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GETTING OVER THE BARREL – ACHIEVING INDEPENDENCE FROM FOREIGN OIL IN 2018

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USAWC STRATEGY RESEARCH PROJECT

GETTING OVER THE BARREL – ACHIEVING INDEPENDENCE FROM FOREIGN OIL IN 2018

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GETTING OVER THE BARREL – ACHIEVING INDEPENDENCE FROM FOREIGN OIL IN 2018

> America is addicted to oil, which is often imported from unstable parts of the world. The best way to break this addiction is through technology
>
> —President George Bush's 2006 state of the Union Address

The purpose of this document is to prove that the United States can achieve independence from foreign oil imports by leveraging domestically available energy resources and converting our fleet of 240 million internal combustion based vehicles to alternate fuel sources. Reducing or eliminating the nation's dependence on foreign oil imports will improve the security of the United States by guaranteeing an abundant, diverse and readily available domestic energy supply. Oil independence will free the Unites States from economic coercion inflicted by the world's oil producers via price fixing and production quotas. The leverage oil producing states wield will evaporate as the United States gains its energy independence. Additionally, oil independence will enable the United States to reevaluate many aspects of its foreign policy and diplomacy initiatives. As a result, current trade agreements and defense policies may no longer remain relevant.

The United States is addicted to oil - the American way of life is fueled by oil. We rely on it for the vast majority of our transportation needs. Most Americans have a car, some even have two or three - maybe even a low gas mileage sport utility vehicle, motorcycle, boat or airplane. The mobility oil provides us today is unprecedented in the history of man and we've grown accustomed to a plentiful supply of inexpensive oil. Americans are more tied to automobiles and the associated oil leash than ever before. The idea of significantly changing our way of life by reducing oil consumption, and

losing the associated mobility, freedom and conveniences we enjoy is frankly an anathema to most Americans. Simply stated, the average American is addicted to oil.

Our economy is oil fired, relying on massive distribution systems to transport goods across the country and worldwide overnight. The blood that courses through the nation's thousands of miles of highways, rail networks, ports and air corridors is oil. Without relatively cheap and abundant oil, the American economy would seize up like an engine with no oil in it.

Although oil imports benefit the United States economy in the short term, they also jeopardize it in the long term as we become more and more dependent on foreign oil. The largest component of the United States trade deficit is the cost of importing oil.[1] In October 2008 the United States imported $208.9 billion of goods and services and exported only $151.7 billion, generating a monthly trade deficit of $57.2 billion.[2] In the same month, the U.S. imported over $29.8 billion worth of foreign oil, roughly 15 percent of the total imports for the month.[3]

In 2007 alone, the United States paid over 291.7 billion dollars[4] to import 4.39 billion barrels of crude oil.[5] Every barrel purchased represents a transfer of wealth and jobs from the United States to the oil exporting country. The high oil prices of 2008 fueled one of the biggest wealth transfers in history. In 2008, the United States paid over 435.2 billion dollars to import roughly the same amount of oil it imported in 2007.[6] Based on the average cost of a barrel of crude oil increasing from $72.33[7] in 2007 to $99.08[8] in 2008, the United States paid $141.7 billion more for oil in 2008 than it did in 2007. This extra $141.7 billion cost United States' consumers an additional 388.2 million dollars a day.

At least two of the countries benefitting from this windfall profit are using their newly accumulated power to oppose the national interest of the United States. Venezuela's president, Hugo Chavez, is using his wealth to expand his influence in South America and to build relationships and alliances potentially harmful to the security of the United States. Although the United States does not purchase oil from Iran, Iran still benefits from the increased price of crude oil and associated wealth transfer from other countries. The billions of dollars Iran receives in oil revenue make it less susceptible to the United States' sanctions on Iran's nuclear programs. The Council on Foreign Relations 2006 study on The National Security Consequences of Oil Dependency[9] highlights several key impacts of oil dependency on national security. Their work indicates that the lack of sustained focus on energy issues is undermining the United States' foreign policy and national security. Additionally, they postulate that the United States' growing dependency on imported oil increases the nation's strategic vulnerability and constrains the ability to pursue many strategic foreign policy and national security objectives.

To put America's addiction in context, consider that the United States has only 5% of the world's population, but uses over 25% of the world's oil.[10] The United States of America consumes approximately 21 million barrels of petroleum products every day.[11] Transportation consumes about 70 percent of the nation's oil; this figure is expected to remain constant through 2020.[12] In 2007, the Unites States consumed an average of 15.1 million barrels of crude oil per day for transportation.[13] Each barrel of crude oil yields several varieties of fuel and other petroleum products. Gasoline accounted for roughly 61 percent of total transportation oil usage, with diesel and jet fuel

accounting for 28 percent and 11 percent respectively.[14] In order to limit the scope of this document, proposed changes focus solely on ground based, non-rail transportation. However, additional oil created or saved via these changes produces the same basic ratio of transportation fuels per barrel: 61 percent gasoline, 28 percent diesel and 11 percent jet fuel.

