HYDROGEN AND TORT LAW:

LIABILITY CONCERNS ARE NOT A BAR TO A HYDROGEN ECONOMY

William Vincent *

I. EXECUTIVE SUMMARY

Hydrogen holds great promise to provide clean energy, produce major reductions in greenhouse gas emissions, and reduce or eliminate dependence on foreign oil. Although a complete transition to a hydrogen economy is decades away, significant advances are currently being made toward affordable, safe, and non-polluting energy based upon hydrogen.

Recent news reports suggest that widespread hydrogen use, particularly in consumer applications, could give rise to unusually extensive liability under the legal theories of negligence, strict products liability, and abnormally dangerous activities. The research and experience with hydrogen, however, suggest that the opposite may be true.

First, although hydrogen differs from gasoline, propane, natural gas, and other fuels, studies have shown that the differences do not make it any more dangerous. Hydrogen is non-toxic, disperses quickly if leaked, and produces no smoke or toxic fumes when burned. Furthermore, hydrogen burns faster, and at a lower temperature, and radiates far less heat than fires fed by other fuels.

Second, hydrogen has been in significant production and transportation for over fifty years and has an enviable safety record. Although there have been incidents involving hydrogen, a thorough search of the case law has failed to produce a single instance where liability was assessed as a result of hydrogen's unique nature. In fact, there are very few reported cases containing the word "hydrogen." By contrast, there are literally dozens of cases involving gasoline, natural gas, propane, and other fuels in use today.

Third, although there are technical challenges in delivering hydrogen at the consumer level, these challenges will likely be met by technology, training, and strong safety standards. Furthermore, significant investments are currently being

* The author is General Counsel for Breakthrough Technologies Institute, a non-profit dedicated to promoting advanced energy and environmental technologies. He graduated with honors from the George Washington University National Law Center, where he served as an associate editor of the George Washington University Law Review. He also is a magna cum laude and Phi Beta Kappa graduate of the University of Connecticut. Mr. Vincent has practiced law at a major Washington, D.C., law firm and was appointed by President Clinton to serve in the U.S. Department of Transportation. The author is especially grateful for the advice, counsel, and assistance provided by Mr. Richard Dighello, a Principal in the firm of Updike, Kelly & Spellacy in Hartford, Connecticut. Mr. Dighello focuses his practice in the areas of professional design and engineering defense, construction law, and products liability. The author would also like to thank John Mulcahy, a summer associate with Updike, Kelly & Spellacy, for his assistance.

made in each of these areas to promote such technological developments.

Finally, a strong national interest exists in pursuing alternative energy sources, including hydrogen. The national security, environmental, and other costs of continued fossil fuel reliance are too great. It is important to explore an alternative like hydrogen and ensure that public investments lead toward sustainable markets for these options.

II. INTRODUCTION

According to the U.S. Department of Energy (DOE), "[h]ydrogen is a potential answer to satisfying many of our energy needs while reducing (and eventually eliminating) carbon dioxide and other greenhouse gas emissions."[1] The promise of hydrogen is so great that President George W. Bush included a major hydrogen initiative in his 2003 State of the Union Address.[2] California Governor Arnold Schwarzenegger announced a major initiative to create hydrogen highways in California, and hydrogen initiatives are underway in other states, such as New York and Ohio.[3]

Despite the great promise of hydrogen, the move toward a large scale use is not without its critics. History shows there will always be those who oppose shifts in traditional approaches. One relevant example involves reaction in Congress to the invention of the automobile.

Toward the end of the nineteenth century, the Congressional Horseless Carriage Committee (Carriage Committee) sounded alarms about the invention of the gasoline-powered car. The Carriage Committee found that because "horseless carriages . . . might attain speeds of 14 or even 20 miles per hour[,]"[4] they constitute a "menace" requiring prompt legislative action.[5] Furthermore, the Carriage Committee stated that horseless carriages "would wreck our agriculture" and involve "forces of nature too dangerous to fit into our usual concepts."[6]

Looking back, it is easy to see that the Carriage Committee's fears were not well justified. The internal combustion engine did not destroy agriculture, but rather, greatly enhanced it. Also, our regulatory and legal systems adjusted by allocating risk and responsibility, ensuring a vibrant industry and widespread

1. U.S. DEP'T OF ENERGY, HYDROGEN, FUEL CELLS & INFRASTRUCTURE TECHNOLOGIES PROGRAM, *at* http://www.eere.energy.gov/hydrogenandfuelcells/future/ (last updated July 1, 2004).

2. News Release, The White House, Hydrogen Fuel: A Clean and Secure Energy Future (Jan. 30, 2003), *available at* http://www.whitehouse.gov/news/releases/2003/01/20030130-20.html.

3. *See* CAL. HYDROGEN HIGHWAY, GOVERNOR ARNOLD SCHWARZENEGGER'S CALIFORNIA HYDROGEN HIGHWAY NETWORK ACTION PLAN, http://www.hydrogenhighway.ca.gov/vision/vision.pdf (last visited Sept. 16, 2004); News Release, Congressman John McHugh, New York's Hydrogen "Hi Way" Initiative Secures $2 Million (Nov. 18, 2003), *available at* http://mchugh.house.gov/pr2003/111803_hiway.html (last visited Sept. 30, 2004); New Release, Ohio Department of Development, State Development Director Announces Availability of Ohio Fuel Cell RoadMap (Sept. 1, 2004) *available at* http://www.thirdfrontier.com/documents/09-01-04FuelCellMap.pdf (last visited Sept. 30, 2004).

4. HYDROGEN 2000, INC., COMPANION GUIDE TO HYDROGEN: THE MATTER OF SAFETY 4 (n.d.), *available at* http://hydrogen2000.com/sfty_booklet.pdf (last visited Sept. 16, 2004).

5. *Id.* at 5.

