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A LONG-TERM UNITED STATES' ENERGY POLICY WITHOUT VENEZUELAN OIL

by

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The current energy, economic, and political relationship between the United States and Venezuela can be characterized as mutually dependent. The United States is Venezuelas largest consumer of crude oil and associated refined products, accounting for 60% of Venezuelan oil exports while Venezuela provides 10 percent of the United States imported oil. The U.S. has become increasingly concerned with Venezuelan President Hugo Chavez's nationalization of the oil sector and anti-U.S. rhetoric. If an embargo occurred today, a loss of Venezuelan oil would significantly affect the U.S. ability to meet its own oil demands. This paper examines future U.S. consumption and production as well as the current and future energy relationship between the United States and Venezuela. The paper attempts to develop a long-term comprehensive strategy for a sustained or permanent loss of Venezuelan oil. This paper analyzes future fuel conservation, current and future Western Hemispheric crude oil production (to include the U.S.), and future production of the alternative energy source ethanol. The long-term policy, spanning the next two decades, identifies available future oil sources such as Canadian oil sands and Brazilian ethanol. This paper identifies the impact of fuel standards on fuel conservation and the viability of raising fuel standards. This paper also identifies other untapped sources such as Mexican offshore oil fields and drilling within the Arctic National Wildlife Refuge. Finally, additional recommendations are presented for consideration but carry significant political, diplomatic, and environmental obstacles.

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Preface

This paper addresses United States Southern Command's requirement to assess current and future U.S. dependence on Latin American/South American oil. This paper searches for ways to reduce or eliminate future reliance on Venezuela, by creating a long-term U.S. energy policy that would not include imported Venezuelan oil. With an increasing desire to reduce U.S. dependency on foreign oil, this paper will show the difficulty and the improbability the U.S. will be able to produce all of its energy needs domestically. While most experts agree Venezuelan President Hugo Chavez will continue to provide the U.S. oil in the near term, the long term prognosis is uncertain. This paper explores future options for energy sources such that the U.S. can shift away from Venezuelan oil on its own terms.

I would like to thank Joanne Shore from the Energy Administration Information for her assistance in answering my questions and providing additional data that I would not have easily found in the numerous data tables on the EIA's website. I would also like to thank my family for their patience and understanding for the many Saturdays spent away from the house in the library.

Abstract

The current energy, economic, and political relationship between the United States and Venezuela can be characterized as mutually dependent. The United States is Venezuela's largest consumer of crude oil and associated refined products, accounting for 60% of Venezuelan oil exports while Venezuela provides 10 percent of the United States imported oil. The U.S. has become increasingly concerned with Venezuelan President Hugo Chavez's nationalization of the oil sector and anti-U.S. rhetoric. If an embargo occurred today, a loss of Venezuelan oil would significantly affect the U.S. ability to meet its own oil demands.

This paper examines future U.S. consumption and production as well as the current and future energy relationship between the United States and Venezuela. The paper attempts to develop a long-term comprehensive strategy for a sustained or permanent loss of Venezuelan oil. This paper analyzes future fuel conservation, current and future Western Hemispheric crude oil production (to include the U.S.), and future production of the alternative energy source ethanol. The long-term policy, spanning the next two decades, identifies available future oil sources such as Canadian oil sands and Brazilian ethanol. This paper identifies the impact of fuel standards on fuel conservation and the viability of raising fuel standards. This paper also identifies other untapped sources such as Mexican offshore oil fields and drilling within the Arctic National Wildlife Refuge. Finally, additional recommendations are presented for consideration but carry significant political, diplomatic, and environmental obstacles.