Over 12 million barrels or 58.2%[15] of the nation's petroleum requirements are imported from sources around the globe each day. The United States produces slightly more than 5 million barrels of crude oil every day.[16] To put this in perspective, consider that the United States produces more oil in a day than it imports from its three largest suppliers: Canada (1.888 m/bpd), Saudi Arabia (1.447 m/bpd) and Mexico (1.409 m/bpd) combined.[17] Although the Unites States' crude oil production dwarfs its individual oil supplier's contributions, it still falls far short of fulfilling the nation's requirements. Based on the financial crisis of 2008, the Energy Information Agency (EIA) forecasts United States oil usage actually decreasing for the remainder of 2008 and all of 2009. Even with potential short term decreased oil consumption in the United States, the remainder of the world is still forecast to increase usage by an additional 84 thousand barrels per day in the remainder of 2008. The EIA's 2009 world forecast anticipates an increase of 41 thousand barrels of oil per day. Cumulatively, this represents an increase of 125 thousand barrels a day above the October 2008 usage level.[18]

As the current global economy reaches equilibrium in the coming months to years, oil usage is expected to resume its upward trend. From 1973 to 2007, United States oil usage averaged a seemingly modest 1.85% annual increase.[19]

However, applying a mere 1.85% increase in United States oil consumption projected out for ten years through 2018 equates to an increase in oil use by over 2,400,000 barrels a day, or 876,000,000 barrels a year. Based on a barrel of oil costing $57 on 17 November 2008, this represents an increase in United States oil import expenditures of over $136 million per day, or $49.9 billion per year in 2018. While the United States demand for oil will most likely increase in accordance with the historical rates in the long term, the nation's ability to produce crude oil will probably decrease unless new domestic crude oil fields are found or existing fields are developed. From 1973 to 2007, the United States crude oil production rate decreased an average of almost 122,000 barrels per year.[20] Without significant investment in oil exploration, oil field development or new oil recovery technologies the United States oil production rates will continue to decrease. If production decreases at the same rate it did from 1973 to 2007, the United States will only produce 3,730,000 barrels per day in 2018, a drop of over 32% from 2007 production levels.[21] As the Nation's requirements for oil continue to grow and current domestic oil field's yield diminish, the United States will have to risk increased reliance on foreign oil imports, or commit to finding domestic solutions to meet the increased demand.

Fortunately, the United States has a myriad of domestic means available to reduce and eventually eliminate dependence on foreign oil imports. Many of these means have been historically cost prohibitive to implement; in many cases the cost of replacing foreign oil via an alternate domestic source is much more expensive than simply continuing to import foreign oil. However, with instability in the crude oil markets, ever increasing oil usage and popular recognition by politicians, national security

professionals and the average American, the need to switch to domestic alternatives from foreign oil is increasingly outweighing the cost of implementing domestic oil alternatives.

In order to reduce and eventually eliminate foreign oil dependence the United States must produce more domestic oil, provide domestic alternatives to oil and embrace oil conservation. Although these measures are simply stated, implementing them will require significant government investment, political will and an information campaign near the equivalent of President Kennedy's putting a man on the moon crusade to clearly capture the will of the public and to galvanize their support. To avoid expanding the scope of this document, the ways and means to endear political will and public support will not be addressed. The following sections analyze each of the three methodologies (producing more domestic oil, providing domestic alternatives to oil and conserving oil).

Increasing Domestic Oil Production

The United States produces over 5 million barrels of oil every day from existing domestic oil fields.[22] By increasing oil exploration and developing known but undeveloped oil fields the United States can significantly increase oil production. Additionally, the United States can create oil by converting coal to oil and by extracting oil from oil shale. This section examines how the United States can significantly expand domestic oil production by leveraging all three of these approaches.

Increase Oil Drilling. The United States possesses billions of barrels of untapped oil. The United States Minerals Management Service (MMS) estimated in 2006 that there is in excess of 85 billion barrels of undiscovered but technically recoverable oil

located within the nation's Outer Continental Shelf (OCS).[23] The MMS' assessment is proving accurate – Chevron discovered a vast oil field 175 miles off of the coast of Louisiana in mid 2006 estimated to contain between three and 15 billion barrels of oil.[24] By 2013, it is estimated that Chevron's field coupled with other deep water oil fields in the Gulf of Mexico will produce over 800,000 barrels of oil a day, accounting for close to 11% of US oil production. In addition to the MMS' offshore oil estimates, the United States Geological Survey (USGS) forecasts significant increases in technically recoverable oil in the continental United States and Alaska. In early 2008, the USGS revised its assessment of the Bakken formation in North Dakota and Montana from a reserve of 151 million barrels of oil up to 3.6 billion barrels of oil, almost a 25 fold increase.[25] The USGS's 1998 assessment of area 1002 in the Alaskan National Wildlife Refuge (ANWR) estimates there are almost 21 billion barrels of technically recoverable oil.[26] Although the assessment is over 10 years old, the USGS estimates that seven billion of the 21 billion barrels of oil are economically recoverable at $40 a barrel. ANWR area 1002 is expected to produce 780,000 barrels per day in 2018.[27]

The technological developments in oil exploration, recovery, and production developed between 1998 and 2008 coupled with the increase in the cost of oil will very likely expand the amount of economically recoverable oil. Between them the Outer Continental Shelf, Bakken formation and ANWR area 1002 possess an estimated 109 billion barrels of technically recoverable crude oil. Using the cost of oil on 17 November 2008 of $57 a barrel, over 91 billion barrels of the combined 109 barrels are assessed to be economically recoverable.[28] Although this oil is technologically and economically recoverable, it will take years of exploration, infrastructure development, and

incremental production to realize the benefits of these new oil fields. Best estimates for large scale production range from 2012[29] for the Bakken formation, to 2012-2018[30] for the OCS fields and 2018[31] for ANWR production (assuming ANWR exploration and drilling restrictions are eliminated by Congress). The long lead time to realize the gains from these fields coupled with decreasing yields from existing oil fields and the United States ever increasing demand for more oil makes it highly unlikely that the nation can drill its way to oil independence. However, increased production can stabilize and potentially nominally increase domestic oil production levels. As such, increasing domestic oil production is a key component in the quest to gain independence from foreign oil imports.

