Fuel Cell Folly

Preliminary

E. R. Pat Murphy

May 9, 2003

Table of Contents

Introduction:
In the late 1990s articles about electric cars began to appear with more frequency in the media - heralded as a major societal transition from polluting internal combustion engines to "clean, emission free vehicles". In 1997 small numbers of these "electric vehicles" (EVs) were shipped to test customers. Owner groups were formed, web sites were developed and a new exciting world of fundamental change in transportation began to be extolled in magazines and newspapers.

GM shipped the EV1 in 1997. Ford bought the rights to the "Th!nk" electric car, developed by a company in Norway, and began shipping versions of that vehicle. Ford also developed a truck, the Ford Ranger EV. Honda shipped the EV Plus and Toyota the RAV4 EV. From 1997 through 2000, the EV was proposed as the solution to foreign oil dependence and environmental problems. In that four year period, GM doubled the mileage range of the EV1 with a new battery system.

By 2002, it was all over. Ford stopped selling Th!nk and sold the rights to a Swiss company. GM withdrew the EV1 and began recalling the cars, all of which had been leased to customers. Honda and Toyota stopped marketing their cars, and their Web sites disappeared. The life cycle of the Electric Vehicle, marketed as a wonder, was less than a decade. Its growth and demise overlapped the dotcom phenomena and the disappointments were similar. Over 100,000 vehicles were to be zero emissions by this point in time. The actual numbers – approximately 3000.

The media has now turned to fuel cell vehicles and what is termed "The Hydrogen Economy". This seems to be the latest "new" economy, the Internet Economy having faded almost completely and the Information Economy having gone down in disrepute. The fuel cell and "Hydrogen Economy" will presumably free us from many things, foremost our current dependency on oil imports from other countries, particularly the Middle East – the same claims made for the EV.

It is the assertion of this article that the fuel cell vehicle (FCV) mania will last no longer than that of the electric vehicle (EV), about five years. The first two fuel cell commercial vehicles made by Honda and Toyota, the Honda FCX and Toyotra FCHV, were shipped in late 2002, corresponding to the1997 shipment of GM's EV1. Five years later the EV1 was withdrawn. It is projected that in 2007, five years after the 2002 shipments, the fuel cell vehicles will be in a similar position. This does not mean that the fuel cell will not be developed – only that it will no longer be offered as the panacea for our energy problems. Like the EV, it may be useful in some niche applications.

Selling the Fuel Cell
In March 2003, the US attacked Iraq, within a few weeks conquered it, and stated its intention to occupy the country for some time. Alternating between claims

about Iraqi secret Weapons of Mass Destruction are denials that Middle East oil has any effect on the governments plans. In January 2003, the president announced a plan to spend hundreds of millions of dollars on the fuel cell, "proving" that we don't need the Arab oil since this new technology doesn't require oil.

Much of the fuel cell rhetoric comes from people well known in the fields of environmental research and sustainable communities. The titles and claims are often extremely exaggerated. Consider the following titles of recent books:

> Powering the Future: The Ballard Fuel Cell and the Race to Change the World – Tom Koppel - 1999
>
> Tomorrow's Energy: Hydrogen, Fuel Cells, and the Prospects for a Cleaner Planet – Peter Hoffman, Tom Harkin - 2001
>
> The Hydrogen Economy: The Creation of the World-Wide Energy Web and the Redistribution of Power on Earth – Jeremy Rifkin – 2002
>
> Fuel from Water: Energy Independence With Hydrogen – Michael Peavey – 2003

And from recent magazines:

> Wired Magzine – April 2003 "How Hydrogen Can Save America"
>
> E, the environmental magazine – Jan Feb 2003 - feature article - "The Hydrogen Economy - After Oil, Clean Energy From a Fuel-Cell-Driven Global Hydrogen Web *By Jeremy Rifkin*

Amory Lovins of the Rocky Mountain Institute has "invented" a new automobile called the "Hypercar" which is supposed to result in an efficiency of 200 miles per gallon. The media ignores the fact that this "car" is only a set of drawings and specifications – a conceptual study. There is no actual "Hypercar" on the road getting 200 miles per gallon.

Almost all of these writers speak of the fuel cell with messianic enthusiasm, ignoring the risks and difficulties associated with such a tremendous change in transportation technology. They also ignore the many decades of research and development that have already gone into fuel cell technology, solar photovoltaics (PVs) and wind turbines. Items under development for decades do not typically enjoy breakthrough status overnight.

An example of the "gushing" descriptions is this quote from the article *The Coming Hydrogen Economy* by Rolf Nordstrom. It was printed in the September 17, 2002 Vol. 19, No 9 issue of Minnesota Journal.

> Imagine a form of energy that is clean, inexhaustible, and so abundant that Minnesota could forever meet its energy needs. Imagine a technology that can power your house, car, business or bus and emit only water vapor. What if your car generated profitable electricity for the local grid from the parking lot at work and helped power your home while sitting in the garage? What if this energy could be produced from common fuels in the short term and wind, water, sun, biomass and even algae in the long run? If this sounds fanciful, consider that we already have two central features of such an energy system, fuel cells and hydrogen

More significant because of the national source of this quote is from the report "*National Hydrogen Energy - A National Vision of America's Transition to a Hydrogen Economy – to 2030 and Beyond*. This report was published in February 2002"

> Today we have a hydrocarbon economy. Tomorrow we will have weaned ourselves from carbon and will live in a "hydrogen economy." In the hydrogen economy...*America will enjoy a secure, clean, and prosperous energy sector that will continue for generations to come. American consumers will have access to hydrogen energy to the same extent that they have access to gasoline, natural gas, and electricity today. It will be produced cleanly, with near-zero net carbon emissions and it will be transported and used safely. It will be the "fuel of choice" for American businesses and consumers. America's hydrogen energy industries will be the world's leaders in hydrogen-related equipment, products, and services.(*page 24)

The examples of this type of language are too numerous to list. It is very similar to the rhetoric of the Internet era of the last few years of the 20th century. The claims are completely outlandish and none report that hydrogen must be manufactured. Fortunately, billions have not yet been lost by gullible investors.

The Fuel Cell Stock Market Record

Investors are already showing that the hype will not last too long. Certainly, private investors are no longer rushing to place their money in this technology as they did with the Web - the initial "burning of the investor" has already taken place. The following chart gives an example of the stock price history of the major fuel cell companies:

Symbol	Company	Issue Price	High Price	Q1/03 Price	IPO year	Yearly Revenue
BLDP	Ballard Power Systems	3	105	10	1995	$120 million
FCEL	Fuel Cell Energy	2	45	5	1997	$40 million
GLE.TO	Global ThermoElectric	1	47	2	1998	$22 million
HYGS	Hydrogenics	12	12	4	2000	$16 million
HHO.TO	Stuart Energy	27	27	5	2000	$10 million
PRTN	Proton Energy	32	32	3	2000	$4.7 million

PLUG	Plug Power Inc	20	120	5	1999	$3.4 million
MCEL	Millenium Cell	10	22	2	2000	$.7 million
MDTL	Medis Technologies	23	23	4	2000	$ .3 million

Like in the Internet era, the stock prices show an initial exuberance, at least for the four stocks issued in the 1995-1999 period, followed by collapse. On average these four companies had an IPO price of approximately 6, went to about 80 and are now about 5 – a typical pattern for high tech in the later half of the 1990s. The other five stocks with IPO's in 2000, went public at the peak of the boom with an average IPO price (also their highs) of 24. They now have an average price of 4 as of the first quarter of 2003. There has been little change since the sales pitch of President Bush in January 2003. Both smart and dumb investors today are no longer swayed by high tech rhetoric, even by the president of the United States.

California Air Resources Board (CARB) – EV Folly

In 1990 GM introduced the Impact concept car at the 1990 Los Angeles Auto Show. This was the prototype for the GM EV-1, delivered in 1997. Also in 1990, the California Air Resources Board (CARB) created the Zero Emissions Mandate (ZEV) in accordance with the Low-Emission Vehicle (LEV) Regulations which required an increasing percent of Zero-Emission Vehicles to be sold in California. In effect, ZEV meant battery-powered EVs, because at that time it was the only demonstrated technology with no emissions. The mandate required that, beginning in 1998, 2% of new car sales of the "Big 7" largest car makers would be ZEVs. The mandated volume was to increase to 10% of new car sales in 2003 – approximately 20,000 cars per year.

In 1996, as it became clear that the 2% EV sales requirement would not be possible, CARB eliminated the requirement. The Big 7 manufacturers were to produce up to 3,750 advanced battery vehicles between 1998 and 2000. A few thousand were built by the various manufacturers - many of which were leased to customers.

By 2002, the EV program was in shambles and the electric car had reached the end of its development. As already noted, GM withdrew the EV1 and Ford sold the Th!nk. Toyota announced that they would discontinue production of the RAV4 Electric Vehicle worldwide in the spring of 2003. And the CARB turned its attention to Fuel Cell Vehicles and hybrids. CARB's goals for fuel cell cars are much smaller than those for the EV – they will require only 250 fuel cell cars to be made in the next few years.

The EV effort of 15 years was not wasted. The technology of the electric drive train is used in current hybrid vehicles and will be used in others that will be delivered in years to come. Yet the failure of the EV was predictable at its inception – and the fuel cell failure is predictable as well.

The concept of the EV was to reduce pollution. Originally the designation was ZEV or “Zero Emissions Vehicle”. The solution was the EV – the Electric Vehicle. And the automobiles developed met the requirement of “zero emissions”. Yet the total system emissions were not zero. It required oil to turn the generators that generated the electricity that was used to charge the EV. Proponents of EVs and Fuel Cells speak of the “cleanliness” of these vehicles, noting that they generate no emissions – *at the point of use!!* In truth, emissions are being generated at the point of electricity manufacturing for the EV – the power station. This has the effect of distributing the pollution around a larger area. So for example, pollution in the Los Angeles basin from internal combustion engines would be reduced by increasing the pollution at some other point in the state or a nearby state. This may make it easier to breathe in Los Angeles but over a period of years, the effect on the environment and global warming is the same. This is the equivalent of dumping sewage downstream of one town into the drinking water of the village further down the river.

The fuel cell is similar. The hydrogen used is made from fossil fuels at a generating plant and the emissions are released into the atmosphere. The fuel cell itself has no emissions. However, at the plant plant there are enormous emissions reflecting the hundreds of millions of cars being used. Power plant emissions replace engine emissions. And it may take more total energy to run a hydrogen car than it would to run an electric vehicle!

The typical consumer is unaware of the costs involved in using electricity rather than oil to power an automobile. The fuel cost of electricity generation is analyzed at the Web site of the Energy Information Administration, which is part of the US Department of Energy. The following quotation is found in the Electricity Chapter of the *Energy in the United States: 1635-2000*. This is part of the Annual Energy Review 2001 (www.eia.doe.gov/emeu/aer):

> The unit cost of electricity is high because most of the energy that must be purchased to generate it does not actually reach the end user but is expended in creating the electricity and moving it to the point of use. In 2000, for example, approximately 40 quadrillion Btu of energy were consumed by the electric power sector to generate electricity in the United States, but only 12 quadrillion Btu worth of electricity were actually used directly by consumers. Where did the other 28 quadrillion Btu go? Energy is never destroyed but it does change form. The chemical energy contained in fossil fuels, for example, is converted at the generator to the desired electrical energy. Because of theoretical and practical limits on the efficiency of conversion equipment, much of the energy in the fossil fuels is "lost," mostly as waste heat.