6. HYDROGEN 2000, INC., *supra* note 4, at 5.

consumer availability of the automobile.

Recent reports suggest that fears similar to those expressed by the Carriage Committee are currently being raised regarding hydrogen and fuel cells. According to this line of thinking, hydrogen has certain immutable properties that may lead to widespread tort liability if it becomes a common consumer fuel.[7] This article was written to refute those claims.

Although hydrogen clearly differs from gasoline, propane, natural gas, and other fuels, there is ample evidence that its differences do not make it any more dangerous. Handled properly, hydrogen can be as safe, if not safer, than fuels in common use today.

For example, the United States "produces 9 million tons of hydrogen [annually] . . . for use in chemicals production, petroleum refining, metals treating, and electrical applications."[8] This "[h]ydrogen has been safely produced, stored, transported, and used in large amounts in industry by following standard practices that have been established in the past 50 years."[9]

Despite the longstanding and widespread use of hydrogen, a review of the case law failed to yield a single case where liability was imposed as a result of injury caused by hydrogen.[10] In fact, there are very few reported cases that even contain the word "hydrogen." This suggests that hydrogen is not a significant source of litigation.[11]

It also is important to note that the purpose of tort law is to allocate risk, not to eliminate it.[12] There are many industries that produce risky products yet survive and prosper under our tort law system. For example, as discussed below, the use of gasoline, natural gas, and electricity result in significant injury every year, yet these products are widely accepted and the industries are economically viable.

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7. Russell Moy, *Tort Law Considerations for the Hydrogen Economy*, 24 ENERGY L.J. 349 (2003).

8. U.S. DEP'T OF ENERGY, HYDROGEN QUICK FACTS (n.d.), http://www.eere.energy.gov/hydrogenandfuelcells/pdfs/h2_quick_facts.pdf (last visited Sept. 16, 2004).

9. U.S. DEP'T OF ENERGY, HYDROGEN, FUEL CELLS & INFRASTRUCTURE TECHNOLOGIES PROGRAM: SAFETY, CODES AND STANDARDS FAQS: QUESTIONS ABOUT SAFETY, CODES AND STANDARDS, *at* http://www.eere.energy.gov/hydrogenandfuelcells/faqs_codes.html (last updated July 6, 2004).

10. Mr. Moy claims that "[o]nly one reported case directly addresses liability issues associated with hydrogen storage and transportation." Russell Moy, *Tort Law Considerations for the Hydrogen Economy*, 24 ENERGY L.J. 349, 357 (2003) (citing Gonzales v. Union Carbide Corp., 580 F. Supp. 249 (N.D. Ind. 1983)). However, the court in *Gonzales* did not address liability associated with hydrogen, but rather the interpretation of Indiana's worker's compensation statute.

11. By contrast, there are literally dozens of cases that involve gasoline, natural gas, and propane. In fact, courts have found that because these fuels pose unique dangers, a higher standard of care is required. *See e.g.*, Gulf Ref. Co. v. Williams, 185 So. 234, 236 (Miss. 1938) (holding a vendor of gasoline under a duty to use "cautious care" in distributing commodity due to its inherently dangerous character); Foster v. City of Keyser, 501 S.E.2d 165, 176 (W. Va. 1997) (requiring a natural gas distributor to conduct business with a degree of care commensurate with dangers associated with the product); Stanton v. Ark. Valley Elec. Coop., 49 F.3d 1317, 1320 (8th Cir. 1995) (upholding jury instruction that electric utilities subject to heightened standard of care as adequate under the law).

12. See Mark Geistfeld, *Economic Analysis in a Unified Conception of Tort Law*, *in* BOALT WORKING PAPERS IN PUBLIC LAW (Univ. of Cal., Berkley, Working Paper No. 33, 2003), *available at* http://repositories.cdlib.org/boaltwp/33, for a more detailed discussion of the underlying philosophies of tort law.

This paper first examines the experience with hydrogen to date, the available research on hydrogen, and the unique properties of hydrogen. It then describes how tort law may apply to hydrogen and concludes with how hydrogen appears likely to create fewer liability issues than other fuels, provided that industry continues to develop safe technologies, codes, and standards.

III. WHAT ARE HYDROGEN AND FUEL CELLS?

A. Overview

Hydrogen is the most abundant element in the universe. In its natural state, it is a colorless, odorless, and tasteless gas.[13] On Earth, hydrogen is typically found as a component of water and other common compounds.[14]

A fuel cell is an electrochemical device that combines hydrogen and oxygen to produce electricity, water, and heat.[15] It consists of two electrodes, known as an "anode" and a "cathode," sandwiched around an electrolyte. Hydrogen enters the fuel cell at the anode, while air enters the fuel cell at the cathode. The hydrogen atom splits into a proton and an electron, creating an electric current.

Hydrogen fuel cells offer many advantages. For example, unlike conventional power sources, they emit no pollution and the only by-products are heat and water.[16] Hydrogen fuel cells also are more efficient than conventional power sources. According to the DOE, fuel cells are up to 60% efficient if only the electricity is used, and up to 85% efficient if both the electricity and heat are used.[17] By contrast, traditionally-fueled power plants are only 33% to 35% percent efficient. Similarly, fuel cell automobiles are up to 60% efficient, but traditionally-fueled automobiles are typically less than 30% efficient and often much lower.[18]

B. Safety

As with any fuel or energy source, safety must be a top priority. This does not mean, however, that risk can or should be eliminated. Fuels are useful because they contain energy, and there is always a risk that this energy will be released in undesirable ways and with unfortunate consequences. The important question is whether the risk can be managed in a way that results in a socially acceptable and economically viable industry.

The balance between social acceptability and economic viability is perhaps best demonstrated by energy sources that currently are in common use, such as

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13. BREAKTHROUGH TECHNOLOGIES INSTITUTE, FUEL CELLS 2000, *at* www.fuelcells.org (last visited Sept. 30, 2004).

