

Critical National Need Idea

Title: Novel Hybrid Vehicles System that utilize Alternative Fuel Cells in order to minimize oil dependence and the environmental impact of transportation.

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The United States is in a national transportation energy crisis in which the nation's laws and policies have encouraged the Nation to become energy reliant on hostile foreign states. Currently, according to the Energy Information Administration, the United States imports roughly five billion barrels of oil on an annual basis, this equates to large amounts of control by foreign companies and hostile nations. This control can be asserted based upon the needs and desires of foreign entities that do not have the United States best interest in their dealings. This situation needs to be corrected through government action by additional attention, administration principals and funding which are exclusively focused on solving the energy dependence crisis.

Our addiction to oil equates to the transfer of U.S. wealth and control to foreign companies and hostile nations. The critical national need of energy security and independence urgently needs to be addressed by innovative energy efficient technology development. A new TIP program focused on energy technologies like that described in this white paper would greatly help to accelerate and achieve oil independence for our nation. In addition to oil independence, the reduction of global warming gases and their consequences to the nation poses another critical need that would be impacted by such a program. It is now clear that global and irreversible environmental degradation are directly linked to the way energy is used for transportation systems. Scientists generally agree that carbon dioxide, CO₂, which is produced as a by-product of hydrocarbon combustion, is a major contributor to climate change. A recent National Oceanic and Atmospheric Administration study concludes that changes to the global climate due to rising CO₂ concentrations are largely irreversible for more than 1000 years after CO₂ emissions are completely stopped¹. Transportation related CO₂ emissions accounted for 34% of all CO₂ emissions in the United States during 2006². While most economic sectors are moving fast towards consuming and producing energy from a diversified mix of resources in which renewables are prominent, the transportation sector remains dependent on petroleum.

As last summer's \$ 4 dollar gasoline price exemplifies, dependency on oil exposes the US economy to petroleum price volatility and interruptions in supply. The cost of transportation is so linked to the cost of petroleum that uncertainty in petroleum prices impacts all transportation dependent economic sectors. For example, in the first half of 2008, increasing oil prices contributed to global inflation which put at risk Federal Reserve measures to combat a looming recession. Recently, a fast drop in oil prices has reversed near-term inflationary pressure and has contributed to deflation. The fast and unpredictable change and strong influence on the overall economy reduces the capacity of the US government and US companies to forecast and adapt. Therefore petroleum dependence directly aggravates micro and macro-economic cycles.

This white paper focuses solely on the nation's reliance on oil products in the transportation sector and urges the development of alternative hybrid vehicles which utilize alternatively fueled fuel cells and

¹National Oceanic and Atmospheric Administration, "New Study Shows Climate Change Largely Irreversible", NOAA website (http://www.noaanews.noaa.gov/stories2009/20090126_climate.html), January 2009

² United States Department of Energy, EIA report, "Emissions of Greenhouse Gases in the United States 2006", DOE/EIA-0573(2006), November 2007

advanced chemistry battery storage systems. The objective is to create a fully electrochemical engine with the capacity to be powered by the grid and/or the best available fuel. These fuel cell systems can use fuels such as ethanol, methanol and other bio-fuels produced here in the U.S. to internally generate the hydrogen necessary to operate the fuel cell. Essentially, an alternative hybrid vehicle is a range extended electric vehicle, similar to the GM Volt, but which uses alternative fueled fuel cell systems, instead of an internal combustion engine, to produce additional electricity for electric drive-trains or to actively recharge the battery while driving. Plug-in Battery/Fuel cell power-trains powered by bio-fuels would significantly enhanced energy efficiency over today's hybrid/ ICE systems and significantly reduce global warming emissions.

