PRESENTATION

CIVILIZATION WITHOUT OIL

The world is swamped with discussion and argument about power and energy. What is almost entirely missing is a sense of proportion. As a result, the field has become a political, emotional, and economic battlefield. The purpose of this presentation is to provide experts and ordinary mortals with a reasonable understanding of worldwide energy, its relation to "civilization", and what logical paths should be taken to manage it as our fossil fuels dwindle.

To gain perspective, we will examine world use of energy beginning with energy used by a family of four, at home and away. As we proceed along this path, we will be able to form important conclusions. These will be stated in *italics* as they appear. At the end of this process, we will appreciate the size and nature of the challenge facing the world as its fossil fuel dwindles and finally is exhausted.

A plan can't be made unless you know where you're going. Therefore, the next Step in the analysis assumes all the fossil fuel has been used up. Not a ton, a barrel, or a cubic foot is left. Fortunately there are solutions. To give the reader hope, the solution makes a pretty good world, even better than it is now.

With a solid and detailed view of the future, planning the transition is easy. The transition is not easy, but planning it is.

THE BEGINNING: The energy use by families.

Everybody must eat. We are told that to survive healthily we should eat about 2000 Calories a day.

Food is made up mostly of two chemicals: hydrocarbons and carbohydrates. They are made up of three elements: carbon (C), hydrogen (H), and oxygen (O). Hydrocarbon foods are oils and fats. They are made up of chains and loops of the combination of two hydrogen atoms and one carbon atom (CH_2).

Carbohydrates are made up of units of carbon linked to water: CH_2O. All breads and fruits and sugars are carbohydrates. Vegetables contain mostly carbohydrates with varying but relatively small amounts of fats. Meats have more fat. The energy

of carbohydrates comes from the carbon; the water goes along for the ride. If you drive it out of a piece of bread in the toaster, you are left with a black slab of carbon in the shape of a piece of toast. Don't try it; it stinks up the house. Such is the terrain of food and fossil fuels. Unfortunately, humans can't digest carbon. If carbon were digestible, our principal food would be coal. Toast made of carbon (charcoal) may play a part in our long-term energy plan.

The technology of energy and power (rate of delivery of energy) uses many different units of measurement. To avoid unit confusion, BTU (British thermal unit) will be used for energy and Kilowatt for power in this discussion. A KW is equal to one BTU per second. One food Calorie is equal to 4 BTU's. A BTU is the energy to heat one pound (about a pint) of water one degree Fahrenheit. Boiling one pound of water requires 212 BTU's.

Non-technicals can now relax. This is about as technical as we will get.

The energy content of corn is approximately 6500 BTUs per pound. With the water driven out, the carbon (toast or pure coal) has energy content of 14000 BTUs per pound. The weight of the water and the need to heat it are gone. This is where our coal comes from: carbohydrates with the water driven out by the pressure and heat deep within the earth.

One pound of corn oil or olive oil has a heat value of approximately 16,000 BTUs.
A pound of diesel oil has a heat value of about 19000 BTU's per pound.
Natural gas, with its extra hydrogen atoms, produces 24,000 BTUs per pound.
Hydrogen gas produces approximately 62,000 BTUs per pound. About 40% of the energy in hydrocarbons comes from the hydrogen, even though it weighs only 1/6 as much as the carbon.

Hydrogen is a high-energy fuel. The rub is that essentially all of the earth's vast quantities of hydrogen already have been oxidized to water. To get it from water we'll somehow have to "unburn" it, but this takes significant energy. We'll sort out this problem later.

We've completed examining the characteristics of the fossil and food fuels we use. We've spent all this effort analyzing the heat in food because it sets the stage for intelligent discussion of nearly all of the world's energy needs. Now we will examine the energy expended by a family of four, two adults and two dependent children.