This fundamental fact is ignored in the sales literature for both EVs and Fuel Cell cars. The energy costs of converting a fossil fuel to electricity is very high.

Ignoring this fundamental factor brings into question the very reason for existence of an organization such as the CARB. At least their goals are more limited this time around – 250 fuel cell cars is far less than the 2000 or so EVs developed or the tens of thousands planned for.

The Need for Accuracy – Oil Depletion

The situation of energy and depletion has been discussed in depth in the past years. Books are beginning to appear with more regularity on the subject. Three of the most important and well written books on the subject include:

> The Party's Over: Oil, War and the Fate of Industrial Societies Richard Heinburg, ,New Society Pub., April 2003, 288 pages
>
> Hubbert's Peak: The Impending World Oil Shortage
> by Kennet S. Deffeyes, Princeton University Press, October 2001, 285 pages
>
> The Coming Oil Crisis, Colin J. Campbell, Multi-Science Publishing Company Ltd.,1997, 210 pages

Associations are being formed to investigate the situation in depth, the most notable being the Association for the Study of Peak Oil (ASPO). These groups point out the seriousness of the situation. If poorly thought out alternatives are "marketed" rather than analyzed, the public will have no understanding on which to make their decisions – and one of the most important decisions for consumers to make is to curtail their energy usage. Thus it is important to bring realism into the picture as soon as possible – otherwise, "well meaning" proponents of these "solutions" will contribute to the delay of efficiency and curtailment projects.

An example of the Pollyanna attitude of today is found in the February 28, 2003 Fuel Cell Report to Congress prepared by the Department of Energy. In the introduction section, page viii, under Education, the report emphasizes the need to

> "clearly communicate the hydrogen vision to potential end users, local governments, and others/"

This is further elaborated in the Education section (page 16) of the report. The emphasis is on "selling the public" on hydrogen benefits and does not contain any language showing any intent to provide the full range of risks and potential problems that are necessary for the public to make an informed decision.

What is a Fuel Cell?

A fuel cell is a machine - a device that converts a fuel such as hydrogen to electricity without burning it. It uses an electrochemical process rather than a combustion process. The fuel cell was invented in 1839 by William Grove and was originally called a "gas battery". The term 'fuel cell' was first introduced by

the chemists Ludwig Mond and Charles Langer in 1889 when they attempted to build a device using air and industrial coal gas. In 1932 Dr Francis Thomas Bacon extended the original design developed by Mond and Langer. This device which he named the 'Bacon Cell' was in essence the first alkaline fuel cell (AFC). In 1959 Bacon demonstrated a machine capable of producing 5 kW of power, enough to power a welding machine. Later that year (1959) Harry Karl Ihrig of Allis-Chalmers, a manufacturer of farm equipment, demonstrated the first fuel cell powered vehicle. He produced a fuel cell stack which could generate 15 kW and was capable of powering a 20 horsepower tractor. The fuel cell was used extensively in the space program, beginning in the late 1950s and is still used at this time. In 1993, Ballard Systems launched the first modern version of a fuel cell vehicle with a fuel cell-powered bus.

Outside of the space program its use has been limited in terms of transportation. It can be used as a power generation plant or as an engine for a car. It's safe to say that as of the end of 2002, there were probably no more than a few dozen vehicles in the whole world running on fuel cells. There are a few thousand fuel cells in other applications such as power generation.

It is estimated that the current fuel cell engines in the recently shipped cars each cost over a hundred thousand dollars. (This statement will immediately be used to justify the fuel cell as a future replacement of the internal combustion engine arguing "with a price that high, imagine how far it can fall." This represents the panacea thinking prevalent both in government agencies, automobiles manufacturers and duped environmentalists.)

What is surprising is how difficult it has been to find practical applications for fuel cells outside of the space program. From first invention in 1839, to the first development of a vehicle in 1959, to the first delivery of a modern vehicle version in 1993, to the first shipment of a handful of vehicles in 2002 is a very long period of time, particularly in the modern high tech world.

What is hydrogen?

Hydrogen is a manufactured gas used in numerous ways. Hydrogen does not exist on earth in a free state and must be manufactured from some other material that includes hydrogen as one of its components. One of the most popular uses of hydrogen is in the food processing industry where it is used to turn normal fats into what are called "transfats", allowing for a long shelf life for processed foods. (It is universally accepted that transfats are the most harmful form of fats for humans.) It is also used in refining hydrocarbons into fuels, as a fuel for the space program, and as a feedstock for fertilizers.

For the purpose of automobile fueling, hydrogen can be used in two ways. First it can be burned in an internal combustion engine (ICE) serving as a replacement for gasoline. Demonstration cars with ICEs running on hydrogen have been available for years. When used as a fuel for ICEs, the hydrogen does not pollute

at the point of usage. But pollution is generated at the point of manufacturing the hydrogen.

The second way of using hydrogen is in a electro chemical process previously described to generate electricity in a fuel cell to turn the wheels of the car. This is the familiar fuel cell vehicle.

Sources of hydrogen

The big question is "where does the so called "non polluting" hydrogen come from"? It comes from a polluting process called "reforming" (or "steam reforming"). In this process a hydrocarbon fuel that contains hydrogen (coal, oil, natural gas) is "reformed" creating hydrogen and carbon dioxide (CO2) as well as other pollutants. The CO2 and pollutants are released into the atmosphere. The fundamental difference between a fuel cell car and an internal combustion engine car is that the hydrogen fuel for the fuel cell car is manufactured in a factory and the CO2 is released into the atmosphere at the hydrogen factory. In a conventional car, the CO2 is released wherever the car is being driven.

Fuel cell proponents have invented the concept of "sequestration" which means that the CO2 will be buried in the ground at the factory site, although that has not been done as yet. Like the nuclear waste to be stored at Yucca flats, the CO2 will hopefully stay underground for several centuries.

96% of the hydrogen used today comes from this reforming process, with natural gas the primary "feedstock" (48%) for the "reformation", followed by oil (30%) and coal (18%). The small remainder (4%) comes from electrolysis, which is a process of separating water into hydrogen and oxygen using electricity.

Hydrogen usage must be evaluated for its merits and weaknesses in many areas. It seems to be the ideal fuel for launching space ships. This does not mean it will be an effective replacement for internal combustion engines. It may do poorly in that area but be effective as a load leveling system for the daily and seasonal fluctuations of power production by solar or wind – no one yet knows. It is the description of it as a panacea that is questionable. The fact that it has some applicability does not make it a proven replacement for today's power networks.

An alternative approach to the fuel cell is to use the natural gas from which hydrogen is made as a fuel for natural gas powered cars and the oil from which hydrogen is made for ICE cars. Since there are already natural gas engines and Internal Combustion Engines, it is not clear why the fuel cell needs to be developed. Hydrogen is that component of "hydrocarbon fossil fuels" which is burned in conventional engines. Pollution will occur either at the factory or at the car. It is important to determine which is the most efficient way to use the resource.

The Fuel Cell/Hydrogen Battery System

The fuel cell can be viewed as an electricity generator which works by processing hydrogen. Current electricity generators operate by rotating a copper (or some other material) coil in an electromagnetic field. The energy to rotate the coil and to generate the magnetic field comes from burning fossil fuels, by water flow, or by nuclear power.

A fuel cell combined with hydrogen forms the equivalent of a battery. Electricity is placed into a battery and later drawn from a battery. In the same way, electricity is placed into a fuel cell/hydrogen combination, this electricity being generated by conventional means. And again similar to a battery, electricity is later drawn from the combination of fuel cell and hydrogen. The original electricity in both cases is generated from fossil fuels, nuclear power or hydroelectric dams, with a few percent coming from solar photovoltaics and wind turbines. The main distinction is that the battery that is charged and the electricity released later come from the same physical unit while in the case of the fuel cell/hydrogen combination, the hydrogen tank is “charged” and the fuel cell can be at a different locale.

Use of the fuel cell implies a further shift to electricity and away from direct burning of fossil fuels, at least natural gas and oil. If fossil fuels are depleting than the current reformation of natural gas and oil to form hydrogen will be increasingly limited. And the use of oil for transportation will also become more limited. The production of this electricity for creating hydrogen for fuel cells will come from nuclear plants, coal fired generators (coal is an unsatisfactory fuel for cars), hydroelectric plants, wind turbines and photovoltaic cells.

Fuel Cell Misrepresentations

There are several precepts of fuel cell and hydrogen proponents that must be addressed. Like other technology miracles, many of the statements made are to be taken on faith, accepted as emotional experiences offering a feeling of comfort and safety. In this senses they are somewhat meaningless. The first precept is:

The fuel cell is clean – it generates no pollutants

True and misleading. The hydrogen manufacturing process of extracting hydrogen from fossil fuels (gas, oil, coal) generates pollutants – and 96% of hydrogen used is only available through such a manufacturing process. The remaining 4% come from electrolysis which uses electricity generated mostly by fuel burning polluting power plants.

You can drink the water from a fuel cell car exhaust

True if the car uses tanks filled with hydrogen. If it uses a reformer and you drink from the reformer, you may die – particularly if the reformer fuel is methanol. Methanol is a popular fuel for fuel cell reformers and is much more poisonous to humans than gasoline. Drinking from the exhaust pipe is a publicity stunt and

intended to mislead the public into thinking the whole hydrogen process is non-polluting.

The fuel cell produces no harmful CO2 emissions when burned; the only byproducts are heat and pure water.
True and deliberately misleading. Harmful CO2 emissions are produced at the hydrogen manufacturing plant as discussed above.

Hydrogen is the most abundant element in the universe
True but meaningless. Of all the hydrogen in the universe only .0000000000…..1 % exists on the planet earth. (I have no idea how many hundreds of 0's need to be typed to make this accurate. And it makes no difference. We can't get hydrogen from the sun)

Hydrogen is the most abundant element on earth.
Hydrogen is part of water and all life forms on the surface of the earth as well as the fossil fuels formed from living organisms. But beneath the oceans and beneath the surface of the earth, there is none, except in a small number of oil, coal and gas fields. It is not clear if this statement is true. Most abundant can be by atomic weight or by number of electrons or not or if it has any meaning. Hydrogen is always some part of some other elements. Whatever the percentage on the earth, it takes more energy to "form" the hydrogen than will be produced when the hydrogen is burned.

You can make hydrogen from water
True and very misleading. Hydrogen is made from water by a process of electrolysis. (Hydrogen is made from fossil fuels by a process of "reformation".) Electricity, generated by burning fossil fuels or by nuclear power, is needed for the electrolysis process. Unfortunately, more energy in the form of fossil fuels is burned to turn the generators to create the electricity for electrolysis than is produced by the resulting hydrogen.

