doubtful if public opinion would allow a major dam construction project in this country again.

Lack of good sources and public opinion have gradually reduced the percentage of U.S electric power being produced by hydroelectric means to just under 6%. This percentage will likely continue to decline unless some of the identified alternative power sources that utilize moving water prove to be economically viable, like tidal and free-current turbines.

Fossil-fueled Power Plants

While electricity generating power plants using fossil-fuels as their primary energy source have very different pollution potentials depending on which fossil-fuel is being burned, they are still burning fossil-fuels. The worst offender is the coal-fired plant, which produces more than 67% of U.S. electricity. Burning coal in these plants produces solids and gases that are highly toxic to the environment. In fact, the majority of the widespread damage to the earth's environment for which industrialization is responsible can be traced directly to pollutants produced by the burning of coal. Even when smokestack scrubbers are used to keep fly-ash from getting into the atmosphere, the fly-ash is difficult to get rid of because it can still leach toxins like mercury and arsenic into the ground water if not disposed of properly, which is expensive and almost guarantees it will not be properly handled. One way or another, these pollutants eventually end up contaminating our soil and our water, even the oceans, and thereby entering the entire bio-system that sustains life on this planet.

Oil-fired plants (of which there are few) are a little better simply because oil has fewer natural pollutants than coal, i.e. the coal has already been refined courtesy of millions of years of attention from Mother Nature. Following this natural refinement chain up the ladder we come to natural gas-fired plants. These plants are relatively clean burning, producing few pollutants to be dealt with by the natural soil, water, and air environments.

Producing gas for these plants from coal, so called clean-coal technology, needs some serious consideration as one of the short-term ways we can meet electric power requirements with minimal air pollution impact. While the processes used for removal of potentially toxic substances from the coal before it is burned is better for our air, those processes themselves produce pollution and wastes for which disposal is difficult. On top of that, envisioned clean-coal technology is so expensive that it can only happen as a government subsidized operation, and this will not save us past the short term.

Nuclear Power Plants

Nuclear power plants have had a much better safety record than the environmental lobby envisioned during their construction. Although their costs per energy output unit has been much higher than originally envisioned, like oil, it has been subsidized by the government to make it a competitive source of energy. However, we are currently just considering the environmental viability of the technology, and except for the government's bungling of the long-term storage of wastes, its environmental impact record over forty years is excellent when compared to its fossil-fuel competitors. A nuclear electrical power generating plant produces a minimum of environmental contaminants unless there is some accident in operation or in the handling of wastes. It produces no carbon dioxide, and therefore, does not contribute to the greenhouse effect, which many feel is the primary contributor to climate change and global warming.

It is important to note that the technology of U.S. nuclear power electrical generating plants is ancient history in the fast-growing, global power industry. While we allowed our commercial use of nuclear power to be virtually immobilized by a well-meaning and rightfully cautious environmental lobby, the rest of the world was paying attention to our technological success in commercial nuclear power, the diminishing supply of the world's oil reserves, and the growing dependency of the world's economy on oil production. They jumped into nuclear power with enthusiasm and are now leading the way in commercial power plant technology.

Fortunately for the U.S., our navy has continued to push the envelope in nuclear power plants in terms of size, cost, and safety technology, which is eminently transferable to the commercial sector. If we built commercial nuclear power plants today, they would be smaller, cheaper, and even safer.

A small digression appears appropriate here on the nuclear fission plant of today. It is already a tottering dinosaur with a nest of nuclear fusion eggs waiting to hatch if enough money is provided for research and development. While the fission plants can produce cheap energy, they produce lots more waste than will their fusion brothers. It is these wastes that drive up cost and produce the most vocal outcries from the special interest groups. We need to move this research and development to the top of our agenda, but predictably, we have recently taken a back-seat position in an international consortium to pursue fusion by agreeing to build the research's major facility in France. What are we thinking?

The Rest of the Electric Generating Technology Arsenal

Looking beyond the big three, what other types of currently available electricity generation technologies have the least adverse environmental impacts, proven or low-risk technology, and reasonable expectations of seemingly acceptable costs? There are quite a few, many being alternative energy sources under consideration the last time we had a serious energy plan in the '70s, but politics succeeded in killing work on them when energy prices fell and availability no longer became a problem. The most promising of these technologies are:

Ocean Thermal (unknown but probably low environmental impact; dependable output; conceptual extension of proven technologies) – limited to U.S. coastal region supply because of transmission/transportation inefficiencies and probably in the upper range of cost acceptability because the plants must be designed to operate for a reasonable life-cycle in the harsh ocean environment, with a long developmental lead-time.

Tidal (low to moderate environmental impact depending on which concepts are selected; dependable but intermittent output; proven technology requiring scale-up) – limited to U.S. coastal region supply because of transmission/transportation inefficiencies, with limited sites because of possible restrictions to waterborne transportation systems.

Geothermal (low to moderate environmental impact; dependable output; proven technology with considerable scale-up potential) – limited to areas of natural thermal upwelling or requiring expensive drilling techniques if deep-drilling technology is utilized; usually has costly maintenance and transmission/transportation inefficiencies.

Solar Cells, Earth-based (low environmental impact; moderately dependable output; proven technology) – requires large land areas in arid locations to minimize low or non-productive periods (with attendant transmission/transportation inefficiencies) but should be cost-effective with the economies of scale inherent in the high-volume production the photo-voltaic materials that would be required.

Solar Cells, Space-based (low environmental impact; dependable output; conceptual extension of proven technologies) – electrical power is converted to microwaves and transmitted to receiving grids on earth that are non-injurious to flora or fauna but will probably have to be remotely sited (with attendant transmission/transportation inefficiencies), with much higher costs and very long lead-time for development of the required infrastructures.

Solar Thermal (low environmental impact; moderately dependable output; proven technology) – has the same limitations as earth-based solar cells but some thermal storage can be utilized at lower efficiencies to minimize output interruptions, or it could be hybridized with a clean fuel source like hydrogen it could produce during periods of maximum solar incidence.

Current Flow Water Turbines (low to moderate environmental impact depending on site and scale; dependable output; conceptual extension of proven technologies) – limited siting availability in salt water currents with high costs for construction and maintenance of a saltwater system, with attendant transmission/transportation inefficiencies. Fresh water use of this technology would be limited to the utilization of smaller, multiple turbine installations, which might also have economic limitations.

Wind Turbines (low environmental impact; low dependability output; proven technology) – requires specific and usually remote siting, with reasonable costs, except for transmission/transportation inefficiencies which would grow as choice sites became limited to more remote locations. The best and most immediately deployable alternative.

All of these potential electrical energy generation sources with proven technologies, particularly wind turbines, should be considered as potential stop-gap technologies for the envisioned fifteen years required to put the energy plan operationally in place. While their limitations make them poor candidates for primary source technologies, they could be valuable auxiliary contributors for the foreseeable future. Of course, any of these alternatives could be hybridized with another clean energy source like hydrogen to provide steady electrical output, particularly during a transition period.

However, if dependability is required of these non-fossil-fuel alternatives, they could produce hydrogen and pipe it to areas of high demand where it could power electrical generating plants. This close proximity of the generating plant to the user would suffer lower line transmission losses to offset the efficiency losses inherent in hydrogen production, its transportation, and its conversion back to electricity.

Some of the concepts listed above require further development of existing base technologies before they can be put into physical production. Consequently, they might not serve well even as stop-gap measures; however, they might have a longer term viability for specific applications.

The Internal Combustion Obsession

Let’s turn our attention to the other part of the energy consumption problem, which lies mostly with our cultural addiction to the automobile. The death knell for public transportation was sounded at the end of World War II when the immense capacity of our wartime production capability for internal combustion driven machinery was converted to peacetime production. This conversion was needed and encouraged by the government to provide jobs for the returning GIs, meet the Marshal Plan commitments to post-war rebuilding, and generally keep the hard-won industrial capacity of the nation cranking at a pace that ensured our economic dominance in the world. It was also, in no small part, a statement of the dominant political position war had provided to the military-industrial complex that continued to be fueled by the cold war with the Soviet Union and whose companies would be the major players in any commercial conversions of the war technologies.

Regardless of the reasons, we essentially gave up on public transportation (as stupid in hindsight as that might seem) and proceeded to build a mystique of personal power and potency around freedoms inherent in private transportation. However, even the combined power of the government, industry, and Madison Avenue couldn't have done this without there having been a kernel of truth in the concept. Being able to jump in your car and go wherever you want, any time you want to do it, is both stimulating and liberating. And liberty is what this country is all about, isn't it?

