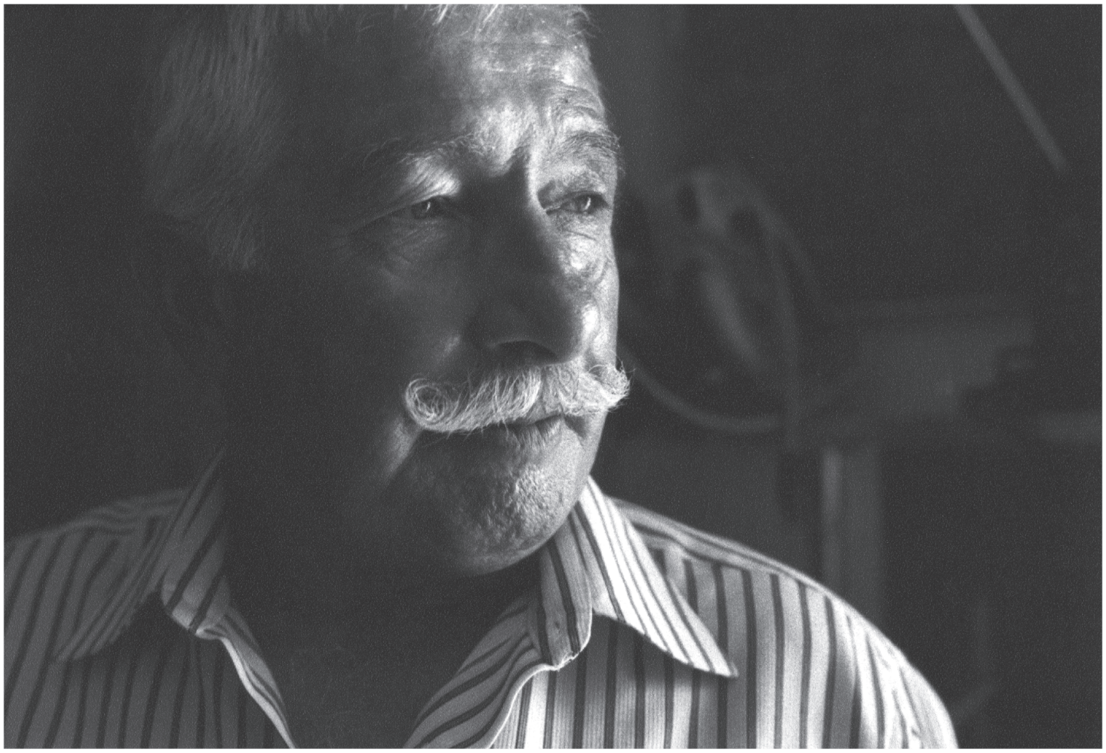
STEAM



(How a 61 year-old Bulgarian in the Mojave Desert invented an engine that could save the world but no one will take his phone calls.)

An
Information Guide
For The
Highly Skeptical

A NOTE TO READERS:

In an effort to ease the task of verifying the data to follow, we have attempted, whenever possible, to quote from reputable sources readily accessible on the internet. Certain materials, however, can only be found in printed form. To request a copy of any such materials, please contact:

WORKSHOP ENTERTAINMENT
3350 ROWENA AVENUE, SUITE 2
LOS ANGELES, CALIFORNIA 90027
323.829.6531/V 323.662.3216/F
WWW.WORKSHOPONLINE.COM

Written by: Matthew Moriarty
Workshop Entertainment, LLC
Copyright 2002

CONTENTS

Preface i.

Frequently Asked Questions

Who *is* this guy?	1.
Does this thing really work?	3.
How will that thing move a car?	4.
What about mileage?	5.
How do you make hydrogen peroxide anyway?	5.
Sounds Complicated. Does it pollute?	5.
Wait a minute. You forgot that the Delchev Turbine emits 11.7% carbon dioxide!	6.
Fine. But I bet sugar refnining is a nasty operation!	7.
How much will the mixed fuel cost?	8.
You keep disparaging fuel cell vehicles. Why?	11.
Gee, fuel cells aren't there yet, are they?	12.
Yeah, how *are* they solving the safety problem?	13.
Conclusion	15.

Epilogue

What about the movie?	16.
Who *are* you people?	16.

Annotations A1-2

PREFACE

I was introduced to Nick Delchev by my mother (of course). She had met him through some friends shortly after moving to Ridgecrest in California's Mojave Desert. Certain that his fantastic claims would be of interest to me, she arranged for my wife and I to meet him over breakfast in her new dining room.

Nick began to explain his device, talking loudly over the murmuring television which carried the latest news on our impending war with Iraq. Given the juxtaposition, President Bush in my right ear, a petroleum-free invention in the left, I was every bit as interested as Mom thought I'd be. I followed the science as well as I could, desperately jostling whatever high school chemistry remained in my head. I added and subtracted atoms. I scribbled on paper. The machine did make sense. I was impressed. After Nick took us to his shop, mixed up a batch of "fuel" and brought the machine to life before our eyes, I was truly impressed.

But the real star of that day was Nick himself. The handlebar moustache, the voice, the cigarillos, the twinkle in the eye. He is a loner, an outcast. A self-taught, blue-collar genius with big dreams and no driver's license. Were it not for the fact that he has invented a machine that could revolutionize transportation, you'd think Nick was auditioning for a sitcom. Well, he isn't. He simply wants his day in court, and I believe that only a full-length documentary about him, about his machine, and about the crushing power of Big Money can be of any help to him and, by extension, to the rest of us who inhabit this fragile planet.

The trailer you've just seen was photographed in one, eight-hour day. We assembled the piece to give proof-positive of the story potential of Nick's crusade. In total, we rolled for just under three hours, ferrying Nick to various locations, hosing down everything we could in the time we had. We knew we were in town to craft a five-minute teaser, and three hours of footage would require liberal use of the "scissors." But there were at least three more hours we *wish* we had rolled on: Nick's dirty jokes, his flirting with the bank teller, his theories the night before shooting about what to wear on camera. He is a gold mine. And, despite the wealth of technical information the rest of this packet will offer, despite the facts and figures which will point to the viability of his device, it is imperative that I make this one simple point: That regardless of what happens to Nick's invention, whether he fails or succeeds, the heart of *STEAM* is and always will be Nick himself.

He is all of us. He is everyone who ever had a dream and pursued it to the last. And the clock is ticking. He's 61. His patent will expire at the end of 2004. Tens of billions of dollars are being spent by global corporations and legislation is being passed to make so-called "hydrogen fuel cells" a *fait accompli* in transportation – a done deal despite the fact that the technology is a decade away from viability and that petroleum (!) is still the planned fuel source. So time is short, and the stakes for Nick are high. But, as the polar icecap continues to melt, as global oil production exceeds 75 million barrels *per day*, and as war with Iraq looms nearer, it would seem the clock is ticking on the rest of us as well.

In order to gain your interest in a film about Nick and his machine, it will be necessary to first prove the validity of our chosen topic. Though I'm sure you found him to be a cute and cuddly character in the five minutes you've spent with him, I will need to convince you that his quest, while certainly Quixotic, is quite legitimate. I am less interested than anyone in telling a half-baked tale of an obscure kook doomed to failure. Thankfully, though, the material you are about to read will point to the viability of Nick's device. You will be allowed to compare for yourself the efficiency of Nick's machine with that of his competitors. You will find that even the Utopian vision of the coming "hydrogen economy" has its problems. You will be asked to follow the money trail: Where has it gone? Who is spending it? Will these billions cure our addiction to petroleum? These are the exact issues that will come into play in the film, structured against Nick's cross-country media tour.

But, as I said, the film does not *require* Nick's success.

The unlikely scenario is that ours will be a true David and Goliath tale in which David wins. Happy ending. Popcorn sold. What is a more likely conclusion, however, is that *STEAM* will become the only known chronicle of a perfectly viable pollution-free engine concept lost at the hands of Big Energy, Detroit and government bureaucracy. It has happened before. The list of pollution-free engine inventors who couldn't get past the secretaries is long and distinguished. Our advantage here, is that we shall film it as it happens, allowing Nick, his machine and his dreams to outlive us all.

And maybe, after *STEAM* reaches the public, and we begin to question the decisions being made behind closed doors, and we look at where the money goes and wonder why it goes there...just maybe Nick's phone will start ringing again.

We have done our utmost to anticipate your questions and to answer them clearly. We have further attempted to present an unbiased look at the viability of the Delchev Turbine and, as such, we welcome a critical eye as you review this proposal. We want you to verify our data, as doing so will only strengthen Nick's case. It is our hope that the balance of science, politics and character offered herein will excite you and compel you to support this documentary film.

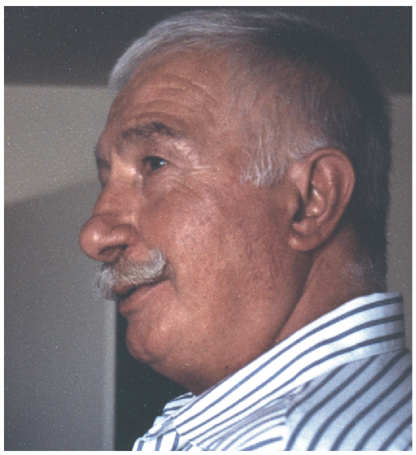
And please accept my sincere thanks for your time.

Matthew Moriarty
Los Angeles
October, 2002

FREQUENTLY ASKED QUESTIONS

WHO *IS* THIS GUY?