Chapter 1

Introduction

Since President Hugo Chavez took office in 1999, relations between the United States and Venezuela have rapidly deteriorated. Chavez's government views the U.S. as the "evil empire" and perceives a continued economic dependence threatening its existence.[1] In his political fight against the U.S., Chavez likens himself to Simon Bolivar, the 19th century leader who fought for the South American colonies' independence from Spain.[2] Chavez's solution to reducing Venezuela's dependence on the U.S. has been increasing the role of the state in the Venezuelan economy and creating extensive social programs.[3] The social programs are largely funded through the nationalization of Venezuela's oil sector and the institution of higher royalties to foreign countries.[4] These social programs receive substantial funding so long as world market oil prices remain high, but are adversely affected when oil prices drop.

The U.S. is concerned with Venezuela's centralization of power, socialistic economic policies, and bellicose rhetoric while at the same time wanting assurances of continued access to Venezuelan oil.[5] Yet, despite the strained relations between Venezuela and the U.S., both continue to rely upon each other economically. Venezuela provides 10 percent of U.S. imported oil, ranking behind Canada, Mexico, and Saudi Arabia.[6] The U.S. is Venezuela's largest consumer of crude oil and its associated refined products, accounting for 60% of Venezuelan oil exports.[7] If an embargo occurred today, a loss of Venezuelan oil would significantly affect the United States' ability to meet its own oil demands and likely cripple the Venezuelan economy. In the short term it is unlikely Venezuela will take measures to cut off exports to the U.S. The concern for the U.S. should be the possibility that Chavez or his supporters will remain in power for decades. If Chavez does follow through on his anti-U.S., anti-capitalist rhetoric, is the United States prepared for an extended or permanent loss of Venezuelan oil?

The purpose of this paper is to develop a long-term comprehensive U.S. strategy for a sustained or permanent loss of Venezuelan oil and indirectly assesses the United States' future dependency on Venezuelan oil. Using forecasts from the Energy Information Administration's (EIA) 2008 and 2009 Energy Outlooks, the analysis, conclusions, and recommendations in this paper provide an over-arching strategy covering the next two decades. The loss could be the result of either a U.S. or Venezuelan imposed embargo or if Venezuela decides to divert its oil exports to other nations. The focus of the paper is not the origins of the loss, but rather the quantity of oil lost. This paper looks at three major aspects affecting U.S. oil production and consumption. First, the paper analyzes future domestic and foreign oil production. Second, the growth of the alternative fuel ethanol produced domestically as well as imported is explored to determine its impact on future U.S. oil consumption. Finally, the effects of government mandated fuel conservation programs are examined to determine their effectiveness on U.S. oil consumption. By examining these areas of U.S. energy consumption and production, possible energy surpluses are identified that can replace Venezuelan oil.

A long term U.S. energy policy dealing with a permanent loss of Venezuelan oil requires a mixture of initiatives that includes fuel conservation programs, increased domestic and foreign oil production, expansion of alternative fuels, and changes to current laws. This paper is not an attempt to create a Venezuelan contingency plan that should be executed when or if an embargo occurs. The recommendations and identified energy surpluses determined through this research are intended for consideration into a long-term strategy that is implemented long before any loss of Venezuelan oil occurs.

Chapter 2

The Significance of Losing Venezuelan oil

A late 2001 Venezuelan oil-industry strike illustrates the United States' reliance on Venezuelan oil as well as the impact of a permanent loss. With the backing of Chavez, the Venezuelan government passed the Hydrocarbons Law in 2001, effectively consolidating state control over the oil industry. The government increased royalties paid by private oil companies from 16.6 percent to 30 percent, and guaranteed the state owned company, Petroleos de Venezuela Sociedad Anonima (PDVSA), at least 51 percent share in new oil production and exploration.[8] In December 2001, business leaders initiated temporary work stoppages in protest of the Hydrocarbons Law. The opposition intensified its efforts with a two month general strike beginning in December 2002 which completely shut down the oil sector.[9]