In bringing this rekindling of American liberty, General Motors, Ford, and Chrysler brought us the internal combustion engine, in spades. And what better way to stamp on any remnants of a more efficient method of transportation after the cultural seduction of the automobile than to build an interstate highway system that would assure that trucks would displace the last stronghold of the railways, the transport of freight. The result was more internal combustion engines plying a less efficient mode of transportation.

Thus, we have petroleum-based pollution in the areas of primary internal combustion usage that rivals the worst periods of industrialization-caused pollution from the burning of the much dirtier coal. Ah, but the pollutants are much more subtle, since the gasoline engine doesn't produce the visible evidence of its presence like coal particulates. But they are there in awful splendor.

We must give ourselves some credit, however, for having had the courage and tenacity to clean up some of the most immediate offenders like sulfur and gasoline additives like lead and for mandating catalytic converters to remove some of the less-visible offenders. What we haven't done and what we can't do, however, is to remove the real offenders like carbon-dioxide and carbon-monoxide. These are and will always be by-products of gasoline combustion, and their impact on the environment has reached potentials well beyond the immediate effect of bad air in major cities.

Can the fossil-fuel burning internal combustion engine be cleaned up in any manner? Yes, but only a little. The diesel engine produces lower levels of some pollutants and gas-turbines also have the potential to produce better results, but all have their drawbacks. Thus, we have the sudden flurry of interest in hybrid technology vehicles.

The best hybrid concepts offer a way to harness some of the efficiencies of the electric motor in vehicle applications while simultaneously utilizing the good old combustion engine in more efficient modes of operation. Much of the pollution produced by conventionally-powered autos is during periods of acceleration, when the engine is operating at less than optimum efficiency and fuel is being burned in less that optimal air mixtures. This is done to provide high torque to overcome the inertia of our particularly massive cars or during deceleration when this mass is still turning the engine over and burning fuel. Electric motors do not have this problem and can even recapture energy during deceleration. Consequently, if the majority of power demands can be handled by an electric motor driven by a battery having its charge replenished by a stably and efficiently operating combustion engine, efficiency goes up, requiring less overall fossil-fuel consumption, and less pollution is produced by the combustion engine when it is recharging the battery.

Obviously, every car on every road needs to be fitted with this technology (or something better) as soon as possible, particularly when the extra cost of the vehicle (primarily the battery, which will continue to fall in price with economies of scale, if not improved technology) is mostly offset by the life-cycle cost savings in fuel. Moreover, it *will* happen, and not because of sensible government mandate, which is too much to expect, but because of the economic incentive to the consumer to make it happen. It just wouldn't happen soon enough if left to market dynamics.

Of course, batteries are not produced or recycled without environmental impact, so wide-scale use of batteries in hybrids will require careful regulation and monitoring to assure the technology produces net environmental benefits. However, the economic and foreign oil dependency benefit will be tangible.

This wonderful stop-gap that will be the child of soaring fossil-fuel prices, as good as it is, still consumes fossil-fuels, still spews pollutants into our atmosphere, and still requires the use of a fuel source that is diminishing in availability while growing in demand. It's only a stop-gap.

The Other Consumers of Fossil-fuels

Before we leave fossil-fuels, let's go beyond the infernal . . . oops!, internal combustion engine. Even with the improved efficiency of today's heat pumps, many of today's houses rely on fossil-fuels for heat in the winter. Where this heating is done with natural gas, the pollution is low but the sources are even scarcer than for petroleum, or the cost of transporting it from areas of abundance to the U.S. will significantly drive up the costs, and gas like oil is in finite supply. Where oil is burned for winter heat in our homes and businesses, the pollution levels are much higher than with gas but lower than those produced by the internal combustion engine. This is simply because the combustion cycle is simpler and usually more efficient. So while the pollution is low compared to vehicle consumption, we still must rely on a fuel source that is unreliable and diminishing in availability.

The one major survivor of mass transportation also needs a little discussion—the modern airplane. Here we are burning fossil-fuel in a jet engine which has higher efficiencies than the reciprocating engines of automobiles, offers economy of scale in terms of passenger miles traveled per barrel of oil needed, and since time is frequently money, speed, but it still uses petroleum and it still pollutes. While this pollution is lower than that of the reciprocating engine because of the jet engine's more complete combustion cycle, it is deposited primarily in the more fragile and much more dispersive ecosystem of the upper atmosphere. The amounts of jet fuel being consumed are large, growing every day, and likely to continue until we find a way to drive our personal vehicles across the world's oceans.

The other major consumer of fossil-fuels doesn't even use them for fuels. It uses them for feedstock in the chemical and plastics industries. Most people don't realize the scale of these consumers and their impact on fossil-fuel consumption in modern society, but it is significant. Ironically, it is to this use as feedstocks that the rest of the world's fossil-fuels needs to be consigned before they are used up, but it won't happen. We'll burn them all and the millions of years of free hydrocarbon concentration in Nature's underground retorts will be inefficiently expended. Rationality is not a governing force in energy consumption; so hopefully, we will develop new material technologies that do not rely heavily on hydrocarbons (there's lots of silicon.)

The Pigheaded Reality

Neither Americans nor the rest of the world's population are going to give up the freedom and life-style of personal transportation until all of us are choking on its wastes and starving from its devastation of the environment. All-electric cars require storage technologies allowing energy densities beyond those seemingly available from current or near term projections for batteries, capacitors, or flywheels suitable for personal vehicles, and this doesn't solve the problem of producing the electrical power and getting it to your neighborhood.

If combustion engines are going to continue to function in a similar fashion to the way they function today, they must utilize different combustible fuels like bio-fuels or hydrogen. Refueling must be a couple of minutes endeavor, not an overnight recharge. Power must be available seconds after the switch is turned, and it must be enough to accelerate quickly on demand. At least one family car must be large enough to seat four passengers comfortably for a long trip—preferably six, and a whole lot of people obviously want SUV-like cars that have the power to haul boats and campers across the country while carrying the whole family in comfort on an extended vacation. This is what the American public has been conditioned to want and expect. A proposed solution to the crisis that ignores this reality will have a hard time gaining public support.

Since most families have more than one car, maybe sanity will at least bring the American family to an acceptance of one large, combustion engine car and one smaller electric or hybrid car. This might be as far as we can push the psychological envelope until public transportation is truly resurrected and our society has made the necessary high energy costs demographic shifts that are inevitable.

If combustion engines are to be replaced entirely by electric motors, electricity must be available on-demand to recharge batteries or spin up kinetic rotors. This again emphasizes that alternatives like solar cells and wind turbines, which already have reasonable cost/output ratios, just wouldn't work as primary sources for electricity generation—the wind doesn't always blow, even atop Grandfather Mountain, and the sun doesn't always shine, even in the desert. And while solar thermal will always work when there is sufficient thermal gradient, the efficiency falls off markedly with the level of sunshine. Once again, however, they could produce hydrogen.

Bio-mass, Offshore Drilling, and Fossil-fuel Conversion

To readers that are at all familiar with the hoopla surrounding bio-fuels, the absence of any mention so far in this essay should be striking. It was meant to be. We will therefore indulge in a small digression to explode the myth that bio-mass conversion could ever be an answer to our consumption of gasoline by the automobile. The use of harvested bio-mass (like corn) to produce methanol takes so much petroleum-based fertilizer, fuel for the harvesting process, fuel for the operation of the fermentation tanks, and fuel for the distillation to usable methanol that its contribution to reduced fossil-fuel imports is virtually non-existent. This is physics at work again as it is just not possible for a single season's storage of energy from the sun, nutrients from the soil, and CO_2 from the air in the form of grain or switchgrass (or even a multiyear storage process like with wood) to produce a fuel with an energy density anywhere near that of oil, which has been naturally distilling and concentrating for millions of years.

The fact is that agribusiness sold this myth to the politicians for a lot of silver coins in the campaign contribution box, and they have been laughing all the way to the bank. We are doing this only because of politics, chicanery, greed, and gullibility, not because of rational thought. This hoax has cost the American public billions in subsidies and increased profits that went into agribusiness pockets, not to mention the trillions of dollars lost to the economy by delaying needed action on a rational approach to the energy crisis that confronts us. And not to mention the resultant increases in U.S. and worldwide food prices caused by elevated grain prices.