Nedelko "Nick" Delchev was born in Lubiemez, Bulgaria in 1941. He attended the State Institute of Mechanical Trades, which opened his eyes to the world of mechanical design and sparked an inventor's spirit. The communist culture that surrounded him, however, stifled this spirit. Thus, at the age of 19, he made a desperate run for freedom, past the guard towers and across the barbed-wire border into Greece. After 18 months in a refugee camp, his immigration application to the U.S. was approved. Soon after, Nick boarded the Italian liner, *Volcania*, and steamed toward New York. On passing the Statue of Liberty, Nick knew he had found his home.



Based on his knowledge of tool and die design, Nick soon became employed as a machinist for Kaiser Aerospace in Burbank, California. During his tenure with Kaiser, Nick designed custom tooling and machined essential parts for Boeing, Sandia and Grumman, as well as for the Lunar Excursion Module (LEM) used in the Apollo landings. Nick remained with Kaiser until 1972, when corporate reshuffling would have forced him to relocate. He opted out and started his own machining business. Only one year later would Nick realize how fortuitous this decision was...

1973 ushered in the "Oil Crisis," and with it the rationing and endless lines Nick thought he'd left behind in Bulgaria. Dismayed by an America that had begun to look like the "old country," Nick decided to do something about it. He began tinkering with ideas for man-made fuel in his free time, but soon realized that his basic knowledge of science would not get him far. So he turned to books, spending literally thousands of hours in the L.A. Public Library, teaching himself chemistry, physics, aerodynamics and steam theory...gaining the knowledge sufficient for him to pursue his dream of creating a pollution-free engine.

While a legion of other "Crisis Era" engine inventors either gave up or disappeared, Nick kept at it, splitting his time between his invention, his machine shop and consulting work for Delsen Labs and Lockheed.[1] By 1987, Nick had received a patent[2] on his design and had constructed a working demonstrator out of parts he found in a junkyard.

Throughout the 1990's, Nick pursued his invention, seeking money to build his prototype engine and mate it to a Volkswagen Bug. As interested parties came and went, Nick perfected other derivatives of his concept. One such variant employed miniature Delchev reactors on the rotor-tips of a rapid deployment helicopter.[3] Photos of the prototype chopper adorn the walls of Nick's shop today.

In September of 2000, Nick moved to Ridgecrest, California on the promise of money and machining equipment with which to build his prototype engine and install it into a Volkswagen Bug. The businessman who made these promises, like many others before him, has yet to make good on one of them. The small town, however, has proved more suitable to Nick's current mode of transportation, his bicycle.

In July of 2001, Nick was visited by a group of engineers from the New Business Development department of Eka Chemicals in Marietta, Georgia. Extensive tests were performed on the Delchev Turbine to accurately assess Nick's zero-pollution claims. A substantial report was generated, indicating that the exhaust indeed contained precisely 88.3% water (steam) and 11.7% carbon dioxide.[4] These numbers represent an unheard of real-world demonstration of atomic theory, given that these proportions reflect the actual atomic weight percentages of either gas on paper. According to the report, Nick had also achieved 100% combustive efficiency[5] with parts he'd found in a junkyard.

The Eka report concluded with the recommendation that "*work be done now to investigate the numerous applications in which this device shows promise.*"[6] Unfortunately, the post-September 11th economic downturn caused Eka Chemicals to eliminate its New Business Development wing, to disband of all the researchers who had witnessed Nick's machine and, in the process, crush Nick's hope for the $70,000 he needs to build his prototype Bug. However, several N.B.D. group members have since gone into private consulting and continue to openly endorse the Delchev Turbine as a highly efficient, pollution-free power generator.

Since then, Nick has maintained a daily regimen of letter-writing and phone calls, including repeated appeals to the California Air Quality Management District, which denied Nick a grant on the basis that his funding request was under the $100,000 minimum grant threshhold.

AQMD
South Coast
Air Quality Management District
21865 E. Copley Drive, Diamond Bar, CA 91765-4182
(909) 396-2000 · www.aqmd.gov

October 3, 2002

Mr. Nick Delchev
President & CEO
DTM
725 Inyokern Rd.
Ridgecrest, CA 93555

Dear Mr. Delchev:

Thank you for submitting your pre-proposal entitled, "Hydrogen Peroxide & Organic Fuel Power Generator." Upon staff review, it was determined that your pre-proposal is not being considered for funding for the following reason(s): as a motor fuel, hydrogen peroxide and sugar (or other carbohydrate) do not have infrastructure for vehicle fueling; no funding by other sponsors; refueling pressure vessel time consuming. The AQMD appreciates the time and effort spent on this pre-proposal.

Due to the tremendous response to the Program Opportunity Notice – Technology Advancement #2002-01, not all of the pre-proposals received can be awarded funding. Thank you for the opportunity to review the project. If you have any questions about our decision on this specific proposal, please contact Mike Bogdanoff at (909) 396-3254.

Very truly yours,

Geri Koerner
Staff Specialist
(909) 396-2778
gkoerner@aqmd.gov

GK

cc: Mike Bogdanoff
Ref: 59

One of Nick's many rejection letters.

Nick later submitted a similar proposal to the California Air Resources Board in Sacramento, and was again denied, this time due to the state of California's economy.

Undaunted, Nick continues to seek the necessary money to prove his concept on the road – living the American dream he began some forty years ago.

obtained during this segment of the trial were outstanding. The generator facilitated combustion with a methane outlet level of 0.00 wt% and a hydrogen peroxide outlet level of 0 mg/L. Within the detection limits of the instruments used, the reaction was 100% efficient. Also, the carbon dioxide emissions under certain conditions were 11.7%. Along with a 0.0% oxygen emission, this again indicates ideal combustion. The temperature within the generator surpassed 1300°F.

AKZO NOBEL

The pollutant gas emissions were equally as promising. At steady-state operation, the outlet gas stream contained zero NO, zero NO_2 and zero hydrocarbons. These results are striking, as the latest efforts in clean-burn technologies are yet to produce a generator that yields less than 5 ppm total NOx. These low levels of NOx are reached because the generator does not use air as an oxygen source. When air is subjected to high temperatures, the nitrogen in the air reacts to form nitrogen oxides. Because this generator operates free of nitrogen, no nitrogen oxides are produced.

Recommendations

The above results are very promising and indicate a great potential for this device as a high-efficiency, low-emissions power generator. Fitted with an ejection nozzle, the device will be ideal for power generation through a turbine generator.

The above noted work represents a comprehensive device analysis. It is the recommendation of Eka Chemicals that work be done now to investigate the numerous applications in which this device shows promise.

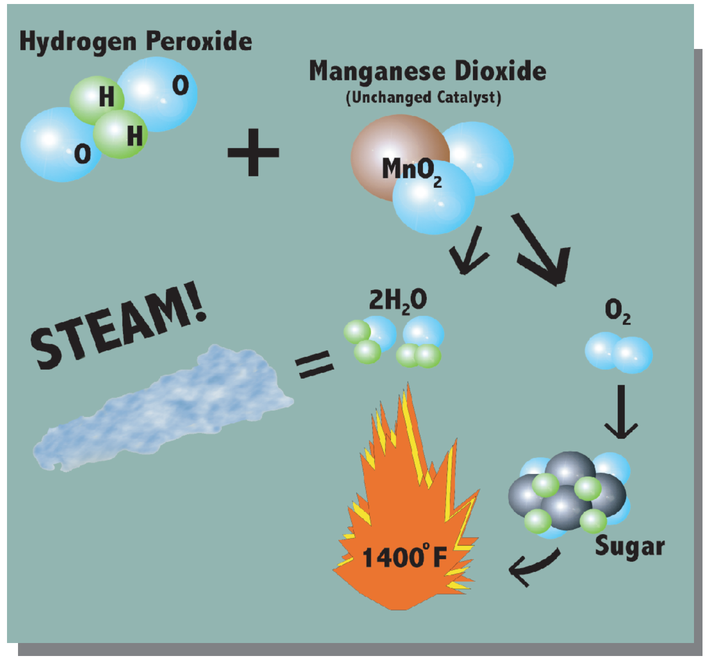
Excerpts from the Eka Chemicals report.

Does this thing really work?

Yes. And the chemistry involved in the reaction is surprisingly simple...

Hydrogen Peroxide (H_2O_2) and almost any liquid hydrocarbon (so far, you've heard about sugar, but it could also be grain-based alcohols or ethanol, or methanol) are mixed to form the fuel. The fuel is then injected into a soda can-sized combustion chamber which is heated by glow plugs from a diesel engine. Here, the H_2O_2 reacts with a catalyst of Manganese Dioxide (MnO_2) crystals to form the plume of vapor you saw in the opening shot of the *STEAM* trailer. This reaction liberates one oxygen atom from the hydrogen peroxide to create water and oxygen. The oxygen atom is then available to completely oxidize (burn) the hydrocarbon (the sugar – $C_{12}H_{22}O_{11}$) at a temperature of 1200º – 2000ºF, which in turn superheats the water that was previously hydrogen peroxide. The superheated water (steam) is then ejected at speeds ranging from Mach 2 to Mach 10, through a de Laval supersonic expansion nozzle, to drive a radial turbine at 8,000 to 60,000 rpm. The "throttle," or the speed of the turbine, is controlled much the same as in any existing engine: by regulating the flow of fuel into the combustion chamber.