Coal to Oil Conversion. Coal can be converted to oil via the Fischer-Tropsch coal-to-liquid (CTL) process, also called the Direct Coal Liquefaction (DCL) process. The Fischer-Tropsch process was invented in Germany in the 1920s.[32] Starved for oil by allied actions, Germany turned to CTL production to fuel its war machine during World War II, producing 124,000 barrels of coal based oil per day.[33] Likewise, the South African Apartheid regime turned to CTL to provide domestic oil when faced with international oil embargos. Today, South Africa is the largest producer of CTL oil, converting coal to 195,000[34] barrels of oil per day, fulfilling approximately 30%[35] of its entire oil requirement. Since its invention the process has been improved significantly, yielding higher output and more environmentally friendly fuels[36] via the Indirect Coal Liquefaction process (ICL).

The United States has the largest deposits of coal in the world. The Department of Energy estimates that the United States has in excess of 264 billion tons of

recoverable coal.[37] At current usage rates, America's coal reserves will last for another 245 years.[38] Both the DCL and ICL CTL processes can produce two barrels of oil from one ton of coal.[39] Producing 2 million barrels of oil per day via the CTL conversion process would require 365 million tons of coal per year. Coupled with existing coal consumption of roughly one billion tons per year, the United States has adequate coal for approximately the next 183 years.

The Department of Energy estimates that CTL oil can be produced economically at $40 per barrel[40]; however, other sources believe the production cost is significantly higher, upwards of $75 a barrel.[41] Part of the cost per barrel can be reduced by other commercial products produced via the ICL CTL process: .415 KWh of electricity, worth roughly $1.50 and .14 barrels of naphtha worth approximately $6.50. There are multiple small to mid-sized facilities under construction, in design or in the midst of a feasibility study. The first few plants are anticipated to start production as early as 2011.[42] As with the production cost per barrel, total coal to oil production estimates vary. Low end estimates forecast 800,000 barrels per day with high end estimates reaching almost 3 million barrels per day by 2030[43].

As with increased oil exploration and drilling, building enough coal to oil conversion production facilities to meet a significant portion the United States oil requirements will take decades. However, oil production from the initial production facilities in 2011 will start to reduce our foreign oil dependency. If CTL proves to be profitable, and production reaches the 2 million barrel per day mark by 2020 as predicted by the National Coal Council, coal to oil conversion could replace one sixth of our foreign oil imports.

Oil Shale Extraction. Oil shale is a carbonate rock rich in organic sedimentary material called kerogen. Kerogen can be converted into oil via heating in the chemical process of pyrolysis.[44] Depending on the richness of oil shale, it can produce between 5 and 100 gallons of oil per ton of shale.[45] Oil shale is considered recoverable if it is rich enough to produce at least 15 gallons of oil per ton.[46] Over 80% of the world's known oil shale reserves reside in the United States.[47] Although all of this shale isn't technically recoverable, RAND Corporation estimates that recoverable shale could yield 800 billion barrels of oil – more than triple the proven oil reserves of Saudi Arabia.[48] To put 800 billion barrels of oil shale derived oil into perspective, consider that the United States consumes about 21 million barrels of oil per day. If the United States can produce 2 million barrels of oil shale petroleum per day, the recoverable 800 billion barrels worth of oil shale would last for almost 1100 years.

Although there is massive potential to produce huge quantities of domestic oil via oil shale, there are significant economic, technological and environmental challenges to producing oil shale on a wide spread commercial basis; all three of these challenges are closely linked. Oil giants Chevron, Shell and ExxonMobil are all researching and developing efficient and cost effective oil shale production methods.[49] All of these technologies are either in the testing or small scale production phase. Many of these tests are proving promising; however they haven't proven to be efficient enough to be deemed economically viable.[50] Production of oil from oil shale has a myriad of negative impacts on the environment. Large scale production will significantly increase green house gas emissions during the production process. Both air and local water quality will

decrease based on gas emissions and run off of heavy metals released in the extraction process.[51]

These hurdles are daunting; however, the consensus between oil shale experts is that the oil shale industry will meet these challenges and produce 2 million barrels of oil shale per day by 2020[52] and over 3 million barrels per day by 2025.[53] The additional domestic oil produced via oil shale by itself won't be sufficient, or timely enough to free the United States from dependency on foreign oil in the near term. However, as production technology matures and overall production increases in the next five to twelve years, up to the 2 million barrels per day level, the United States will markedly reduce its dependency on foreign oil imports. The additional 2 million barrels of oil shale produced oil is roughly equivalent to the United States' 2007 daily imports from Venezuela (1.148 mbpd), Algeria (.443 mbpd), Kuwait (.175 mbpd), Brazil (.165 mbpd) and Libya (.084 mbpd) combined.[54]

Potential Benefits of Increasing Domestic Oil Production. When combined, increased oil production, coal to oil conversion and oil shale extraction can markedly decrease foreign oil imports. By 2018, the Alaska National Wildlife Refuge and Outer Continental Shelf oil fields are expected to produce 780,000 and 800,000 barrels per day respectively. Bakken oil production is templated to increase through 2018, and should contribute roughly 25,000 barrels per day. Together, these three resource areas should produce 1,605,000 barrels of crude oil per day. Although America can't drill her way to foreign oil independence, the additional 1,605,000 barrels per day from domestic drilling will significantly reduce the need to import foreign oil in 2018. The economic value of this domestic oil exceeds $91 million a day, and over $33.4 billion a year.