As this essay is being written, it seems inevitable that we are once again on the same red herring treadmill but this time the push is to open up new areas of offshore drilling. This time it's the oil companies that will benefit and, once again, not the American people. If all the U.S. controlled offshore sources of oil were made available, it wouldn't be a drop in the ocean of foreign oil that comes to our shores. It just wouldn't make any real difference in oil prices and it's still fossil-fuel. The insult to this injury is that it would be ten years before that oil would be available, making it too late to have any benefit in solving our crisis. Just like bio-fuels, however, we will hoopla this into another costly delay to taking real action.

We must also be vigilant to foreclose any effort on the part of the fossil-fuel industry to seduce us with the ready availability of hydrogen from fossil-fuels by any of the carbon stripping techniques available to them. Since the processes that would produce the hydrogen are a lot less than 100% efficient in their conversion, they could use even more foreign oil, not less. Even if this approach would reduce air pollution and the ensuing environmental degradation, it would still be using up fossil-fuels and wasting their future, but needed, potential as chemical and plastic feedstocks. While using the fuel for future hydrocarbon-rich feedstocks is clearly a more efficient use of petroleum, it is not nearly as immediate and alluring as a dollar in hand.

These three examples should galvanize the reader to the fact that big-business driven politics will be the first hurdle of any plan to solve the energy crisis, as there seems no limit to the flimflam the American people will embrace if it's said loud enough and long enough. Barnum would be proud.

Produce More or Use Less?

In almost every discussion of reducing the country's dependence on foreign oil we hear pleas for conserving energy. These are usually espoused by small but vocal groups that can sometime be annoying with their persistence. However, in this case, they are absolutely right!

So, how can we conserve energy? Now there are some who champion simply reducing our consumption by foregoing convenience—tightening the belt, as it were. I'm not in league with this group because I don't think it has a chance of working. When decisions need to be made that are painful, self-sacrifice is a characteristic having few followers in the human community. But if someone else is willing to bear the burden, we're all for it.

Fortunately (or unfortunately, depending on how you look at it), energy use efficiency in this country is so bad that there is an enormous opportunity for savings without giving up much in the way of convenience, performance, or even luxuries. Instead of giving up things, all we have to do is be smarter about how we get them.

Doing just that is a first line strategy for any solution to the energy crisis. It only requires a firm national will, rational politics (that might be trouble), and a reasonable commitment of incentive funds. Some major changes to the nation's building codes with substantial tax incentives for retrofitting, a major tightening of the Corporate Average Fuel Economy (CAFE) standards for automobiles, and a new, ground-based public transportation system, again with appropriate tax incentives, would do it.

Neither the auto-makers nor the home-builders are evil or even stupid. They are simply in a business where the product they make produces the greatest profits when it matches the demands of the potential consumer, and while clever marketing can nudge the consumer this way or that a few percentage points, that's about all it can do, and it's expensive. Of course, a farsighted automobile manufacturer or housing contractor might be able to build a loyal base of buyers, but how often do you buy a new house or even a new car. Company executives need to focus on *this* year's bottom line if they are going to keep their jobs long enough to enjoy the fruits of a larger base of loyal buyers.

Few products can be functionally improved without incurring additional costs. This is particularly true when the functionality of the product has been pretty much the same for a very long time. What would spur these businesses to be more innovative and to offer products with higher energy efficiencies?

If they improved their products and had to raise the cost, they would risk losing business to their competitors, because most people buy cars and houses with cost as a major component of their choice. Whether we like it or not, few people are willing to delay immediate gratification for long term benefits. Saving money on the electric bill next summer just doesn't trump having that four-dollar cup of coffee every morning, all winter.

The only real answer to how we can spur businesses to make more energy efficient products in time to be of benefit in solving the energy crisis is to force them through governmental regulation. Free-market dynamics just will not get the job done in time.

Energy Efficient Automobiles

When all the auto manufacturers selling cars in the U.S. have the level playing field that is produced by regulations, innovation is at its highest. Everybody is rushing to meet the new requirements with the most economical methods. They are no longer afraid to stick their necks out because all the manufacturer's necks are out. In fact, they can't not stick their necks out if they want to stay in business.

So stringent CAFE standards that force the product-size-mix and engine efficiencies of automobiles sold in this country are a must, and they must be standards that are to be achieved on a short schedule. The options for changing automobile designs to deliver greater energy efficiency are multitudinous, and we really haven't had that much money focussed on the problem to date, despite what the marketing people want you to believe. The direction these changes take will be governed mostly by any grand energy scheme that the government places into motion. So the quicker the government has a plan, the quicker fuel efficient cars will be available, no matter what they are using for fuel.

The life-cycle for a car is fairly short, and the effects of regulations that lower energy use would start to be noticeable as the percentage of new cars on the road increased. Some technology is so old and still unused that benefits could result in as little as two years. Static weight, for instance, could be reduced just by going to lighter materials for fabrication. They would cost more, but they would increase mileage, particularly for stop and go driving.

European and Asian countries have long had standards in place that U.S. auto-makers have successfully avoided through political maneuvering. These standards and proven technologies could be adapted and produce significant mileage increases within four years. Consequently, the benefits from CAFE regulations could be much quicker than the auto industry states. They need to be pushed.

Most importantly, much larger taxes or even surcharges could be placed on the sale of large-engine vehicles that are not used for businesses proven to need such capacity. The auto industry will vigorously resist all of the above. They need to be pushed—hard. We must significantly reduce the sales of gas-guzzlers.

Energy Efficient Housing

Building code changes would be very unpopular with the businesses who provide building materials to construction contractors because they would require shifts to new product lines and a resultant reshuffle of business priorities and risks. The states would scream because such a plan could only be effective if implemented on a national level. The construction workers would complain because they would have to learn how to do things a little differently (but not for long once they realized that they were paid by the hour and there would probably be more hours involved.) Everybody resists change, but the long term payoff would be money in the bank for everyone.

The housing industry is just as competitive as the auto industry, and the same level playing field provided by regulation would have a similar effect on them. The requisite new federal building code should have enough scope to encompass the differing construction requirements of different areas of the U.S. This would not be easy, but it is doable, and it should be a phased approach with the first phase using only building materials that are readily available—that is it should concentrate on how these materials are used and exactly how the house is to be designed and constructed. Later phases could require more innovative design and higher technology products. While this might raise the cost-per-square-foot of housing in the U.S., the higher mortgage cost would be offset by the lower cost of energy usage and more innovative use of interior space.

While the changes to building codes would be slow because of long house and building life-cycles, both businesses and citizens could be induced to retrofit their houses and buildings with more energy efficient materials and technologies, if sufficient tax incentives were offered. Retrofitting along with rational new construction could result in significant fossil-fuel savings for the nation in just five years.

And we shouldn't forget that every appliance and convenience we now pack into our houses can be made more efficient if the screws were tightened on the manufacturers. The recent and successful raising of efficiency for new air-conditioning components through regulation is a lesson in just how much room there is for improvement. We should follow this success by instituting a three-year phase out on the sale of incandescent light bulbs. And the list of specifics that would nibble away at total energy consumption could go on and on.

Energy Efficient Public Transportation

Public transportation is a major player in most of the world's developed countries but still eludes the U.S. This is primarily a problem of politics and determination and not one of economics or technology. We cannot expect a simple refurbishment of a century old system like our railways to be efficient or acceptable to the public. We need a totally new system and maybe even a totally new approach where the contribution to conservation and the environment is potentially very high.

Here again, we could achieve quick results by levying a surcharge on all truck freight that could travel a significant amount of its transport distance by rail instead. This would initially result in higher freight charges and consumer prices for shipped goods, but make a quick and significant reduction in oil imports.

Raising Energy Efficiencies Reprise

Actually, raising auto, housing, and public transport fuel efficiencies are topics well worth their own essays, but for this essay, suffice it to say that these three areas of potential energy use reduction could permanently reduce the overall demand for foreign oil and gas by as much as ten percent all by themselves.

While the energy savings of using less will be real and significant in the transition effort, the overall favorable effect of conservation measures will grow slowly. Those economies will always be with us, but they will become more difficult to perceive as growth in demand overtakes efficiency savings and continues to increase geometrically with the world's population and technological hunger. However, by that time, our crisis will be over and we will have learned our lesson—ha!

The Perfect Fuel

The common fossil-fuels that drive the U.S. economic and personal luxury engines are coal, petroleum, natural gas, and natural gas liquids. They and their refined products can all be transported by ship, rail, truck, and pipeline to the point of utilization. Any effective and efficient substitute for fossil-fuels should be similarly transportable if at all possible, since this would greatly reduce the requirement for new infrastructure to support their use, which would, in turn, speed their adoption. The fantasy of methanol would fit this criteria, but it would still leave a carbon footprint, and we would never be able to make enough of it.