With 2000 Calories per day for each member, this family will require approximately 12,000,000 BTUs per year. There are about 70 million families in the United States. This amounts to a need for 840 million million BTUs. With food containing a healthy 20% fat (8000 BTUs per pound), we need 105 billion pounds of food per year. To produce this much food we already use more than 80% of all of our tillable land and a large percentage of our available water. Feeding the whole world this well would require

2,200,000,000,000,000 pounds of food per year.

So examining the energy demands just for food leads to an important conclusion:

There are too many of you! Do any of you want to get off the planet? You're welcome to go, but don't use any energy to do it.

The only example of how this problem might be solved is China's draconian one child per couple edict. If enforced, the world would be reduced to one Chinaman in 637 years! No solution is presented here. The remainder of this discussion assumes that population growth eventually will come under control.

We will discuss food again later when we consider biomass as a fuel. We will leave it now and consider the other needs of our family of four.

We will assume that we have water, gas, and electricity delivered to our homes and that we own a car. Producing and delivering these requires lots of energy, but we will ignore that for now. First we'll add a hot water heater. Mine uses gas, a very efficient heating fuel. The label attached to the heater says I will use gas to produce 31.7 million BTUs per year.

Our hot water heater alone needs about three times the energy contained in our food.

Our furnace consumes 250 million BTUs, 20 times the energy contained in our food.

Our car consumes 72 million BTUs per year 6 times that contained in our food!

Our electricity, converted to the fuel used to generate it, requires about 143 million BTUs of fuel, 12 times the energy contained in our food!

These other family needs add to 40 times the energy in our food! By interpreting our living style as "civilization", we can conclude:

It is very unlikely that burning biomass or biomass brewed into ethanol could make even a tiny contribution to filling our massive energy needs; we are already straining our tillable land and water resources just to raise food. Our efforts to use ethanol made from corn to fuel our cars is ludicrous. A sensible use is mixing the ethanol with wine to make brandy.

Our huge need for energy is not the need to eat to live. It is our way of life, our civilization that burns our fuel. Few are willing to change their way of life significantly enough to be of any real help. Even dropping one zero in the number recording our needs would destroy our economy and much of our civilization.

Most of us spend more than half our waking hours away from home, at work, school, or other locations. Energy use by these facilities is approximately equal to that used in our homes. Thus the total use for one family, at home and away, is estimated to be 509 million BTUs. For 70 million families in the US, this usage is 36 million billion BTUs. That is 36 followed by 15 zeros! If we printed this on a linear scale bar chart with one family's need for food energy plotted at the 1/10 inch point, plotting the total for the nation's family usage would require a paper 5000 miles long! All the remaining needs for energy approximately equal three times that used by families. There is no need to detail these.

Here are the annual totals for all uses:

USA: 100,000,000,000,000,000 BTUs per year
World: 400,000,000,000,000,000 BTUs per year

We get this energy principally by burning fossil fuels. A lesser amount comes from falling water and nuclear power. Tiny amounts come from solar and wind generators.

Without fossil fuels, our civilization wouldn't exist and our population would be orders of magnitude smaller. These fuels took millions of years to form. We have used them at such an enormous rate that the end of our hydrocarbons is clearly in sight. Whether it takes 50 years or 250 years, it will happen. Our coal might last a hundred years or so, but many don't want to see it burned because of the threat of global warming.

What can we do when it's all gone?

THE SOLUTION FOR THE FUTURE WHEN ALL THE FOSSIL FUELS ARE GONE

Our only long-term meaningful sources are wind, water, solar power, and nuclear energy. Burning plant material or derivatives is out of the question; all of our land and water will be needed to supply food.

Both wind and solar power have significant disadvantages. They both are intermittent and variable. Both require the use of vast area because the energy density is very small. They both require significant maintenance, and marrying their variable input to the grid is difficult. Both these will be used, but only in special circumstances preventing the use of mass power sources. It can be predicted that when bulk power becomes widely available, most of the solar and wind generators will become relics, just as farm windmills did when the Rural Electrification Program was implemented by President Roosevelt.

Falling water will continue to provide a portion of our needs, but it will be a small one compared to total needs.

