

U. S. Fuel Cell Technology Speech (SAEPR -V10)
Neil A. Schilke, 2001 President, SAE International

Delegates, Honorable Guests, it's a privilege and an honor to speak as part of this Round Table on "New Vehicle Propulsion Technologies." My compliments to the other speakers for their excellent and substantive reviews.

My talk is to review so-called "other technologies" with emphasis on fuel cells and hydrogen fuels.

So, let's review the evaluations to date of the competitive technologies.

Fuel cell output – measured in terms of kilowatts per liter – has experienced a 20-fold improvement over the past 10 years. Currently, a single fuel cell, when operating at peak output, achieves 100 kilowatts, compared to maximum output of 5 kilowatts in the early 1990's. To put it into terms with which you are all familiar, a drive motor powered by that same fuel cell is roughly equivalent to 134 BHP, or a typical 4-cylinder gasoline engine.

We must recognize that any technology must be evaluated on a system basis. The interaction between individual vehicle subsystems, the operation of the vehicle in relation to our natural environment, and the safety, comfort and function for the operator are all key concerns.

As a systems engineer, I can say that fuel cell technology offers promise for the future, perhaps very dramatic promise, but it also creates a myriad of challenges between the vehicle, operator, and infrastructure that will need to be solved. As these challenges are solved, the automotive industry will find itself in the midst of change, perhaps very dramatic change. And, in fact, if all challenges are overcome, the world will find itself in a very dramatic Global Paradigm Shift.

It has taken a century to design and produce the modern automobile. However, our achievements to date will pale in comparison to the advancements in vehicle technology during the next several decades. And all parts of the world have both different challenges to overcome, as well as different capabilities from which to start.

Throughout history, continuous engineering advancements have made our vehicles safer and more reliable, reduced the impact of vehicle operation on our natural environment by means of reduced emissions and better efficiency, and created transportation systems that are more user friendly. These advancements have been made by improving existing technology, while continuing to rely on internal combustion engines as the primary power source. Today, however, we are at the forefront of fundamental developments in transportation technology that will revolutionize our vehicles.

During the last decade, the world has witnessed a synergy between vehicle and electronics technologies. The conversion of mechanical systems into electrically controlled systems in vehicles is taking place at a fast pace. So quickly, that a higher standard voltage system, 42-volt, is being developed and will soon be in production, globally.

Further, the conversion of the vehicle powertrain from purely mechanical to at least partially electric has also started.

In the 1990's we witnessed the first series of commercially produced hybrid vehicles. As you've already heard, these are vehicles that feature two power sources that can be used in a variety of power configurations. Typically, they involve some form of electric power, like batteries, a conventional engine, and an electrically based drive system. Currently, automotive manufacturers are in the process of developing what are called "soft" hybrid vehicles for the commercial market. "Soft" hybrids provide power assist, for high power situations like accelerations, and some form of energy recovery during braking.

This advancement in powertrain technology is the first logical step toward significantly increasing vehicle efficiency and enables automobile manufacturers to demonstrate electric drives as viable for widespread use and production. Government mandates to produce low or zero-emission vehicles and to improve fuel economy are also a driving force in adapting "clean technology" for widespread use in transportation. Fuel Cells can deliver this "clean technology," and that's the exciting incentive that drives all of today's extensive research and development.

Fuel Cells are electrochemical, energy conversion devices that convert the chemical energy of fuels, most commonly hydrogen, into electrical energy. The fuel cell combines this hydrogen and oxygen, in the presence of a catalyst, to produce electricity. With the only by-products being heat and water, fuel cells offer the automotive industry the potential of ultra-low or even zero emissions. In addition, fuel cells offer efficiency 2 or more times greater than our existing internal combustion engines. A feature of the fuel cell system that significantly contributes to its increased efficiency, as well as its anticipated durability, is that it produces energy using no moving parts.

The fuel cell system consists of a fuel, fuel processor, fuel cell stack, and a power converter/inverter. The fuel processor, or reformer, is needed whenever a fuel, other than pure hydrogen, is used in order to convert the fuel source to hydrogen. A fuel cell consists of two electrodes sandwiched around an electrolyte. Oxygen passes over one electrode and hydrogen over the other, generating electricity, water and heat.

As long as fuel and oxygen are supplied to the system, electricity will be generated and the application will be able to operate.

There are three broad application categories of fuel cells: Stationary, Portable, and Transportation. Current research has application for fuel cells in any situation where there is a demand for electrical energy. There are many uses for fuel cells — right now, all of the major automakers are working to commercialize a fuel cell car. Fuel cells are envisioned to power buses, boats, trains, aircrafts, and scooters, even bicycles. There will be fuel cell-powered vending machines, vacuum cleaners and highway road signs. Miniature fuel cells for cellular phones, laptop computers and portable electronics are on their way to market. Hospitals, credit card centers, police stations, and banks are all primary targets to use fuel cell technology to provide uninterrupted power to their facilities. Wastewater treatment plants and landfills have

the potential to use fuel cells to convert the methane gas they produce into electricity. The possibilities are endless, basically any required electrical power could be provided by fuel cell technology. However, for the purpose of our discussion today, we will focus on Transportation development and application.