With estimates ranging between 800,000 and 3,000,000 barrels per day by 2030, coal to oil conversion will significantly help reduce the foreign oil import requirement in 2018. Averaging production estimates and projecting them on a linear plot equates to roughly 860,000 barrels per day of coal derived oil by 2018. This represents a reduction of United States dollars flowing to oil exporting nations in the amount of $49 million a day, or over $17.8 billion a year.

Oil shale production is estimated to reach 2 million barrels per day by 2020. Plotting production on a linear scale from 2008 through 2018 projects an estimated production rate of 1,666,000 barrels of oil shale derived oil per day by 2018. Based on this level of production, oil shale derived oil will reduce the cost of foreign oil imports by over $94 million a day, or $34.6 billion a year. Figure 1 depicts the potential benefits gained from increasing domestic oil production.

Effects of Increasing Domestic Oil Production by 2018

System	Action	Effect by 2018 (in barrels)	Daily Savings ($ million)	Annual Savings ($ billion)
Increase Oil Drilling	Produce	1,605,000	$ 91.4	$ 33.3
Coal to Oil Conversion	Substitute	860,000	$ 49.0	$ 17.8
Oil Shale Extraction	Substitute	1,666,000	$ 94.9	$ 34.6
	Total Savings:	4,131,000	$ 235.3	$ 85.7

Figure 1.

Providing Domestic Alternatives to Oil

The United States is blessed with abundant and diverse energy resources. This section examines how the United States can develop and leverage these resources to

reduce foreign oil imports by either directly producing petroleum products (bio fuels and natural gas) or by providing alternative energy sources (hydrogen, nuclear, wind and solar) that can replace oil.

Increase Biofuel Production. Biofuels can be produced from a wide array of sources: sugar cane, vegetable oil, animal fat, corn, soybeans, jatropha seed oil, palm oil, switch grass and even algae. Biofuel production techniques and technologies vary widely based on the input source – sugar-based, starch-based or oil-based. This document only examines corn-based ethanol production. The other production sources listed aren't as commonly produced in the United States, or produced in a large enough amounts to make a significant impact on reducing oil dependency. However, these fuels are extremely viable; Brazil produced over 5 million gallons of sugar-cane based biofuel in 2007.[55]

The Unites States produced over 11 billion gallons of corn based ethanol in 2008[56], fulfilling more than 4% of the United States annual gasoline requirements.[57] More processing facilities are under construction and, in the next few years the Renewable Fuels Association estimates an increased ethanol production capacity of over 2.2 billion gallons.[58] Corn based ethanol is sold to U.S. consumers in two basic forms, as E10 or as E85. E10 is a mix of 90 percent traditional gasoline and 10 percent ethanol and is sometimes called gasohol. E10 works the same as traditional gasoline; however it is more environmentally friendly, producing less caustic emissions.[59] E10 accounts for over 33% of all gasoline sold in the United States.[60] E85 is a blend of 85 percent ethanol and 15 percent traditional gasoline and is only usable in specially designed flex-fuel vehicles. E85 is typically cheaper than standard gasoline; the

national E85 and gasoline averages in early December 2008 were $1.53 and $1.65 per gallon respectively, placing E85 approximately 7 percent cheaper on average than gasoline.[61] However, E85 does not provide the same amount of power as traditional gasoline, E85 fuel economy is typically 20-30% below gasohol or traditional gas.[62] Flex fuel vehicles can use E85, E10 or standard gasoline. In states where E85 is significantly cheaper, such as Iowa or Texas where E85 is 18 percent and 22 percent cheaper than traditional gasoline respectively[63], E85 may be the most cost effective fuel.

In 2008, corn based ethanol production accounted for 23 percent of the United States corn supply, up from 11.5 percent in 2003.[64] There are a multitude of arguments against using corn to produce ethanol based on the amount of corn ethanol production takes away from the food supply and export market. The increase of 11.5 percent of the nation's corn supply dedicated to ethanol production coupled with the increased cost of food at the grocery store seems to support this argument. However, considering that the United States corn production increased from 9 billion bushels in 2003 to 13.1[65] billion bushels, with only an additional 1.9 billion bushels dedicated to ethanol production while exports simultaneously increased by 800,000 million bushels disproves the argument that ethanol alone is increasing food prices. Additionally, a 56 pound bushel of corn produces 2.8 gallons of ethanol and 18 pounds of high protein distiller's grains for livestock and poultry feed.[66] These residual grains effectively reduce ethanol corn consumption by a third because they can be used to fulfill a large portion of the corn feed requirement.

Although corn based ethanol production will increase over the next few years, the United States Department of Agriculture forecasts that growth will start to slow in 2015

based on the amount of corn the United States can consistently produce. Ethanol production growth through 2015 is predicted to add an additional 3 billion gallons per year to the United States gasoline supply.[67] Annual production of 14 billion gallons of ethanol will account for approximately 5 percent of the United States gasoline requirement, a one percent increase in capacity (3 billion gallons) from 2008.

Natural Gas. The Department of Energy estimates that the United States possesses in excess of 1525 trillion cubic feet[68] of domestic natural gas reserves, and that the United States consumed 23,054,056 million cubic feet[69] worth of natural gas in 2007. Based on these estimates and estimates of future natural gas consumption, the United States has roughly 75[70] years of natural gas resources available. Natural gas accounts for roughly 22 percent of the nation's energy production.[71] It is used for a myriad of purposes: electrical power generation, residential heating, cooling and cooking, industrial power and as fuel for vehicles. The United States' natural gas production is expected to increase by 6 percent in 2008 and by an additional 2 percent in 2009.[72] These increases are anticipated to reduce the amount of natural gas the United States imports, and lower the price of both domestic and imported natural gas.[73]

Natural gas, either compressed or liquefied, can easily substitute as a replacement for gasoline, effectively reducing the amount of crude oil the United States imports. In 2007, the United States used 26,280 million cubic feet of natural gas as fuel for vehicles[74]; this accounted for less than 0.1 percent of the nation's total usage. Considering that 125 cubic feet of natural gas provides the same amount of energy as 1 gallon of gasoline[75], in 2007, natural gas saved the equivalent of 210,240,000 gallons of gasoline or over 5 million barrels of crude oil.