HOWEVER:

Even with current technology, nuclear fission can provide the needed energy. Its use will require (1) a complete change of public attitude and (2) the reversal of what may turn out be one of the worse political decisions made in our time.

In the nineteen seventies, Presidents Ford and Carter dictated a policy of "once through" for our uranium use in reactors.

This decision reduced the potential of nuclear fission power by nearly 100 times! It was the equivalent of our government demanding that of every 100 barrels of oil pumped only one barrel could be used. The other 99 barrels would be declared waste. We have lost 40 years in moving to solve our energy problem.

Our spent nuclear fuel, now declared waste, is stored, waiting for a place to be buried. These storage areas are not waste dumps; they are fuel dumps. Reprocessed, they permit the use of not 0.7% of our uranium but nearly 100%. The amount of other radioactive material left after breeding and recycling is tiny in comparison to the useable uranium in storage over 40 years.

Changing strategy reduces the waste by nearly 100 times. Even now 45 year's of so-called "waste" is contained in an Olympian swimming sized water pool at each nuclear plant. Using this uranium and its derivatives, these plants could run for 4500 years. ***Even though this fuel is very heavy, its energy content per pound is 2 million times that of coal.***

It has been estimated that there is up to five billion years' worth of uranium-238 for use in these power plants.[wiki, nuclear] The sun is expected to explode and become a red giant encompassing the earth at about this time.

Our present approach is to handle waste is to encapsulate it, collect it at a remote "safe" location, store it, and then guard it (for 10,000 years?). There even is action being taken to warn later generations beyond 10000 years of the risks they are inheriting!

Now, with the waste reduced 100 to 1, handling it is vastly simplified. we should (1) divide it into small quantities, far too small to be useful in making a bomb or anything else, (2) dilute it further with the addition of inert material like sand or concrete, and (3) dispose of it in a manner that it is unrecoverable.

The best approach is to bury it at the subduction boundary in the deep ocean trenches. If these small packages are dispersed widely along the edge of the subduction zones in the trenches, they ultimately will be drawn down into the earth's mantle where they came from. Buried 35,000 feet below the ocean surface, they would be uninteresting, inaccessible and risk free. The cost of implementing this approach would be negligible compared to that of our present approach that even now, after 45 years, has yet to be proven workable and safe. The US Navy could handle this task during its normal training tours.

With the above changes made, nuclear fission energy can meet our needs until the earth dies.

In the long term, what is the best form of energy to serve the world? It is electricity provided by nuclear fission reactors. The world will convert everything possible to electricity. Any other fuel will have to be manufactured, dependent on using electricity to produce hydrogen as a source material. Compared to electricity, this approach wastes more than half of the energy produced, because burning manufactured fuel, a heat process, is at most 40% efficient.

Although hydrogen will play a large role, the economy will be electricity rather than hydrogen dominated.

We will need to use fuel for some forms of transportation. The most likely fuel is pressurized liquid anhydrous ammonia (NH_3). It is non-flammable but burnable. It is much safer than gasoline and propane, and it emits no greenhouse gases. It is already in high volume production as fertilizer. Each year, four million tons are delivered to one million farms.

Most of our transportation will be electrically driven, by feed lines. Ships will be driven by nuclear reactors. Aircraft will use anhydrous ammonia. If this fuel had powered the aircraft that hit the World Trade Center, the towers would not have fallen!

SYNERGIES

The generation of electricity produces a great deal of waste heat. Rather than depending solely on large cooling towers, we will put to work a significant portion of this heat. Here are some of the applications that will be made:

1. **Desalination by evaporation**
2. **Treatment of sewage to provide safe distilled water and to convert organic matter to pure sterilized carbon usable by the petrochemical industry, carbon fiber manufacturers, and to manufacture of a very useful product, silicon carbide.**
3. **Reprocessing of recycled material.**
4. **Treatment of storm water to make it potable.**
5. **Hydrogen and ammonia production**
6. **Other processes requiring bulk heat.**

Adding these facilities to the plant site provide a major increase in value-added while simplifying the reactor cooling facilities. The nuclear sites will be well

protected against terrorists. Putting the above facilities within the sites will improve their security as well.