Prior to the 2001-2002 PDVSA strike, Venezuelan worldwide crude oil production levels averaged 3.1 million barrels per day (mbd).[10] This strike temporarily decreased world oil supplies by about 2.3 mbd, or approximately 3.0 percent of total world daily oil supply, and reduced oil exports to the U.S by about 1.2 mbd.[11] By February 2003, U.S. crude oil stocks fell to almost 270 million barrels, classified at the "lower operational inventory"[12] level, but not requiring releasing oil from the U.S. Strategic Oil Petroleum Reserve. The price for a barrel of crude oil increased from $27 per barrel in November 2002 to $37 in late February 2003,[13] contributing to a gasoline price jump of 30 cents per gallon.[14]

While this increase in gasoline prices may seem manageable, especially after the high gas prices of 2008, the impact of the strike could have been much worse. During the Venezuelan strike, it was estimated that as much as 5.6 mbd of spare oil production capacity was available from Mexico, West Africa, and the Middle East.[15] In order to meet world and U.S. demands, these regions increased oil production. The majority of U.S. oil refineries that normally received Venezuelan oil were supplanted with Mexican Maya, Brazil, and West African crude oil.[16]

Many Americans may not have realized or felt affected by this temporary loss of oil. However, the effects of the strike were significant enough to catch the attention of U.S. lawmakers. The Chairman of the U.S. Senate Foreign Relations Committee requested the General Accounting Office (GAO) to conduct a study on the future of Venezuelan oil production and its effects on the United States. The study, completed in June 2006, concluded "a sudden and severe reduction in Venezuelan oil exports would have worldwide impacts,"[17] raising gasoline prices world-wide. The effect on the U.S. would be especially felt since its oil refineries would experience higher transportation costs by importing oil from countries further away than Venezuela.[18] The study based its conclusion on a Department of Energy model in which a 6-month disruption of crude oil (approximately 2.2 mbd lost) was analyzed. The model predicted the loss of oil would temporarily increase a barrel of oil $11 (based on an assumed initial price of $55 per barrel) and result in a $23 billion loss to the United States' Gross Domestic Product.[19] The GAO also concluded the U.S. is not prepared for a long-term loss of Venezuelan oil.[20] The report noted that lead energy security agencies, such as the Departments of Energy and State, do not have specific plans to address a long-term oil disruption from Venezuela.

While the economic and political conditions that exist today are different than during the PDVSA strike, even a temporary loss of Venezuelan oil today would have a more drastic impact. Several oil experts consider the total world spare production capacity is only around 1 mbd.[21]

When compared to the 5.6 mbd available during the strike, this smaller amount is substantial considering world oil consumption increased from 79.6 mbd to 84.9 mbd between 2003 and 2006.[22] As the oil balance tightens and surplus production capacity continues to shrink, increasing production levels in response to disruptions will be unlikely. The current U.S. plan for a short term loss of Venezuelan oil, centered on persuading oil-producing nations to increase production, is worrisome.[23] The current alternative plan is utilizing the Strategic Petroleum Reserve.

Chavez's recent threats towards the U.S. are indications that the future U.S.-Venezuelan oil relationship may be in jeopardy. After a disputed Venezuelan takeover of ExxonMobil oil fields, Chavez threatened to stop oil shipments to the United States when ExxonMobil attempted to freeze Venezuelan petroleum assets.[24] Venezuelan President Hugo Chavez's numerous threats towards the U.S. are usually not taken very seriously. In the near-term, most analysts do not think Chavez will make good on his threats since the only non-Venezuelan refineries that can handle its heavy crude oil are located in the United States and U.S. Virgin Islands. A loss of access to these refineries would have significant damage to the Venezuelan economy. However, there are indications Venezuela is looking to shift its production and business away from the United States. PDVSA sold its interest in one of its largest refineries to a U.S. company.[25] In August 2006, Venezuela reached an agreement with China starting oil production at 100,000 barrels per day (bbl/d) and increasing to 500,000 by 2011.[26] In addition, Venezuela and Ecuador announced an agreement to build a refinery south of Quito, the first Venezuelan refinery outside its country, the U.S., or Virgin Islands.[27] With no expected increase in its oil production capacity, Venezuela's recent business ventures with other countries ultimately means less Venezuelan oil will reach the United States.