According to the Natural Gas Vehicle Coalition, there were over 150,000 natural gas vehicles in service in the United States in 2007.[76] On average, each of these vehicles used approximately the equivalent of 1400 gallons of gas.[77] The majority of these vehicles are municipal or commercial fleet vehicles. These vehicles represent less than .1 percent of the estimated 234,646,314 vehicles in the United States.[78] Although the number of natural gas vehicles has increased by over 30 percent a year since 2000 globally, they have only increased an average of 3.7 percent per year in North America.[79] The slow proliferation in the United States is due to the very limited natural gas fueling infrastructure. There are only approximately 1300 compressed natural gas fuel stations in the United States. However, only half of these are available for public use, the remainder are government owned or commercial fleet fueling facilities.[80]

As the natural gas fueling station network expands, sales of natural gas cars will most likely increase proportionally. These vehicles will either replace existing gasoline based vehicles or fill new vehicle requirements as the nation's vehicle demand grows. If these vehicles mirror 2007 usage levels, each one of them will use roughly 175,000 cubic feet of natural gas, replacing 1400 gallons of gasoline or roughly 33 barrels of crude oil per year. Assuming a 3.7% growth in natural gas vehicles per year, the United States will grow from 150,000 vehicles in 2008 to 240,500 vehicles in 2020. These additional 90,500 vehicles will consume upwards of 15.8 billion cubic feet of natural gas per year, replacing the usage of over 126 million gallons of gasoline. Although seemingly large numbers, both natural gas consumed and oil saved by these additional 90,500 vehicles is a proverbial drop in the United States' energy bucket. Legislation

and tax incentives coupled together could speed the proliferation of natural gas infrastructure and vehicles proliferation while simultaneously reducing the United States' foreign oil dependency.

Hydrogen. There are two ways hydrogen can reduce foreign oil dependence - it can be used to fuel internal combustion engines, or to power fuel cells. The Department of Energy estimates there are no more than 500 of these vehicles in operation in the United States.[81] The few hydrogen combustion vehicles in operation are either concept cars as is the case with BMW's Hydrogen 7 model, or are hobbyist conversion cars. Most of the fuel cell vehicles are either concept cars or are part of municipal test fleets. Both methodologies show promise, however, as with natural gas, they are hampered by a next to nonexistent hydrogen fueling infrastructure. As of October 2008, there are only 66 hydrogen fuel stations in the United States. The majority of these stations are government or manufacturer owned.[82] The Department of Energy's Hydrogen Research Program highlights the following challenges with adopting wide spread hydrogen use:

> In addition to the lack of infrastructure available to fuel and maintain hydrogen vehicles – both combustion and fuel cell types, there are numerous technical obstacles to large scale implementation. The Department of Energy summarizes many of the key challenges as follows: "There is a wide gap between today's capabilities for hydrogen production, storage and use and those required for a future hydrogen economy. To be economically competitive with the present fossil fuel economy, the cost of fuel cells must be lowered by a factor of ten or more and the cost of producing hydrogen must be lowered by a factor of four. In addition, the performance and reliability of hydrogen and fuel cell technologies must be improved dramatically."[83]

In 2003, the United States produced in excess of 9 million tons of hydrogen, enough to fuel 20-30 million hydrogen fueled cars or to power 5 to 8 million homes.[84] This hydrogen was used for a myriad of applications - less than a fraction of one

percent of it was used to fuel hydrogen vehicles. The Department of Energy estimates that hydrogen powered vehicles will need at least an additional 140 million tons of hydrogen by 2040. This level of hydrogen vehicle proliferation will eliminate the need for 18.3 million barrels of oil per day if the hydrogen is generated from sources other than petroleum. If the hydrogen is produced via petroleum, the United States will still save 11 million barrels of oil per day[85] - roughly the amount of foreign oil the United States imported per day in 2008[86].

Electricity. Significantly increasing electricity production is a major requirement in the United States' pursuit of foreign oil independence. Electricity will serve as both a fuel and as an enabler to assist with the creation, transportation and storage of other fuels. As a fuel, electricity will provide all the energy for plug in electric vehicles, and a good portion of the energy for plug in hybrid vehicles. As an enabler, electricity will provide the power to create hydrogen from water via electrolysis, and it will provide the power to drive the coal to oil, oil shale, biofuel and traditional oil refineries. Electricity is a critical component to increasing any of the multitudes of domestic energy alternatives.

The United States Department of Energy reports that the nation can produce 1,022,347 megawatts of electricity at peak production.[87] They estimate that electrical production capacity will increase an average of 17,415 megawatts a year through 2011. The vast majority of this electricity will come from natural gas and coal at 9205 and 5940 megawatts a year respectively. Non-hydro renewable energy is only anticipated to provide 1675 megawatts a year.[88] All of this data is based on 2006 production and investment plans; chances are all of these numbers will increase, especially renewable energy, when the Department of Energy releases its 2007 data in late December 2008.