Here's one for the engineers and entrepreneurs.

One of the most important Synergies is providing facilities to produce hydrogen and oxygen using electrical energy. Nuclear generators work best when they are fully loaded. Shutting them down for significant time requires a complex time-consuming process. Adding electrolysis facilities connected to the generators through multiple high speed switches permits the system to be fully adjustable between grid and the electrolysis system.

This greatly improves the stability of the electrical network. Instead of being just an on-off source that may have to be turned off to protect itself during disturbances, nuclear generator will be a very flexible source of variable real and reactive power to help stabilize the disturbed network. The recent blackout in Florida is a good example. Instead of shutting down to protect themselves, the reactors, supplemented by switchable electrolyzers, would have provided the means for preventing the blackout.

The operation of the combined plant will provide the hydrogen fuel needed and input material for the ammonia production process and for other uses. Oxygen will have substantial utility as well.

GLOBAL WARNING

The present social momentum is toward elimination of the use of carbon for energy in order to lower CO_2 levels. Although the long term solutions above eliminate this problem, the worldwide daily needs for energy are so great and demanding that any significant lowering the use of carbon could be accomplished in the short term only by great sacrifice and damage to our civilization's economic and physical health.

We should watch the potential problem but put major actions to alleviate it on hold while we concentrate on our transition. Humans have proved their adaptability. Over the next few decades, the center of our agricultural activities may move somewhat to the north. Southern areas may need more air-conditioning but more northerly areas will somewhat less energy for heating. Some shorelines may be lost, at considerable cost to their owners and insurance companies, but there also will be

gainers at the new shoreline. We should try to be sensible in our adaptation. For example, a sensible adaptation to Katrina would be to move to high ground and rebuild the city there, returning the ocean bottom to the ocean.

Unfortunately, we don't seem to be sensible in New Orleans. We are spending billions to rebuild the old vulnerable city. It may be completed just in time to be washed away again!

The net cost of the undesirable results of global warning can be absorbed during the period of our power generation transition, and any serious attempt to reduce significantly the use of carbon in the near term would exact unacceptable losses to civilization. The faster we can move to the new system, the quicker CO_2 will no longer be a problem.

CONSERVATION AND EFFICIENCY

Our energy development and usage processes are surprisingly efficient. For example, the efficiency of electrical generators and motors is in the high 90 percent level. Even our gas guzzling autos are about 20% efficient, compared to the theoretical maximum of about 40% for heat engines. Our newer homes and buildings are well insulated.

Efforts to conserve and increase efficiency will continue under the economic pressures to come, but these efforts will have only a modest effect on the magnitude of our energy needs. The potential improvement is too small.

OTHER FUTURE NEEDS

The new electrical world requires vast new infrastructures. A few of these needs are described below.

The railroads will be electrified and any one track lines will have to be expanded at least one additional track (no both-way traffic on the same track). Two-track electrified railways will be gradually added.

New vehicles will be required. Electric or combination electric/diesel locomotives will replace diesel-electrics, a rather simple transition. Long range trucks will be shipped by rail. Short-range electric trucks will be used for end-point distribution.

A new and novel individual transporter will be developed. I call it the GIT (General Individual Transporter). Entrepreneurs, here is my suggestion.

The GIT will be all-electric driven by series electric motors mounted in the wheels. The wheels will be double, rubber for the road and metal for motoring on the electrified railroads.

These motors provide high torque at low speeds and high efficiency at high speeds so the car will need no transmission, transaxle, or rear axle gearbox. It will have sufficient high power delivery and recharge capabilities. It will have sufficient energy capacity to reach electrical electric supply lines for charge maintenance and longer distant travel. It can be recharged at home or work or at recharge stations provided along the way.