This is a difficult concept to grasp, not because it is intellectually complex, but because it is contradictory to the popular views about hydrogen which are being disseminated in huge quantities by the media. The average person finds it hard to believe that the government or hydrogen advocates would mislead him or her in such an obvious way. Thus they tend to question and challenge the naysayer. Hydrogen advocates have developed skillful language including the invention of the term "transition fuel" to obscure the issue. This includes the statement, "It is true that hydrogen is currently made from fossil fuels and we will continue to use natural gas as a "transition" fuel until renewables are 'on line'. "

Hydrogen will be made from renewables
True. It can be made from water with electrolysis using electricity from wind mills or solar panels. However, at the beginning of 2003, extremely small amounts of hydrogen are being produced by renewables. A quick approximation of "small

amoutns" is calculated by multiplying the 4% of hydrogen being produced by electrolysis and the 4% of electricity produced by hydroelectric plus wind plus solar resulting in an approximation of about 1/10 of 1%. In other words, more than 99.9% of hydrogen comes from non-renewables. We can make hydrogen from renewables but we have no idea if sufficient quantities can ever be made available.

Hydrogen is a carrier, rather than a source. *(Or a "currency" as used by Ballard)*
Carrier implies something or someone carrying something else. Hydrogen does not "carry" energy, then deposit it somewhere, and continue on its way. Hydrogen is a "form" of energy and is most directly related to electricity. Electricity is typically generated by burning natural gas or coal or from a nuclear plant. Hydrogen is generated from a process that also requires energy from burning fossil fuels. But hydrogen also requires a "feedstock" which is also a fossil fuel. Both electricity and hydrogen are forms of energy. Both cannot be stored in their original state, which is not true of fossil fuels. Both require a storage device – either a battery or a tank. And both can "leak" – electricity from the battery and hydrogen from a pressurized tank. Leakages are absorbed by the earth or the air.

Hydrogen is an exciting new technology.
Hydrogen has been used for decades and the fuel cell was used by NASA in the 1950s. Reviewing the fuel cell and hydrogen relative to the automobile, one notes that the leading provider of fuel cell engines was founded in 1979. A fuel cell bus was first demonstrated by Ballard in 1993. The first test cars shipped to test customers occurred in late 2002. The California Air Resources Board expects 250 shipments to be made in the next four years. The manufacturers hint at manufacturing rates of about 1 car per month. The technology is not at all new and the development rates, as compared to computers, internet equipment, and biotech are extremely slow.

Hydrogen powered fuel cells are more efficient than ICEs
This may be true but it is meaningless. The important question is if the total system, sometimes called "well to wheels" is more efficient. This can easily be measured even today. On that basis, the fuel cell/hydrogen combination and the methods of obtaining the hydrogen are less efficient.

The Real Cost of Hydrogen – When the experts ignore data
In the Jan/Feb 2003 issue of E Magazine, Jeremy Rifkin wrote an article *"The Hydrogen Economy - After Oil, Clean Energy From a Fuel-Cell-Driven Global Hydrogen Web"*. After explaining that electricity is used to generate hydrogen which is used to generate electricity, the article then proceeded to the next paragraph:

> "People often ask: Why generate electricity twice, first to produce electricity for the process of electrolytic hydrogen and then again to

> produce electricity and heat in a fuel cell? The reason is that electricity can be stored only in batteries, which are cumbersome to transport and slow to recharge, while hydrogen can be stored at much lower cost. Internal-combustion engines capture only 15 to 20 percent of the energy in gasoline, and the conventional electric power grid is only 33 percent efficient. But as Amory Lovins' Rocky Mountain Institute (RMI) points out, "Fuel cells can convert 40 to 65 percent of hydrogen's energy into electricity." "

Mr. Rifkin notes that electricity can only be stored in batteries, which aren't very good, while hydrogen can presumably be stored at a lower cost. The cost comparison for generation of the electricity for the battery or hydrogen for the alternative is not provided.

His next sentence introduced the concept of inefficiency. ICE's (internal combustion engines) capture 20% of gasoline's energy and electric power plants are only 33% efficient. Would this mean that an electric power plant is more efficient than an ICE when charging a battery for an electric vehicle? Isn't this comparing an apple to an orange?

Next he quotes Amory Lovins, who says fuel cells can convert 40-65% of hydrogen's energy into electricity. Is this the same efficiency of the ICE and the power plant? Does that mean that a power plant operating on natural gas can generate electricity that, when converted to hydrogen to operate a car, is 3 times more efficient than a car burning the natural gas? (Natural gas has been used as a fuel for vehicles for years.) And does that mean that a car of the same weight when run by a fuel cell gets three times the mileage of an ICE using gasoline or natural gas? If the hydrogen is made from natural gas, is there more or less natural gas used for the hydrogen car than for an equivalent weight and efficiency ICE car using natural gas as the fuel?

A very important number is the cost of the electricity, generated by whatever process used, which is converted to the "form" of hydrogen. The December 2002 issue of BioScience Magazine contained an article entitled *"Renewable Energy: Current and Potential Issues".* The author, David Pimentel, notes "The energy required to produce 1 billion kWh of hydrogen is 1.4 Billion kWh of electricity. Later on the same page he says "The conversion of hydrogen into direct current (DC) using a fuel cell is about 40% efficient". One might conclude that this means 60% is wasted, or that, of the 1 billion kWh produced, only 400 million kWh is used. Using 1.4 billion kWh to produce hydrogen of which 400 million kWh implies a total cost of 1.4 Billion kWh to realize 400 Million kWh in useful energy, a loss of about 70% of the original energy available.

How Efficient Is the Fuel Cell?

The issue of efficiency as noted in earlier comments can be extremely confusing. Efficiency has to be converted to energy used to move a vehicle of the same

shape and weight a certain distance at a certain speed. The comparison between two fuels or engines can only be made meaningful when they are measured using the criteria of equal weight, shape, distance traveled and speed of travel.

In February 2003, the Department of Energy delivered the "Fuel Cell Report to Congress" comparing fuel cell vehicles to internal combustion engine (ICE) vehicles. On page 3 of that report, a table lists the following:

Vehicle Type	**MPGE**
Gasoline-fueled ICE Vehicle	.150
Gasoline-fueled ICE Hybrid Electric	.105
Diesel-fueled ICE Vehicle	.105
Diesel-fueled ICE Hybrid Electric	.095
Gasoline-fueled Fuel Cell Vehicle	.085
Compressed hydrogen Fuel Cell Vehicle.	.075

MPGE – miles per gallon equivalent measured as liters/miles.

What is astounding is the improvement from the basic ICE engine to the hybrid car, a 1/3 reduction of energy used. What is equally astounding is the relatively low improvement forecasted for the Fuel Cell Vehicle (FCV). From the volume of fuel cell hype, one would expect the FCV to offer something far more substantial than a 50% reduction from the ICE. This is even more noteworthy when one realizes that, with absolutely no fanfare, Honda and Toyota, who developed the first hybrid cars, reduced the energy usage by about 2/3 of the ultimate offer of the fuel cell vehicle.

Probably a 50% reduction in fuel consumption has occurred in the last 50 years with normal improvements in the gasoline engine. Honda alone achieved close to that on the Honda Civic over a 10 year period. The 1991 Honda Civic Hatch back DX weighed 2158 pounds and its gas mileage (city/highway) combination was 31/35. The 1992 Honda Civic VX hatchback weighed 2100 pounds and its gas mileage was 48/55. This amazing increase was based on a new VTEC-E engine, which utilized a finely timed valve control system and new lean-burn combustion technology. This was the only car in California that did not require a catalytic converter. In 1999 the Honda Insight was delivered which weighed 1847 pounds with mileage of 61/70. This represented a doubling of gas mileage in Honda's smallest car in less than a decade.

It is possible to speculate that Honda and Volkswagen, the two leaders in high mileage vehicles development and manufacturing, may well achieve another 50% in the next 50 years with ICE hybrids, possibly with diesel engines.

The case for the Fuel Cell as the panacea for reducing automobile energy use has not been made, particularly since the fuel cell has existed for over 50 years. It is not reasonable to expect a 50 year technology to suddenly offer the

breakthroughs suggest by the hype. The push for fantasy solutions such as the "Freedom Car" and the "Hypercar" may well distract us too long from the need to make corrections in our life style to more efficiently and fairly use the earth's resources.

One "Not so Hidden Agenda" – Nuclear Power

Many Fuel Cell and Hydrogen proponents are either naï ve orhave a "hidden agenda". The naï ve ones have not performed thebasic calculations to show how many renewable devices will be required to replace oil (millions of windmills) and how practical it is to use these since they will be erratic and seasonal and cannot be located anywhere that power is needed. Those with "hidden agendas" are using the arguments as a way to develop nuclear power. The "hidden agenda" designation is not applied to Geoffrey Ballard, founder of Ballard Power Systems and now Chairman of General Hydrogen, who is quite open about his support for nuclear. Dr. Ballard was named a "Business Leader of the Year" by Scientific American magazine in December of 2002 – one of only fifty such individuals to have received that honor. Dr. Ballard recently made two speeches from which I quote:

Speech 1 - Masters of Technology – a video tape from Scientific American
An Interview with Dr. Ballard
http://www.sciam.com/mastertech/Ballard_Interview_transcrip.doc

The interview begins with Mr. Ballard recalling the 1973 oil crisis in the United States and his realization of the need to replace the internal combustion engine because oil is a finite resource and cannot last forever. He relates the story of leaving his job and buying a motel in Miracle Valley, Arizona and beginning his research on batteries. He bought a restaurant and his wife ran it to put food on the table while he started his research. He speaks of his dream of there being a chance to find the energy conversion device that would allow a new economy to come into existence.

After rejecting lead batteries he began studying lithium batteries and lithium sulfur dioxide. After some time his attention moved to the fuel cell technology of the proton exchange membrane (the PEM fuel cell) used in the Gemini space missions in 1965, after accepting the limitations of batteries.

The fuel cell, even thought simple in concept, invented in the early eighteen hundreds and used in 1965 by NASA, was not useful for ordinary transportation because of the exotic and expensive materials required. Ballard realized it would only work if it was made out of ordinary materials. After more than a decade of work, optimum materials were found and money was invested from government and private investors. A new management team was installed at his company, Ballard Power Systems.

Dr. Ballard then describes the technology which uses methanol, a liquid fuel made from fossil fuels. Methanol is pumped into the vehicle's tank and a small chemical plant in the back of the car called a reformer, "reforms" the methanol into carbon dioxide (released in the atmosphere) and hydrogen, which is sent to the fuel cell. There is presumably less pollution and more efficiency.

After successful demonstrations of the fuel cell, Ballard Power began attracting more investors. Daimler Chrysler was an early investor. Later investments came from other automobile manufacturers.

Dr. Ballard continued discussing advantages of the fuel cell, particularly relative to electricity generation, where there are major opportunities to reduce the peaks and valleys of electricity generation. Hydrogen could be manufactured with any excess electricity that might be available during the valley periods and then used to generate electricity at the peak periods.