For example, the Department of Energy anticipated electricity from all non-hydro renewable sources would increase by 2032 megawatts in 2008. Electricity generated by wind power alone increased by 4200 megawatts during the first three quarters of 2008.[89] Total 2008 wind production is expected to reach 7500 megawatts by the end of 2008.[90] The Department of Energy forecasts requirements for electricity will increase by 1.1 percent per year through 2030.[91] Their forecast is based on historical growth data and does not account for the massive amounts of electricity required to power new fuel generation infrastructures. The electricity required to power these vehicles and enabling infrastructures will most likely be produced from a wide variety of fuels and technologies. Natural gas, coal, wind, solar and nuclear power are the leading candidates – all are readily available domestic energy sources.

Potential Benefits of Increasing Domestic Alternatives to Oil. When combined, increased ethanol production, natural gas and hydrogen can dramatically decrease foreign oil imports.

Ethanol production is expected to increase by 3 billion gallons a year by 2015[92] at which point production is expected to peak at 14 billion gallons a year. The additional 3 billion gallons of ethanol per year can reduce foreign oil imports by almost 196,000 barrels a day or over 71 million barrels per year. This will save the United States over $11.1 million a day or $4 billion per year based on a barrel of oil costing $57.

Natural gas fueled vehicles will save an estimated 126 million gallons of gasoline per year by 2020 based on their current growth rate. This equates to over 8200 barrels of oil per day or 3,000,000 barrels a year. Although these numbers are small, they equate to a savings of $467,000 a day or $171 million a year.

There are too few hydrogen powered vehicles in service to provide a meaningful amount of oil savings in 2008. There are a multitude of hurdles hydrogen must clear in order to be an economically viable alternative fuel source to oil. Despite these challenges, the Department of Energy's projections claim that by 2040, hydrogen will proliferate to the point where it can replace 18.3 million barrels of oil per day. If this projection is accurate, hydrogen could eliminate 87 percent of 2008 oil consumption. Projecting ahead to 2018 on a linear plot, hydrogen could replace 5,718,750 million barrels of oil per day, or 23 percent of estimated oil consumption in 2018. These savings are massive – almost $326 million per day, or almost $119 billion per year based on a cost per barrel of $57.

Increased electrical generation capacity is a critical enabling component of the hydrogen fuel infrastructure. Significant investments in both generation capacity and transmission systems are needed in order to produce, transport and store hydrogen effectively. Electricity will reduce oil by powering gas-electric plug-in hybrid and all electric vehicles. These savings are addressed later in this document.

If United States government's estimates prove accurate, these three fuel sources will replace over 5.9 million barrels of oil per day or over 2.1 billion barrels per year. Figure 2 below illustrates the potential oil saved via increasing domestic alternatives to oil.

Effects of Producing Domestic Alternatives to Oil by 2018

System	Action	Effect by 2018 (in barrels)	Daily Savings ($ million)	Annual Savings ($ billion)
Increase Ethanol Production	Substitute	196,000	$ 11.1	$ 4.0
Increase Natural Gas	Substitute	8,200	$ 0.5	$ 0.2
Produce Hydrogen	Substitute	5,718,750	$ 325.6	$ 118.9
	Total Savings:	5,922,950	$ 337.2	$ 123.1

Figure 2.

Conserving Oil

The easiest way to reduce dependence on foreign oil imports is to reduce consumption. More efficient vehicles, higher Corporate Average Fuel Economy (CAFE) standards and an increase of the gasoline tax will all conserve oil thereby reducing the United States' oil import requirements. In addition to these gains, the United States can significantly decrease oil consumption by increasing the number of hybrid vehicles in use and by accelerating the development of fuel cell and plug-in electric vehicles. This section examines how the United States can dramatically reduce oil consumption by conserving gasoline.

Increased CAFE Standards. The federal CAFE standard for cars and light trucks is 22.2 and 27.5 miles per gallon respectively.[93] These standards changed minimally in the past decade; car standards didn't change at all, light truck standards increased from 20.7 to 22.2 miles per gallon. The Energy Independence and Security Act of 2007 raises average CAFE standards to 35 miles per gallon by 2020 – a 40 percent increase in fuel economy.[94] The first increases go into effect in 2011.[95] The Union of Concerned

scientists estimates these new standards will save 1.1 million barrels of oil per day by 2020[96]. Assuming a linear implementation of these standards, the United States will conserve 880,000 thousand barrels of oil a day or over 321 million barrels a year by 2018. This equates to a savings of over $50 million a day and over $18.3 billion dollars per year based on a barrel of oil costing $57.

Increased Federal Gasoline Tax. The United States government levies an 18.4 cent per gallon tax on gasoline.[97] In addition to the federal gasoline tax, states also tax gasoline on a per gallon basis. The national state average is 47 cents per gallon. California has the highest tax at 63.9 cents per gallon while Alaska has the lowest at 26.4 cents per gallon.[98] The Congressional Budget Office (CBO) estimates that increasing the federal tax per gallon of gasoline by an additional 46 cents will reduce gasoline consumption by 10 percent.[99] Based on the current economy, a tax of 46 cents per gallon is most likely not politically palatable. However, reducing the CBO's proposed tax by 50 percent, down to 23 cents per gallon, would still yield a five percent reduction in gasoline use, and coupled with a strategic information campaign would probably be more acceptable to the American people. A five percent conservation of oil would reduce foreign oil import requirements by 600,000 barrels per day or over 219 million barrels per year, saving the United States over $32 million a day or almost $12.5 billion a year.