14. *Id.*

15. BREAKTHROUGH TECHNOLOGIES INSTITUTE, FUEL CELLS 2000, *at* www.fuelcells.org.

16. In the long term, hydrogen may be produced from renewable sources such as solar or wind. This would enable a nearly emission free "wells-to-wheels" energy system.

17. U.S. DEP'T OF ENERGY, HYDROGEN, FUEL CELLS & INFRASTRUCTURE TECHNOLOGIES PROGRAM—THE HYDROGEN FUTURE, *at* http://www.eere.energy.gov/hydrogenandfuelcells/future/benefits.html (last updated July 1, 2004).

18. *Id.*

gasoline, natural gas, and electricity. Despite more than a century of experience, accidents continue to occur with some regularity, resulting in significant liability. Yet, consumer use of these energy sources is widely accepted, and the industries are economically viable.

For example, "[i]n 1998, there were 4,700 gasoline fires in U.S. homes, resulting in 86 deaths, 463 injuries and $92 million in direct property damage."[19] Between 1994 and 1998, there were an average of 7400 gasoline service station fires per year.[20] Between 1992 and 2003, at least 149 gasoline service station fires were caused by static electricity.[21] "Static [electricity] was blamed for 3.2 percent of [the gasoline service station] fires that occurred outside vehicles or structures."[22]

Similarly, "there were 1,600 [propane] fires in U.S. homes in 1998, resulting in 41 deaths, 260 injuries and $30.8 million in direct property damage."[23] "There [also] were 38,300 reported home electrical fires in 1998, resulting in 284 deaths, 1,184 injuries and $668.8 million in direct property damage."[24] Between 1990 and 2000, 5860 electrocutions occurred as a result of consumer products, with an average of 533 electrocutions per year.[25]

Fuel transportation also creates significant damage to persons and property. There were 3298 hazardous liquid pipeline accidents between 1986 and 2003, resulting in 37 fatalities, 254 injuries, over $856 million in property damage, and over 1.8 million barrels of product lost into the environment.[26] Similarly, there were 1469 natural gas transmission accidents between 1986 and 2003, resulting in 60 fatalities, 232 injuries, and over $366 million in property damage.[27] During the same period, there also were 2406 natural gas distribution accidents, resulting in 301 fatalities, 1363 injuries, and over $302 million in property damage.[28]

Research and industry experience suggest that hydrogen can be as safe, if

19. NAT'L FIRE PROT. ASS'N, NFPA FACT SHEETS: GASOLINE SAFETY, http://www.nfpa.org/Research/NFPAFactSheets/Gasoline/gasoline.asp (last updated Feb. 2002).

20. NAT'L FIRE PROT. ASS'N, NFPA FACT SHEETS: SAFETY AT SERVICE STATIONS, http://www.nfpa.org/Research/NFPAFactSheets/ServiceStations/SafetyStations.asp (last updated July 2002).

21. PETROLEUM EQUIP. INST., FIRES AT REFUELING SITES THAT APPEAR TO BE STATIC RELATED, *at* http://www.pei.org/static/fire_reports.htm (May 19, 2004).

22. *See* NAT'L FIRE PROT. ASS'N, NFPA FACT SHEETS: SAFETY AT SERVICE STATIONS, http://www.nfpa.org/Research/NFPAFactSheets/ServiceStations/SafetyStations.asp (last updated July 2002).

23. NAT'L FIRE PROT. ASS'N, NFPA FACT SHEETS: PROPANE SAFETY, http://www.nfpa.org/Research/NFPAFactSheets/PropaneSafety/PropaneSafety.asp (last updated July 2004). "In the United States, LP-gas for residential use is almost exclusively propane; however, butane is also an LP-gas." *Id.*

24. NAT'L FIRE PROT. ASS'N, NFPA FACT SHEETS: ELECTRICAL SAFETY, http://www.nfpa.org/Research/NFPAFactSheets/Electrical/electrical.asp (last updated Feb. 2002).

25. RITA CHOWDHURY, CONSUMER PROD. SAFETY COMM'N, 2000 ELECTROCUTIONS ASSOCIATED WITH CONSUMER PRODUCTS (July 2003), *available at* http://www.cpsc.gov/library/Electro.pdf.

26. OFFICE OF PIPELINE SAFETY, U.S. DEP'T OF TRANSP., HAZARDOUS LIQUID PIPELINE OPERATORS ACCIDENT SUMMARY STATISTICS BY YEAR, http://ops.dot.gov/stats/lq_sum.htm (generated Sept. 15, 2004).

27. OFFICE OF PIPELINE SAFETY, U.S. DEP'T OF TRANSP., NATURAL GAS PIPELINE OPERATORS INCIDENT SUMMARY STATISTICS BY YEAR, http://ops.dot.gov/stats/tran_sum.htm (generated Sept. 15, 2004).

28. OFFICE OF PIPELINE SAFETY, U.S. DEP'T OF TRANSP., HAZARDOUS LIQUID PIPELINE OPERATORS ACCIDENT SUMMARY STATISTICS BY YEAR, http://ops.dot.gov/stats/dist_sum.htm (generated Sept. 15, 2004).

not safer, than existing fuels. For example, the Idaho National Engineering and Environmental Laboratory conducted an extensive study of hydrogen safety in 1999, concluding that "[n]o safety issues are foreseen that would warrant cessation of hydrogen as a vehicle fuel." [29] In 2002, the Bellona Foundation released a detailed report concluding that "hydrogen is no more or less dangerous than any other energy carrier and . . . hydrogen has properties that in certain areas make it safer than other energy carriers."[30]

In 1977, the DOE reviewed more than 400 industrial incidents involving hydrogen, concluding that there were no "statistically significant differences that would preclude future widespread use of hydrogen with a safety record comparable to that of natural gas today."[31] Similarly, in 1974, the National Aeronautics and Space Administration (NASA) reviewed ninety-six incidents involving hydrogen, concluding that "[t]he experience with hydrogen in NASA and AEC operations has been extremely gratifying in that relatively few accidents have occurred."[32] This finding is significant because the space program is one of the largest consumers of hydrogen in the world.