Dr. Ballard also notes: "The Ballard fuel cell today would not be in existence if judiciously placed funds from the provincial and federal governments had not been given and placed with us in order to do the development."

The interviewer than asked about conservation. Dr. Ballard replied:

> "Conservation will get you a little bit but it won't get you the energy levels that we need. I think that the Bush administration, the rhetoric I'm hearing about right now, has got it about right. They're saying they're going to produce more electric power plants, they're going to continue with the power plants they know how to build, gas, etc., which is very efficient, even going to coal. But at the same time, you'll notice in the rhetoric, there is a re-look at nuclear energy. Nuclear energy is the future of a pollution free economy."

The interviewer continued with this line of questioning reminding Dr. Ballard that he had been Time Magazine's "Hero of the planet 1998". Dr. Ballard repeated:

> "I want to move steadily towards a sustainable future. The only sustainable future we can possibly see with the energy levels we know we need is a hydrogen economy backed by a nuclear power infrastructure."

He then notes that more efficient power plants that are less polluting can be built. In addition "sequestering" (storing in underground reservoirs) of carbon dioxide can also be used.

The interviewer continues by saying,

> "….I want to get this right because it's not often you see a champion of environmentalism say nuclear power is the way to power electricity for the hydrogen economy because people say nuclear power, Three Mile

Island, Chernobyl. The risks don't, and the dangers, do not outweigh the benefits."

Dr. Ballard then recalled the positive experience France has had with nuclear power. He noted that France had developed some very good techniques for waste disposal.

Dr. Ballard also gave a key talk at the World Hydrogen Energy Conference, June 2002, in Montreal. In April 2003, this speech was available on line at http://home.generalhydrogen.com/pdf/WHEC.pdf.

Mr. Ballard opened his talk with a statement about the Kyota Protocol to whit:

"I believe no developed nation, which has seriously studied the environmental issues that confront us, can in good conscience sign this protocol.

He then notes that:

"Economic progress, as we know it, correlates very well with per capita energy consumption. So do all other forms of social progress…"

He states that we need to limit and then reduce the use of coal and petroleum. However, he follows that with the statement that:

"It may be necessary to fully utilize and perhaps increase our utilization of coal and petroleum based energy production; but this should be done with great care, utilizing the latest technologies and insisting on cleaning or sequestering the Green House Gases they emit."

Sequester means "bury" just as nuclear fuel residue are to be "buried" at Yucca Flats in Nevada. Mr. Ballard notes that we must introduce a new Energy System, which, he suggests, be the Hydrogen Economy. Next he says:

"It must be noted, Hydrogen is not an energy source. Hydrogen is only a currency, but it is such a currency that it makes all sources of energy available to the Energy Economy. It is the first truly reversible currency."

Well that leaves us a bit confused since we know what currency is and a gas doesn't seem to be a currency. Like "carrier", currency is a trendy word but not totally clear. But the key statement is accurate, that is - "Hydrogen is not an energy source". Further in his speech he notes:

"The Hydrogen fuel cell allows us to use any primary energy source to fuel our economy, geothermal, wind, solar, hydro, nuclear, coal and petroleum."

Note the energy source list does not include hydrogen. Since hydrogen only produces electricity, we can understand the next statement:

"As the world progresses to the Hydrogen Economy, I believe Hydrogen and Electricity will become so indistinguishable from each other that they will be referred to as a joint currency called HYDRICITY™. "

Next he replaces The Hydrogen Economy when he says:

"I believe that we will eventually emerge to the HYDRICITY™ ECONOMY."

Maybe all of this makes sense if we look upon hydrogen as a battery. Instead of lead plates, we will have a tank of hydrogen. But by now, the reader should understand that hydrogen is normally made from some other fossil fuel, most often natural gas. And this is done at great expense using some other energy source to make the hydrogen.

Mr. Ballard then discusses Nuclear Energy:

"I said I wanted to comment on Nuclear Energy. My comments are a direct fallout of our need for a new energy system. If the new energy system is to be a hydrogen economy we have already mentioned the potential for this system to accommodate any primary energy source. In Iceland it may be geothermal, in Sweden it may be hydro-electric, in Argentina it may be wind driven. Throughout the world many remote applications will employ solar energy. But, environmentally desirable as these sources of energy are, they are unlikely to provide the vast amounts of primary energy that social progress will demand.

If carbon based energy sources must be set aside, and I believe they must, then the only remaining viable source, at this stage in our development, is nuclear. Yes, there will be other possibilities in the future. Recently there has been speculation in the press that Hydrogen could be mined directly from deep earth sources, and Hydrogen is the fuel and element of space. But within the scope of today's technology, nuclear fission is the only viable, clean source of large quantities of energy. "

During the last few years there has been a remarkable change in the rhetoric of economists, politicians, engineers and scientist on the subject of nuclear energy. On the science side, many thoughtful, world renowned, environmentalists have stated that they see no alternative to energy supply other than nuclear. Nuclear generated electric power does not pollute our atmosphere, and mitigates against global warming.

On the engineering side we are hearing that remarkable progress has been made in the realm of safety. The nuclear industry has established a solid safety record during the past decade. Engineers are taking a system-wide view of the nuclear fuel cycle from mining nuclear ore to

waste management and disposal. To quote from Scientific America, *"The Case For Nuclear Power"*:

> 'Today 438 nuclear power plants generate about 16 percent of the world's electricity. In the U.S. 103 nuclear power plants provide about 20 percent of the country's electrical production. Although no new nuclear facilities have been ordered in the U.S. for more than two decades, the electrical output of U.S. generators has grown by almost 8 percent a year as the industry matured and became more efficient. In the past 10 years alone, American Nuclear Plants have added more than 23,000 megawatts, the equivalent of 23 large power plants to the total electrical supply despite the lack of any new construction."
>
> From the economists we are hearing that much of the cost of previous nuclear plants was a lack of uniformity and replication - each new plant being designed from scratch instead of evolving a standard and a pattern. Furthermore, the regulations that crept into the system to allay the public's fears because of incidents like Three Mile Island and Chernobyl are largely unnecessary and not cost effective. These issues are being examined closely to build a level playing field for future nuclear plant construction.
>
> From the politicians, at the highest levels of government, we are hearing that Nuclear power production deserves a second look.'

Dr. Ballard then discusses one of his favorite themes - pollution, especially in the inner city. One of his key comments in this section is:

> "One of the important things about fuel cells and Hydricity is that they produce no carbon dioxide emissions *at their point of use*." (italics mine)

This is once more recognition that hydrogen is manufactured and the carbon dioxide emissions are at the point of manufacture, not at the point where it is being used. This is also true of electric cars, which generate no emissions but whose batteries are charged by electricity from power plants burning fossil fuels.

I bring these comments forth because Dr. Ballard is an important person in the fuel cell business. He firmly believes in his product and acknowledges that hydrogen has to be made from fossil fuels or with electric power, principally from nuclear power plants. His "agenda" is not hidden. Probably every conservative and every liberal and every independent would agree with him that fuel cells should be developed and should eventually run on hydrogen created by electrolysis. I think there would be agreement that wind turbines and solar cells should be developed and that hydrogen should be manufactured using the electricity from these sources.

Violent disagreement would arise based on his assertion that nuclear power would provide the electricity. At this point, he might no longer be lauded as the father of the fuel cell economy. Furthermore, surprise and shock will arise when proponents of the fuel cell understand that the fuel is manufactured from fossil fuels.

Dr. Ballard has made significant contributions to the world. He is clear in his position and is knowledgeable about his facts. His position is far more realistic and far more accurate than that presented in popular media articles on hydrogen.

However, he is not alone in assuming nuclear power as a major source of the electricity for the hydrolysis process. All the government reports have similar comments buried in some section or the other, with a reminder of how safe nuclear power has become and extolling newer and safer plants. Nuclear waste storage is typically not mentioned.

In a Wall Street Journal article entitled "Congress Takes Up Energy Bill, And Fireworks Are Expected" dated 4/9/2003, the following paragraph is included"

> "The bill also is likely to include $1 billion to build a federal prototype for a new generation of nuclear power plants that are intended to be simpler, safer, and designed to produce hydrogen for fuel-cell-powered cars, as well as electricity. The measure would also include federal loan guarantees for utilities that opt to choose to build new nuclear-power plants."

Renewables and Hydrogen Production – A Huge Risk

In the preceding section, Dr. Ballard commented on wind turbines and solar cells, noting "But, environmentally desirable as these sources of energy are, they are unlikely to provide the vast amounts of primary energy that social progress will demand." Wind turbines and solar photovoltatics are not consistent producers of electricity. The wind and sunshine is intermittent, changing on an hour to hour and a day to day basis. In addition, the quantities are seasonal – the sun shines much less in the winter and with less force, limiting the amount of electricity that can be produced. Winds change their patterns. Thus the electricity produced fluctuates constantly. This is one of the arguments for hydrogen – it serves as a form of battery to store electricity.

The two main questions about renewables are site availability and storage capacity. Hydroelectric dams are an example. There are very few available sites remaining for building new dams. The sites are limited by the number of rivers and the limited topological sites available on each river. Similarly, sites for renewables are also limited. In California, a large percentage of wind turbines have been placed in only two locations – Tehachapi Pass in Southern California east of Los Angeles and Altamont Pass in Northern

California east of San Francisco. One cannot simply place wind turbines on a grid laid out on the country, the spaces of the grid being based on the total need for energy. Capital costs of turbines are high, in the range of $1,000,000 each. Nor do they scale easily. A $1,000,000 turbine with blades 60 feet in the air is not the same as 100 turbines costing $10,000 each with blades 20 feet in the air. Wind turbine history shows that the larger more expensive turbines are more efficient in electricity production relative to manufacturing costs than smaller turbines.

This suggests that, like dams, there are a limited number of sites available for wind power. Proponents argue that the average wind and sunlight blowing or shining on the land that forms our country is sufficient to provide power in amounts far greater than what we are using. A parallel argument would be that there is sufficient water falling on the land that flows through rivers, streams, and channels, which, if dammed, could provide the desired energy for all our needs. A quick comparison of water falling on the land to that part of the falling water flowing through dam turbines would make the point.

A popular place proposed for solar photovolatics is the Sahara desert in North Africa. The energy required to move the electricity across the Mediterranean sea to Europe has as yet not been reported.

The second question, energy storage, addresses the question about hydrogen and the fuel cell in their joint role as a battery. If the sun is shining during the day on photovoltaic cells, some of the energy generated would be used immediately and some would be stored either in batteries on in the form of hydrogen to power lights, water heaters and furnaces during the night. The amount stored would hopefully be balanced so that the battery or hydrogen would be exhausted just as the sun comes up and begins shining on the PV cells again.

The number of batteries (or tanks of hydrogen) needed (assuming a single size) is based on the number of cloudy days. If every other day is cloudy, then twice as many batteries or tanks are needed to provide additional storage. Expand this concept to seasons and one can imagine the huge size of the batteries and tanks needed to provide winter energy for a single home.