Hybrid Vehicles. There are 1,152,200 hybrid vehicles in service in the United States as on July 2008.[100] The National Renewable Energy Laboratory estimates that hybrid sales increased 72% per year for the past five years, and expects this trend to continue.[101] As hybrids proliferate in larger numbers, their 45 percent average fuel

savings[102] over conventional cars will reduce the amount of foreign oil the United States imports. The average American uses 500 gallons of gasoline per year[103], based on an average savings of 45 percent, gas-electric hybrid drivers only use 275 gallons per year – a savings of 225 gallons per hybrid per year. Based on the 1,152,200 hybrids on the road in July 2008, this accounts for an annual fuel savings of 316,856,650 gallons of gasoline, or over 720,000 barrels of oil per year.

Plug-in hybrid drivers use considerably less gasoline. Their fuel consumption ranges from the same 45 percent fuel economy gas-electric hybrids enjoy up to 100 percent fuel economy for cars seldom or never driven past their electric battery range. Since 78 percent of Americans commute less than 40 miles a day to work, plug-in gas-electric hybrids can significantly reduce oil usage even further.[104] However, since these vehicles are in test and evaluation there are only a few hundred in service. Ford, Toyota and General Motors all plan to introduce production models in 2010.[105] The Department of Energy's Oak Ridge National Laboratory's "Potential Impacts of Plug-in Hybrid Electric Vehicles on Regional Power Generation" speculates that by 2020, the gas-electric hybrid will comprise 25 percent of the vehicle market.[106]

Based on Oak Ridge Laboratory's estimates, in 2018 there will be roughly 49 million plug-in hybrid vehicles in service. Assuming that 60% of these vehicles won't use significant amounts of gasoline based on battery range and commute distance, these vehicles will save roughly 1,310,000 million barrels of oil a day or over 478,000,000 million barrels a year - a savings of almost $75 million a day or over $27 billion a year.

Plug-in Electric and Hydrogen Fuel Cell Vehicles. Pure electric and hydrogen fuel cell vehicles by definition don't use gasoline. As such, each vehicle saves on average of 500 gallons of gasoline per year.[107] As with plug-in gas-electric hybrid vehicles, there are only a few hundred of both types of these vehicles in service. As battery and fuel cell technologies improve, extending range and reducing charge time, the single power source electric and hydrogen fuel cell vehicle market shares should increase. Like gas-electric plug-in hybrid vehicles, pure electric and hydrogen fuel cell vehicles will significantly reduce the amount of oil the United States imports and consumes. Although there are no plug-in electric or hydrogen fuel cell vehicles in production today, many of the major automobile manufacturers believe they will have one or both of these propulsion systems in their vehicle fleets by 2018.[108]

Potential Benefits of Conserving Oil. CAFE standard increases mandated in the Energy Independence and Security Act of 2007 coupled with an increased gasoline tax and wider proliferation of gas-electric hybrid vehicles will significantly reduce the amount of oil the United States must import.

The savings from increasing the CAFE standards will begin taking effect in 2011. By 2018, these standards should save an estimated 880,000 barrels of oil per day. This savings equates to 7.3% of the United States' current daily crude oil imports. Economically, an 880,000 barrel per day reduction in oil importation saves the United States over $50 million a day, and over 18.3 billion a year based on a $57 price per barrel of oil.

Increasing the federal gasoline tax by 23 cents per gallon is a bold political move. It will be a challenge for the President and his administration to convince the American

public this tax is in their best interest. However, if the CBO's gasoline savings estimates prove accurate, the tax increase will reduce gasoline use by five percent, saving 600,000 barrels of oil per day. This savings in oil consumption equates to saving over $32 million dollars a day and $12.5 billion dollars annually.

Gas-electric hybrids and plug-in gas-electric hybrid vehicles are expected to increase from the current 1.15 million vehicles in service in 2008 to over 49 million vehicles in service in 2018. This massive movement from internal combustion based propulsion to gas-electric hybrid propulsion will save the United States roughly 1.3 million barrels of oil per day. This conversion will save the United States almost $75 million per day and over $27 billion a year based on a $57 price per barrel of oil.

Plug-in electric and hydrogen fuel cell vehicles both completely eliminate the need for gasoline. With each vehicle put in service eliminating an average of 500 gallons of gasoline per year, these technologies both have massive potential to reduce oil consumption. Since none of the major automobile manufacturers have production plans for either vehicle until possibly 2018, these systems won't contribute significantly to oil conservation in the short term.

Between higher CAFE standards, an increased gasoline tax and wider proliferation of hybrid vehicles, the United States can save an estimated 2,780,000 barrels of oil per day or over 1 billion barrels per year. Figure 3 shows these potential savings.

A Plan for Oil Independence by 2018. If the United States aggressively implements the programs outlined in this document to increase domestic oil production, increase production of domestic alternatives to oil and foster oil conservation, the nation

will gain independence from foreign oil imports by 2018. A summary of how the current 12,034,000 barrels per day of imported oil are replaced by the plan is depicted below in figure 4.

Effects of Conserving Oil by 2018

System	Action	Effect by 2018 (in barrels)	Daily Savings ($ million)	Annual Savings ($ billion)
Increased CAFE Standards	Conserve	880,000	$ 50.1	$ 18.3
Increased Federal Gas Tax	Conserve	600,000	$ 34.2	$ 12.4
Hybrid Vehicles	Conserve	1,310,000	$ 74.6	$ 27.2
	Total Savings:	2,790,000	$ 158.9	$ 57.9

Figure 3.