Finally, a review of Hazardous Materials Incident Reports, which are available from the U.S. Department of Transportation (DOT), showed that, between 1987 and 2003, one of the nation's leading hydrogen transporters suffered forty-seven accidents involving hydrogen transportation.[33] In most cases, the hydrogen vented harmlessly from the vehicle. There were no fatalities and only three injuries requiring hospitalization. One injury occurred when a truck lost control and rolled over. Despite the rollover, however, no hydrogen was released in that incident.

Although industry standards and practices have helped establish that hydrogen can be used safely, hydrogen also has some unique properties that may contribute to its safe use. Hydrogen is non-toxic and 14.4 times lighter than air, enabling it to dissipate very quickly when released in an open or well-ventilated area. In contrast, petroleum based fuels are extremely toxic and their fumes are heavier than air, which increases the risk of exposure and the risk that the fumes will encounter an ignition source.[34]

Hydrogen burns quickly and emits only one-tenth the radiant heat of a hydrocarbon fire, reducing the risk of burn injury and other damage.[35] Moreover, because hydrogen rises very quickly, the flame can burn above ground level where it can do the least amount of harm. As one report stated,

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29. L.C. CADWALLADER & J.S. HERRING, IDAHO NAT'L ENG'G & ENVTL. LAB., SAFETY ISSUES WITH HYDROGEN AS A VEHICLE FUEL 69 (Sept. 1999), *available at* http://energy.inel.gov/fossil/hydrogen/pdf/h2safetyreport.pdf.

30. BJORN KRUSE, ET AL., BELLONA FOUND., HYDROGEN: STATUS OG MULIGNETER 45 (2002), *available at* http://www.bellona.no/data/f/0/26/97/0_9811_1/Hydrogen_6-2002.pdf.

31. U.S. DEP'T OF ENERGY, COMPILATION & ANALYSIS OF HYDROGEN ACCIDENT REPORTS: FINAL TECHNICAL REPORT i (1978).

32. P.M. ORDIN, NAT'L AERONAUTICS & SPACE ADMIN., REVIEW OF HYDROGEN ACCIDENTS AND INCIDENTS IN NASA OPERATIONS 2 (1974).

33. U.S. DEP'T OF TRANSP., HAZARDOUS MATERIALS INCIDENT REPORT (July 2003).

34. *See* KRUSE ET AL., *supra* note 28, at 45.

35. *Id.*

"Standing in a carpet of fire is far more dangerous than standing below a nearly non-luminous clear flame that goes upwards."[36]

Burning hydrogen does not produce any smoke or emissions, eliminating the risk of inhaling toxic fumes or hot particles.[37] By contrast, injury or death can result from toxic gases emitted by burning hydrocarbons.[38]

Contrary to popular opinion, it is difficult to cause a mixture of air and hydrogen to explode. A constrained volume and elongated shape generally are required,[39] and the hydrogen/air mixture must be twice as rich as a natural gas/air mixture and four times as rich as a gasoline/air mixture.[40] Moreover, "[u]nlike natural gas, . . . hydrogen . . . is far likelier to burn than to explode, . . . because it burns at concentrations far below its lower explosive limit."[41] In cases "where [hydrogen] might explode, its . . . explosive power . . . is 22 times weaker than [the explosive power] of gasoline vapor."[42]

Finally, it is important to note that hydrogen poses few, if any, known threats to the environment. By contrast, a petroleum product spill is an environmental disaster requiring massive clean up efforts and resulting in substantial penalties and damage awards against industry.[43]

Although hydrogen has many favorable properties, it also presents some unique challenges that must be addressed before it can become a widespread consumer fuel. In its gaseous state, the most significant challenge is combustibility. Hydrogen has the widest flammability range of any fuel, meaning that it can ignite over a broad range of concentrations in the air. Hydrogen also requires less energy to cause ignition than other common fuels, and a pure hydrogen flame is nearly invisible. Thus, in some applications it will be important to implement leak and flame detection systems, and to provide appropriate training and warnings about the combustible nature of hydrogen.[44]

In a cryogenic state, hydrogen can cause tissue damage if it comes in contact with the skin. The extreme cold also can cause some metals to become brittle.[45] Technologies will need to ensure the integrity of cryogenic storage systems, preventing contact with the extreme cold.

In a compressed state injuries may occur by coming in contact with escaping gas or if the storage vessel ruptures or explodes. This is of particular concern in the vehicle context where very high-pressure storage may be required to provide adequate range and performance. Extensive testing is underway, and

36. AMORY B. LOVINS, ROCKY MOUNTAIN INST., TWENTY HYDROGEN MYTHS 10 (Sept. 2, 2003), *available at* http://www.rmi.org/images/other/Energy/E03-05_20HydrogenMyths.pdf.

37. *See* KRUSE ET AL., *supra* note 28, at 45.

38. *See e.g.*, U.S. CONSUMER PROD. SAFETY COMM'N, CARBON MONOXIDE DETECTORS CAN SAVE LIVES, http://www.cpsc.gov/CPSCPUB/PUBS/5010.html (last visited Sept. 16, 2004).

39. LOVINS, *supra* note 33, at 9.

40. *Id.*

41. LOVINS, *supra*, note 33, at 9.

42. *Id.*

43. Consider, for example, the results of the Exxon Valdez disaster off the coast of Alaska and the Prestige disaster near Spain.

44. CADWALLADER & HERRING, *supra* note 27, at 9.

45. *Id.* at 18.

more will be required, to ensure that storage tanks maintain their integrity in the event of an accident.