Several key elements make the Delchev Turbine unique among propulsion systems. First, Nick's hydrogen peroxide fuel is utilized in only 50% solution (50% H_2O_2, 50% water), making the fuel non-combustible during handling. Nick demonstrates this by dropping a piece of flaming toilet paper directly onto the fuel, which, of course, extinguishes the flame.[7] Previous hydrogen peroxide powerplants[8] have used the fuel in concentrations of 90-100%, making the handling of the fuel (as well as the cost) a key consideration. These high concentrations were necessary because of the lack of an organic hydrocarbon (the sugar), which Nick uses to create a reaction 4.6 times more powerful than that available in the 50% hydrogen peroxide alone. But such explosive force, again, is dependent on both the manganese catalyst *and* upon reaching a threshhold temperature of 800ºF – not a likely occurrence under normal handling! Even in a catastrophic collision, Nick's fuel will do little more than bleach your hair and irritate your eyes.



Second, Nick's engine requires no cooling system. Remember, the fuel mixture itself is nearly one-half water. The catalyst then creates a fuel that becomes more than two-thirds water upon entry into the combustion chamber. The steam created in the reaction thus serves a dual purpose: to provide motive force for the turbine and to cool the combustion chamber. Without this cooling effect, the energy inherent in the sugar/oxygen reaction would literally melt the chamber. Still, 2000ºF is plenty of heat, requiring insulation of the combustion chamber. Thus, while the "reactor" appears in the STEAM trailer to be the size of a large coffee can, most of what is visible is thermal insulation. The actual chamber, as mentioned previously, is roughly the size of a soda can. The fact that Nick's engine has only *one moving part* further reduces the need for system-wide cooling.

Finally, Nick's engine utilizes no outside air. By decomposing the hydrogen peroxide into water and oxygen, Nick creates "air" within the chamber. This means his engine will perform as well underwater as it will atop Pike's Peak, or even in outer space. Ambient temperature is also eliminated as a performance concern. And, by reacting the organic hydrocarbon with pure oxygen, exhaust gasses remain free of any hydrocarbons, nitrogen oxides, carbon monoxide and smog-producing ozone.[9] Zero!

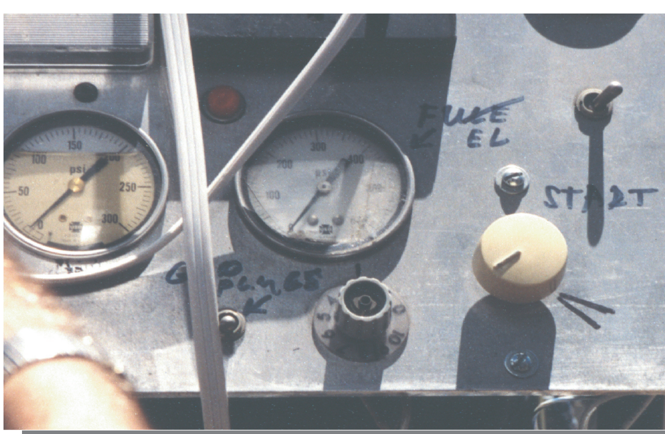
How will that thing move a car?

The cheesy "thing" you saw in the video *will not* move a car. Remember, the demonstrator engine was produced out of $400 worth of junkyard parts to prove Nick's combustion theory. A myriad of improvements will be required to produce an engine capable of propelling an automobile.

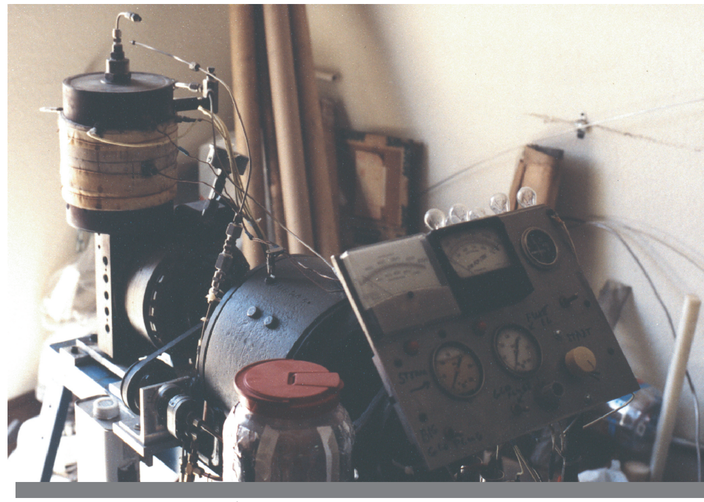
The Glow Plugs: All diesel engines require a heated combustion chamber in order to "jumpstart" the sparkplug-free combustion. Nick will require more durable and efficient "high-energy" glow plugs to sufficiently pre-heat the chamber in a few seconds, as opposed to the two minutes the junkyard demonstrator now requires. Eventually, the entire start-up sequence will be computer-controlled, allowing the driver to simply turn the key and drive away. Hydrogen fuel cell vehicles, by comparison, face an even greater challenge in reducing start-up times to those of the internal combustion engine.[10]

The Fuel Injector: It is essential to fully atomize the fuel mixture upon injection into the combustion chamber. Currently, Nick's fuel injector performs its task with roughly the precision of a plant sprayer, making fine control over turbine speed difficult to achieve. Improvements to fuel delivery will also enhance fuel efficiency.

The Steam Nozzle: The expansion of gas is the foundation of every engine we have. Reciprocating engines rely on the expansion of gas to push a piston. Turbojet engines rely on expanding gas to propel turbine blades. Steam turbines, like the ones responsible for nearly every watt of electricity in the world, also rely on gas expansion. Thus, the supersonic expansion nozzle is a critical part of any steam turbine. Nick's automobile prototype will require a true "de Laval" nozzle, capable of channeling the steam's energy, and accelerating it to 2-10 times the speed of sound. The nozzle utilized in the current demonstrator is incapable of ejecting steam at even Mach 1.



Nick's homemade control panel.



Nick's $400 hydrogen peroxide demonstrator engine.

The Impulse Turbine: The turbine used in the demonstrator is actually a fifty year-old Bendix air starter for an early jet engine – inefficient, clunky and totally wrong for the application. The ideal turbine would be custom machined by Nick himself out of either 316 stainless steel or titanium. Its blades would be cupped *toward* the nozzle, converting roughly 80% of the impulse power into rotational motion, and would be aligned *perpendicular* to the nozzle's flow. The blades of the demonstrator "turbine" are barely cupped at all, and are aligned somewhat *diagonally* to the impulse flow, allowing much of the steam to escape as exhaust without ever having produced rotational force. Proper turbine design is the key to a working prototype. And remember, it is the only moving part in the entire engine.[11]

Given the theoretical design blade efficiency of 80%, and the 100% known efficiency of the reaction,[12] the prototype Delchev Turbine has a theoretical operating efficiency of 80%. Even with anticipated losses due to machining tolerances, heat and friction, the prototype is estimated to realize 65% total operating efficiency – nearly *double* the average figure attributable to any current "hydrogen fuel cell" design and *three times* that of the typical piston engine! [13]

What about mileage?

Nick estimates that the *prototype* Delchev Turbine Vehicle (DTV), a $600 Volkswagen Bug, will achieve 34 miles per gallon of H_2O_2/sugar fuel. Remember, this is a prototype, built for $70,000 including the car. Design and manufacturing improvements would undoubtedly push this figure higher. By comparison, global corporations have spent *three billion dollars a year*[14] since 1995 to come up with hydrogen fuel cell designs that currently achieve 8.3 miles per gallon[15] of H_2,[16] and are *projected* to someday attain 50-80 miles per gallon.[17]


Nick and his machine.

How do you make hydrogen peroxide anyway?

Hydrogen Peroxide was "discovered" by French scientist Louis-Jacques Thenard in 1818. Thenard found the substance to be highly reactive with decomposing agents (catalysts), to the extent that he originally termed it "oxidized water." His later studies proved the substance to be extremely stable, with no discernible effect on decomposing agents. Today the chemical is used primarily by the paper industry in the bleaching of pulp, though it is also employed in such varied fields as wastewater treatment, cosmetics and, of course, medicine.

Though hydrogen peroxide can be manufactured in several ways, including the electrolysis of water, producers have universally adopted the four-step auto-oxidation (AO) method. In this process, hydrogen gas is first mated with a compound called an anthraquinone[18] and oxidized with plain air to form a working solution. 40% hydrogen peroxide is then extracted from the working solution with recycled solvents. Distillation then purifies the hydrogen peroxide to about 60% strength, at which point it is either diluted or further distilled depending on the strength desired.[19] The final step is to stabilize the solution (depending on strength) with small amounts of transition metals.

Sounds complicated. Does it pollute?

That depends. And from this point on, any discussion of "pollution," including all greenhouse gas emissions, will involve a complete well-to-wheel analysis, along the lines of the **Ecoprofile**[20] protocol now popular in Europe. What this means is that all factors pertinent to the environment, from the moment raw materials leave the Earth to their eventual *return* to Earth through a vehicle's tailpipe, must be evaluated as a whole. No single apparent pollution savings is sufficient to qualify a given propulsion system as **Climate Neutral**. Each step in the process must pass the test.

That said, let us look at hydrogen peroxide production...

If the source hydrogen gas is created through the steam reforming of methanol (natural gas), then the answer is *yes*, pollution does occur. This process creates 70% hydrogen, 24% carbon dioxide, 6% nitrogen and traces of carbon monoxide,[21] in addition to the horrendous emissions from whatever fossil fuel or electrical plant happened to power the reformer.

If the source hydrogen gas is produced through the electrolysis of water, however, using renewable electricity (solar, wind, biomass, nuclear), emissions resulting from production of the *source hydrogen* are zero[22]– Climate Neutral.