That leaves hydrogen, the most abundant element in the universe. And while it is rarely found on the earth in its free state, it is abundant in compound with other elements, like oxygen, which is common water, H_2O. Hydrogen is the perfect combustion fuel. It creates no pollutants. It leaves no residue from its combustion process except water vapor. It is the perfect internal combustion engine fuel. It's just not very energy-dense.

It has been the magic-answer fuel for at least a century, but its availability at a competitive cost with petroleum has been non-existent—until now. Hydrogen can be burned in reciprocating engines and turbines designed for it, and new technologies like fuel cells can go directly from hydrogen to electric power on a scale suitable for personal automobiles.

As the cost of petroleum climbs, the cost of producing hydrogen through electrolysis gets more cost-compatible even if not more cost-effective, particularly if the necessary electricity can be generated at a reasonable cost. Nuclear, electric generating plants utilizing already stockpiled military-designated nuclear materials or even reprocessed cold-war warheads, can provide this reasonably priced electricity for longer than we will probably need it (a real and measurable peace benefit). Moreover, we get the bonus of solving all three elements of the energy crisis at the same time: electrical power, reciprocating and turbine power, and zero carbon footprint. Finally, **ONLY** nuclear power plants making hydrogen can produce the large volume of liquid/gaseous fuels we need to continue the American lifestyle and do it quickly enough to meet our energy crisis.

Basically, this is how it would work. Nuclear power plants would be built in remote locations with the primary purpose of producing hydrogen, but secondarily to supply electrical power to consumers if transmission inefficiencies make it feasible. The hydrogen or a second-derivative fuel from the hydrogen like methane or methanol would be pumped into a nationwide (or North American) grid of pipelines supplying most of the primary population centers of the country just like natural gas and sometimes oil products pipelines do now. More remote areas would be served by coastal and riverine tankers or tank trucks like gasoline and propane currently use.

Gas stations would be gradually converted to provide hydrogen as the system comes on line, while the auto industry produces hydrogen cars and the demand for hydrogen grows. All houses would be converted to high-efficiency, electric heat-pumps, since they already have electricity (not all houses but almost) and little new infrastructure would be required except for more electric generation plants. Existing electrical generating plants would be converted to burn hydrogen rather than fossil-fuels as quickly as the fuel is available, and any new plants would be sighted as close as possible to areas of high consumption, which would minimize transmission losses. The only combustion by-product would be pure water.

In a parallel effort, long-haul trucking by internal combustion engine trucks would disappear by federal mandate as the building of modern freight-hauling rail systems (or an even more efficient system) came online as a result of government driven incentives or outright participation in its construction—whatever is needed. Only short-haul trucking from railheads to consumers would be allowed in an energy-efficient America.

Is It Really That Simple?

No, it's not. It is unbelievably complicated by the details, which this essay is much too limited to reveal. To start with, hydrogen is difficult to deal with because it doesn't have the high energy per volume unit content of gasoline or even of natural gas. However, it can be compressed, liquefied, and even solidified efficiently in some compounds, so it can be pumped, stored, and used successfully, just with extra effort. If the extra effort is too much in the early years, hydrogen can be used to produce carbon-neutral fuels. Dedicated science and technology must determine the best way to do it, focusing on hydrogen production as the only sane way to replace fossil-fuels in the reciprocating engine.

Will the cars of the future burn hydrogen directly in reciprocating engines or turbines, will they use hydrogen fuel cells, will they burn hydrogen derived fuels, or will they do something we haven't heard about yet? It is way too early to say what will be the most economical method, what method will garner the greatest political push, and what method the auto and energy companies will see as providing the greatest profit. Don't forget profit and politics, as they are the true determining factors in the successful attainment of energy independence.

It will also not be simple to build the state-of-the-art nuclear power plants needed to produce the electricity to make hydrogen at a reasonable cost while assuring safety and protection for the environment. Specifications for and oversight of construction must be tight to ensure safety and protection for the environment, but those requirements must not be such that they stifle innovation or uselessly drive up the cost of the completed plants.

More About Site Selection and Distribution

Site selections will be a political football, but the government must be firm in its insistence that the best sites be selected for the good of the nation rather than the whims of states or special interest groups. Not only must the selections be rational, they must be firm and timely to allow the specifics of the sights to become primary factors in plant design and construction strategies as well as allow an early start on producing the transportation infrastructures that will be required.

We have already discussed why remote siting is required, but we haven't discussed the advantages of cluster sighting. The U.S. will need so many plants that many remote sights will have to be chosen, which if carefully done, will also contribute to distribution efficiencies to all areas of the country. However, these sites should be for large clusters of power plants rather than single plants or even a few plants. Clusters should be a minimum of ten and probably more on the order of twenty or thirty plants depending on what size plants are selected as optimal.

Large clusters of plants would greatly facilitate the speed at which new plants could be constructed by centralizing construction logistics, allowing series production of major plant assemblies on the site, and allowing efficient utilization of construction labor as work shifts from one plant to another during the construction process. Our World War II, large-scale, series production experience could be used with great effect for nuclear power plants.

In fact, such a plan was envisioned and put into operation in the early seventies (again, when we were motivated to do something about our energy supply problems) by a joint venture of Westinghouse and Tenneco (through its Newport News Shipbuilding subsidiary) as Offshore Power Systems. While the facility constructed for this venture never produced the envisaged, floating, nuclear power plants, the only thing that prevented the series production of these plants was a postponement and eventual cancellation of the contracts for them. And the contracts evaporated only when the oil cartels saw that it was in their best interest to raise production and reduce costs enough to discourage the development of alternative energy sources in the U.S.

Such a concept could still be reconstituted for siting on the Great Lakes or protected coastal harbors but would probably face stiff opposition from the environmentally sensitive public. However, the same production technologies could be applied to land-based concepts if clusters were employed.

Large clusters would also make the establishment of a small city environment to attract and hold labor needed to operate these plants and their primary distribution systems feasible. This would be a problem for single plants or a small number of plants located in remote areas.

Clusters would also ensure the efficiency and consistency of distribution systems for either hydrogen or electric power by serving as hubs, and all clusters could be designed to produce both electric power and hydrogen if the flexibility proves desirable. In all likelihood the hydrogen would be carried via pipeline from these centralized production centers to feed into a network of smaller distribution systems covering large and overlapping areas of the country to enhance reliability.

Fortunately, the right-of-ways necessary for these pipelines already exist as current petroleum and petroleum-product pipeline right-of-ways, and the extensive and barely used network of railway right-of-ways. Or the pipelines could share electrical right-of-ways. Electrical power, if generated for direct distribution would flow out on high-voltage lines to feed into existing or expanded power grids.

Security Concerns

In the world today and for the foreseeable future, terrorism will be a real threat to security and safety for all power plants and distribution systems in the U.S. This will be particularly true for nuclear power plants because the collateral damage from destroying a nuclear plant would be extensive, making them an enticing target. Having the plants in a cluster will make it possible to provide a security level that is more effective, more comprehensive, and less expensive than that now found at U.S. nuclear power plants. Of course, the downside to clustering the plants makes them more vulnerable to destruction in the event of a nuclear missile exchange with some foreign power, but if that occurs, life as we know it (if anyone survives) is over anyway.

For the same security concerns, any new pipeline distribution infrastructure devised for hydrogen should be placed underground. This would make terrorist bombings of pipelines much more difficult and unlikely, even though it wouldn't make it impossible for a determined attack to be successful. It would, however, make it likely that even determined attacks would be feasible only in areas remote enough to allow excavation before placing bombs and thus minimizing destructive effects and discouraging efforts.

Other Sources of Electrical Power During a Transition to Hydrogen

Alternative methods of producing energy were briefly described earlier in the essay, most of which were at least examined and some developed during the previous focus on energy independence during the 1970s. A few of these need further examination as potentially quick and inexpensive ways to get the transition to hydrogen moving, and there is no reason that they couldn't provide a meaningful input for a hydrogen system for the long-term as well. Wind turbines, solar-cells, and solar thermal are particularly well suited to hydrogen production because they are subject to intermittent drops (sometimes totally) in output based on the vagaries of the weather. These alternatives require siting in the same sorts of places (not first choices for human habitat) that we have already identified as preferable for nuclear plants and therefore are suited to taking advantage of the efficiencies of clustering. It is also important to note that their manufacture produces no particularly unfriendly environmental contaminants.