The renewable proponents have not to date provided a model of a system that would deal with the situation. No verifying data from the years of operation of the wind farms at Altamont Pass and Tehachapi Pass is available to illustrate the possibility of an easy transition to wind energy as the major provided of fuel for the country.

Needed – An Objective Evaluation

Fuel Cells and new hydrogen applications will undoubtedly be developed and will be used in some applications, just as electric vehicles are used in a few niche

markets. Enough effort has been expended to show there is some technical validity. It is not obvious that these will be other than niche offerings. And it is extremely dangerous and unconscionable for proponents to “sell” the idea when we are faced with ever depleting resources. An impartial evaluation of the work done to date would be of great value. Well justified projections of the future, taking into account the familiar “law of diminishing returns”, would also be very important. This requires individuals with integrity who will provide the information necessary in the form that the lay person can understand. Questions to be addressed would include:

1. What is the manufacturing cost of the fuel cell vehicles recently shipped (December 2002) by Toyota and Honda?

In a December 23, 2002 article in Business Week entitled “Fuel Cells: Japan's Carmakers Are Flooring It”, it is estimated that the current Honda FCX and Toyota FCHV cost about $1 million each to build. The president of Honda is quoted as saying “"My goal is to build one a month over the next two or three years."

2. What are the projected costs of a fuel cell car?

In the same article referenced above, It is noted that the Honda's engineer in charge of fuel cells, Yozo Kami, admits it will take at least 10 years to bring sticker prices down to $100,000, the cost of today's most expensive gasoline cars.

3. Are there sufficient resources for the rare components such as platinum to provide a large volume of such cars?

Platinum has always been a rare and expensive metal. Is there enough platinum to provide fuel cell engines for 700 million cars?

4. What would be the cost comparison of fleets based on electric vehicles or natural gas vehicles as compared to fuel cell vehicles? What is the equivalent energy used for these different options?

This is a comparison that could have been made at almost any time in the last year. Its lack is significant.

5. How would hybrid vehicles (internal combustion and batteries) be expected to evolve in the same time period and how would they compare to fuel cell vehicles, including hybrid cars with battery charging capability?

All car manufacturers are announcing hybrid models. Possibly they already know the answer.

6. What is the difference between the various configurations of alternate fuel cell/hydrogen options and what are the comparison costs of the options - including fuel cell with hydrogen tanks, fuel cell with reformer, ICE with hydrogen

tanks and ICE reformer, pure electric vehicles charged by power networks, pure electric vehicles charged by fuel cell power plants, etc.?

This could be provided in a simple chart. Its absence is also noteworthy.

7. What is the cost difference between an EV1 running on electricity and a regular car running on gasoline? Assume the electricity being generated is by an oil turbine.

This information has been available for several years now. It is surprising to find it missing in the popular literature

Most of these questions can easily be answered by the experts involved in the industry, should they care to do so.

A report written in January 2003 entitled Energy and the Hydrogen Economy http://www.methanol.org/pdfFrame.cfm?pdf=HydrogenEconomyReport2003.pdf by Ulf Bossel and Baldur Eliasson contains the following comments in their Summary of Results:

> The reported results are by no means final. The readers of this study are invited to refine the analysis and to contribute further details. The energy cost of producing, packaging, distributing, storing and transferring hydrogen must have been analyzed in different contexts. The results of those studies may be used to verify, correct, or reject our numbers. Whatever, the intent of this compilation is to create an awareness about the weaknesses of a pure hydrogen economy. *We are surprised to discover that, apparently, the energy needed to run a hydrogen economy have never been fully assessed before.* (Italics added)

The authors are surprised but do not add that they may also be dismayed, as many are who observe the fuel cell solution being sold to people by experts, governments and corporations, rather than being explained to them.

The Real Problem – The Consumer

America is a free country. Americans have free will. We make our decisions based on free market choices. We believe that the free market doctrine of each person choosing what is best for his or her self interest optimizes our country's development economically and presumably satisfies us psychologically.

Denial

Americans know that advertising is misleading. They have known since the arrival of the Volkswagen Beetle in the United States after World War II that there are options to large cars that use excessive amounts of gasoline. Yet in the last 20 years more and more Americans continue to choose larger and larger cars with faster acceleration over smaller cars with less rapid acceleration. At the same time, fuel efficiencies have continued to improve. Volkswagen, Honda and

Toyota have been making fuel efficient cars for several decades. As already stated, Honda has improved the mileage on their smallest cars (the Civic Hatchback and the hybrid Insight) by almost a factor of 2 since the Civic introduction in the 1970s.

Today, the mileage of the average car selected by Americans is slightly more than 20 miles to the gallon, little changed for two decades. For four years now, Americans have had the option of choosing cars like the Honda Insight and Toyoto Prius – cars getting three times the mileage. Yet the total number sold is less than 1/10 of 1% of the autos sold.

What Americans do not want to acknowledge is that they prefer comfort, convenience, speed, fashion and power over the environment. Information that may jeopardize those values is easily ignored.

Blaming Producers

Americans tend to criticize oil companies and car companies as if these companies are forcing them to drive cars and are selecting the cars they have to drive. The American economic system and its associated values support the idea of a person or persons or companies working to maximize their income within the constraints of the legal system. Puffery, exaggerated lies, is part of the business code. It is the charter and the responsibility of car companies to maximize their profits. Car companies maximize their profits by building the largest vehicles possible and by building them in large volume. Small cars, mass transportation, and car pooling injure those companies. They are doing so within the value systems of America and the laws of the land. One can expect nothing else. Experts in the field cooperate with this approach. No one got rich by telling someone to buy something cheaper and more reliable. Corporations are happy to accept the blame and promise to redeem themselves – as long as customers keep buying their products. In the world view of this culture, producers are guilty and consumers are innocent.

Americans like techno-fixes. The American psyche assumes there is a technical solution to every problem. If the solution is not here, then it is the fault of either the government or the manufacturer. The fuel cell is the ideal American techno-fix, the follow on to the fix of the last decade - the EV (electric vehicle). But like the EV, the fuel cell vehicle will be less convenient and cost more money than the ICEs. And when that occurs, the fault will be either the companies or the government. American's will forgive themselves for their purchases of SUVs during that period.

Ignorance is Bliss

The state of oil depletion has been known since 1930 when oil discovery peaked in the lower 48 states. It was further made clear when the Japanese bombed Pearl Harbor in 1941 based on the US embargo of oil sales to Japan. It was noted again in February of 1945 when President Franklin D. Roosevelt

guaranteed the divine right of kings in perpetuity for the countries of the Arabian Peninsula in exchange for guaranteed cheap oil. In 1956, M. King Hubbert of Shell Oil predicted the peak production of oil in America to be around 1970 and in 1970 his prediction was validated. In 1964 worldwide oil discovery peaked. In 1978 world oil production per person reached its peak and has been declining ever since. Recently it became clear that production has peaked for all countries outside the Middle East. Oil is a finite resource in spite of what free market advocates may claim. Yet more and more oil is used for driving – a choice made by consumers.

The Car and Values – "America's Love Affair"

It is common to refer to Americans and their autos as "having a love affair with the automobile. (A recent book entitled "Divorce Your Car!: Ending the Love Affair with the Automobile**"** by Katharine Alvord and Stephanie Mills discuss the history of the automobile in this country.) A love affair is often described as illicit or passionate or short term or sexual. Love affair implies a set of values, one of which is self satisfaction at the expense possibly of spouse, family or community.

American values for cars include speed, comfort, trendiness, convenience, power (over others), fashion, "sexiness", conspicuous waste, peppiness, conspicuous consumption, etc. Ad language includes words like "muscle", peppy, performance, and acceleration. An anti value, and one of the worst words to describe a car is to call it "sluggish". All these values inevitably lead to larger cars, bigger engines and more driving.

There is also an implied value of violence in the culture, most apparent in media. This value carries over to our selection of automobiles. Joan Ryan wrote an article entitled "An all American vehicle" in the April 6, 2003 issue of the San Francisco chronicle about the 2003 H2 Hummer. (The Hummer is a recently developed large automobile. Its ad program includes cartoon pictures of a Hummer terrorizing cabs driven by caricatures of third world citizens.) She quotes the salesman as saying "All steel. You get into a head-on collision with a Suburban, say, and this will win by a lot." And "The only thing you have to worry about when you're in one of these things is a semi or a bus. The vehicle you hit – thats the one that needs the extra air bags." The steel Hummer weighs 6400 pounds and gets 10 miles to the gallon. The aluminum Honda Insight weights 1800 pounds and gets 70 miles per gallon. Ms. Ryan goes on to talk about what she calls the "strain of self preservation-at-all-costs taking root across the country". She then relates this to the fear in our country and the world situation particularly the Middle East.

The name of the cars, their size, the macho adventuresome advertising all combine to provide an air of competitiveness, danger and violence around the car. There is a sense of excitement at having a large powerful "muscle" car. The concerned person buying a small car in order to conserve resources is viewed as quaint, not quite "with it" and to some extent as weak. This partly explains the

continued purchase of every larger cars in the face of resource depletion. They are not transportation vehicles – they are "fundamental to our way of life" or "part of our high standard of living"

People who drive small efficient cars typically are not having "a love affair with the automobile." The automobile is a tool – a way to get from one point to another. Acceleration is secondary to thriftiness. A smaller car stops quicker and can be more easily and quickly maneuvered, increasing safety. The owner of a small car is not viewing himself or herself as in combat with another driver. A small efficient car includes the values of frugality and thrift as well as caring for others – caring for the progeny (children and grandchildren), caring for the other motorist and caring for environment.

E. F. Schuhmacher notes in the chapter called Technology with a Human Face of his seminal work *Small is Beautiful*:

> "The modern world has been shaped by its metaphysics, which has been shaped by its education, which in turn has brought forth its science and technology. So, without going back to metaphysics and education, we can say that the modern world has been shaped by technology.

America is a machine culture. That means the machine determines the culture within which we find ourselves. This current culture is addicted to machines and thus to the burning of ever increasing amounts of fossil fuels. As we reach the peak of world oil production, a frantic effort is underway to continue this wasteful way of life by finding a new machine to replace the old machine that is depleting the resources in question.

Conclusion

The tremendous push for the fuel cell seems to come more from a spirit of panic than anything else. It is being marketed as an amazing new technology that will completely restructure human life – an argument last seen in the year 2000, as the Internet Economy collapsed. The fuel cell is to correct a major problem – the depletion of fossil fuels (pollution being secondary). Yet the fuel cell is a new technology designed to replace another technology which, not too many decades ago, was being touted as something that would restructure human life. And in the Western world – 20% of the population – it has altered life drastically.

Yet the fuel cell is not so much a new technology as an incremental improvement to an existing technology. It is a new engine to replace the internal combustion engine in the same automobile bodies. It will not affect the death and injury rate from automobile accidents. It will not change the increasingly crowded nature of our streets and highways. It will not relieve the number 1 anxiety of all parents – that their child will be killed or injured in an automobile. It does not address the cultural problem – the values noted above.