The next step in the chain is the plant itself. Assuming the plant's electricity is renewable, and the source hydrogen gas is Climate Neutral, its total emissions are:

Pollutants/GHG (in grams) per 1kg of H_2O_2 produced:[23]

Pollutant	Transport	Process	Total (g)
Carbon Dioxide	4.7	39.0	43.7
Carbon Monoxide	0.032	0.037	0.069
Sulfur Dioxide	0.037	0.4	0.437
Nitrogen Oxides	0.045	0.21	0.255
Hydrocarbons	0.013	0.15	0.163
Dust	--	0.12	0.12
Aromatic Hydrocarbons	--	0.15	0.15
Other Organics	--	0.41	0.41
Hydrogen	--	0.34	0.34
All other pollutants	<0.001	<0.001	<0.001

What this table shows is that the auto-oxidation process itself is exceptionally "clean." Carbon dioxide emissions, for example, amount to only 3.9% of product by weight (at the process level). The addition of transportation emissions brings this figure to just 4.4%. When one considers that 50% H_2O_2 weighs 4.5 kg per gallon, an intriguing comparison can be made:

Each gallon of H_2O_2, manufactured with renewable electricity, distributed and consumed in a DTV will produce **197 grams of CO_2**. Each gallon of gasoline manufactured, distributed and consumed in a conventional vehicle will produce **over 11,000 grams of CO_2**![24]

Even current, non-renewable hydrogen peroxide manufacturing creates *one-tenth* the carbon dioxide of gasoline when viewed from well to wheel.[25] It is further important to note that at the heart of the AO process is chemistry – with electricity used primarily to power pumps which move the solvents from point to point.

Wait a minute, you forgot that the Delchev Turbine emits 11.7% carbon dioxide!

The Delchev Turbine does not *emit* carbon dioxide. It *recycles* carbon dioxide which is already at play in the atmosphere, making it 100% Climate Neutral.[26]

Due to the closed combustion of Nick's reaction, every last molecule can be accounted for on paper. When hydrogen peroxide decomposes upon contact with the manganese dioxide, it becomes water and oxygen – nothing more, nothing less. Given this, it is mathematically impossible for the carbon dioxide which *is* emitted to come from anything but the sugar. And, as we all know, sugar cane and beets literally *are* the carbon they once removed from the atmosphere through photosynthesis.

If this sounds like a theory Nick made up to forward his effort, let us look at what the U.S. Environmental Protection Agency has to say:

> "Each new generation of energy crops will, as it grows, remove from the atmosphere through photosynthesis a quantity of CO_2 roughly equivalent to that released when the biomass is converted to fuel and burned to release energy. If sustainably managed energy crops supplant energy that otherwise would be generated by fossil fuels, net CO_2 emissions may decrease...
>
> ...An executive order issued in August, 1999, calls for tripling U.S. use of biomass energy by 2010. In addition, the federal government has established a biomass energy tax credit of 1.5 cents per kilowatt-hour for the production of electricity from biomass energy crops..." [27]

The burning of petroleum, however, produces carbon dioxide from plants which ceased recycling the gas into oxygen millions of years ago and have since become oil – adding billions of tons of "new" carbon to the atmosphere each year. The use of **biomass fuels** is achieving worldwide recognition as an economical and attainable path toward Climate Neutrality. And the DTV is perhaps the only vehicle on earth to use a biomass fuel under ideal circumstances: completely controlled, airless combustion!

Fine. But I bet sugar refining is a nasty operation!

Actually, sugar refineries are among the most self-sufficient refining operations on earth! When sugar is harvested, only the stalk is suitable for making refined sucrose. The husks and trimmings left over are called *bagasse*. A majority of sugar refineries will burn this bagasse (a Climate Neutral, biomass fuel) to create the necessary heat for refining, and use only enough non-renewable electricity to run the lights, motors, etc. Many refineries, particularly in South and Central America, use bagasse to both fire the refining boilers *and* produce heat for steam turbines which provide on-site electricity to power the building, making the entire operation self-sufficient. Some operations, such as the Okeelanta Sugar Mill in South Bay, Florida, create excess electricity – clean, *renewable* electricity – which is actually sold *back* to the grid for profit! [28]

The most significant pollutant associated with bagasse-fired refining operations is particulate matter (ash), though mechanical collectors and "wet-scrubbers" eliminate from 60 to 90% of this ash.[29] Carbon Monoxide, Methane, Nitrogen Oxides (NOx) and Sulfur Dioxide (SO_2) can also be emitted periodically, due to improperly washed or poorly prepared cane. Wet scrubbers, however, can also absorb these emissions to a significant extent.[30]

A 1998 proposal out of Brazil, a nation which has for years relied on bagasse to make ethanol for its automobiles, advocates a large-scale changeover from coal- and oil-based electricity to ethanol/bagasse operations. The study estimates that such a changeover would reduce its CO_2 emissions by nearly 13 million tons per year.[31]

How much will the mixed fuel cost?

It is doubtful that any man-made fuel will ever be as cheap as gasoline or diesel – including, as we shall see, the pressurized hydrogen gas at the core of the so-called "hydrogen economy." We must remember, however, that the price of motor fuel in America is held low – subsidized in fact – with state and federal taxes of only 36 cents per gallon.[33] Europeans, by comparison, pay an average of $2.50 *per gallon* in tax,[34] which helps to explain the fact that 78% of all the gasoline in the world is consumed by the United States alone.[35] Our leaders, and the powerful interests to whom they are beholden, *want* it that way.

That said, in September of 2002, the "official" retail price of 50% hydrogen peroxide was $759 per metric ton, which equates to $3.45 per gallon,[36] roughly double the cost of gasoline in California. While in the process of verifying this figure, however, a representative of Solvay Interox quoted to this author a retail price of $661 per metric ton, which equates to $3.005 per gallon.[37] Further investigation revealed an even lower price of roughly $500 per metric ton, or $2.27 per gallon.[38] So, what is the actual price of hydrogen peroxide? Only a full understanding of the existing H_2O_2 infrastructure can reveal the answer.

Hydrogen peroxide is manufactured in the United States in only seven plants, known in scientific circles as the infamous "Seven Sisters." The corporations which run these plants are the OPEC of H_2O_2 production. Each plant utilizes essentially identical methods of production and creates essentially identical products, making it not only difficult, but *undesirable* for any one manufacturer to offer the product at a lower price than his competitors. This arrangement has thus helped to "fix" the price of H_2O_2 at a level agreeable to manufacturers.

In 1998, German chemical giant, Degussa, which has operations throughout North America, including one plant in Mobile, Alabama, attempted to purchase DuPont Chemical's entire U.S. H_2O_2 operation. Their attempt was blocked by the U.S. Federal Trade Commission on the basis of both past price-fixing and anti-competitive behavior (though Degussa proceeded to buy several DuPont operations *outside* the U.S.). Excerpts from the FTC complaint are shown on the next page:

NOTE:

The use of actual granulated sugar in the Delchev Turbine is primarily a public relations move. The pink and white bag of C&H "pure cane sugar from Hawaii" makes for excellent images and adds a modicum of, pardon the pun, *sweetness* to Nick's crusade.

It is presumed, however, that any large-scale implementation of Nick's technology would involve a low-cost, liquid blend of varied biomass energy sources – akin to ethanol, for example. The only real requirements are water-solubility and burnablility – as well as an ability of the biomass providers themselves to respond to an ever-changing political and environmental landscape. The hydrocarbon blend in Nick's fuel must be economically agile, one which can respond quickly to hurricanes in the Caribbean, forest fires in the Northwest, floods in the Southeast, volcanic activity in Hawaii, labor strikes and so forth. The beauty of the Delchev Turbine is that it allows for exactly this sort of material flexibility with respect to the organic portion of the fuel.

Given 1/1000th the funds devoted to hydrogen fuel cell research, a qualified team of experts could develop an appropriate, Climate Neutral biomass blend at a cost well below the current world sugar price of 5.9 cents a pound,[32] which even today would equate to only 12 cents per gallon of Delchev Turbine fuel. Those astonished by the above-quoted sugar price must know that the Unites States currently maintains a $100/ton tariff on imported sugar to protect the interests of its comparatively tiny community of sugar producers. Such tariffs would, of course, need to be eliminated in a large-scale changeover to Delchev Turbine fuel, bringing the average U.S. cost in line with the rest of the world.

Given that the degree to which actual sugar will provide biomass for Nick's fuel in a large-scale application is uncertain, future discussions of projected fuel price will revolve around a biomass blend at a conservative estimated cost of 7 cents per pound (14 cents per gallon of Delchev Turbine fuel).