Wind turbines are relatively small devices that can be (and are) easily mass-produced and shipped by conventional means to almost any selected site. They are usually clustered at sites having high, sustained winds to turn them. Instead of having the unsteady power being generated fed directly into the power grid with conventional power plants leveling the grids output, the electricity produced could produce hydrogen, which being its own storage medium, is relatively insensitive to output fluctuations.

Similarly, solar-cells are very small devices that are utilized in large arrays and can be efficiently mass-produced. Their non-mechanical nature requires few operators and also minimizes maintenance, which is a big plus in the remote, high solar incidence (usually desert) sites utilized. Again, output fluctuations are not a major concern for hydrogen production.

Solar thermal plants are sited similarly to those for solar-cells but produce power using computer-controlled mirrors or lenses to focus the sun's rays on heat collecting pipes or boilers. Steam is then used to produce the electricity. While this alternative does require operators and maintenance, it is very efficient and utilizes immediately available and conventional steam-turbine generators to produce its electricity. It also has the advantage of being able to use some of its stored hydrogen output to power its boilers in periods of low solar incidence.

Deep drilling geothermal plants could offer a major long-term source of usable energy if the technology were given priority. This is where very deep drilling is used to get water down to areas of the earth's crust that are hot enough to produce steam (preferably) or very hot water that could, in turn, be used to power electricity-producing turbines. This would be a significant departure from conventional hydrothermal plants that must be sited in the few areas where the earth's mantle is naturally thin and most often has its own water incursion. These are also high-risk areas where earthquake and even volcanic activity are prevalent. Deep-drilling hydrothermal plants would inject their own water and could be located over a much broader area of the U.S. and North America. Their environmental impact would be minimal, since the water would not be in the ground long enough for significant leaching of undesirable minerals to occur and no other significant pollutants are produced by the process.

Some of the other alternative technologies could be used as intermediate-term sources of hydrogen, as well as significant contributors in the long term. They are the water-related sources, like tidal (kinetic energy) and ocean thermal (stored solar energy). Development of these source technologies would take a longer time, but could be significant contributors to the system with close proximity to many of the high demand areas on our abundant coastlines. They also have a ready supply of water for the electrolysis process that produces the hydrogen.

One final note on the use of alternative technologies. They could all be used to produce other things than electricity or hydrogen that would contribute to reducing fossil-fuel dependence. They could produce chemicals that are currently large consumers of fossil-fuels in their own right like ammonia and production process acids where the economics of site might favor such use. We need to consider everything.

Energizing the Nation

We come again to the long subtitle of this essay: "While Collaterally Solving the Persistent U.S. Problems of Unemployment, Economic Growth, Impending Inflation, and an Unenlightened Foreign Policy." That's quite a mouthful. We have talked a lot about energy independence, but very little about these other problems, so here goes.

Without energy independence, the most visible problem facing the nation in the next twenty years, it will be impossible for the U.S. to hang on to its position as the dominant economic power in the world. Worse, if we lose that position, it is likely to come in the form of a massive economic collapse from which recovery will be slow and painful, if at all. The trigger to this collapse will occur as the economy of the U.S. is squeezed by rising oil prices to the point where investment in U.S. markets is no longer as attractive to the oil-rich nations as investment in Europe or China or some other political and economic entity. We will know the trigger point has been reached when the oil cartels decide to shift the oil trade from its current conduct in dollars to another currency, and we are getting close to that situation already.

In fact, we were saved from already facing that shift before now by only one thing—the nation's long-term commitment to the space race. But how could putting a man on the moon have anything to do with the oil currency basis and global economics? It has to do with momentum and confidence, which come from sound government policy and economic growth, which in turn comes from the U.S. technological dominance it has held on to since World War II.

The underdeveloped, the oil-rich, the emerging economy, and the struggling old economy countries of the world all want the standard of living that has been shoved in their faces by the explosion in world communications. While still diverse in some ways, the world has become a group of technologically driven societies that make up the global market. The nation with the lead in technological innovation will always continue to dominate the global economy.

We were about to loose that edge in technological innovation when President Kennedy made a national commitment to putting men on the moon before the end of the '60s. We did that, but more importantly, our energy, capital, focus, and spirit were committed to technological innovation. This commitment rekindled the American spirit of risk-taking necessary for research and development. It demanded real leadership from our corporations and not just the management of assets approach that was beginning to dominate the board rooms. We were vital again with new and basic technologies in our pockets that had so many spin-off possibilities that we couldn't follow them fast enough without a whole new generation of scientists and engineers going through our schools. But we lost it. "Not with a bang, but a whimper" (thank you Mr. Eliot), like someone had opened a main artery in the nation and its blood was pumping out onto the ground.

As the technological lead gained from the space race has waned, so has our world economic position and so has our internal economic stability. With the bursting of the technology bubble, the fertile minds of Wall Street set about to invent clever ways to manipulate the legacy of that vital period of true growth—capital wealth, which was still available for exploitation. They did a fine job, and now that's gone too.

We must have another period of true growth where the payoff this time will be the same boost to technology and attendant business spinoffs, but we will add a complete redo to our aging and failing infrastructure for energy production and distribution, and for the already failed infrastructure that supports the transportation of people and commerce.

To do this, we will have to work, and the work will be everything from shoveling dirt, to construction of machinery and buildings, to sophisticated engineering, to research in nuclear physics, to very innovative management. The people of America will be as fully employed as they want to be, and there will be enough work left still to be done that we will have to not only have jobs for the currently accepted level of immigration, but for the illegal immigrants as well. Then we'll have to intelligently expand our immigration policies just to get the job done. Or even more radically, we might include Canada and Mexico in our move to a hydrogen-based society. Unemployment in all of North America would then be a state of existence only for those who do not want to work.

Economic growth is already slowing as the capital needed for successful business is flowing out of the country to the oil producers and inflation is inevitable with energy prices driving up the costs of everything. Everything, because everything uses energy either directly or indirectly.

If the plan being proposed in this essay is aggressively pursued, the price of oil will immediately go down and production levels will no longer squeeze supply. The oil cartels will have no other options. The last thing they want is for their revenues to fall because demand is insufficient to support sales. The oil speculators will rudely see that their investments have significant risks they had not anticipated. Why will this happen? History will tell us.

The first sign that the less-developed economic powers of the world wanted their share of U.S. wealth and its attendant standard of living was the oil embargo of the early '70s, but we scared them away when we immediately started to put our proven technological prowess to work on weaning the U.S. from foreign oil and its debilitating effects on our economy and way of life. The world's wannabe economic powers made a strategic retreat to wait for a more vulnerable time and a more favorable shift in the U.S. power structure itself. They were patient. It took thirty years, but they were right.

Now they're knocking on the door again. Have we learned anything? Do we still have that core of American vitality we can tap in time of crisis? I think so, and I think that a national commitment to energy independence will be able to tap it.

The Final Word

This plan needs a long list of ingredients to make sure we're baking an apple pie and not the double-fudge, pecan-crunch, triple-layer cake with cream cheese icing that unbridled politics would produce. It needs decisive and rational leadership from the White House in making this a bitingly true national priority, and it needs to be a continuing item on the bully pulpit agenda until it is completed, because it must capture the imagination of the public. (You must be thinking it's impossible already.)

But the plan needs more than strong leadership. It needs subtlety as well. There is no chance of success without making sure that the current power, oil, and auto companies have an integral role in the planning, their profits protected during the transition, and their relative positions reserved as much as possible in the final outcome. If we can't devise a plan that will do this and convince them of it, the plan will fail because their resistance is truly that powerful. Leave as much of your idealistic baggage at the door as possible if you plan to join this party.

A project of this magnitude and scope will step on thousands of special interest toes, from whole states to individuals. So the only way progress will be made is to set up a new and completely independent agency (like NASA during the time of the space-race, but stronger, along with the urgency of the Manhattan Project) that has as complete control of its direction and funding as possible—that is, well beyond the point where the political powers are crying uncontrollably.

I have one more comment on the ancillary benefits of energy independence (I have not forgotten that part of the subtitle: Unenlightened Foreign Policy.) No matter what you have been told by the people in power and not told by the press, energy has been and is the major driver of U.S. foreign policy. I urge each reader to take a few moments to contemplate all the foreign policy mistakes you personally think the U.S. has made in the last twenty, or even fifty years. Ask yourself what we would have done instead if we had secure and virtually unlimited energy resources for both our military and our commerce during this period. It is my belief that you can't help but come to the conclusion that we would have acted differently on almost all the big issues.

Above all, the mission of the proposed project should be the achievement of energy independence without giving up the American way of life embodied in personal transportation, a free-spirited life style, and new technological conveniences at every turn. What good is it to have your apple pie if you can't eat it? And when we bake that pie we have to do it in a pan that gets washed (true recycling) and put back on the shelf for when we need it again.