A new element (attention entrepreneurs) is the inclusion tow bar extending the length of the car. It will have electric engage/disengage clamps at both ends, with an electrical connector. This will permit cars to be linked in drafting-vehicle strings to be cooperatively driven under computer controlled load sharing (the ultimate car pool) or towed by trains or special buses. This will be similar to the bumper to bumper strings we currently experience, except the new strings will travel at highway speeds at great efficiency. Major increases in highway capacity and safety will result.

The tow bar also can perform as a conventional one for towing and being towed.

Many, if not all, customers may not be willing to trust the energy storage devices and will desire backup. Small backup internal combustion motor generator sets fueled by liquid ammonia can be provided. At the sacrifice of the loss of race car performance, ranges of a few hundred miles can be provided. When the car is plugged in for recharging when at home, the backup generator can act as backup for house power when grid power fails.

All vehicles that use ammonia fuel will need pressurized fuel tanks. A solution (attention entrepreneurs) is to design the strong frame members of the vehicle as enclosed and pressure proof fuel structures. The internal pressure strengthens the structures and no separate fuel tanks would be required. In the aircraft, the major wing, tail, and rudder spars would serve the need. The GIT will use this approach; its frame and tow bar will contain fuel.

SAFETY

During the last 60 years, nuclear installations in the US have proven to be the safest of all industrial operations. Not a single person has been killed or seriously hurt. There is no reason we can't maintain this record. We must, for we have no other reasonable alternative to meet our energy needs.

The above material describes a very satisfactory long term energy system. It provides a fine target. Actions incompatible with it should be avoided unless absolutely necessary. Now we are ready for the transition.

THE TRANSITION

To improve our national security, lower fuel prices, and support our energy needs through what could be a long transition, a full-scale effort should be mounted to develop additional fossil fuel supplies close to home. Example: the Alaskan oil fields, on shore and offshore The small footprint at these sites presents no risk to wild life and environment, and the field's presence may actually be a positive force in the area. Essentially, the opposition is emotional. This statement will draw an outcry, but it is true.

The north/South natural gas pipeline should be completed on an accelerated basis. Offshore site exploration should be accelerated without lengthy, expensive, and restrictive obstacles. The same is true of domestic refining. Serious exploration of nearby sea-bottom deposits of frozen methane should begin.

Staged electrification of the railroads supported by nuclear power plants should be begun immediately. At each section, consideration should be given to track additions and preparation for high-speed service. Designs should take into account provision for possible additional uses of the track; the least used of our transportation paths.

Early work should be done for installing at least one electrified lane in long distance highways for use by GIT's or BGET's (Big Electrical Transporters). During rail electrification implementation, the possibility of constructing additional highways on the same right-of-way should be studied. This aids in reducing the need for

securing expensive highway land. It also would promote the use of the new electric vehicles.

As the railroad electrification matures, long distance road trucking should be phased out and replaced by rail shipment. This can be done by a mix of short range electric trucks mounted on flatbeds, standard parcel rail shipment, and development of rail/road vehicles that could couple into the train, disconnect at the delivery site, and complete the delivery with electrical drive.

We should begin the transition immediately, by moving to expand our nuclear energy. All new power plants should be nuclear. Breeder reactors are needed to maximize use of the uranium. Fuel reprocessing facilities should match the growth of power plants, hopefully using the new on-site equipment.

Conventional trash and waste handling requires a new strategy based on maximum recycling. Use of landfills should cease. All waste should be collected and sorted at a centralized location in each community. It will use mechanized sorting to the maximum degree possible. Metals that are separable and fully recyclable should be sent to the users.

Other metals and all plastics should be sent to special fabricators for manufacture of usable products. For example, mixed metals could be melted together and fashioned into common building studs to substitute for wood in new building construction. Molded parts that could be made with mixed-plastic pellets could be produced. Some of this product manufacturing plants could be located at the collection site.