These critical issues of oil dependence and environmental impact need to be addressed with a sustained effort on a national level. The U.S. has poured billions into combating oil dependence, but large scale tangible technologies and infrastructure has not been the product. Such innovation has primarily come in the form of either hybrid vehicles or electric vehicles. These stop gap technologies are currently being researched and developed, but each viable technology still requires oil which has geo-political consequences and strong environmental impacts. For example, current hybrid technology still uses oil based products for energy production. According to HybridCars.com as of December 2008, there are currently over 40 production and concept vehicles that use hybrid technology but each of these vehicles still uses oil or fossil fuels as the main power source. Hybrid vehicle technology needs to be taken to a new level that eliminates the need for foreign based oil reserves and greatly reduces the addition of CO₂ to the atmosphere. This can be accomplished through the use of alternative hybrid vehicles that use bio-fuel driven fuel cells instead of gasoline engines to generate electricity for long range driving.

This approach will be transformational to the automotive and energy production industries in that it will be home grown technology that utilizes carbon-neutral fuels that can be grown domestically. Additionally, the use of a battery/fuel cell engine drastically surpasses the efficiency of today's fossil fuel hybrid cars.

The technology path toward alternative hybrid vehicles will be to develop energy systems on a plug-in electric vehicle platform. Integrated within this platform will be alternatively fueled fuel cells and advanced battery technology. The fuel cells and advanced battery technology will have a symbiotic relationship. This is necessary because fuel cell technology works best in constant energy output situations and not in ones where the fuel cells have to provide direct large power outputs needed for automobile acceleration. This additional power will come from energy stored in an advanced battery. Stored energy will be constantly replenished from energy created by the fuel cell.

Recent advances in battery technology will encourage the development of alternative hybrid vehicles. Currently, lithium-ion battery cell chemistry is surpassing the industry standard nickel metal hydride chemistry for automotive needs. Lithium-ion batteries have twice the energy density of nickel metal hydride, which means electric vehicle batteries need half the size and weight to produce the same power. The next logical step, which currently is not being funded by other government programs, will be to integrate new alternatively fueled fuel cells with lithium-ion batteries to produce a novel power-train for an electric vehicle with a driving range acceptable by most consumers.

The current funding of fuel cell technology has been directed toward creating a new expensive hydrogen infrastructure to support automobile fuel cell systems that only use pure gaseous hydrogen to produce energy. This focus is too limited and constrained to one approach that may not be successful. Research funding is needed from TIP that should be directed towards creating fuel cells that do not rely on new infrastructure, but on fuel cell technology that can use available bio-fuels. According to Argonne National Labs, hydrogen will cost twice as much as gasoline at the pump and require the installation of a half trillion dollar infrastructure. In addition, large scale hydrogen production is currently not available. This infrastructure and dependence on hydrogen can be avoided through development of automobile fuel cell systems that use alternative fuels such as bio-diesel, bio-alcohols or bio-derived ethers. The transformation can occur fairly quickly because current gasoline infrastructure is suitable for liquid bio-fuels with minimal retrofit. This approach would greatly reduce the import of oil from a small cadre of nations and redirect our automotive energy needs towards domestically manufactured electrochemical battery and fuel cell systems utilizing home grown bio-fuels.

The United States scientific community is seeing the need to remove foreign control over the domestic energy requirements. Recently, the President's Council of Advisors on Science and Technology (PCAST) released "The Energy Imperative: Report Update", November 2008. It states the following:

"The recent turmoil in global markets has led to a drop in oil prices from mid-2008 highs, as well as a slowing of private investment in the development and deployment of new energy technologies. The clean-energy market will likely cool somewhat as the private sector is less able to invest in advanced technologies that increase up-front costs and risk. Nevertheless, from a long-term perspective, the fundamental need for national and global energy security and environmental sustainability remains unchanged. While an economic slowdown may temporarily ease the pressures associated with a rapid growth in demand, consistent government investment in this area remains essential, particularly in the area of basic research focused on breakthroughs that will enable broadly competitive clean and efficient energy technologies."

This gloomy outlook of industry investment and the call for research and technology development indicates the strong necessity for governmental involvement in high-risk, high-return technologies that can transform the nation's energy needs. Industry and capital investors are shifting to lower risk investments because of the current economic situation. This shift is stifling the development of step-out technologies described here which are important to the growth of a self sustaining domestic clean-energy economy. It is therefore crucial that additional government support from a program like TIP be made available to fill the gaps that now exist in government funding that are focused on hydrogen based technologies. Such a TIP program would greatly accelerate the growth of electrochemical and bio-fuel technologies necessary to enable such a transformation in our economy. .