Can we do it? Why not? This is America, and we've done it before.

A Rhetorical Outline for the Envisaged Hydrogen Project

The Plan in Outline

This started out as a topical outline but as I got to the end of my expansion of the essay narrative into its current form, I found that there were still too many ideas I wanted to impart about what needed to be done in order for this necessary but difficult project to work. To cram in as many ideas as time would allow me, I have expanded the topical outline to a rhetorical one. However, the envisioned project is too broad to ever stop digging into the details, so I'm sure the details will continue to disturb my sleep.

The outline is presented broken into blocks of time, but no effort has been made to sequence topics within the individual blocks. A timeline or a PERT diagram would be nice, but really impossible without more knowledge of what needs to be done. Without a lot more planning, this is as far as I can go.

Year 1: Off the Mark

Declare Energy Independence a National Priority

This would require a major commitment by the Administration to the goal of reaching energy independence in fifteen years by the creation of a national energy policy based on the production of hydrogen primarily through the building of nuclear-powered electric-generating plants, but with additional production from other renewable energy sources. It should be introduced by a primetime speech from the President, and it must be bold enough to state the gravity of the situation we face.

Set Up an Independent Agency

Congress should set up an independent agency for the conversion to and operation of a hydrogen-based energy infrastructure, which I will arbitrarily name and refer to as the Hydrogen Technology Agency (HTA) in the rest of this rhetorical outline. The agency should be structured at the cabinet level and should be empowered to use the resources of other governmental agencies like Energy, Transportation, Labor, and Commerce on a subcontract-like basis, i.e. control will stay firmly under the direction of the HTA. The new agency should be charged with avoiding duplication of staff capabilities with other governmental agencies, but the HTA alone should make the decision to use other agencies, build internal capabilities, or to subcontract to commercial entities.

Provide Funding

Funding should be adequate to the task (which will be very large) and free of earmarks or any other restrictions on its use. The budget for its use should be flexible enough to allow shifts in approach as the project progresses and reveals its full range of requirements. It must also be flexible enough to quickly pursue any new technology that might offer dividends in reaching project goals.

Seduce and Cajole Industry

Industry should first be convinced that the project will not veer from its goals, then assured that their active and sincere participation will assure future participation in the nation's new energy use and conservation profile. Then it should be solicited for proposals as to how they can best participate by bringing their expertise and resources to bear on the problem.

Since national infrastructure will be so revamped and so many products will be impacted, there will be a huge number of interested businesses, making this one of the more massive management efforts of the project. Business must be convinced of the future participation so thoroughly that they will provide active support for required legislation and not become a negative influence on the political process.

Select Interim Technologies

This must obviously be a phased endeavor as some technologies are just waiting to be purchased and put in place, some are proven but not in full production, some still require development to produce a working product, and some require further research. However, windmills are available off of current production lines since they are already in use in this and many other countries. Solar cells are currently in production for charging batteries in remote areas and can easily be scaled up to large megawatt outputs. These technologies should be unleashed immediately through higher tax breaks or limited-time subsidies and businesses should be encouraged to build as fast as possible. Existing power companies that must accept these new generating sources must be compensated for any inefficiencies this might cause to their current operating profiles long enough to allow their rational integration.

Solar thermal plants should be produced of sufficient size to allow for efficient operation, and when fully proven, should be encouraged just like the photo-voltaic plants. The installation of geothermal plants should be similarly encouraged wherever good sites are available.

All of these alternative source plants should be designed initially for electric power generation, but the solar thermal plants should consider including hydrogen generation and storage so the boilers could be activated by clean combustion when solar energy levels are low. The operation of hybrid plants would be useful experience later in the project.

Legislate Energy Conservation Measures

This is a huge amount of required legislation and is only possible in one year if Congress gives the hydrogen project top priority and is enthusiastically supportive of the concept. CAFE standards must be passed that are stringent enough to significantly change the character of American-built autos in five years, with reasonable efficiency improvements in each of those years. The end product must make it prohibitively expensive to build and sell new gas guzzlers. It isn’t a matter of those buying the cars being able to afford whatever the cost of gasoline happens to be, it is a matter of the nation not having to depend on foreign oil for its energy needs and suffer all the baggage that goes with that situation, and a matter of saving the planet from the fossil-fuel-triggered environmental degradation.

A national building code that mandates the building of only high-efficiency homes and buildings must be passed by Congress. To do this will require that new building techniques (both passive and active) be employed, that new and probably more expensive materials will be required, and that new technologies will be incorporated in the finished products. This will be a complicated and very contentious process and will take several years to complete, but the first year’s efforts could concentrate on mandating the use of techniques, materials, and technologies that are already available but underutilized, because there are lots of them. To complement these federal building codes for new construction, tax incentives and subsidies should be legislated for the retrofitting of existing homes and buildings. Again, these retrofitting incentives should cover installation of both active and passive technologies.

Trucking is one of our most inefficient uses of fossil-fuels, and legislation should be passed that is aimed at eliminating long-haul trucking on American roads of freight that could be moved more efficiently. This could be in the form of an excise tax on hauling cargoes that could be moved by more efficient means like rail, ship, and coastal or riverine barges. This excise tax and whatever other monies that are required would be used to refurbish and ultimately replace the nation's rail freight system. It could also be used to expand and automate existing ports and intermodal transfer points. As a corollary to this effort, a research and development study should be funded to design and field a new integrated and intermodal system for the energy efficient movement of freight of all types throughout the country.

Finally, public transportation should have a major upgrade throughout the country, particularly in and between major urban areas, and this will require federal money and policy. Not only is public transportation orders of magnitude more energy efficient than personal automobiles, its upgrade and effective deployment could speed the demographic changes that are coming as a result of higher energy prices. These changes will discourage suburban sprawl and encourage higher density housing, which itself will have significant energy savings. This area too should have a funded research and development program to select, design, and implement an energy efficient public transportation system capable of operation over the next fifty to sixty years.

Start Site Selection Process for Alternative Technologies

This is first time the HTA will select sites for generating plants, so all the right precedents need to be established. These sites will garner approval more easily than those for the nuclear clusters because of nuclear power's emotional potency, but they will still have a lot of special interest opposition. If EPA regulations prove too difficult or (more likely) too lengthy, they will have to be streamlined or modified to accommodate the hydrogen project. Likewise, if other governmental agencies like the Departments of Energy and Interior have regulations or procedures that will be too cumbersome for the necessarily swift-moving hydrogen project, they will have to be changed as well. And if legislation is needed to make the necessary changes to give the HTA the clout it needs to make quick decisions and take swift action, Congress will have to make it happen.

The states will probably be a big roadblock, if not over the actual site selections and their operations, then over the issue of States Rights. We might as well establish right up front that this is a project that falls under the purview of the U.S. Government pursuant to interstate commerce. If such a finding needs to go through the court system, it should be dealt with as soon as possible.

The first year is the right time to establish that every decision made by the HTA will be made on the basis of the best good for the whole country, which means that some states and localities will just have to give up their "put it in someone else's backyard" attitudes. And if all else fails, the government should be ready to exercise its rights of eminent domain.

Evaluate Availability of Nuclear Fuels

Due to the classified nature of this information, direction must come from the top to release information to the HTA on the status of potential nuclear fuels for the planned generating plants. The large amount of fuel required over the fifteen year period will probably require new processing plants be built, but there will be time if this effort is started immediately. New plants will undoubtedly be needed if old war materials are to be reprocessed, which is recommended because it would have great public support. Reactor fuel processing plants for the hydrogen project should be under the control of the HTA, and Congress will have to provide enough budget to include this effort.

Evaluate Designs for Hydrogen Fueled Electric Generating Plants

Standard boiler-fired steam plants to generate electricity should be easily modified to use hydrogen rather that fossil-fuel; however, hydrogen gas turbine designs should also be evaluated because of their potentially easier maintenance, lower manning requirements, and ability to respond quickly to unexpected demands.

Multiple designs for different plant sizes should be considered, but should utilize standardized components where possible. Noise generation and aesthetics should be adequate for both urban and suburban installations.

Solicit Bids for Alternative Technology Unit Production Contracts

Bids for wind and solar thermal electric generating plants should be solicited as soon as possible, using streamlined procurement procedures. A variety of different designs should be sought for the first plants so they can be evaluated for future efforts at standardization. The selected designs should be capable of efficient operation in a wide variety of environmental sites and conditions. Major components should be restricted to those of U.S. manufacture or to those U.S. companies that have signed licensing agreements for their future manufacture in the U.S. Where possible, these efforts should be undertaken by private enterprise with HTA providing regulation and financial support.