Even more important, it is unlikely that the fuel cell vehicle will even achieve the goal of eliminating dependence on fossil fuels. The fact that almost all hydrogen is made from fossil fuels is always skirted as an issue or dismissed with some casual reference to “transition fuels”. The decades spent in development with few results are ignored - which indicates a high risk technology. Ballard, the leading supplier of fuel cell research engines and founded in 1979 is still not profitable – 25 years later.

And the nuclear issue is completely obfuscated, although continual small hints are being made in books, media articles and government reports.

What is desperately needed is a change in values – for Americans to abandon their “love affair” and become concerned about the values and health of the human family, which any ordinary love affair threatens. Efficient cars are available and have been for years. When a car is viewed as transportation and also as a machine that requires care to insure others are not hurt by ones use of the machine – then the values will lead to different choices.

A PROPOSAL FOR THE

Ride Share Transportation System

A Ride Sharing Utopia and An Alternative to Chaos

Introduction

Americans use a tremendous amount of fossil energy sources to fuel a geographically diffuse style of living. Many have had the experience of living in a region where even the simplest errand requires traveling several miles. A quart of milk requires either a car trip or several hours to walk to the market and back. Our current lifestyle can require the family car for everything, from finding playmates for our children to attending church to simply visiting friends.

It is this pivotal point, the repetitive use of the automobile, where pressure can be brought to bear to change how Americans think and act about oil. We have all seen, or been in, rush hour traffic in which the vast majority of cars are occupied only by a single occupant. For now, gasoline is still cheap enough that we use it to purchase this convenience.

But what if sharing cars *was* convenient, as well as efficient? We could save enormous amounts of energy by attacking that portion of our energy expenditures which performs enormously redundant tasks, namely many people, driving individual vehicles to the same destinations.

We asked ourselves how such efficiency might be created. One answer is to use our advanced technology to compile and disburse information about individual vehicles, their destinations, and their riders. The use of such technology save enough oil to allow many additional years of transition between our centralized, city-based culture, and decentralized, smaller communities.

Getting started

Once our country really feels the pinch of depleted oil reserves, early generation solutions will probably be imposed. These solutions, already existing in many places in the world, include car pools, ride sharing, well managed and well maintained mass transportation systems, and better vehicle gasoline mileage. However, a state of denial exists in the industrialized world, and particularly in the United States, regarding the predictions of rapidly decreasing oil production later in this century. It seems likely that the nation will not plan for such a program, and solutions will need to be radical and quick in their effectiveness.

These problems could be solved quickly by designing a ride-sharing program that could quickly be implemented. The term for this program is “Ride Share”. It is based on using our existing transportation infrastructure of private vehicles but

insuring that there is always more than one person per car, optimally 3-6 riders. This country has no shortage of automobiles or roads, but the average rider load of 1.5 (quote the OTA source) people per vehicle per trip implies a huge consumption of fuel and massive traffic problems, which in itself increases fuel usage still further.

We believe that there will be a crisis because of the failure of the country to address this issue and that when this crisis comes, speed of change will be vital. There will be no time to develop something new and elaborate, or something that will be slow to implement and costly. For many Americans, the crisis may appear sudden, as most people in the US want to believe in a limitless supply of fossil fuels. This belief is so strong that we may attack and control other nations in the Middle East to sustain it. The sudden awakening to the reality of depleted fossil fuels will require quick action, resulting in systems that use existing and widely available technology.

The existing cell phone network can be tapped as the user interface between drivers, riders, and the routing system. Computers and software experts from the military command and control communication systems can be reassigned to work with engineers and programmers from the nation's Airline and Automobile Reservation Systems. These experts would produce the tracking and scheduling database for a new nationwide human transport system using existing cars. Satellites can be utilized on a time-sharing basis with military specialists retrained to provide real-time input about traffic and weather conditions. Even the National Security Agency (NSA) "listening systems" could likewise be modified to provide information input to the new transportation system.

A Brief Description

The system works by using a cell phone system as the communication interface for a ride reservation system. All citizens will have a modified cell phone incorporating a Global Positioning System (GPS) function. GPS technology is already being installed in some cell phones based on emergency response mandates from the federal government.

A special "vehicle cell phone", based on an enhanced individual phone, would become a permanent part of each vehicle. It would include a fixed identification code for the vehicle as well as readout capability for location and speed (modified GPS), which could be triggered either by satellite systems or police and other emergency vehicles.

The goals for the Ride Share program would be to reduce auto gasoline usage by 80%, and to reduce commute time by an average of 50% within two years. As the system is developed, a huge decrease in the number of vehicle accidents and fatalities could also be expected. This would, of course, result in substantially fewer payouts and, hopefully, a concurrent reduction in insurance premiums. Additionally, a major cost reduction would be incurred for the nation in road

construction and maintenance since wear and tear would be reduced. We expect that as people became aware of the benefits of such a system, any sense of sacrifice would diminish and be replaced with a sense of excitement.

The Cultural Barriers

In terms of a technical effort, the Ride Share program is not at all difficult. There are many computerized reservations systems from the oldest – airplanes – to car rentals and tickets to sporting and cultural events. And the benefits are obvious – less commute time, less cost and less environmental harm. However, many of these benefits could already have been achieved by simply buying smaller cars. Unfortunately, the trends are in the opposite direction. This is because the private automobile provides psychological benefits that outweigh the simple issue of getting from one place to another.

There are three main issues the limit the possibilities of rapid and easy change:

a. The privacy issue
b. The individuality issue
c. The personal issue

Privacy - The privacy issue concerns the privacy of a person's trips. In the following sections, it is noted that a police patrol car could have the possibility of ticketing a moving vehicle without stopping it, since the license number would provide a way to rapidly search a data base and determine the driver. A simple extension would mean that the patrol office could also determine the identification of the passengers on the vehicle. This typically leads to an instant negative reaction and comments about Gestapo agents and attacks on privacy. A person planning a questionable liaison or activity would immediately consider the possibility of parents, spouse, boss or others searching a file for their location at some point in time. Obviously such a system could be extended to provide much of this information.

American's are very sensitive to this type of invasion of privacy. Other cultures are less concerned. Japanese friends report that neighborhood police kiosks give them a sense of safety and providing their reasons for being in an area to a questioning police officer is not a concern. And Japan has a much smaller crime rate than America and far fewer crimes of assault or passion. Yet Americans readily accept the invasion of their privacy by intelligence agencies and corporations. Each of us has multiple dossiers held by businesses and government agencies, the contents of which we have no knowledge.

Recent investigations and severe penalties to the finance industry has brought forth the realization that deleted E mails are not eliminated and anything anyone writes by E-mail is available to some agency or corporation. This also is accepted by the population.

In spite of this, the knowledge that their location and destination could be made available to others strides a chord of concern and fear. No guarantee of privacy or the destruction of ride records after a period of time would be generally accepted. It is not clear why the society will accept privacy violations by business and intelligence agencies but not by local law enforcement. It is possible that business and big government are more tolerant of minor violations than the law enforcement in the community. Or that business and government are only interested in marketing products and catching espionage agents while local law enforcement must deal with drug violations and domestic disputes. There will be no effort here to analyze the phenomenon in detail, although it is expected that the reasons will be quickly identifiable and can be resolved.

Individuality – America is the home of the "rugged" individual, the person who knows and insists on their "rights". One frequent "right" being exercised in the nation is that of the teenager walking through a shopping maul carrying a boom box with the volume set at or near the maximum. Another "right" is the right of corporations and businesses to operate TVs in public places with constantly running advertisements. Airlines have a right to place a TV screen in the back of the seat facing a passenger and display changing ads throughout a long flight. Teenage girls have the right to wear a minimal amount of sexually attractive garb while older men have the right to ram the car ahead of them as they gawk. Teenage boys have the right to dominate the sidewalk as they stroll through an area in a typical boisterous and somewhat intimidating manner.

The latest "right" is the right to conduct a conversation on a cell phone in a public place. Few need elaboration on the ire often generated by such actions.

The constant exercise of "rights" in public places often leads to a general feeling of aggressiveness or some other negative quality amongst people. In America, "good manners" are now a thing of the past, to be ridiculed and certainly to be avoided so as not to be teased or ostracized by one's peer group.

This is also a severe limiting cultural aspect for a ride sharing system. For example, should a passenger be allowed to make a series of sales calls on his or her portable phone during a Ride Share trip? What happens when the inevitable gum chewer who has taken popping the gum to a high art enters a vehicle?

Personal – When media speak of "America's Love Affair With The Automobile", they often refer to joyful and exciting times and a spirit of adventure. However, many people report a sense of peacefulness and relaxation when driving. Consider a busy parent who after a hectic morning and dropping the children at school now begins a 30 minute commute to the office where pressure and activity will again dominate the day. It is not uncommon to see people buying coffee and rolls at a drive in, placing their favorite music in the car tape recorder or CD, and beginning their commute with the intention of enjoying the time alone.

It is said that Americans lead “busy” lives and the stresses associated with that “business” are well known.

The System Specifications

To provide a model of how this hypothetical Ride Share ride sharing system could work, a set of design requirements, that is, what exactly do we need it to do for it to work, is described. Typically programmers and other technology workers, those people who have the capacity to produce such a system, often begin a design with a review of the desired capabilities of the finished product.

Basically, each person that wants to take a trip, whether it is to work, school, shopping or recreation, would use his or her cell phone to request a ride from the system. The system will then locate the appropriate vehicle and driver to pick up and deliver the rider (or riders) making the request. Drivers are those who have planned a trip of their own and need riders to fulfill the requirements for ride sharing – individual trips no longer permitted in normal circumstances. Every person may be either a “driver” or a “rider” at different times. Drivers are connected with riders by the Ride Share system which will optimize the connection from a pool of driver and rider requests to insure optimum routing and minimum time delays

There are nine major sets of design parameters in such a system. While discussing all the myriad social and physical aspects of what we were trying to conceptualize, we began to refer to the nine sets of parameters as “rules”, and began describing the system in those terms. The major classes of rules are:

1. Function Rules
2. Vehicle Rules
3. Driver Rules
4. Rider Rules
5. Police Rules
6. Privacy Rules
7. Dispatching Rules
8. Fleet Rules
9. Reporting Rules

1. Function Rules

The Function Rules list all the capabilities that are required for the Ride Share system to work. The main functions available would be:

1. Ride request - entering time, location, and destination or using information stored in the rider’s phone memory for Most Frequent Destinations (MFD). It includes a profile (special needs or requests) of the rider and other optional space requirements such as small freight that might be carried (like a suitcase) carried as well as unusual requirements such as extra large physical size.
2. Ride commitment - rider accepting an alternate time, location, and destination or an alternate one if the requested one is not quickly available.
3. Ride arrival notification - alerting the rider that the vehicle will arrive in 2 minutes, allowing time to get to the street.

4. Check in - assuring that the correct rider and driver have found one another.
5. Check out - notification of the rider leaving the vehicle.
6. Emergency - asking for police assistance in case of accident or illegal/improper confrontation.
7. Transgression report - report smoking, drinking, or harassment violations.
8. Radio turnoff/other special requests - requesting no music, smoking, news radio programs or other unwelcome stimuli.
9. Random ride request - available for pickup immediately at listed GPS locations.
10. Non-emergency accident notification - contacting dispatcher for towing services or accidents not requiring emergency service.