Chapter 3

Defining how much oil

Before determining a policy towards Venezuela, the amount of oil must be defined. Specifically, how much Venezuelan oil will the U.S. have to supplant if an embargo or stoppage occurs? Since 1993, U.S. imports of Venezuelan oil have averaged 1.4 mbd.[28] This number not only includes crude oil but also approximately 300,000 bbl/d of other refined products such as jet fuel, heating oil, and asphalt.[29]

1.1 mbd	**Crude Oil**
35,000 bbl/d	Unfinished Oil
54000 bbl/d	Motor Gasoline Blending Components
6000 bbl/d	Finished Motor Gasoline
36000 bbl/d	Jet Fuel
12000 bbl/d	Distillate Fuel Oil
16000 bbl/d	Residual Fuel Oil
14000 bbl/d	Asphalt and Road Oil
1.4 mbd	**Total Crude Oil and Other Products**

Table 1. Avg. Total U.S. Crude Oil and Petroleum Products from Venezuela (1993-2008)[30]

The most significant impact to the U.S. would be a loss of Venezuelan crude oil. Venezuelan crude oil is important because all U.S. imports are refined primarily in the Gulf Coast region and specifically designed to handle Venezuela's heavy crude varieties.[31] CITGO, a wholly-owned subsidiary of PdVSA, has the ability to refine 749,000 bbl/d in its Texas, Louisiana, and Illinois plants.[32] The effects of Venezuelan oil products refined in Venezuela would likely have a minimal effect on the U.S. and for the purpose of the paper will not be examined.

The 1.1 mbd of Venezuelan crude oil provides a starting point in defining the amount of oil in question but requires further analysis. As represented in Venezuelan exports, refined crude oil provides a plethora of products such as transportation fuels (diesel, gasoline, jet fuel), heating oil, liquefied petroleum gases, lubricants, and even asphalt base.

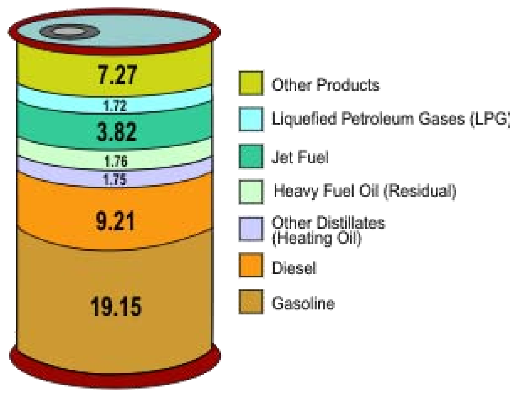

Figure 1: Products Made From a Barrel of Crude Oil (Gallons)[33]

A single U.S. barrel of crude oil is 42 gallons and once refined, can provide over 44 gallons of products.[34] The refined products, gasoline and diesel, account for approximately 64% (27 gallons) of one barrel of crude oil.[35] While a loss of other refined products would affect the U.S., the focus of this paper will be limited to the two largest refined products, gasoline and diesel, since these two products have a much higher economic impact than the others. Therefore, the equivalent amount of oil in question is further reduced to 704,000 bbl/d or 29.7 million gallons of fuel. These amounts provide the foundation to allow analysis of increased domestic and foreign oil production, fuel conservation programs, and alternative fuels. However, more factors must be considered when comparing different energy solutions.

The EIA forecasts Venezuela's total oil production will remain between 2.5 and 2.8 mbd until 2015 resulting in U.S. imports remaining relatively constant.[36] These production levels are expected to increase after 2015 to over 3 mbd by 2030 because it is assumed the Venezuelan government will permit foreign investment into the oil sector and thus facilitate increases in production.[37] Assuming Venezuela does not change crude oil import levels to the U.S., the 704,000 bbl/d calculated is an adequate number for comparison until 2015. While the forecast after 2015 assumes an additional Venezuelan production capacity of 500,000 bbl/d over current levels, it cannot be determined from the EIA forecast if any of the additional capacity would be imported to the U.S. Until further analysis is completed, 704,000 bbl/d will remain the assumed amount between 2015-2030.