Start Nuclear Plant Design Evaluations

The major U.S. nuclear power plant contractors should each be tasked to produce two different plant designs for evaluation that focus on low water usage requirements and utilize the latest, proven technologies. The design parameters should specify that the plants are to be built on a production-line of modularized major components where they will either be assembled to produce finished plants or to produce major assemblies that are capable of being moved overland to the construction sites. If it is impractical to utilize plant sizes capable of being fully assembled before being moved to the operating site, the assemblies should be designed with minimal interface requirements for final assembly.

At least two different designs from at least two different companies should be selected and given contracts for producing the plants. These companies would then compete for future work on the basis of actual costs incurred during early construction.

Start Evaluation of Hydrogen Transportation, Delivery, and Storage Methods

Methods considered must utilize proven technology to allow immediate production and stockpiling of system components. The HTA should produce design specifications to assure components manufactured by different companies will properly interface.

Start R&D on Hydrogen and Derivative-Fueled Gas Turbines

This effort should be across a wide spectrum of turbine sizes, including those suitable for automobiles, trucks, heavy machinery, large electric generators, and ships. The effort should be broad enough to include research in specialized materials. Access to all research results and use of any granted patents should be provided to U.S. industries for further development and production as the effort progresses.

Start R&D on Hydrogen Fueled Reciprocating Engines

This effort should be across a wide spectrum of engine sizes, including those suitable for automobiles, trucks, heavy machinery, and small ships. The effort should be broad enough to include research in specialized materials. Access to all research results and use of any granted patents should be provided to U.S. industries for further development and production as the effort progresses.

Start R&D on Hydrogen and Derivative-Fueled Aircraft Engines

This effort should consider both pure jet and turboprop engines across a wide spectrum of sizes, including those suitable for personal, commercial, and military applications. The effort should be broad enough to include research in specialized materials. Access to all research results and use of any granted patents should be provided to U.S. industries for further development and production as the effort progresses.

Start R&D on Hydrogen and Derivative Fuel Cells for Vehicles

As a considerable amount of research in this area has already been performed, the HTA should solicit early participation by these parties. The program should then proceed under direction of the agency with the goal of producing vehicles that are capable of efficient and economic operation using hydrogen for the direct production of electricity. Access to all research results and use of any granted patents should be provided to U.S. industries for further development and production as the effort progresses.

Start R&D on Hydrogen Production Process Designs

The HTA should initiate and perform this program in-house, since little research has been done on large-volume production of hydrogen by electrolysis. The goal should be to determine materials and operational profiles (particularly high-temperature electrolysis) for a range of plant sizes from those capable of efficiently producing hydrogen using the full output capacity of nuclear clusters to those capable of producing small amounts in areas having only electric power but the need for operating hydrogen or hydrogen-derivative powered equipment. This would include the smaller plant sizes required by alternative energy sites.

Start R&D on National Mass Transportation Upgrade

This project falls mostly in the domain of the Department of Transportation and should probably be performed by them but under the control and oversight of the HTA. The goal should be to plan and execute a phased program that would as quickly as possible encourage the wider use of public transportation. The early stages would probably have to continue the use of fossil fuels, but it would be with a much higher passenger-mile to energy-used ratio than currently experienced.

Later stages of the upgrade should be designed to utilize either electricity or hydrogen and should allow for a shift to faster and more efficient technologies like high-speed rail or even more exotic technologies like MagLev vacuum tubes. All possibilities should be considered for future systems.

Start R&D on National Freight Transportation Upgrade

This effort should start with a national upgrade to freight-specialized rail transport that is synchronized with reduction of long-haul freight trucking. Its early use would still be with fossil-fuel power but the goal would be to replace this with electric or hydrogen power as soon as possible.

The changes required should go beyond upgrading of existing rail-beds and equipment to the immediate need for new rail-beds and capital equipment. This might also require new right-of-ways where demographic changes over the last hundred years dictate. This would undoubtedly require Congressional action to smooth the use of eminent domain in their acquisition, particularly in securing terminals inside urban areas to ensure efficiency of distribution.

Year 2: Rolling

Start Negotiations and Technical Interface with U.S. Energy Companies

The HTA must engage the nations electric utilities and fossil-fuel providers in the planning and ultimately in the operation of both the interim technology and the nuclear technology systems. It is essential that the nation's new hydrogen economy infrastructure be run by private enterprise even though its construction must be government funded. Consequently, early input to HTA decisions is essential to their preparedness to take the reigns as the system comes on line.

The basic guidelines for HTA negotiations are to leave the generation and delivery of electricity to the nation's electric utilities and their expertise in such, to leave the generation and delivery of hydrogen to the nation's fossil-fuel energy companies that are experienced in dealing with flammable liquids and gases, to decide on the proper hand-off points between the two, to workout the financial details for the takeover of the system by industry, and to decide how and how much regulation is in the best interest of the nation's future.

Start Processing of Nuclear Fuels

Processing of fuels should be keyed to estimates of nuclear plant activation schedules and should start with plants already available and transferred to HTA control.

Start Nuclear Cluster Site Selection Process

This could be a lengthy and difficult process as most states, if not all, will want to avoid having clusters on their soil—even thought they will demand their participation in the project generated benefits. Sites should be chosen to minimize environmental impact, optimize both electrical and hydrogen distribution, and for their availability to necessary resources. Again, Congress must take whatever actions are required to prevent issues of states' rights from interfering with decisions that have the highest national interest as their criteria.

Water for plant operations and as hydrogen feedstock will be a resource of prime consideration. All water sources must be considered, even the Great Lakes.

Start Production Facility Design Process for Nuclear Plants

A team of major U.S. construction, aerospace, and shipbuilding companies should develop the facility designs in conjunction with the nuclear plant designers. The effort should be under the control of the HTA and focus on providing the throughput required to meet the 15 year goal. The production facilities should be standardized, as much as the different plant designs will allow, to maximize commonality and thereby speed production of the major fabrication equipment that will be required. If possible, the facilities should be designed to allow at least non-fixed facility components to be moved to new cluster sites when production efforts at earlier sites are complete.

Select Alternative Technology Cluster Sites

Sites should be chosen because of their proximity to areas of high electrical demand and needed resources while minimizing environmental impact. Water for plant operations and as hydrogen feedstock will be a resource of prime consideration.

Award and Start All Necessary Alternative Technology Infrastructure

This should include water feedstock pipelines, hydrogen pipelines, and hydrogen storage facilities. These early system designs should be used to field-test several of the best ideas, so production, installation, and operation data are available when nuclear plant infrastructure design decisions are being made. Components of the selected systems should utilize standardized interfaces to allow poor selections to be easily replaced by those proven better in the field. Foreign components should be allowed but only under the strictest applications of quality assurance and control.

Award and Start Alternative Technology Cluster Installations

The primary function of initial clusters should be the direct production of electric power for existing utilities. Some later clusters should be designed to produce both electricity and hydrogen or just hydrogen as generating plants close to areas of high electricity demand are constructed. Again, early system designs would field-test the best ideas for utilization in the larger infrastructure serving the nuclear plant clusters.

Start Construction of Hydrogen Fueled Electric Generating Plants

Early plants should be sized to the anticipated hydrogen output levels of the early alternative technology clusters. These designs should be very similar to existing natural gas-fired plants.

Start Research on Hydrogen Power System Efficiency Improvements

As interim technology production of hydrogen comes on line, field monitoring should produce valuable data on system operations that can be utilized for all future designs. The goal will be to have energy-efficient designs incorporated by the time work starts on the nuclear clusters and their support infrastructures.

Evaluate Nuclear Power Plant Types and Sizes

The goal should be to pick no more than two types of nuclear plants for construction. The plant designs chosen should have a high degree of commonality and modularity so that any problems encountered in the production or operations of the plants would have an immediate, engineering fallback.

Start Research on Long-term Energy Sources and Delivery Systems

We cannot stop improving the efficiency and efficacy of our energy production technologies. At this point, the sources that appear to offer the best balance of efficiency and environmental impact are nuclear fusion and deep-drilling hydrothermal, and all aspects of these systems should have HTA directed and funded research.

The primary delivery system for the foreseeable future is electrical conductance at least somewhere in the intermodal mix of electricity and hydrogen. Consequently, HTA should direct research efforts in super-conducting technologies, capacitor/battery hybrids, wireless power broadcast, and things undoubtedly not yet imagined.