"The North American market for hydrogen peroxide is highly concentrated. Seven manufacturers currently possess all of the North American production capacity...The proposed acquisition would rest control over approximately **81% of production capacity with the three largest manufacturers...**

...(this) acquisition, if consummated, would result in a **violation of Section 5 of the Federal Trade Commission Act and Section 7 of the Clayton act...**

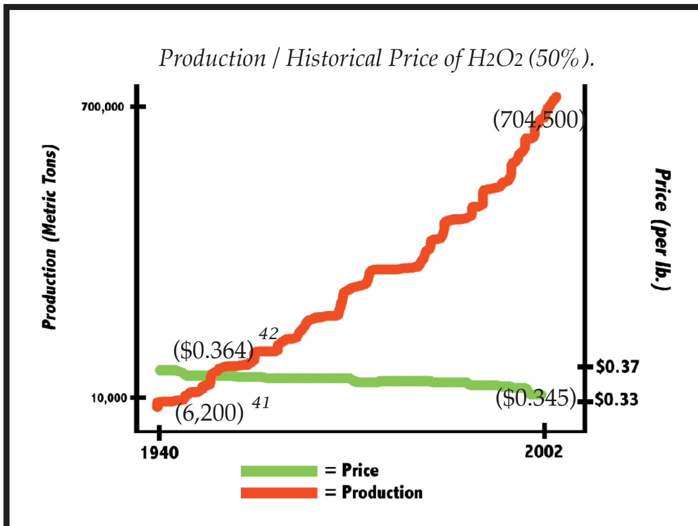
...There is a past history of express collusion among hydrogen peroxide manufacturers in Europe...including producers that after the acquisition would be the leading producers in North America.

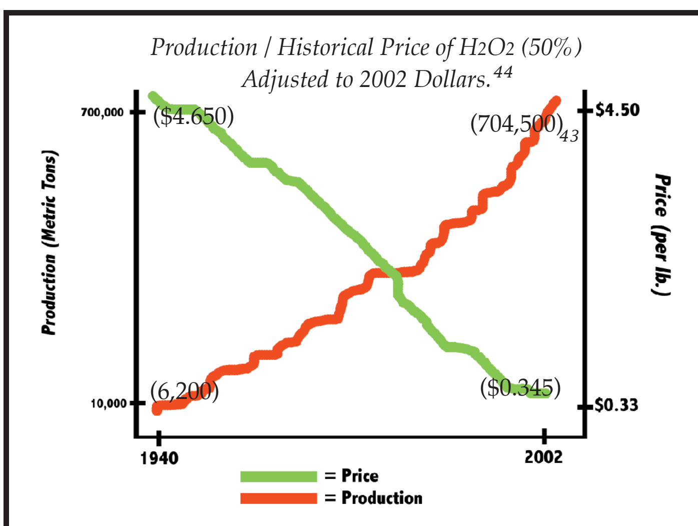
...Over several years, producers have maintained **large differentials in pricing among different end-users for a product that is essentially indistinguishable in its performance characteristics...**

...Higher hydrogen peroxide prices are projected as a result of the proposed acquisition." [39]

Personal experience has shown that it is nearly impossible to contact any of the Seven Sisters by telephone and receive a price quote – wholesale *or* retail. After all, as the Federal Trade Commission stated above, large differentials in price exist for the same product depending upon "who's asking." Given this, it would be poor business practice indeed to publicly quote anything other than the highest possible price – one that makes no allowance whatsoever for bulk ordering. Inquiring minds are thus invariably referred to a web address, magazine article or another department entirely – anything to avoid committing to a telephone quote – at which point any inquiry is, in my experience, directed to voice mail. As of this writing, no representative of any of the seven corporations has returned a single one of my phone calls. And I'm trying to *expand* their business!

While this situation makes (and will make) for good cinema, and has certainly helped me identify with the plight of Nick Delchev, it has made it difficult to create a realistic cost projection for Nick's fuel should production ramp up to an amount equal to the 12 million barrels per day of gasoline and diesel consumed by the U.S. in 1999.[40] What *can* be proved, however, is the powerful inverse relationship between production and price with respect to hydrogen peroxide. If one considers even the "official" retail price of $3.45 per gallon, a comparison of today's values with those of sixty years ago creates a staggering profile (graphs at right):





The graphs on the previous page show that as production increased 113.6-fold, the price *fell* by a factor of 13.5. On average, this means that for every multiple of production increase, price *decreased* by a factor of 0.1188 (113.6 x 0.1188 = 13.5). Though production began to increase in a linear manner as early as 1927,[45] making the year 1940 a sound choice for illustrative purposes, a future cost projection based on this conversion ratio would be quite optimistic. Numerous technological advances occurred during the years since 1940, including the mass adoption of the auto oxidation technique in the early fifties.

Let us however make a projection of fuel price for the year 2012 that is based on a price reduction ratio *twenty-five times weaker* than that shown between 1940 and 2002:

$$0.1188 \div 25 = \mathbf{0.0048}.$$

And remember, this ratio functions independently of time. It is based purely on production increase, making the number of years over which production increased (62 in the historical graphs, 10 in the table below) irrelevant for our purposes.

2002 U.S. Consumption of Gasoline & Diesel:		4,380,000,000 *bbl* [46]
2002 U.S. Production of H_2O_2:		3,690,000 *bbl* [47]
H_2O_2 Production Increase to Parity (factor):		1187
Price Reduction Ratio (1/25th of 1940-2002 ratio):	*x*	.0048
Price Reduction Factor:		**5.698**
Computed Price of H_2O_2 at parity with current U.S. fuel consumption (before tax) [$3.45 ÷ 5.698]:		$.60/gal
Estimated price of mixed DT fuel (including 868g of biomass blend / gallon):		$.74/gal
Distribution, Marketing and Retail Station Costs & Profits [currently 13% of gasoline retail price]: [48]		$.19/gal
Federal & State Taxes [1/2 current nat'l average]:		$.19/gal
Projected Price of DT Fuel:		**$1.12**/gal
Price projected for year 2012 (5% inflation):		**$1.82**/gal

There are, of course, an extraordinary number of other factors involved with a production increase of this magnitude. The single biggest cost to the national economy would be the switch from current methods of hydrogen extraction – those based on non-renewable petroleum sources – to the use of Climate Neutral electricity for the electrolysis of seawater. These costs would run into the tens of billions of dollars over time – as they will in any legitimate, Climate Neutral "hydrogen economy" scenario.

Numerous new hydrogen peroxide plants will need to be built, as shipping 50% H_2O_2 over great distances is inefficient, given the volume of plain water contained in the solution. Such plants will need to assume the burden of creating the H_2O_2/biomass mixture as well as the costs of transporting the liquid biomass to them. Filling stations will also incur costs during the changeover, though, as we shall see, not even a fraction of those associated with direct hydrogen fuel cell vehicles.

But the addition of new plants, and the marketplace competition created thereby, would ruffle the Seven Sisters' feathers and bear favorably on the cost of hydrogen peroxide. **Princeton Advanced Technologies** in South Carolina has already developed a highly efficient, alternate method for the production of hydrogen peroxide, one designed to eliminate recycled solvents entirely, produce essentially *zero* emissions, and greatly lower the cost of manufacturing, with commercial implementation to begin in 2005.[49]

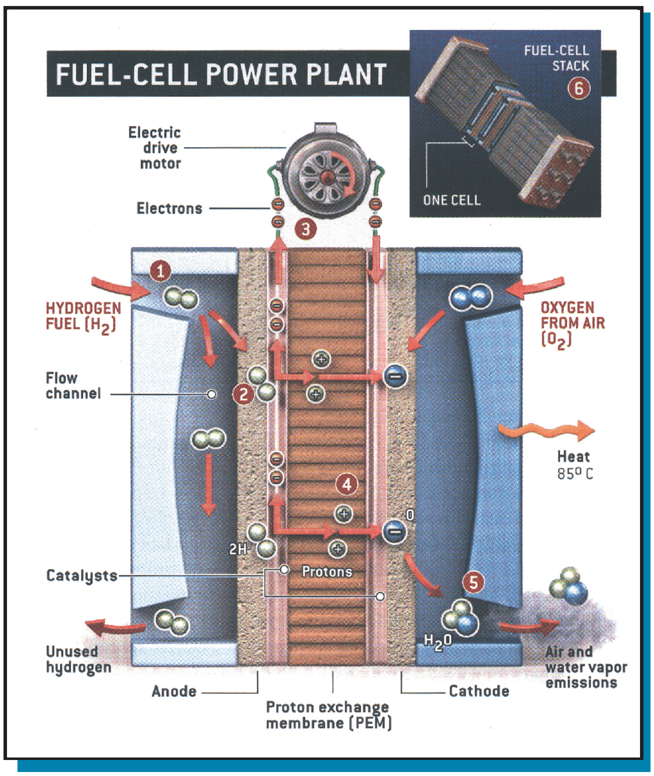
Huge opportunities would also exist in the biomass sector, in which fuel would be made from plant refuse that today goes to waste. The federal government could cease paying farmers to *not* grow their crops, freeing up hundreds of millions of dollars per year to ease the changeover. Entirely new industries would evolve, turning what is now considered "compost" into a billion dollar industry.

Great reductions in automobile manufacturing costs would be possible, given the utter simplicity of the Delchev Turbine. These savings would be passed on to the consumer, and further help to absorb the costs of an energy changeover. It is furthermore conceivable that the above 2012 projected price already *accounts* for many such additional changeover costs, given the highly conservative use of a production(+)/price(-) ratio only *one twenty-fifth* as profound as that shown throughout history.

And finally, we must remember, given our brief lesson on the Seven Sisters, that these projected figures assume that the "official" hydrogen peroxide price of $3.45/gallon is to be taken at face value.

You keep disparaging fuel cell vehicles. Why?

Hydrogen fuel cells are being touted as the world's path to environmental salvation and our nation's path to energy independence. And I am one American who would wholeheartedly support any such endeavor, were it legitimate. Upon closer inspection, however, it would appear that the hydrogen fuel cell will become little more than a convenient compromise between the environment and the powerful petroleum lobby. This compromise becomes especially evident when vehicular applications of the technology are considered. As far as the automobile is concerned, hydrogen fuel cells find themselves in an unfortunate Catch-22. But more on that later...