United States Oil Produced, Substituted or Conserved in 2018

Program	System	Action	Effect by 2018 (in barrels)	Daily Savings ($ million)	Annual Savings ($ billion)
Increase Domestic Oil Production	Increase Oil Drilling	Produce	1,605,000	$ 91.4	$ 33.3
	Coal to Oil Conversion	Substitute	860,000	$ 49.0	$ 17.8
	Oil Shale Extraction	Substitute	1,666,000	$ 94.9	$ 34.6
Produce Domestic Alternatives to Oil	Increase Ethanol Production	Substitute	196,000	$ 11.1	$ 4.0
	Increase Natural Gas	Substitute	8,200	$ 0.5	$ 0.2
	Produce Hydrogen	Substitute	5,718,750	$ 325.6	$ 118.9
Conserve Oil	Increase CAFE Standards	Conserve	880,000	$ 50.1	$ 18.3
	Increase Federal Gas Tax	Conserve	600,000	$ 34.2	$ 12.4
	Hybrid Vehicles	Conserve	1,310,000	$ 74.6	$ 27.2
		Total Savings:	**12,843,950**	**$ 731.4**	**$ 266.7**

Figure 4.

The plan yields a total of 12,843,950 barrels of oil per day - 809,950 barrels more than the United States currently imports per day in 2008. Although the plan appears to produce more oil than the nation will need, it does not account for the increased demand for oil in 2018 or the decreases in domestic oil production by 2018.

The current foreign oil demand of 12,034,000 barrels per day must be indexed by the historical average oil consumption growth rate of 1.85 percent. This adjustment projects an increased demand of approximately 2,400,000 barrels per day in 2018. Additionally, the plan must be further adjusted to reflect the average annual decrease in production from U.S. domestic oil fields of 122,000 barrels per year. Decreased oil production projected out through 2018 equates to the existing domestic oil fields decreasing production by 1,334,000 barrels a day. Combined together, a new demand of 2,400,000 barrels per day and decreased production of 1,334,000 barrels per day creates a requirement for the United States to import or produce an additional 3,734,000 barrels per day for a grand total of 15,768,000 barrels per day. This indexing is depicted in figure 5 below.

2008 Oil Demand Indexed Out to 2018
(in barrels per day)

Oil Demand in 2008:	**12,034,000**
Increased Oil Demand by 2018:	**2,400,000**
Decreased Oil Field Production by 2018:	**1,334,000**
Oil Demand in 2018	**15,768,000**

Figure 5.

The United States can meet this increased demand if we expand the definition of domestic oil to include oil imports from Canada and Mexico. Although Canada and Mexico clearly aren't part of the United States, they share thousands of miles of borders with the U.S., and their governments are exceptionally friendly, stable, and interdependent with the U.S. government and economy. Continuing to import Mexican and Canadian oil will help provide their governments and economies stability as the world's oil markets are flooded over the next ten years with the millions of barrels of oil per day that the United States imported prior to gaining independence from foreign oil. Maintaining stable governments and economies in Canada and Mexico is arguably in the United States' national interest; hence, it makes sense to stabilize their economies and our security by continuing to import their oil until they can adjust their national economies or find other oil buyers.

Combining Canadian and Mexican oil imports with the oil produced via the programs in the plan will produce a total of 16,132,950 barrels of oil per day in 2018 to fill a demand of 15,768,000 barrels per day. This leaves an excess of 364,950 barrels of oil per day for future growth or to make up production deficiencies in any of the program areas. This calculation is depicted in figure 6 below.

In addition to providing independence from foreign oil, this plan also provides significant tax revenue from the 23 cent per gallon increase in federal gasoline tax. The United States consumes 390 million gallons of gasoline per day.[109] This equates to tax revenue of $89.7 million per day or over $33 billion year. This revenue could be used to provide various incentives for any of the plan's components. Significant federal

investment would most likely accelerate new technologies, infrastructure and production.

Plan Factoring In "Domestic" Foreign Oil Imports	
Plan Produced Oil in 2018:	12,843,950
Canadian Oil Imports:	1,880,000
Mexican Oil Imports:	1,409,000
Total Oil Available in 2018:	16,132,950
Imported Oil Demand in 2018:	(15,768,000)
Excess Oil in 2018:	364,950

Figure 6.

This multi-component plan has the potential to eliminate the United States' dependence on foreign oil by 2018. Although the plan is feasible, there are multiple technological, environmental, economic and political hurdles that must be cleared in order for the plan to succeed. The challenges differ for each component of the plan; however, every component is affected to some extent by each of these challenges. A comprehensive analysis of how these challenges affect each component of the plan exceeds the scope of this study.

The benefits of getting the United States from a position of being over the barrel and freeing the nation from the restrictive economic and political yokes of oil dependency are staggering. Once energy independent, the United States can consider many more foreign policy options and selectively choose international engagements.

Without the “big oil” stick to wield, nations who have historically passively resisted or actively challenged U.S. policy will realize diminished ability to induce and coerce the United States. Equally as important, their ability to wield power in the international system with other countries will also diminish as the oil the United States previously consumed may flood the world’s oil markets, driving supply up and demand down. The net effect is that the United States will regain independence lost during our decades of oil addiction, at the cost of oil exporting nation losing both power and relevance. This new found economic freedoms will markedly change the face of the U.S. and world economy. New fuels, production processes and technologies associated with this plan will create multitudes of new jobs in most areas of the energy and transportation sectors. The U.S. trade deficit will decrease by almost 50 percent by eliminating the net import of 12 million barrels of foreign oil per day. Energy dollars will reinvest in the United States economy vice being transferred to oil exporting nations.

The research conducted to craft this paper leads me to believe that the United States can gain independence from foreign oil imports by 2018. More importantly, I now conclude that the nation must take aggressive action immediately to preserve our national security, protect and expand our economy and reduce the oil provided power of the petroleum-states.

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