Select First Cluster Nuclear Plant Design

Since two plant designs are to be selected, this might require design of two different nuclear clusters, but hopefully, HTA would be successful in assuring design commonality to the point where one basic design would suffice. The selected design(s) should be as modular as possible to allow easy switch-out of major components for maintainability or system upgrade and should be intimately integrated with the construction facility capabilities. The selected design(s) should be optimized for series production.

Year 3: Low Gear

Select Cluster Sites for Nuclear Plants

The site selection criteria of the HTA should focus on minimizing environmental impact, proximity to major demand areas, and proximity to water. Opposition to site selections by special interest groups, states, and localities should not be allowed to deter selections made in the best interest of the country as a whole.

Select Utility and Energy Companies for Initial Cluster Operations

Specific utilities and energy companies for the operation of the first nuclear clusters should be selected by HTA based on cluster locations and areas of demand that will be supplied by the early completion of storage and delivery systems.

Select Source & Start Nuclear Plant, Water Pipelines

Water will be required for nuclear plant operations, hydrogen production feed-stock, and cluster communities to provide labor and services. Fortunately, prime locations for nuclear clusters are situated near the center of the U.S. mainland where there are many major rivers from which water could be piped. If these rivers cannot provide adequate water resources, water from the Great Lakes should be evaluated based on cost and environmental impact. Water pipelines are off-the-shelf technology, and foreign components should be allowed but only under the strictest applications of quality assurance and control.

Complete Nuclear Plant Production Facility Design

HTA management should assure that all cost and efficiency tradeoffs between nuclear plant design, production facility design, and project scheduling have been completed and their results properly incorporated into the design or designs if a cluster for each nuclear plant design is to be built simultaneously. The selected design(s) should be optimized for series production. The output of this effort should be a full set of detailed construction plans and a list of required long-lead items for the (or each) facility that are suitable for bids and construction by contractors.

Incentivize Hydrogen Retail Conversion

Utilizing the input of HTA, Congress should enact legislation offering incentives for the owners of all stores now selling fossil-fuel to upgrade or modify their facilities and operations to provide hydrogen fuels (there might be different requirements for combustion engines and fuel cells requiring more than one type.)

Select Nuclear Plant Hydrogen Delivery and Storage Methods

Based on testing and field results from earlier, alternative source cluster operations, select the hydrogen storage and delivery methods to be used for the nuclear cluster infrastructure.

Start Construction of Nuclear Plant Production Facility

Start all activities required for building the nuclear plant production facility or facilities if two are to be built simultaneously. Meeting schedule requirements should be a major consideration in all construction decisions.

Continue Construction of Alternative Technology Production Plants & Infrastructures

As many of these systems as prove economically efficient and environmentally sound should be installed using the latest technology improvements.

Start Retail Delivery of Hydrogen from Alternative Technology Plants

Delivery of hydrogen to upgraded or new fueling stations should be available as soon as vehicles to use them are on the road. Availability of fuel should not become a drag on consumer acceptance of hydrogen-powered vehicles, even if initial financial incentives are required to make it happen.

Develop Nuclear Facilities Security Plan

Homeland Security, the FBI, and DOD under the management of HTA should develop plans for cluster security. This plan should consider all types of possible terrorist attack and provide redundant capabilities to deal effectively with them all. This would probably require the siting of support communities sufficiently distant from the cluster to establish effective buffer zones and active countermeasure installations. Special transit systems between cluster communities and cluster installations would probably be required.

Start Mass Transit and Freight System Upgrades

Early recommendations from the R&D programs should start to be implemented. The upgrade for both systems could take the full fifteen year period and more, but fuel savings should begin to accrue as soon as the first upgrades go into operation and continue into the future.

Year 4: High Gear

Start Nuclear Plant Hydrogen Delivery and Storage Infrastructure Construction

Delivery and storage infrastructure for the first nuclear clusters should start using experience gained from alternative technology, hydrogen production installations, and operations. Any newly developed technologies should be considered for upgrading system capabilities.

Start Nuclear Plant Construction

Production facility startup should be planned to reach steady-state operations as quickly as possible. There should be enough materials and long-lead equipment onsite to ensure the continuous, series production of plants.

Complete and Start Operation of First Alternative Technology, Hydrogen-fueled Electric Plant

This first use of hydrogen produced by the HTA to fuel a normally fossil-fueled, steam-powered electric generating plant will be a milestone for the nation. Its operation should prove the efficiencies accruing to electric power production in close proximity to the area of its use.

Incentivize Hydrogen Power System Efficiency Improvements

HTA should offer businesses, institutions, and individuals incentives of various types to discover, prove, and produce ideas and inventions that would improve the efficiency of the system or its components. HTA should be open to innovation and should not tolerate a “not invented here” attitude by its personnel.

Start Development of Promising Long-term Energy Sources

By year four it should be time to move from research to developing the hardware that will make these energy sources available. That doesn’t mean research should stop on these ideas, because there may be more than one approach to accessing these energy sources, and we don’t want to miss any.

Install First Nuclear Facilities Security Systems

I envisage a rather complex and in-depth security system would be conceived for nuclear clusters, so this effort will be significant. However, it is imperative that the installation process be planned to prevent slowing the process of getting the reactors online and producing electricity and hydrogen.

Year 5: Full Speed Ahead

Legislate Subsidy Decrease for Fossil Fuels

Legislation should be passed that gradually decreases all direct and indirect subsidies of fossil-fuels as hydrogen comes on line and displaces their use. Having this legislation in place will encourage the shift by the public to hydrogen, as it will clearly indicate a coming rise in gasoline prices. It will also continue pressure on the fossil-fuel industry to make the shift to generating and selling hydrogen instead of fossil-fuels.

Complete First Nuclear Production Plant

The first nuclear-powered hydrogen generating plant should be completed and activated during year five.

Activate Nuclear Facilities Security Systems

With the fueling of the first reactor, the nuclear cluster security systems should be fully operational.

Continue Construction of All Types of Production Plants & Infrastructures

HTA's focus should be on optimizing the series production of nuclear power plants and working out any problems that might occur in infrastructure installation. The construction of more alternative technology plants by private utilities and businesses should continue to be incentivized and supported by HTA.

Year 6: Overdrive

Start Production of Some Long-term Energy Sources

It is impossible to know the output of the various R&D programs started during the first year of the project, but hopefully, some of the long-term sources exploitation technologies would by now be ready to enter at least field-trial production.

Continue Construction of All Types of Production Plants & Infrastructures

Lessons learned during completion of the first nuclear plant and the first year's operational data should provide a basis for design modifications to the plants being produced, the plant production facilities, and plant processes.

Start Independent U.S. R&D Program on Fusion Reactors

As the intense research in early years of the project slows down, HTA should ramp up its research on fusion reactors to a full scale and independent U.S. effort, with the goal of leading the way into a new era of fusion-reactor-generated electricity and hydrogen. This technology would not only be essential to meet the long-term requirements of the nation, but would also be a valuable export technology for the foreseeable future.

Years 7 – 15: Cruising

Legislate Restrictions on Fossil Fuel Sales and Use

Even when hydrogen availability become as ubiquitous as gasoline is today, many people will resist a full shift to its use until they are forced to do so. Even financial conversion incentives cannot overcome apathy and active resistance to any form of change. Congress will have to put teeth into a gradual ban on the use of fossil-fuels where electricity or hydrogen would be adequate.

Activate Nuclear Waste Storage Facility

At some point the decades of grumbling and bumbling over the nuclear waste disposal plan for Nevada's Yucca Mountain must truly come to an end and the facility be opened to accept nuclear wastes. Large quantities are already held in inadequate storage around the country, and a steady flow of new wastes will be generated as a result of the nation's conversion to hydrogen as its liquid/gaseous fuel.

Construct Selected Long-term Energy Production Facilities

Again, hopefully, some of the longer term concepts for long-term, carbon-footprint-free, energy production will have gotten to the stage where facilities could begin construction before the impetus of the project wound down.

Continue All Promising R&D Programs

Those R&D concepts that are not quite ready for full-scale production and new technology possibilities that spring-up from the focus of the fifteen year project should continue to be funded and shepherded by HTA. America must stay in the forefront of energy technology.

Provide Production Adequate for Electricity and Hydrogen Demands

The ultimate goal of the hydrogen project is, and will continue to be, providing the nation with a source of energy that is free from foreign influence, environmentally friendly, affordable, and sustainable for the rest of this century, if not centuries. If we do this, America will turn back or avoid all together the problems stated in the subtitle of this essay.

We've done it before! We can keep on doing it!