How do fuel cells work? A fuel cell creates power by splitting hydrogen gas into its component electrons (-) and protons (+), and transmitting the harnessed electrical energy to a motor. The "exhaust gas" of a pure-hydrogen fuel cell is water vapor and oxygen. There are five major types of fuel cells, through the type receiving the greatest scrutiny for vehicular applications is the Polymer Electrolyte Membrane, or PEM, cell.

Okay, how does a PEM cell work? A PEM cell is essentially an electrochemical sandwich, with an anode (-) on one side, a cathode (+) on the other, and an electrolyte, which seizes electrons and releases protons, in the middle. As hydrogen gas flows into the cell from the anode side, a platinum catalyst splits the atom into its component ions (electrons and protons). From here, the ions flow into the electrolyte membrane and combine with oxygen to produce water. The electrons, which cannot pass through the membrane, flow from the anode to the cathode through an external channel, which "closes" the circuit to make electricity.[50]

Couldn't you have explained that more simply??? Actually, no. That passage was taken almost verbatim from a Los Alamos National Laboratory information guide on fuel cells and it contained the simplest explanation we could find. Just be glad you're not the auto mechanic who has to repair these things!

To continue, then...

The maximum theoretical output of a single fuel cell is 1.16 volts. **The actual electrical output of a PEM cell is 0.7 volt.**[51] And no, that's not a misprint. It's a function of atomic theory. Thus, in order to make enough power to propel an automobile, fuel cells must be stacked together in huge quantities, making large, slow-moving municipal busses an ideal test bed. Their enormous underfloor and/or roof capacity, as well as the amount of sheer protective mass surrounding hydrogen tanks pressurized to 5,000 psi (no misprint) has allowed cities such as Chicago and Georgetown to employ such busses in test fleets, achieving a whopping **0.382 miles per gallon**[52](again, no misprint). Palm Desert, California's *SUNLINE* operator has been awarded

$2,000,000 by the Federal Transit Authority for the purchase of five (5) such busses.[53] Simple math will reveal the staggering cost of each bus.

How do fuel cells compete with Nick in terms of fuel price? In my research, I have come across projected fuel prices so varied that one cannot make sense of them. In each of these cases, the projections made are every bit as speculative as those made for Delchev Turbine fuel, in many cases, more speculative, given the gargantuan challenge of switching our transportation sector from a liquid base, to one based on highly pressurized gas. In order to avoid spoiling the final part of this section on fuel cells, I will simply offer, verbatim, the assessment of research firm, Arthur D. Little, Inc., as contained in the report, **Guidance for Transportation Technologies: Fuel Choice for Fuel Cell Vehicles**, commissioned by the U.S. Department of Energy (at right):

Gee, fuel cells aren't there yet, are they?

No. They're not. In all fairness, of course, neither is the DTV! But let us remember that the term "hydrogen economy" was coined by General Motors in 1970.[54] Thirty years of "effort" and tens of billions of dollars, many of them *taxpayer* dollars, have been expended to find the hydrogen economy still an embryo – *praying* for its infancy. For all the talk about energy self-sufficiency that began with the oil crisis of 1973, and has continued to make headlines with every middle eastern conflict since, we find our nation more dependent than ever on petroleum, specifically *foreign* petroleum.

At least fuel cells will one day fix that, right? It's doubtful, and this is the basis of the Catch-22 mentioned above.

A hydrogen fuel cell needs 100% pure, highly pressurized hydrogen gas in order to function. The safety implications of storing a gas with extremely high detonation potential at 5,000 psi onboard a passenger vehicle – vehicles which collide with other large objects 6.4 million times per year in the U.S. alone[55] – are proving difficult to surmount. The 345-page report by Arthur D. Little, Inc. concluded that, "*Despite the attention on hydrogen safety, it appears that the on-road safety of fuel cell vehicles is not being addressed.*"[56]

"The most economical hydrogen fuel chains are expected to be **over two times more expensive than gasoline**." (p. S 24)

"...Transportation and distribution costs (including compression and storage) are **far higher than those for gasoline**." (p. S 24)

"...Local fueling station capital costs are significant, ranging from **$300,000 to $2 million per station**, far outstripping franchise owners' resources." (p. M 70)

AS FOR THE VEHICLES THEMSELVES...

"...**Substantial additional technology breakthroughs will be required** to achieve FCV cost competitiveness with internal combustion vehicles." (p. S 28)

"...Based on our analysis, factory costs of future FCVs would likely be **40-60% higher than conventional vehicles**." (p. S 31)

"...**The cost and performance of the fuel cell stack remains the key barrier** to achieving cost parity with conventional vehicles." (p. S 29)

Here are more excerpts from the Arthur D. Little report:

"Fuel cell vehicles will require modifications to garages, maintenance facilities and on-road infrastructure that would be costly and difficult to implement." (p. M 97)

"...The greatest combustion-related concern for hydrogen is a **slow leak** in a garage or enclosed area resulting in a **fire or explosion."** (p. M 99)

"...ignition energy (sliding over a car seat) is **10 times greater than** [ISO] **minimum."** (p. M 99)

"[We recommend wearing]...NOMEX 11A **static resistant protection while fueling."** (p. M 99)

"[We recommend]...**no open flame heaters in garages,** [urge the use of] **gas leak sensors** [as well as] **slanted, vented** [garage] **roofs to allow escape of buoyant gasses."** (p. M 103)

"...the fact that **hydrogen is odorless and has no visible flame in daylight** raises further safety concerns." (p.M 98)

"[The implications of fuel cell vehicles]...in tunnels and other public road works...[could be]...**potential show stoppers."** (p. M108)

Delchev Turbine fuel, by comparison, requires *no* pressurized storage and will actually *extinguish* an open flame. And as for long-term stability, Nick has had plastic bottles of mixed fuel sitting in the Mojave sun outside his shop since the end of January, 2002. A thermometer in one bottle reads roughly 125ºF nearly every afternoon in the summertime. He checks them once in a while, just for fun.

Let's furthermore look at the U.S. Department of Transportation's handling regulations for either fuel. According to CFR 173.115, hydrogen is a flammable gas, as defined by its ability to explode at concentrations of less than 12% by volume. Hydrogen *peroxide*, on the other hand, is considered a liquid oxidizer in CFR 173.127. This may not mean much at first glance. But upon a comparison of the number and type of approved shipping containers, the comparison becomes night and day:

Approved non-bulk shipping containers.[57]

H_2O_2 (liquid in 40-60% sol.)	H_2 (gas)
Steel drum	Seamless aluminum cylinder
Aluminum drum	
Plywood drum	
Fiber drum	
Plastic drum	
Wooden barrel	
Steel jerrican	
Plastic jerrican	
Steel box	
Aluminum box	
Natural wood box	
Plywood box	
Reconstituted wood box	
Fiberboard box	
Expanded plastic box	

That seamless aluminum cylinder also comes with about ten regulations governing pressure capacity, valve threading, connector metal, etc. Exactly the sort of thing that makes insurance companies run for cover. But rather than launch into a further study of how an insurance company would view either system, let us look at how the automakers have chosen to solve this critical safety concern.

Yeah, how are they solving the safety problem?

As we learned in the earlier section about hydrogen peroxide manufacturing, pure hydrogen gas can be created through steam reformation of natural gas (methanol). This process would normally take place at a stationary facility. Automakers, however, have ingeniously devised a way to perform this wizardry *onboard* the vehicle with a device called, you guessed it, an On-Board Reformer. Doing so will partially eliminate the explosion and "slow leak" concerns, since natural gas is stored at much lower pressures than hydrogen. Storage volume is further reduced, given that hydrogen gas, even at 5,000 psi, requires *ten times* the volume of a liquid.[58] There is, however, another source of hydrogen gas which can be stored onboard a vehicle, one which eliminates the pressurized storage issue entirely...

GASOLINE, of course!

Before we delve too deeply into the politics of this issue, let us first look at the environmental implications of petroleum reformation. Even those who barely passed high school chemistry (like this author) will recall the the Law of Conservation of Energy – a technical term for the phrase "*There are no free lunches.*" One cannot split apart a molecule without having to account for the location of all of its components. Therefore, the reformation of methanol or the partial-oxidation of gasoline into hydrogen gas, regardless of *where* the operation takes place, will unfold as follows:[59]

Every kilogram of H_2 produced through the steam reformation of methanol will produce 340 grams of "new" **carbon dioxide**, 85 grams of **nitrogen** and traces of **carbon monoxide**. This process furthermore requires energy sufficient to create a temperature of **392ºF**, and the emissions released to provide this energy must be added to total emissions.

Every kilogram of H_2 produced through the partial oxidation of gasoline will produce **473 grams of "new" carbon dioxide**, 1.1 kilograms of nitrogen, **52 grams of methane**, and traces of **carbon monoxide**. This process requires energy sufficient to create a temperature of **1,472ºF**, and the emissions released to provide this energy must be added to total emissions.

Of the gasses created through partial oxidation of gasoline, **only 38% is hydrogen**.

Partially because the gasoline refueling infrastructure is already in place, as well as for other, less innocent reasons we shall explore below, the idea of gasoline-based fuel cells has found a convenient niche with automakers, most notably General Motors, titular authors of the so-called "hydrogen economy." A visit to their corporate website provides an enlightening look at their fuel cell strategy:

"**We believe gasoline is the answer**," says Byron McCormick, co-director of General Motors Global Alternative Propulsion Center (GAPC). "While it is easier [*and cleaner*] to extract hydrogen from methanol than it is from gasoline, methanol-powered fuel cells won't make a dent in the country's fuel consumption without an established infrastructure. **People won't buy methanol fuel cell vehicles** without a place to refuel them, and **creating a methanol infrastructure would be a major and costly endeavor**." [60]

Gasoline may be the answer to the question General Motors is asking, but is it the right answer to any of the most important questions? About our environment? About our national security as we race off to war in Iraq? About energy self-sufficiency as a nation? About the fact that each of us breathes 30% more carbon dioxide than we did 100 years ago?