Although some argue that hydrogen is unreasonably dangerous, particularly in consumer applications,[46] the experience and research to date suggest just the opposite. Moreover, both government and industry appear committed to investing in the technologies, codes, and standards necessary to meet the unique challenges posed by hydrogen, and the initial results of these investments are promising. According to the DOE, tests of hydrogen systems "show that hydrogen can be produced, stored and dispensed safely."[47] Going forward, the challenge is to understand hydrogen's potential use in the marketplace, assess where the safety risks and potential liability issues reside, and focus future research and development efforts in those areas.

IV. LEGAL LIABILITY

The three theories offered for potential hydrogen liability are strict products liability, negligence, and abnormally dangerous activity.[48] Each of these theories has been applied to manufacturers and distributors of current fuels, and there is little question that they will be applied to hydrogen as well. There is nothing to indicate, however, that these theories will create unusual problems for the hydrogen and fuel cell industries. In fact, the many favorable properties of hydrogen, coupled with the current safety record, imply that the litigation experience resulting from the use hydrogen could be favorable when compared to such experience with our current fuels.

Moreover, manufacturers, transporters, distributors, and suppliers of hydrogen and hydrogen products will have the same legal protections and defenses that are available to fossil energy and fuel suppliers. These include, but are not limited to, comparative and contributory negligence, assumption of the risk, product misuse and alteration, compliance with statutes and industry customs, use of state-of-the-art technology, and use of adequate warnings.

Finally, as discussed above, tort law is merely a tool for allocating risk. These risks can be allocated in various ways depending upon the philosophy of a particular court and the balance between the risks and the benefits to society. Tort law does not, by itself, determine the economic viability of products and industries.

A. *Products Liability*

Under a strict products liability theory, the general rule is that a commercial seller or distributor of a product is liable only where the product is defective and the defect caused harm to persons or property.[49] Thus, the threshold question

46. *See* Moy, *supra* note 7, at 349.

47. U.S. DEP'T OF ENERGY, HYDROGEN, FUEL CELLS & INFRASTRUCTURE TECHNOLOGIES PROGRAM: SAFE USE OF HYDROGEN, *at* http://www.eere.energy.gov/hydrogenandfuelcells/codes/safeuse.html (updated July 1, 2004).

48. *See* Moy, *supra* note 7, at 349.

49. Specifically, "[o]ne engaged in the business of selling or otherwise distributing products who sells or distributes a defective product is subject to liability for harm to persons or property caused by the defect."

will be whether the hydrogen, or the packaging in which it was delivered, was defective. There are three types of product defects that could give rise to liability: manufacturing defects, design defects, and defects due to inadequate warnings or instructions.[50]

1. Manufacturing Defects

"A product . . . contains a manufacturing defect when the product departs from its intended design even though all possible care was exercised in the preparation and marketing of the product[.]"[51] This rule imposes strict liability rendering a seller or distributor liable for harm, regardless of how careful or reasonable the manufacturer was regarding quality control standards.

Manufacturing defects typically arise where products are physically flawed, damaged, or incorrectly assembled. Manufacturing defects do not arise just because the product itself is dangerous or creates a risk of harm. Rather, the product must somehow differ from other identical products.[52]

The mere occurrence of a hydrogen incident will not create liability under this theory. There must be some defect that occurred in the manufacturing process, and this defect must have caused the injury. Defects could occur where impurities are mixed with the hydrogen or where the packaging containing the hydrogen is flawed or damaged.

Despite many decades of experience with hydrogen, a review of the case law did not produce any cases involving manufacturing defects and hydrogen. By contrast, there are many cases involving defects with other fuels. For example, in both *Guidry v. Frank Guidry Oil Co.*[53] and *Jackson v. Standard Oil Co.*,[54] damages were awarded following explosions caused by diesel oil contaminated with gasoline. Similarly, there are many cases involving contaminated kerosene,[55] propane,[56] and natural gas.[57]

It is possible that manufacturing defect cases will arise as hydrogen use

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RESTATEMENT (THIRD) OF TORTS: PROD. LIAB. § 1 (1998).

50. RESTATEMENT (THIRD) OF TORTS: PROD. LIAB. § 2 (1998). *See also* Caterpillar Tractor Co. v. Beck, 593 P.2d 871 (Alaska 1979); Dart v. Wiebe Mfg., Inc., 709 P.2d 876 (Ariz. 1985) (en banc); Cassisi v. Maytag Co., 396 So. 2d 1140 (Fla. 1981); Hoffman v. E.W. Bliss Co., 448 N.E.2d 277 (Ind. 1983).

51. RESTATEMENT (THIRD) OF TORTS: PROD. LIAB. § 2 (1998).

52. *See* Cavalier v. Werner Co., 976 F. Supp. 672 (E.D. Mich. 1997).

53. Guidry v. Frank Guidry Oil Co., 579 So. 2d 947 (La. 1991)

54. Jackson v. Standard Oil Co., 505 P.2d 139 (Wash. Ct. App. 1972).

55. *See, e.g.*, Schmidt v. Union Oil Co., 149 P. 1014 (Cal. Dist. Ct. App. 1915) (awarding damages where an explosion was caused by kerosene with a flashpoint of eighty-eight degrees Fahrenheit, rather than 110 degrees Fahrenheit, which was considered safe); Shermer v. Crowe, 186 S.E. 224 (Ga. Ct. App. 1936) (allowing for damages where kerosene was sold with a flashpoint less than 115 degrees Fahrenheit, which was the limit established by state law); Gulf Ref. Co. v. Jinright, 10 F.2d 306 (5th Cir. 1925) (affirming judgment for plaintiff where kerosene sold by wholesaler was mixed with gasoline).

56. *See, e.g.*, Blueflame Gas, Inc. v. Van Hoose, 679 P.2d 579 (Colo. 1984) (en banc) (failing to properly odorize using ethyl mercaptan); Parsons v. Honeywell, Inc., 929 F.2d 901 (2d Cir. 1991) (failing to properly odorize).