For comparative analysis, the barrels of oil or gallons of gasoline alone are an insufficient number by themselves because not all crude oil is the same. Crude oil is generally defined by two of its properties: viscosity and sulfur content. The term "heavy, medium, or light" oil refers to its viscosity and is measured in terms of its specific gravity. The standard measurement for the specific gravity is from the American Petroleum Institute (API) with light oil defined as an API gravity greater than 31.1 degrees, middle oil between 22.3 and 31.1, and heavy oil being less than 22.3.[38] While Venezuela produces all different types of oil with an API gravity ranging from 17.4 to 36.6, the majority of Venezuelan crude is considered heavy.[39] The term "sweet" or "sour" oil refers to the amount of sulfur in the oil. High sulfur content is undesirable since it affects the refining process and product quality, resulting in higher production costs.[40] Venezuelan oil, depending upon the oil field, contains both sweet and sour crude.

These classifications are important since U.S. refineries are normally specifically designed to handle certain gradients of crude oil. The majority of refineries in the U.S. can process light, sweet crude oils, while a smaller fraction of refineries processing the heavy, high sulfur crude oils, such as those produced in Venezuela.[41] A refiner that normally processes a lighter crude oil cannot refine an intermediate or heavy crude oil. Refineries that process intermediate sour crude oil can process small quantities of heavy sour crude so long as it is blended with a light sweet crude oil.[42] The refiners of heavy crude oil can refine lighter mixes of crude oil, but as in the case of the PDVSA strike, these refiners preferred to blend the lighter mix with an already available heavy crude oil.[43] A solution that includes the use of U.S. refineries needs to ensure the heavy crude refineries can continue processing whether it be a lighter mix or a blend with non-Venezuelan heavy crude oil.

When comparing oil production between Venezuela and other countries is based upon the amount of gasoline and diesel produced from one barrel of crude oil, 704,000 barrels of Saudi Arabian oil is the same amount as Venezuelan oil. However, energy content in a barrel of crude oil is different than one from Mexico, Canada's Tar Sands, or the North Slope of Alaska. If Venezuela and Saudi Arabia each produced 704,000 bbl/d, their total energy content is different. A barrel of Venezuelan oil contains 6.1 million BTUs while a barrel of Saudi Arabian oil contains 5.8 million BTUs.[44] Energy comparison is necessary in order to compare crude oil to alternative energy sources. Energy converted from a gallon of gasoline does not equate to a gallon of liquid ethanol. A typical barrel of crude oil produces 20 gallons of gasoline and 7 gallons of diesel, while one gallon of gasoline averages 124,000 BTUs of energy with one gallon of diesel producing 139,000 BTUs.[45] Therefore, in one barrel of Venezuelan crude oil, gasoline and diesel combine to produce approximately 3.45 million BTUs or 57% of its total energy. When comparing energy content with alternative sources and using Venezuela's adjusted output of 704,000 bbl/d of crude oil, the total energy content must equate to approximately 3.8 trillion BTUs per day of energy. With the problem now defined in terms of equivalent barrels of oil and energy content, based upon consumption of gasoline and diesel, oil producing countries, conservation programs, and alternatives can be adequately analyzed.