These are not the questions Big Money wants us to ask.

So, you see, the Catch-22 of fuel cells is that the use of Climate Neutral hydrogen gas, which could rid us of our addiction to petroleum and almost singlehandedly neutralize the greenhouse effect, is plagued by high costs and monumental safety concerns. The DTV would do all of the above at far lower cost and be immeasurably safer in doing it.

Petroleum-based fueling of hydrogen fuel cell vehicles, on the other hand, is much safer and less expensive and will occur much sooner and people might buy them in bigger quantities, but...

But...

I'll let you answer that one.

Photo by Ingrid Franz Moriarty

CONCLUSION

The bonds between Detroit and Big Oil run deep. On January 9th of this year, the Bush Administration eliminated mileage requirements placed upon the automakers during the Clinton era, in favor of subsidizing future research into fuel cells. Despite receiving $1.5 billion in taxpayer money, Detroit claims to have been unable to create a family sedan that would have attained 80 mpg by 2004. Beyond the fact that both the Bush Administration and the automakers seem to have reached this conclusion two full years *before* the due date, it is obvious that mileage is just a tiny fraction of the equation. According to Energy Secretary, Spencer Abraham, "*We are not going to have in 2004 a vehicle that people will be out buying that gets 80 mpg.*" [61]

This phrase, "*What people will buy*," seems to be a common refrain. But it is little more than a convenient excuse. A means of laying sole blame for pollution at the feet of consumers. After all, we do keep buying Chevy Suburbans. Why blame Detroit? They just make them and spend billions of dollars to advertise 'em!

An excuse like this, however, would be short-lived without the express complicity of the federal government. Despite a reasonably dignified history of government intervention when the desires of the market run contrary to the common good, we are witnessing the beginnings of a government-subsidized smokescreen, the size of which is paralleled only by the weight of carbon dioxide in the atmosphere.

The premature dissolution of the Clinton Administration's "Partnership for a New Generation of Vehicles," *without* the return of at least a *portion* of the funds handed over to Detroit since 1994, should theoretically amount to a felony. If your local mechanic took $600 of your hard-earned money, only to tell you a week later, "Sorry. Just couldn't fix it," would you leave without a refund? The federal government would. And did. And *has*. Repeatedly.

What of the demise of the EV-1 electric vehicle? Or of any of a dozen other environmentally sound vehicle concepts to come and go since the 1970's – all of which received federal money? What is the purpose of all these expenditures? What has happened to any of the billions of dollars spent on these failed ideas?

They are gone. Lost forever. And that's exactly the way they want it.

Name me one CEO who relishes the thought of presiding over a company during a 5- or 10- or 15-year changeover to a new technology and I'll show you someone who flunked out of business school. Each and every dollar spent, even wasted, on "new technology" further cements the notion that "it's all a ways off," and buys us another decade of petroleum dependence. The more money they blow, the better they fare and that's simply the cost of doin' business.

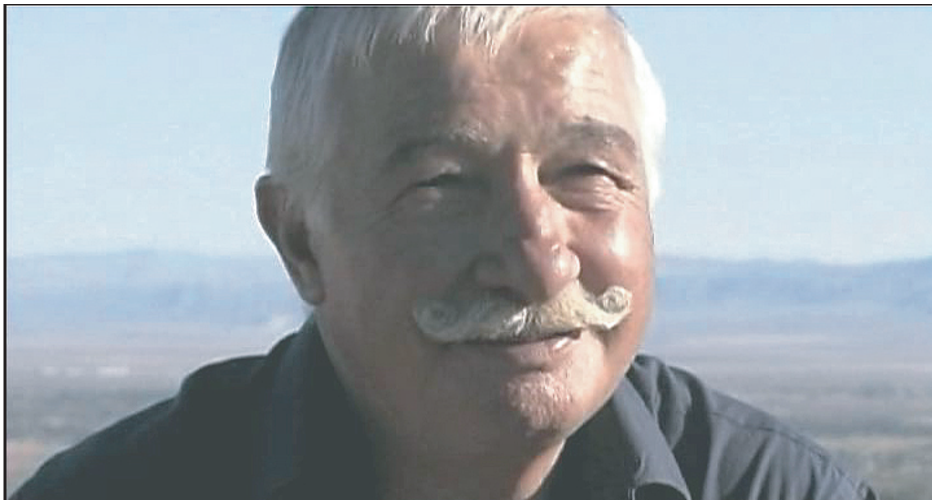
Just ask Siemens-Westinghouse, DuPont, 3M, United Technologies, Gore Laboratories, Ballard Power Systems and any of the sixteen other billion dollar companies whose corporate logos have been melded into one single, multi-colored letterhead for official correspondence with the legislators who are writing their tax credits and grant money into law. They *love* that "pre-existing gasoline infrastructure" angle, and have quietly written off direct hydrogen vehicles.

Ask any of the General Motors researchers who are working on fuel cell designs and they'll tell you, *with smiles on their faces*, that fuel cells are a good decade away from viability and that they "just can't get the cost of the prototype under a million dollars." This, you understand, is exactly what they *must* say, because any real effort, any notable progress, any *marginal* sense that an energy changeover is looming near, will send their stock price into the ground and cause their big oil counterparts to toss their cookies.

All this while a 61 year-old Bulgarian in the Mojave Desert is sitting on an engine that could change the world tomorrow. Not next year. Not in ten years. *Now*.

And no one will take his calls.

(Sounds like a movie to me.)



EPILOGUE

What about the movie?

This information guide was compiled for the express purpose of gaining for myself and my colleagues at Workshop Entertainment a face-to-face discussion with anyone interested in furthering this documentary film. To reveal in these pages specific details about my vision of the film would undoubtedly color any such discussion – for better or for worse. You've seen the trailer. You've read the information. You are either interested in this project or you're not. As such, I must withhold any specific details about our plan of attack – the "plot," to whatever extent it may be pre-planned – in order to increase the impact of any sit-down meeting that may occur. I will say only that contact has been initiated with many potential interviewees – from CalTech professors to chemical industry insiders to politicians in Sacremento and Washington – and that logistical planning is indeed underway to turn Nick's cross-country "Media Tour" into a reality.

I will focus instead on another question you may be asking, namely:

Who *are* you people?

Workshop Entertainment was formed by three respected motion picture craftsmen with the intent of making movies that matter, and making them in a way that is humane to cast, crew and audience. We are not famous. You will only know our names if you sit through the end credits. But our years of experience in the Hollywood system have had two by-products:

1) **A knowledge of *how* to make movies**
2) **A desire to make our *own* movies**

Given these goals, we have compiled several film projects, each one characterized by its originality. STEAM happened to fall into our laps while in the midst of producing another picture, an offbeat drama about a land deal. The chance to chronicle Nick's struggle seemed the sort of thing found once in ten lifetimes; something that, like our other properties, had never been done before. Given our experiences in the film industry, we believe these are the only kinds of movies left to make. The brief bios shown below should support this belief.

MATTHEW MORIARTY (Director / Producer) has been an Assistant Cameraman in Hollywood since graduating from the University of Iowa in 1996. In 2001, he played key roles on two of the biggest films of the year: *Spider-Man* and *Men in Black II*. His other feature credits include *Cast Away, The Anniversary Party, Rules of Engagement, Lethal Weapon IV, 6 Days 7 Nights, For Love of the Game, Living Out Loud* and *As Good As It Gets*. He works with such famed cinematographers as John Bailey, Don Burgess, Michael Chapman, Dariusz Wolski, William Fraker and Conrad Hall. The list of directors for whom Matthew has worked includes James L. Brooks, Richard Donner, William Friedkin, Sam Raimi, Barry Sonnenfeld and Robert Zemeckis. *STEAM* will be Matthew's first foray into the documentary realm.

INGRID FRANZ MORIARTY (Producer / Still Photographer) began her career in Casting under Francis Ford Coppola on the films *Jack* and *The Rainmanker*. Her other feature and television casting credits include *The Rock, Great Expectations, Flubber, The Fan* and *Nash Bridges*, which put her in the company of Michael Bay, Alfonso Cuaron, Les Mayfield and Tony Scott. Since leaving San Francisco in 1996, Ingrid has become one of the most respected members of the commercial casting community in Hollywood, with a list of clients that include Joe Pytka, Bryan Singer, Sam Bayer, Baker Smith and Christopher Guest. Ingrid has also found success as a still photographer, selling numerous commissioned portraits, and will document *STEAM* as it unfolds.

MATT COHEN (Producer) is a motion picture Video Engineer with feature credits that include *The Incredible Hulk, Minority Report, K-Pax, Space Cowboys, Ed TV, Mercury Rising* and *Sphere*. He has worked closely with such directors as Ron Howard, Barry Levinson, Clint Eastwood and Steven Spielberg. Among his television credits are *The West Wing, Star Trek: Voyager*, and *JAG*. Matt also spent several years documenting car chases, shootings and other assorted mayhem for *Real Stories of the Highway Patrol*, an experience that will serve him well in producing *STEAM*.