57. *See, e.g.*, City of Vila Rica v. Couch, 281 F.2d 284 (5th Cir. 1960) (establishing duty of gas wholesaler to odorize before distribution); Noa v. United Gas Pipeline Co., 305 So. 2d 182 (Fla. 1974) (finding that wholesaler must odorize gas before it is delivered to distribution pipe).

sticking one's hand blindly into a running automobile engine,[69] burning one's hand by spilling coffee,[70] and inserting one's hand into an operating meat grinder.[71] Public education about the safe use of hydrogen will help ensure that the risks are known and obvious, and thus limit liability.

Finally, even though hydrogen has been in widespread use for well over half a century, there have been no cases involving the failure to odorize hydrogen. This suggests that odorization of hydrogen may be less of an issue than odorization with other gases.

B. Negligence

It was recently suggested that negligence liability could result from a hydrogen incident involving "a breach of duty of care."[72] This analysis failed to consider all of the elements necessary to establish a prima facie case for negligence, and it ignored the defenses available to negligence actions.

1. Prima Facie Case for Negligence

There are four elements that must be proven to establish a prima facie case for negligence: (1) the defendant must have a duty to conform to a specific standard of conduct designed to protect a reasonably foreseeable plaintiff against an unreasonable risk of injury; (2) the defendant must breach that duty; (3) the breach must be the actual and proximate cause of the plaintiff's injury; and (4) the plaintiff must suffer damages.[73] Based on the research and the record regarding hydrogen, negligence theory is not likely to create unusual liability problems for the hydrogen industry.

First, it is well established that a duty arises only where the risk of harm is reasonably foreseeable.[74] Courts often look at the likelihood and magnitude of the risk to determine whether a particular risk of harm was reasonably foreseeable.[75] Courts also look toward the utility and social value of the activity in which the defendant was engaged—the greater the social value, the less likely an actionable duty will arise.[76] Hydrogen's buoyancy, fast dispersal rate, low

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Apr. 13, 1992).

68. *See, e.g.*, Garman v. Magic Chef, Inc., 173 Cal. Rptr. 20 (Cal. Ct. App. 1981).

69. *See, e.g.*, Johnston v. Hartford Ins. Co., 623 So. 2d 35 (La. Ct. App. 1993).

70. *See, e.g.*, Holowaty v. McDonald's Corp., 10 F. Supp. 2d 1078 (D. Minn. 1998).

71. Hernandez v. Biro Mfg. Co., 674 N.Y.S.2d 72 (N.Y. App. Div. 1998).

72. Moy, *supra* note 7, at 353–54.

73. RESTATEMENT (SECOND) OF TORTS § 328A (1965); *see also* Fabian v. E.W. Bliss Co., 582 F.2d 1257 (10th Cir. 1978); HealthONE v. Rodriguez, 50 P.3d 879 (Colo. 2002).

74. RESTATEMENT (SECOND) OF TORTS §§ 289, 291, 293 (1965); *see also* Lopez v. Three Rivers Elec. Coop., 26 S.W.3d 151 (Mo. 2000) (en banc); Nicole M. v. Sears, Roebuck & Co., 90 Cal. Rptr. 2d 922 (Cal. Ct. App. 1999).

75. *See, e.g.*, RESTATEMENT (SECOND) OF TORTS §§ 291, 293 (1965) (setting forth that negligence depends, in part, on the magnitude of the risk involved); *see also* Manchenton v. Auto Leasing Corp., 605 A.2d 208 (N.H. 1992).

76. *See, e.g.*, RESTATEMENT (SECOND) OF TORTS § 292 (1965); *see also* Matthews v. Ashland Chem. Inc., 703 F.2d 921, 925 (5th Cir. 1983) (finding that no cause of action lied against manufacturer of water cooler, where the electric motor of the water cooler ignited leaking propane gas, the cooler could not feasibly be produced without electric motors emitting some sparks, and the social value of water coolers far outweighs

heat radiance, tendency not to explode, lack of toxicity, and enviable safety record indicate that the magnitude of the risk associated with hydrogen may be less than the magnitude of the risk posed by current fossil fuels. Thus, fewer injuries may be deemed foreseeable.

Moreover, the use of hydrogen creates tremendous social value. Hydrogen produces only water and heat when consumed in a fuel cell, it can help reduce our dependence on foreign oil, and there are no known environmental risks if spilled.[77] Hydrogen also is the most abundant element in the universe and can be produced virtually anywhere on Earth. Unlike fossil fuels, almost any nation can have a domestic supply of hydrogen. Courts may conclude that the social value of hydrogen far outweighs the risk of injury in particular circumstances.

Second, the standard of conduct likely to be applied may mitigate against substantial liability. It is well established that manufacturers and distributors of butane, gasoline, natural gas, and propane are held to a very high standard of care because of the dangerous nature of their products.[78] To date, however, no court has deemed hydrogen to be a dangerous product, and hydrogen's many relatively benign properties may prevent it from being deemed so in the future. Thus, sellers and distributors of hydrogen may not be held to the same standard as sellers and distributors of butane, gasoline, propane, and natural gas.

Moreover, regardless of the standard of care involved, the safety record of the hydrogen industry may help limit liability. To determine whether the duty of care has been breached, courts often consider whether the defendant acted reasonably under the circumstances.[79] An important measure of reasonableness is often whether the defendant complied with standards and practices of the industry.[80] To date, hydrogen industry standards and practices have yielded excellent safety benefits. Thus, some courts may find no breach of the duty of care if standards and practices are complied with and the safety record associated with those standards and practices continues.

Third, even if a duty is established, and there is a breach of that duty, the defendant's actions may not be the actual cause of the plaintiff's injuries. There are many cases where a defendant was negligent, yet that negligence did not cause the plaintiff's injury.