The PCAST report above sums up with bold accuracy the need for TIP investment in alternative hybrid technology: "The need for dramatic improvements in the U.S. energy sector remains as apparent today as it did in 2006, when PCAST published The Energy Imperative: Technology and the Role of Emerging Companies. In the past year, fuel costs reached record levels. Meanwhile, global carbon emissions continue to increase and the Nation's transportation sector remains heavily dependent on oil." Finally,

the reports state a warning against slowed innovation: “The long-term prosperity of the United States depends on continued innovation in technologies for electric power generation, transportation, and industrial uses.”

There are substantial gaps in government funding for alternative hybrid vehicles using alternative fuel, fuel cells and advanced chemistry battery storage systems. The United States Department of Energy established the Energy Hydrogen Program to support the overall strategic plan towards a hydrogen economy³. A total of \$1.2 billion over 5 years was committed to DOE’s program that primarily focuses on the hydrogen economy and infrastructure and promotes fuel cell vehicles using onboard hydrogen as a fuel. The scope of the Energy Hydrogen Program encompasses basic research, production and delivery, storage, conversion (fuel cells), technology validation, safety/codes/standards, education and system analysis/integration. There is no support for alternative fueled, fuel cell/battery based hybrids and little support in general for pragmatic technologies like hybrids.

In response to energy independence and environmental need, there are several corporations and industries that would compete for financial support to develop alternative hybrid vehicle systems. Ener1, Inc., which is the parent company of EnerDel (a Li-ion automotive battery maker) and EnerFuel (a fuel cell developer) would be candidates for this competition. In addition, the Toyota, Hyundai, Honda, Ford, GM, Nissan, VW, Mazda and Chrysler are pursuing or have pursued this technology, but have not demonstrated a commercially feasible system that is based on alternative fuels other than hydrogen. Recent advances, however, in high temperature membranes and in reformer technology now point to a new way to design automotive fuel cell systems using liquid fuels that overcomes past issues. This opens up a window of technological opportunity for TIP.

There are several stationary fuel-cell companies that use alternative fuels to generate energy. These include GE, Ballard, Nuvera, Idatech and Plug Power. These companies currently have working alternative fuel-cell technology for stationary applications which could be utilized for automotive needs if paired with advanced battery systems. Most companies still focus fuel-cell technology on hydrogen alone because of the complexities of using other alternative fuels. Competitive funding and government encouragement would help mitigate this mind set.

Vehicle manufacturers are the most likely institutions to pursue alternative hybrid vehicles. They understand the need to produce vehicles that enable the use of alternative fuels but they do not have the desire or means to venture into specialized areas. The switch to alternative hybrid technology is a long and cumbersome process which requires large amounts of capital and thorough knowledge of fuel cell and battery systems. According to www.autoobserver.com, “the Big Six automakers reported sales declines. In total, the industry sold 13.2 million vehicles for an 18 percent drop from 2007’s 16.1 million.” 2008 was the worse year for the Big Six since 1992. This level of decline will preclude vehicle manufacturers from investing resources, money and engineering, into long term high-risk, high-reward activities.

³ United States Department of Energy, United States Department of Transportation, “Hydrogen Posture Plan”, December 2006.

This type of high level research is going to be left to innovative smaller research and development firms. Unfortunately, capital for such R&D activities is not readily available without some cost shared support from government institutions like TIP. Automobile companies and private investors do not have the capital to invest in large research and development projects and without government intervention, the high-risk, high-reward project of alternative hybrid vehicles will not become a reality. As a result, the U.S. dependence on foreign oil and the harsh environmental impact of oil will continue. In addition, competing countries will eventually pass the U.S. in alternative fuel development if there is a failure of capital infusion. It is essential that TIP invest in this technology, as no other institutions appear willing and able to take the risk.