ANNOTATIONS

1. In 1980, the legendary engineers at Lockheed's top-secret SkunkWorks were having tremendous trouble drilling holes through the Stealth Fighter's new composite body panels without splintering the entire panel. They tried diamond blades, extrusion, even lasers – all to no avail. The future of stealth itself hung in the balance. Then Nick solved the problem in two hours by sandwiching the composite material between two layers of aluminum and drilling through all three layers. Since then, Lockheed patented this process and has licensed it to Boeing and Northrop Grumman. Nick was paid $18 for his efforts.

2. # 4,698,965; **Hot Gas Source and Fuel Therefor**; (www.uspto.gov/patft/index.html)

3. Developed and tested by the Lockheed SkunkWorks.

4. The Delchev Turbine does not produce carbon dioxide, *per se*. It recycles carbon dioxide that was previously consumed by sugar cane plants, making it 100% Greenhouse Gas neutral. See P. 7 for or a detailed discussion of greenhouse gas emissions.

5. Smith, Evan, *ed.*: **Trials of Delchev Power Generator**, November 7th, 2001; Eka Chemicals Inc., 1775 West Oak Commons Court, Marietta, GA 30062; p. 6.

6. Ibid; p. 12.

7. Upon request, we can provide a long-form version of the STEAM trailer which includes this demonstration, the full "Desert Interview" with Nick, and much more.

8. Hydrogen Peroxide was used as a power source as early as World War II. The Nazi V-2 rocket employed the liquid in 100% concentration as a propellant. Later, the X-15 rocket plane would borrow the technology for directional control at Mach 6.7. The first known use of a hydrogen peroxide-fuelled steam turbine is attributed to German scientist Hellmuth Walter, who employed the powerplant in a submarine which attained a then-unprecedented underwater speed of 24 knots! Thankfully, the war ended before the U-boats became fully operational. Today, hydrogen peroxide is being used as a rocket-fuel in the prototype *DarkHorse* spaceplane, which will travel into space without the use of booster rockets.

9. Ibid, Smith; p.1.

10. Hydrogen fuel cell vehicles, especially those employing onboard reformers to convert petroleum to hydrogen gas, requre a lengthy period of heat and humidification prior to beginning the reaction.

11. Of course, standard accessories such as alternators, compressors, reduction gears and transmissions contain moving parts. None of these, however, can be considered part of the powerplant. In contrast to the Delchev Turbine, the average piston engine contains literally hundreds of moving parts, each of which requires constant lubrication and/or cooling.

12. Ibid, Smith; p. 1; "*...Within the detection limits of the instruments used, the reaction was 100% efficient.*"

13. Arthur D. Little, Inc.: **Guidance for Transportation Technologies: Fuel Choice for Fuel Cell Vehicles**; Cambridge, MA, February, 2002; p. M55. The full 345-page report , commissioned by the United States Department of Energy, can be downloaded in PDF format from the DOE website: www.cartech.doe.gov/research/fuels/best-fuels.html. Relative engine efficiencies can also be found easily at www.howstuffworks.com/fuel-cell4.htm.

14. Rose, Robert, *ed.*: **Fuel Cells & Hydrogen: The Path Forward**; September 5th, 2002; p. 4. This report was prepared for eventual submission to Congress to secure tax credits for users (and designers) of fuel cell technology. It was compiled by Rose on behalf of nearly 30 global corporations, including such giants as Siemens-Westinghouse, Shell, United Tecnologies and DuPont. Available at: www.fuelcellpath.org/path%20forward.pdf

15. Ibid, Arthur D. Little, Inc; p. M44.

16. Ibid, Arthur D. Little, Inc; p. M44. (Direct Hydrogen PEM cells require fuel to be stored onboard the vehicle at a pressure of 5,000 psi.!!)

17. Ibid, Arthur D. Little, Inc; p. M55.

18. Each manufacturer has its own proprietary collection of anthraquinones. What is important is that the anthraquinone is not consumed, but rather recycled throughout the process. However, small losses (less than 3%) do occur due to degradation of the agent as is it repeatedly recycled. Anthraquinones are generally extracted from the mineral bauxite.

19. Schumb, Walter; Charles N. Satterfield, Ralph L. Wentworth: **Hydrogen Peroxide**; Reinhold Publishing; New York; 1955; pp. 71-82. An excellent overview can also be found at the U.S. Peroxide website: www.h2o2.com/intro/faq.html#5

20. **CEFIC Ecoprofile**; A guide to Ecoprofiles, as well the ecoprofile of hydrogen peroxide, can be found at: www.cefic.be/sector/peroxy/ecohydro/tc.htm

21. Thomas, Sharon and Marcia Zalbowitz: **Fuel Cells: Green Power**; Los Alamos National Laboratory; Los Alamos, New Mexico, 2001; p. 15. A report commissioned by the U.S. Department of Energy, which operates the lab. The full report can be downloaded from: http://education.lanl.gov/resources/fuelcells/fuelcells.pdf

22. Faith, W.L.; Donald Keyes & Ronald L. Clark: **Industrial Chemicals**, 3rd Ed.; John Wiley & Sons; New York, 1965; pp. 441-443.

23. Ibid, CEFIC Ecoprofile

24. Ibid, Thomas & Zalbowitz; p. 28.

25. Ibid, CEFIC Ecoprofile.

26. **Biomass Energy**; U.S. Enviornmental Protection Agency information guide. Available at: www.epa.gov/ globalwarming/publications/ outreach/technology/biomassenergy.pdf

27. Ibid.

28. Plant history can be found at: www.westbioenergy.org/lessons/les18.htm

29. **Emission Factors: Bagasse Combustion in Sugar Mills**; U.S. E.P.A. report; p. 2. Available at: www.epa.gov/ttn/chief/ap42/ch01/final/c01s08.pdf

30. Ibid.

31. La Rovere, Emilio Lèbre: **The Challenge of Limiting Greenhouse Gas Emissions Through Activities Implemented Jointly in Developing Countries: A Brazilian Perspective;** Federal University; Rio de Janiero; November, 1998; p. 18 The full 43-page report is available at: www.epa.gov/globalwarming/publications/international/aij_brazil.pdf

32. As of 10/4/02. Daily quotes at: www.sugarnetwork.com/

33. Ibid, Thomas & Zalbowitz; p. 27

34. Ibid.

35. **World Apparent Consumption of Refined Petroleum Products**, Table 3.5, U.S. Energy Information Administration, April 23, 2002. At: www.eia.doe.gov/emeu/iea/table35.html

36. U.S. Peroxide, Inc. Available at: www.h2o2.com/intro/faq.html#14

37. Solvay Interox, Inc.; Houston, TX; Tel: (713) 525-6500 / www.solvayinterox.com

38. September telephone interview with former member of Eka Chemicals' New Business Development Group (on condition of anonymity).

39. U.S. Federal Trade Commission v. Degussa Aktiengesellschaft, Docket No. C-3813. At: www.ftc.gov/os/1998/9806/9710118.cmp.htm

40. Ibid, **World Apparent Consumption of Refined Petroleum Products**, Table 3.5.

41. Ibid; Schumb, Satterfield & Wentworth; p. 20.

42. Ibid.

43. Huckins, Harold: **A New, Efficient, Safe, Direct Hydrogen Peroxide Process**; U.S. Dept. of Energy information guide; August, 2002; p. 1. Available at: www.oit.doe.gov/nice3/factsheets/princeton.pdf

44. Bureau of Labor Statistics, **C.P.I. Inflation Adjustment Calculator**. Available at: http://www.bls.gov/cpi/home.htm

45. Ibid; Schumb, Satterfield & Wentworth; p.20

46. Ibid, **World Apparent Consumption of Refined Petroleum Products**, Table 3.5. (1 metric ton = 8.649 bbl gasoline; 1 bbl = 42 gallons)

47. Ibid, Huckins; p.1. (H_2O_2 quantity is not usually expressed in terms of barrels but rather in pounds or metric tons. However, it is necessary to compare apples to apples. Conversion is as follows: [1.55 billion lb./year U.S. H_2O_2 {10 lb./gallon.} = 155,000,000 {gal} ÷ 42 {gallons in a barrel} = 3,690,000 bbl])

48. A primer on fuel prices can be found at: www.eia.doe.gov/emeu/plugs/plprimer.html

49. Ibid, Huckins; p.1.

50. Ibid, Thomas & Zalbowitz; p. 4.

51. Ibid; p. 13.

52. **Fuel Cells for Transportation**; 6th Edition; p. 9. Information guide produced by the Breakthrough Technologies Institute. Available at: http://www.fuelcells.org

53. Ibid.

54. Ibid; Thomas & Zalbowitz; p. 25.

55. **Traffic Safety Facts, 2000**; N.H.T.S.A fact sheet. Available at: www-nrd.nhtsa.dot.gov/pdf/nrd-30/NCSA/TSF2000/2000ovrfacts.pdf

56. Ibid; Arthur D. Little; p. M106

57. CFR 173.202 (hydrogen peroxide), CFR 173.302 (hydrogen gas) Available at: www.dot.gov

58. Crumbley, Liz: **The Little Cell That Could Power a Revolution**; Virginia Tech College of Engineering, 2001. Available at: www.research.vt.edu/resmag/resmag2001/fuel_cell.html

59. Ibid; Thomas & Zalbowitz; p. 15.

60. www.gm.com/company/gmability/environment/products/fuel_cells/strategy_032101.html

61. "U.S. Backs Fuel Cell Cars"; *The Washington Post*; January 10, 2002; p. E01.