Fourth, even if the defendant's actions are the actual cause of injury, they may not be the legal or proximate cause of the injury, thus reducing or

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the slight risk that an electric spark will ignite leaking propane gas).

77. U.S. DEP'T OF TRANSP., CLEAN AIR PROGRAM: SUMMARY OF ASSESSMENT OF THE SAFETY, HEALTH, ENVIRONMENTAL AND SYSTEM RISKS OF ALTERNATIVE FUELS, 3-14 (Aug. 1995), *available at* http://ntl.bts.gov/lib/000/700/711/CAP.html (finding "no significant environmental hazards associated with the accidental discharge of [hydrogen]").

78. *See, e.g.*, Ambriz v. Petrolane, Ltd., 319 P.2d 1 (Cal. 1957) (butane); Crane v. Adams, 84 So. 2d 530 (Miss. 1956) (gasoline); Hammond v. Neb. Natural Gas Co., 281 N.W.2d 520 (Neb. 1979) (natural gas); Blueflame Gas, Inc. v. Van Hoose, 679 P.2d 579 (Colo. 1984) (en banc) (propane).

79. *See* B&B Insulation, Inc. v. Occupational Safety & Health Review Comm'n, 583 F.2d 1364 (5th Cir. 1978).

80. *See, e.g.*, Rossell v. Volkswagen of Am., 709 P.2d 517, 523 (Ariz. 1985) (en banc) (finding evidence of industry practice generally is admissible regarding whether defendant's conduct was reasonable). If industry standards themselves are not reasonable, however, compliance with them will not be enough to protect one from liability. *See* Lambert v. Park, 597 F.2d 236, 238 (10th Cir. 1979).

eliminating liability.[81] The doctrine of proximate cause enables courts to find that public policy considerations, or other factors, make the connection between the defendant's actions and the injury too remote to warrant liability.[82]

Finally, hydrogen's lack of toxicity, fast dispersal rate, low heat radiance, tendency not to explode, and other relatively benign properties suggest that, even in the event of an incident, damages may be less than the damages frequently suffered as a result of butane, gasoline, propane, or natural gas incidents. Coupled with a strong safety record, this suggests that hydrogen will not lead to an insurability crisis, as recently suggested.[83]

2. Defenses to Negligence

Even if all of the prima facie elements are established, there are defenses that could reduce, or eliminate, liability for an incident involving hydrogen. The application of these defenses will depend upon the facts of the case and the defenses recognized under state law. The following is a brief overview of some of the more common defenses.

Most states have adopted some form of comparative negligence defense.[84] Under this defense, the plaintiff's damages are reduced by the extent to which the plaintiff was found to have been negligent.[85] For example, a defendant who negligently created a hydrogen leak may face reduced liability if the plaintiff negligently started a fire, such as by striking a match, with knowledge of the hydrogen leak.

Some states apply the doctrine of contributory negligence.[86] In these states, the general rule is that defendants will not be liable for any damages if the plaintiff also was negligent.[87] Using the example above, a defendant who negligently created a hydrogen leak may have no liability whatsoever if the plaintiff negligently started a fire, such as by striking a match, with knowledge of the hydrogen leak.[88]

81. *See, e.g.*, Thropp v. Bache Halsey Stuart Shields, Inc., 650 F.2d 817 (6th Cir. 1981).

82. *See, e.g.*, WILLIAM LLOYD PROSSER & PAGE KEATON, PROSSER AND KEATON ON THE LAW OF TORTS § 42 (5th ed. 1984).

83. Moy, *supra* note 7.

84. RICHARD J. HEAFEY & DON M. KENNEDY, PRODUCT LIABILITY: WINNING STRATEGIES AND TECHNIQUES § 5.02[1][b][i] (Law Journal Press 2001) (1994).

85. RESTATEMENT (THIRD) OF TORTS: APPORTIONMENT OF LIAB. § 7, Reporters' Note (2000); Orr v. United States, 486 F.2d 270 (5th Cir. 1973) (affirming decision limiting recovery of employee injured while working on power lines reduced thirty-five percent due to his comparative negligence).

86. HEAFEY, *supra* note 83, at § 5.02[1][b][i].

87. RESTATEMENT (SECOND) OF TORTS § 467 (1965); *see generally* Persinger v. Marathon Petroleum Co., 699 F. Supp. 1353, 1364 (S.D. Ind. 1988) (holding decedent contributorily negligent in entering petroleum storage tank without proper breathing equipment thereby barring the claim of his wife); Moczygemba v. Danos & Curole Marine Contractors, Inc., 561 F.2d 1149, 1154 (5th Cir. 1977) (surviving daughter barred from recovery because late father's contributory negligence proximately caused his own demise).

88. Contributory negligence can be a harsh doctrine, allowing negligent defendants to escape liability even where their negligence was far greater than plaintiffs' negligence. Thus, many courts have adopted the "last clear chance" doctrine, which allows a negligent plaintiff to nevertheless recover damages if the defendant, "by the exercise of ordinary care, could have avoided the consequences of the [plaintiff's] negligence." Pitts v. Mahan, 382 A.2d 1092, 1094 (Md. 1978).

Recovery also can be barred if the plaintiff assumed the risk of injury arising from the defendant's negligence.[89] Generally, the plaintiff must have known about the risk and decided to proceed in the face of that risk.[90] For example, a court has found that a person struck and killed by a train assumed the risk because she knew of the risk posed by trains yet, nevertheless, chose to cross the tracks rather than use an underpass.[91]

The bottom line is that establishing a prima facie case for negligence does not automatically entitle the plaintiff to a full recovery. Defenses are available that can limit or eliminate damage recovery. These defenses will be important in hydrogen cases, just as they are important in cases involving any other fuel or energy carrier.