A person desiring a ride would enter the preferred time of departure and destination into his or her cell phone. In most cases this would be pre-programmed, including the typical time and destination for work or for school. The system would locate a vehicle with available seating which is close to the rider, and which will be going close to the desired destination at close to the desired time. The vehicle driver would receive and accept the request, and upon acceptance, receive directions if needed. The requesting rider is informed as to the time of pickup and information about the driver and vehicle. His or her cell phone rings when the driver is two minutes driving time away (or whatever time stipulated by the requestor) so the rider can be ready for the pickup.

The rider would be delivered at or near his or her destination. If direct ride scheduling is not possible, the rider can accept the option to go to a place closer to his or her final destination and request a second or third ride to reach their final destination. In addition, a rider suddenly needing transportation, having been at an unscheduled activity, can request a ride at his or hers current location based on the GPS location given automatically by the rider's cell phone.

A successful system will have options to deal with accidents and transgressions by drivers or by other riders. Having a "transgress" button on each cell phone to contact the authorities would prove a powerful deterrent to inappropriate behavior. Using such a command on one's phone could be a de- facto request for police to begin monitoring that vehicle as a further discouragement of aggression or malice.

2. Vehicle Rules:

The vehicle rules apply to the actual automobile that both riders and driver share. A vehicle that is part of the Ride Share program would be termed a Ride Share Vehicle (RSV). The RSV's role in the system would be to:

1. Rider Reporting - report rider arrival times, departure times, and pickup and drop off locations.

2. Vehicle Reporting - report its own location, average speed, and load factor changes.
3. Other Vehicle Reporting - through use of radar or other technology, report other vehicles in unsafe proximity or otherwise being driven unsafely.
4. Police response - respond to all police requests.

This reporting would be done via each Ride Share Vehicle's (RSV) cell phone and the accumulated telemetry would aid the central system in planning and dispatching.

3. Driver Rules

Drivers would be volunteers in the community with excellent driving records who would be paid a stipend to cover auto expenses and depreciation. Accidents, police records, or moving violations would be considered potential grounds for suspension of driving privileges. The drivers would:

1. Pick Up - Drop Off - pick up and drop off scheduled riders
2. Reporting No Shows - report no shows and any relevant information (tardiness, confusion about location).
3. Behavior - report rider comportment violations.
4. Remuneration - pay penalties and collect bonuses based on his or her success.
5. Random Change - try to incorporate unplanned riders, those needing spur of the moment rides, and unscheduled stops when requested to do so by the system.

The driver's reporting responsibility would work to weed out those citizens who are rude, habitual no-shows or late arrivals, or otherwise act as a drain on the efficiency of the system.

4. Rider Rules

Riders would go through an elementary screening process to determine their needs. Records would be kept for each individual, including records of complaints or commendations from other members of the ride sharing community, both drivers and co-riders. Excessive violations would result in suspension or restriction of ride sharing access.

The technical problems associated with such a vast new system are trivial compared with the human element. Americans are so isolated in their life styles that frequent social interactions with strangers are avoided, resulting in the need for a prescribed ethic of conduct. Some rules might be simple, such as a no smoking rule. Others would be more controversial but necessary, such as a limit on perfume and a requirement for basic hygiene.

The rider's part of the bargain would be to:

1. Promptness - arrive promptly for pickups.

2. Decorum - maintain a conversational decorum and basic politeness.
3. Behavior - don't smoke or play personal media if it bothers others.
4. Perfumes - avoid wearing perfume and be reasonably clean.
5. Reporting - report violations of safety or dangerous conduct by drivers or other riders.

A central database to correlate the upkeep of vehicles, misconduct by drivers, and notations about riders could result in a community that is mostly self-policing through access to information and subsequent peer pressure. This would tend to limit the traveling options of those who insist on their right to act in a manner not acceptable to all.

Such self-policing communities already exist, mostly among technology workers in online applications. When access to desired community information can be restricted due to peer complaints, we have a rudimentary model upon which to base Ride Share's protocol.

5. Police Rules

Traffic control and vehicle law enforcement would be greatly simplified with the Ride Share program. There is no doubt that traffic accidents and injuries would decrease significantly if fewer cars used our highway system. Law enforcement responsibilities would include:

1. Ticketing - ticket moving vehicles remotely.
2. Enforcement - stop vehicles, make arrests, investigate system violations.
3. Investigate - perform corollary investigations involving use of the system for criminal activity.

The reporting functions built into the Ride Sharing Vehicles would allow law officers to ticket a vehicle, without stopping it, for speeding and other offenses. If a vehicle were ticketed in this manner, the driver would be immediately notified via the vehicle cell phone. Witnesses would be automatically available from the rider records. Since the driver has his or her own identifying cell phone, the police could match the driver with the vehicle and access a database for driving or other records. With a properly designed system, this could be done in seconds. The police would be able to initiate a status read out from the cars under observation, easily identifiable visually from existing satellites.

The implementation of a high-level traffic monitoring and reporting system would have corollary effects on other crime that is not vehicular in nature. When automobile escape routes from crime scenes are monitored as a matter of course, the criminal's options become limited. Ride Share's personal cell phones, all equipped with emergency signal capacities and GPS transmitters, would give crime victims a chance to summon assistance quickly. Unclogged transportation arteries, due to decreased vehicle traffic, would allow a quicker response time from emergency personnel. With proper legal review (available instantly) police

could listen to remote situations via vehicle or personal cell phones. The result would hopefully be a drastic drop in crime rates with minimal invasion of the privacy of law-abiding citizens.

6. Privacy Rules

Since 9/11/01 the right to privacy in the face of increased civilian monitoring by government agencies has been in doubt. Provisions would need to be made for Ride Share's tracking services to be used for traffic efficiency and crime detection only, and would not make such records available to any American secret police agency that might arise. The current political situation, including the approval by Congress of expanded wire-tapping powers by the Office of Homeland Security, makes privacy a sobering issue in the implementation of Ride Share. Privacy laws would be needed to maintain:

1. Confidentiality - keep trip records confidential except for criminal prosecution.
2. Data Security - allow for the compilation of date to better manage the system while still protecting people's privacy.

Despite all the system requirements to report movements of citizens and vehicles, these records must be kept confidential. They must only be made available based on appropriate requests from law enforcement personnel. However, we might suggest that there is so much information being gathered on people even now, that this change is less radical than it at first appears.

7. Dispatching Rules

Implementing Ride Share will require large start up costs, including vast amounts of human capital. Dispatchers, particularly in the early days, will make or break the system. Dispatchers will need to be responsible for:

1. Monitoring Equipment - monitor automobiles and trucks.
2. Monitoring People - monitor for troublemakers and criminals.
3. Responding - respond to drivers and riders.
4. Dispatching - dispatch vehicles and drivers and clear status of vehicles and drivers upon trip completion
5. Contacting - contacting police/highway patrol/towing as necessary
6. Rescheduling - reschedule riders due to problems or sudden destination changes

Dispatchers and their reporting would bear the brunt of making the system work in the early stages, but could eventually become a supplement to properly functioning technology. With real time operating experience to draw from and a fluid design, most functions could eventually become automated. Dispatchers would become troubleshooters instead of the active schedulers.

8. Fleet Rules

Having the populace at large sharing private vehicles will necessitate certain minimum standards of care and maintenance. Vehicles would require:

1. Checking - checking on vehicles every few thousand miles.
2. Certifying - certification for use within the ride sharing system.
3. Recording - keeping stringent detailed maintenance records.
4. Incident Logging - accident or damage log.

Stringent rules would need to be set in place for the vehicles that could be used. Most important would be the periodic safety inspections, which would become more extensive and frequent if the vehicle was in an accident. Vehicles with expired certification or failed safety tests would be reported and removed from the system.

9. Reporting Rules

In order for a traffic system as complex as Ride Share to function, it must adapt, which requires information about performance. Thus reporting from all portions of the ride sharing community will be necessary to ensure efficiency and ease of use for all. Reporting and analysis would allow the system to adapt to both regionalized travel phenomenon, like rush hours or weather disruptions, and to more generalized social transportation trends like summer vacations. Some of the reports that could be compiled from the databases might include:

1. Personal travel report
2. Driver travel report
3. Vehicle travel report
4. Average time waiting report
5. Average gas mileage report
6. Others

These extensive records would be automatically maintained and updated by the system. The information gained would optimize travel efficiency and maintain a high quality of driver and rider satisfaction.

Expected Results

One of the largest societal changes will be to the way we socialize as individuals and groups. We live in a time of great challenge, but our dependence on fossil fuels has stifled our innate human ability for cooperation as community beings. The result is a walling off, a distancing of one person from another that mirrors our increasing geographic isolation. We can break this pattern by re-socializing ourselves to interact with others, and by considering relationships more important than possessions.

Few would argue that some of the things Americans say they want, more time with their families, shorter workweeks and commutes, better quality and more carefully prepared food, are things that were in greater abundance in our past. Those things are still available to us; we simply need to find creative ways, perhaps ways from our past, to implement them in our daily lives.

As an example, many folks would not wish to attach a motor to a bicycle, and make this device their standard vehicle. We have cars for that purpose, and the powered bike sounds suspiciously non-street legal under today's driving statutes.

And yet a powered bicycle, still requiring some muscle power, used to commute to the community garden to fetch home organic produce, accomplishes several quality-of-life goals at a very low cost. Furthermore, at some future point in our lives, sooner or later, such a bike will be a luxury. It is this creativity, this flexibility, this willingness to make do with less that is no longer part of our national character. We must recreate these characteristics in ourselves because the century-long party of wealth derived from fossil fuels will peak soon, and then diminish.

Our current transportation system, based one a one car-one driver model is going to change radically, and other systems and social institutions will be forced to change at the same time. Our social landscape will change into something different, and hopefully better for all.

There are other, more tangible savings, such as money, time, and safety. These savings, brought about by our conservation measures, will result in great changes in how we work, live and play.

Changes in Transportation

The far-reaching effects of minimizing car transportation are many. Disadvantages we take for granted as part of our modern society can be handily eliminated.

Accidents - Car accidents are the leading cause of death for many age groups. Almost 50,000 per year die, and over 1 million are injured in the United States alone. World traffic deaths are approximately 500,000 yearly. Fewer traffic fatalities and injuries, along with fewer deaths from automobile based air pollution would save us tens of billions of dollars. Furthermore, the human savings in pain and suffering are enormous. There are cities in the world where infants and the elderly die from smog, mostly produced by vehicle emissions.

Reduced Crime Rates - Due to the *de facto* monitoring of vehicles necessary for the Ride Share program, a dramatic drop in crime rates would result. As discussed in detail earlier, Ride Share limits escape routes after a crime has been committed, and citizen's cell phones would allow immediate calls for emergency assistance. Additionally, fewer fender benders mean more police officers concentrating on crimes instead of traffic accidents.