All remaining burnable material and plant material should be sent to generation facilities providing waste heat where the material would be dried to carbon and potable water reclaimed. This could be a major source of carbon to manufacture hydrocarbons for the petrochemical industry and other uses discussed above. Nuclear plants should be refurbished to new and improved standards. The stand-alone replacement nuclear heaters should be designed and built to replace existing present fossil fuel burners, giving priority to coal burners.

Development of the GIT should begin immediately. Rail carriers should arrange for pulling or carrying these cars so passengers could travel longer distances by rail and have their smaller cars to use at the destination. Eventually all ground transport will be electrically driven. With no need for large, complex internal combustion engines, the new vehicles should be much less expensive.

Although the petrochemical industry isn't the largest user of energy, there is no substitute for hydrocarbon in manufacture of plastics. If the above described facilities don't provide sufficient carbon, coal should be reserved to fill this need.

GOVERNOR WINN

To see how the transition would be initiated in an effective manner, the author is going to change roles and become governor of California. California is a wonderful place to start because its major industrial city is in a bowl that traps stagnant and polluted air. It also sports a street and highway system that is reaching its limit of expansion, and it is still a magnet for populations, legal and illegal.

It is months from the reelection vote. I may have missed the opportunity to take the lead in solving the illegal immigration problem, but setting out a sensible plan for solving the energy problem and beginning to implement it would substantially improve my standing with the citizens both in California and throughout the world. Possibly it would be enough to initiate a change in the constitution to permit me to become president!

Here is what I plan to do starting immediately.

I plan to announce the plan and provide a short summary of the above material. I then announce an accelerated program to wire the California rail system and set a date that I will require that all trains coming into or in the state to be electrically driven.

To initiate the plan, I would launch a program to build a 1000 Megawatt nuclear demonstration plant near the entry point of the busiest rail line entering the state. It will be state of the art. This pioneer site will encompass synergistic facilities: a water electrolysis hydrogen/oxygen generator, a carbon making waste plant, an ammonia manufacturing facility, with its nitrogen liquefier, and a major facility that requires waste heat. The installation work would parallel the stringing of electrical service wires.

The US labs have developed a new reactor system, the IFR (integrated fast reactor). It is the first fail-safe reactor. If all controls are lost and the cooling liquid turned off, the reactor fission process stops. Using its U238 cladding, it breeds more fuel than it burns, increasing its fuel availability 99 to 1. The recycling of the fuel is

performed at the reactor facility. The rods never leave the site. Nuclear waste is tiny compared to that of the present once-through system.

I will cancel all support for use of ethanol and other bio-fuels in and issue an edict requiring that gasoline not contain any additives that make fuels more expensive in California.

I will cancel any programs subsidizing the installation of solar or wind electric generators, including rooftop solar panels. The technology is well enough developed to let these applications compete. If they can't, they shouldn't be built.

I will urge auto makers to launch design and production projects to produce GIT autos. I will encourage industry to develop pressurized gas tanks and carburetors permitting current autos to convert to ammonia fuel. This will encourage ammonia producers to expand vastly their production and distribution facilities, using natural gas and later shifting to electrolysis to produce hydrogen.

I will initiate a project to electrify the car pool lines in the major highways and the inner lanes of local bus lines.

I will announce a project to build a suspended electrified highway and rail line in the Santa Ana River bed from the ocean and paralleling routes 55 and 91 past Riverside. I will launch a study of the feasible and need to do the same for other California rivers. I will issue an order authorizing offshore drilling in search of oil and gas along the California coastline. That should be enough for this election and to get us moving in the right direction.

GOVERNOR WINN

The next task is the most extremely difficult, more difficult than any of those described above. It is to get the name listed here to "Schwarzenegger". We'll need lots of help.

GOVERNOR SCHWARZENEGGER

I now leave the Governor's office. I am back in my role as author, and I have finished the seventh rewrite of my essay. It now is on its own. Readers and listeners are invited to send me comments, questions, and criticisms. The email address is

listed below. Please use "energy" as the subject so the message can be identified. I promise to reply.

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File: energypresentation3.doc