C. Abnormally Dangerous Activities

The abnormally dangerous activities theory appears unlikely to pose a significant barrier to a hydrogen economy. The standard is not frequently applied, however, when it is applied, the facts generally show an extremely hazardous activity that is both uncommon in the community and conducted in close proximity to people.[92]

Abnormally dangerous activities are subject to a strict liability standard making the defendant liable for damages regardless of the amount of care exercised.[93] As noted by one court, liability is based upon exposing a community to an abnormal risk of serious injury.[94]

The Second Restatement sets forth a number of factors that should be considered in determining whether to find liability under abnormally dangerous theory. These factors include:

> a. The existence of a high degree of some harm to the person, land, or chattels of others;
>
> b. Likelihood that the harm from it will be great;
>
> c. Inability to eliminate the risk by the exercise of reasonable care;
>
> d. Extent to which the activity is not a matter [common within the community];
>
> e. Inappropriateness of the activity [in the location] where it is carried on; and

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89. RESTATEMENT (SECOND) OF TORTS § 496A (1965); *see generally* HEAFEY, *supra* note 83, at § 5.02[2].

90. RESTATEMENT (SECOND) OF TORTS § 496C (1965).

91. Saponari v. CSX Trans., Inc., 727 A.2d 396 (Md. App. 1999).

92. *See, e.g.*, Clay v. Mo. Highway & Transp. Comm'n., 951 S.W.2d 617 (Mo. App. 1997) (blasting); City of Northglenn v. Chevron U.S.A. Inc., 519 F. Supp. 515 (D. Colo. 1981) (storing gasoline near a residential area posed a threat to a nearby community); State Dep't of Envtl. Prot. v. Ventron, 468 A.2d 150 (N.J. 1983) (storing large quantities of mercury posed a threat to a nearby community).

93. RESTATEMENT (SECOND) OF TORTS § 519 (1965); *see also* Ashland Oil v. Miller Oil Purchasing Co., 1979 U.S. Dist. Lexis 11927 (M.D. La. 1979) (illustrating how a company was held strictly liable for engaging in abnormally dangerous activity).

94. McLane v. Northwest Natural Gas, 467 P.2d 635 (Ore. 1970) (illustrating the "basis of the liability is the creation of an abnormal risk"). *Id* at 639.

f. Extent to which its value to the community is outweighed by [the risks].[95]

Hydrogen falls short of the threshold required for liability under each of these factors. First, as discussed above, hydrogen has many favorable properties that tend to reduce the risk of serious harm. Although hydrogen has properties that present challenges, it appears that these challenges can be overcome with reasonable care. Thus, it does not appear that the risks of hydrogen rise to the level of risk typically found in abnormally dangerous activity cases.[96]

Second, there is no evidence that great harm is likely to occur as a result of a hydrogen incident. To the contrary, hydrogen's many favorable properties, coupled with its safety record to date, indicate that the likelihood of great harm is relatively low. By contrast, it is clear that some existing fuels can pose a significant risk of great harm under the right circumstances.[97]

Third, it appears that the exercise of reasonable care is capable of eliminating much of the risk associated with hydrogen. The record to date shows that hydrogen can be safely produced, transported, and stored in large quantities. The challenge for industry will be to maintain or enhance this record as hydrogen transitions to consumer use.

Fourth, in most cases, the presence of hydrogen should be appropriate in the location where it is found. For example, it clearly will be appropriate to have hydrogen at a hydrogen refueling station, just as it is appropriate today to have gasoline at a gasoline refueling station. As hydrogen use grows, it will be important to ensure that hydrogen infrastructure is not inappropriately located.

Fifth, the value to the community of a hydrogen economy should far outweigh the risks. As discussed above, hydrogen offers great promise to improve air quality and enhance energy security. Courts, no doubt, will find that at least some of the risks associated with hydrogen are offset by these benefits.

Finally, once hydrogen goes into widespread use, it will become common in the community and, therefore, will no longer present an abnormal risk. Like gasoline today, hydrogen will be an accepted, and indeed expected, feature of our neighborhoods and communities. This will reduce the likelihood that courts will apply the abnormally dangerous activity theory.

95. RESTATEMENT (SECOND) OF TORTS § 520 (1977); *see also* Allen L. Runtz, *After the Meter: Energy Products Liability in a Deregulated Environment*, 26 CAP. U.L. REV. 421, 431 (discussing how other forms of end-use energy are not considered abnormally dangerous due to their widespread use).

96. *See* Charles E. Cantu, *Distinguishing the Concept of Strict Liability for Ultra-Hazardous Activities from Strict Products Liability under Section 402A of the Restatement (Second) of Torts: Two Parallel Lines of Reasoning that Should Never Meet*, 35 AKRON L. REV. 31, 37 (2001) (providing a general review of activities held to be ultra-hazardous).

97. *Id. See also* Press Release, U.S. Environmental Protection Agency, Colonial Pipeline Company Civil Settlement (n.d.), *available at* http://www.epa.gov/compliance/resources/cases/civil/cwa/colonialfs.pdf (resulting in largest civil penalty in EPA history for a liquid petroleum product spill); Puget Sound Business Journal, *Pipeline Companies and Employees Indicted for Bellingham Explosion* (2001), *available at* http://www.bizjournals.com/seattle/stories/2001/09/10/daily28.html (discussing indictments of pipeline company officials for failing to fix pipeline that resulted in a fuel leak into a creek and subsequent explosion and fireball that killed three people).

V. CONCLUSION

Hydrogen-based energy clearly presents one of the nation's best opportunities to enhance national security, reduce pollution, and curb the emission of green house gases. Although it is prudent to consider potential liability issues, we should not raise the specter of litigation as an argument for avoiding hydrogen. Both the facts and the law clearly show that hydrogen is not likely to create unusual liability problems. To ensure that this remains the case, we must continue to invest in new standards, products, and procedures that will help ensure a safe transition to hydrogen as a common fuel.