Gasoline Savings - As families use cars less they will see a reduction in their gasoline, auto repairs and auto purchases budget. The reduction in family transport spending can be reinvested to enhance local vacations. The current style of vacation, plane flight to a far away place, such as Hawaii or Disneyland,

will be too resource intensive to continue. However, Americans are capable and can easily build local amusement parks and recreation facilities. A county fair can be as exciting as Disneyland for some of us, and a vacation week in the mountains, or at a lake, is fully satisfying for many.

Other Savings - Further cost savings would be realized by people no longer requiring an entire car for themselves. Innovation can produce new designs on our many one-person vehicles, such as bicycles, motorcycles, scooters, powered skateboards, powered wheelchairs, golf carts, or hybrid creations like "It", the small electric personal vehicle recently reported in the news media.

The facilities previously used to manufacture cars could produce such devices in mass very quickly. This sort of quick adaptation of America's physical plant has been done before during wartime, and could be done again with the proper impetus.

Changes in Play and Recreation

There is no doubt that man is a playing animal. Without recreation, productivity and satisfaction decrease. How much of the current expense of oil is used to alleviate boredom, to satisfy our need to be with others? With reduced availability of fossil fuels, the way we play will be different, with more focus on the quality of the interaction than in distances traveled or options taken. Loss of personal interaction due to car travel would be reversed. Community life would again increase in common public spaces. Restaurants would relocate to neighborhoods and distant malls would be a thing of the past. Hotels and motels would be less necessary, less expensive, and more amenable to lengthy stays. Once a citizen had invested the time and money to travel to another town, he or she would be more likely to remain for a longer period of time. Massive amusement parks would give way to local ones. Recreation plays an important role in a healthy community.

Changes in Social Interaction

These changes would throw Americans together in close physical proximity, providing the opportunities for community building. Social interaction will be affected as we try to maintain our American standards of privacy and personal distance despite the increased proximity resulting from the Ride Share system. Like the Japanese, we will develop the ability to enable our own sense of privacy in crowded places without the need for physical distance. In particular, we would see an increased sense of reserve as personal interaction increased. This reserve, this formality, is already present in the world's more physically crowded cultures, where people have a compartmentalized existence despite close physical proximity.

This will require Americans to adopt a "lower profile", or less individualistic manners of dress or speech when interacting with other citizens. Personal noise and scent pollution might become misdemeanors. Outdoor radios without

headphones would be banned, as would other offensive and noisy media in public spaces. Obnoxious or overly loud speech, especially into a cell phone, would be discouraged. This would result in a code of conversational ethics and silence-keeping that would stand us in good stead. Visual or aural assault by commercial advertising will be reduced or eliminated.

There are corollaries to any kind of increased pubic co-existence, which is an increased tolerance for previously undesirable behavior. In particular, young adults, perhaps still living at home, need a replacement for the privacy a car offers. Making such facilities available could well decrease the need to "tool around" burning fossil fuels looking for a place to "make out".

Changes in Work

What can we expect our jobs to be like with less access to private cars? At first glance, it may appear to be less convenient, but perhaps the reduction in commute times will make up for this. Less traffic congestion and no rush hour might be well worth it for many people.

Some people will lose jobs, particularly those who depend on driving. Further elimination of jobs will occur in the military, auto insurance and other auto related industries. The oil companies will be around for a long time, possibly reduced in size, packaging and selling energy, so there will be other opportunities with them. Making bikes and scooters for the American population could keep factories in work for years.

Since there will be fewer, more efficient vehicles gas stations will began to be used for charging batteries, etc. There will still be a need for auto repair, but much of this type of skilled labor will move to energy retrofitting and repair on buildings for optimum use of renewable resources and efficiency. Mechanics will also be needed for small engine repair and maintenance of mechanized people-transportation devices and bicycles. Oil companies will still be profitable but will be reduced in size. Companies which manufacture and install alternative means of heating and cooling will proliferate. New manufacturers of bikes, buggies and other simple transportation devices will come into being. The number of agricultural workers will increase due to the need to reduce our use of fossil fuels for fertilizer and machinery. The large retail chains dominating America today will break apart, resulting in smaller, locally based suppliers. Specialty items will still be available via US mail and the Internet.

Other types of business will flourish, especially those needed to provide a new American technological infrastructure. Communication companies, whose job it will be to manage transportation, will arise. Good communication will be vital. We must gain the ability to project people and interaction and speech over distances without having to spend resources relocating the physical body. We need reliable networking systems, video phones, phone bridges and integrated instantaneous document and photo transmission.

There will be a need for many more construction workers to keep up with the massive amount of remodeling needed to meet new energy efficiency requirements. Medical care costs will be reduced because of fewer auto accidents and because people will become healthier due to a more active lifestyle and because food will be grown organically. Yet with medical care made available to everyone the number of people working in medical fields will not diminish. Finally, with the decrease in conflict caused by trying to control oil-producing countries, resources of time and money will be channeled into new jobs in energy, health and other research.

Conclusion:

The idea of Ride Share may seem farfetched and yet, all the basic elements of such a system are already in existence. There is really no doubt that based on current usage, we will run out of oil within a few decades, and no technology that currently exists offers a renewable energy solution.

The European model of standardizing the work day for carpooling purposes is effective and will be implemented. To make the system work, there are even penalties charged to managers for making employees stay late, something that, at least for now, is unthinkable in America. This, and other measures, will be implemented for greater satisfaction in the work force.

It is a fact that without access to oil, our country will change, hopefully for the better. Self-reliance and a cheerful willingness to face the future we have created will result in Ride Share, or something very much like it.

Additional Points to Develop

1. The quasi permanent car pool – selecting your riding mates.
2. More investigation of privacy issues.
3. Dealing with commerce. Many manufacturers will attack this proposal as a way to avoid curtailment of products. e.g. perfume, smoking, boom boxes

References

Recent Magazines:

E Magazine - E Magazine's January-February issue 2003 Volume XIV number 1. http://www.emagazine.com/january-february_2003/_0103contents.html

This magazine issue featured a set of articles under the heading of "The Coming Hydrogen Economy". The three main articles are: The Hydrogen Economy - After Oil, Clean Energy from a Fuel-Cell-Driven Global Hydrogen Web *by Jeremy Rifkin,* Power Plays - Fuel Cells are Reaching the Market, in What Could be a $100 Billion Industry *by Jim Motavalli and* Building the Hydrogen Economy, an interview with Amory B. Lovins *by Jim Motavalli.* In general these articles are written with messianic fervor.

Wired Magazine –April 2003 issue of Wired Magazine (issue 11.04) is located at http://www.wired.com/wired/archive/11.04/hydrogen.html

This periodical includes an article, featured on the cover, entitled "How Hydrogen Power Can Save America" b*y Peter Schwartz and Doug Randall*. Like the preceding reference, this also extols the virtues of the fuel cell and hydrogen. Information about the limitations are either ignored or glossed over.

PDF Documents References:

Fuel Cell Vehicles – Race to a New Automotive Future – Office of Technology Policy, US Department of Commerce, January 2003 http://www.ta.doc.gov/reports/TechPolicy/CD117a-030129.pdf

Chapter 1 opens with the following quote from President Bush: "Fuel cells will power cars with little or no waste at all. We happen to believe that fuel cells are the wave of the future, that fuel cells offer incredible opportunity." *President George W. Bush,* February 25, 2002. The opening page includes the following comments:

"A new future in automotive transportation is steadily approaching. This future will be one in which light and heavy vehicles are powered by new clean and efficient energy sources. While many technologies will contribute to this future, many see the fuel cell as the leading long-term candidate for becoming the power source for petroleum and emissions-free, mass-produced light vehicles, as well as some types of heavy vehicles."

"Automotive Engineering International expressed it well: "[T]he fuel-cell-powered car—the long awaited 'clean personal transportation of the future'—is moving from laboratory vision to technical reality, if not yet market actuality."

"The Promise - At this point in time, fuel cell vehicles promise the best opportunity to achieve a net-zero carbon energy and emissions future for the automotive mass market. They would deliver high-energy efficiency possibly up to twice that of gasoline-powered internal combustion engines (ICEs), since hydrogen possesses the highest energy content per unit weight of any known fuel (120.7 kJ/g). Fuel cell vehicles could eventually be powered by hydrogen derived from distributed domestic sources of energy, such as wind, solar, biomass, and hydro. They would offer near-zero levels of air pollution and greenhouse gas emissions. They could be made small enough to fit compactly in vehicles, yet strong enough to produce power equivalent to that of gasoline-powered ICE vehicles."

Fuel Cell Report to Congress, February 2003 - http://www.eere.energy.gov/hydrogenandfuelcells/pdfs/fc_report_congress_feb2003.pdf

This report was prepared for Congress and describes the steps necessary to implement a fuel cell vehicle program. It notes that if everything goes according to plan, first production fuel cells would be developed in volume for the commercial market in the year 2020. Most important is a chart on page 3 which shows how small the possible improvement over alternatives actually is.

Hydrogen Futures – Toward a Sustainable Energy Future, Word Watch Paper 117, August 157, August 2001 http://www.worldwatch.org/bookstore/merchant.mvc?Screen=PROD&Store_Code=WIB&Product_Code=BWP157

This paper questions the viability of on board reformers.

The Future of the Oil and Gas Industry: Past Approaches, New Challenges, Vol 5, No 3, World Energy 2002, by Harry J. Longwell, Director and Executive VP, Exxon Mobil Corporation http://www.eireview.org/eir/eirhome.nsf/(DocLibrary)/C80C7406E53166CF85256CBD0059A1A2/$FILE/Future%20of%20Oil%20and%20Gas%20Industry%20Exxon%20Mobil.pdf

This paper includes an important chart showing the discovery curve since the beginning of the 20th century. It clearly illustrates the declining discoveries of both oil and gas. It is significant that this was prepared by a major oil company.

National Hydrogen Energy Roadmap: November 2002, Department of Energy, http://www.eere.energy.gov/hydrogenandfuelcells/pdfs/national_h2_roadmap.pdf

This paper includes the typical glowing reports about fuel cells. Most significant is its emphasis on the need to convince the public that this is the optimum approach for the nation. It includes a proposed major marketing campaign.

National Hydrogen Energy - A National Vision of America's Transition to a Hydrogen Economy – to 2030 and Beyond – February 2002, http://www.eere.energy.gov/hydrogenandfuelcells/pdfs/vision_doc.pdf

This is another document that extols the virtues of hydrogen with no factual information that enables the reader to evaluate the chances of success.

National Research Priorities, Priorities Submission 59, Oz Fuel Cells - 21 August 2002, Australian Road Map http://www.dest.gov.au/priorities/priorities_sub/pdf59p.pdf

Natural Gas, Magic Pudding or Depleting Resource, Brian Fleay, November 2002 http://www.stcwa.org.au/papers/data/WA_Gas_est.pdf

Energy and the Hydrogen Economy, Bossel and Eliasson, January 8, 2003 http://www.methanol.org/pdfFrame.cfm?pdf=HydrogenEconomyReport2003.pdf

http://www.fuelcelltoday.com/FuelCellToday/EducationCentre/EducationCentreExternal/EduCentreDisplay/0,1748,History,00.html