There are several types of fuel cells that are distinguished by the electrolyte type that are used between the anode and cathode plates and their construction. Phosphoric Acid, Proton Exchange Membrane or Solid Polymer, Molten Carbonate, Solid Oxide, Alkaline, Direct Methanol Fuel Cells, and Metal Air Fuel Cells.

I would also like to point out that an application of portable fuel cells is also being researched for vehicle application. This would utilize auxiliary full-cell power units, termed as APUs, in conjunction with conventional engine systems to supply electrical energy while the vehicle is not in normal operation. While the engine is running, all required mechanical and electrical energy would be supplied to support vehicle systems, as is the case with conventional vehicles. However, when the engine is not running, the APU would supply electrical power to selected systems such as heating, air-conditioning, lights or other electronic devices that would maintain conditions that currently can not be supported for an extended period by on-board battery power.

The initial application of APUs will be in the commercial vehicle sector that will permit large diesel powered trucks to maintain cabin climate and heat to the engine and fuel delivery system, while the engine is not idling. In cold climates, this should translate into a reduction in fuel usage. The US Department of Transportation estimates that long-haul commercial trucks use an estimated 1800 gallons of fuel each year in idling conditions.

Automotive manufacturers, automotive suppliers, governmental agencies, suppliers, and energy companies in the United States are spending billions of dollars on fuel cell research. Many automakers estimate that between 7 and 20 percent of the vehicles sold during the next 20 years will be fuel cell powered. That could translate into nearly 40 million fuel cell powered vehicles on the road by 2021. In November 2001, the U. S. Fuel Cell Council identified 43 passenger cars, vans, and light trucks that are being tested and developed by automakers using fuel cells as a primary power source. Limited commercial introduction by U. S. automakers is estimated in perhaps as early as 2004.

A critical challenge to the commercialization and mass introduction of fuel cell vehicles is infrastructure. As I stated earlier, it has taken a century to produce the modern automobile. A similar evolution in fuel cell vehicles needs to be paralleled by a refueling and service infrastructure that will require time, planning, and extensive capital investment to accommodate large volumes of new vehicles for which the option of inter-city travel would be a requirement.

The concept of fuel cell technology has been with us since the 1800's and has been utilized successfully by the U. S. National Aeronautics and Space Administration since the 1960's. Yet there are significant developmental challenges to commercializing the technology safely for mass vehicle production.

Direct use hydrogen may potentially have the greatest overall benefits, and lead to the highest degree of success with fuel cell application for transportation. However, current ability to store and transport hydrogen, in quantities large enough to provide significant vehicle range, is something that needs to be resolved, and is being addressed. Alternative fuels, such as Ethanol, Methanol, Propane and even cleaner gasoline are being studied. Some of these fuels have the advantage of being more easily introduced into the already existing refueling structure. They may serve as an interim step towards the process of a hydrogen-fueling base.

When fuel cell technology will become a key component of public transportation is a subject of intense discussion among academics, government agencies, energy providers and mobility professionals.

The introduction of fuel cell auxiliary power units, for use in conjunction with existing engine technology, is forthcoming. This technology is particularly useful to the commercial truck industry. The U. S. Department of Energy has estimated the energy and maintenance costs of idling a diesel truck, in order to maintain cab heat and other functions, to be extremely costly on an annual basis. Research has already demonstrated that on-board auxiliary fuel cell power is a cost effective and energy efficient option for these vehicles. U. S. truck manufacturers are gearing up.

The first widespread use of fuel cells in transportation will most likely occur in the mass transit and fleet vehicle sectors. It is in these areas that the challenges of fueling and service infrastructure can be most easily addressed.

In passenger cars, the race is on. Automakers, energy companies, and fuel cell manufacturers have formed a plethora of alliances to develop the "ideal" prototype.

This is an exciting time to be part of the automotive engineering community! As we continue to develop, commercialize and implement this new technology, another challenge is the development of codes, standards and recommended practices. SAE International has been on the cutting edge of fuel cell technology and has established working committees to accomplish this task. SAE has published primers on fuel cells and has established a series of neutral forums for the open discussions of information among mobility professionals.

Today, I have only scratched the surface of the issue of fuel cell technology. There are tremendous resources for information in the U. S. Fuel Cell Council, the California Fuel Cell Partnership and through SAE International. All, off which, can be accessed via the World Wide Web.

It has been an honor to share my perspective with you today. Thank you.