The economic cost of crude oil and its impact to the analysis is worthy of discussion. This paper does not attempt to conduct a thorough economic analysis in order to determine recommended solutions. When compared to other oil producing nations, the cost of gasoline from Venezuela is relatively inexpensive for U.S. consumers. The primary factor behind its cheaper cost is found in transportation costs. While it takes thirty to forty days for Middle East oil to reach the U.S., Venezuelan oil can reach the Gulf Coast in only five days.[46] As a result, it will be very difficult to find sources of oil or alternative energy that is significantly cheaper than Venezuelan oil. Gasoline prices are a function of multiple factors such as price per barrel, transportation costs, refineries, and government taxes. This paper will analyze countries whose transportation costs are comparable to the cost of importing Venezuelan oil. Therefore, when looking for increased oil production, the countries analyzed will be limited to Canada, Mexico, Brazil, and Ecuador.

Finally, alternative fuels are defined as methanol, denatured ethanol, and other alcohols, separately or in mixtures of 85 percent by volume or more (or other percentage not less than 70 as determined by DOE rule) with gasoline or other fuels, compressed natural gas (CNG), liquid natural gas (LNG), liquefied petroleum gas (LPG), hydrogen, coal-derived liquid fuels, fuels other than alcohols derived from biological materials, electricity, or any other fuel determined to be substantially not petroleum and yielding substantial energy security benefits and substantial environmental benefits.[47] While there are several types of alternative fuels available, this paper focuses on only ethanol since it accounts for over 90 percent of available biofuels.[48] Other alternative fuels such as biodiesel, LPG, CNG, and LNG will not be specifically analyzed since their expected future production levels is significantly less than the expected contribution of ethanol.

Chapter 4

Future Oil Production Sources

Canada

Canada provides a promising and possible solution to a loss of Venezuelan oil. Canada is the United States' number one customer in crude oil, accounting for 18 percent of U.S. net imports and 12 percent of U.S. crude oil supply.[49] Since 2007, imports of Canadian crude oil increased from 1.4 mbd to 1.8 mbd[50] accounting for 99 percent of Canadian oil exports.[51] Canada's overall oil production is expected to increase from 3.42 mbd in 2008 to 3.59 mbd in 2009.[52] There are three major oil regions in Canada worth examining to determine possible areas of increased oil production: Western Canada Sedimentary Basin, Alberta Oil Sands, and Atlantic Off-Shore.

The conventional oil fields in Alberta, British Columbia, Saskatchewan, Manitoba, and Northwest Territories comprise the Western Canada Sedimentary Basin (WCSB) and have been the primary source of oil over the last five decades. However, Canadian conventional oil has been on the decline since 1997 with the WCSB currently providing only 38 percent of Canada's total crude oil production as compared to 65 percent in 1999.[53] The Canadian Association of Petroleum Producers forecasts conventional oil will decline from 1.09 mbd in 2004 to 726,000 bbl/d in 2015 unless future technology can extract more oil.[54] Only 27 percent of the estimated 216 billion barrels in conventional oil is considered recoverable using current technologies.[55]

Canada has three major offshore oil fields along its Atlantic coast, while its government currently bans offshore drilling along its Pacific Coast. The largest offshore field, Hibernia, is located approximately 180 miles off Newfoundland and produces approximately 135,000 bbl/d.[56]

The other two fields, White Rose and Terra Nova, are located adjacent to Hibernia and each produce approximately 116,000 bbl/d.[57] Canada continues to expand its Atlantic offshore drilling with a 2008 agreement with Chevron on drilling the Hebron field, which is estimated to have between 400 to 700 million barrels of oil.[58]

The Alberta oil sands currently accounts for 46 percent of Canada's total oil production.[59] Oil sands, also known as tar sands, are a mixture of organic matter, quartz sand, bitumen, silt, clay, and water.[60] Bitumen, a very viscous oil (API less than 10 degrees) with high sulfur content, is removed through either surface mining or heating it in place. Through surface mining, the oil sands are removed and transported to a facility where it is pulverized and mixed into a slurry. Ninety percent of the bitumen is removed during this process.[61] During the heating extraction process, heated water (75 degrees Fahrenheit) and chemicals are used to separate the bitumen from the oil sands. The bitumen is sold as either raw bitumen blended with a diluent for transport or as a synthetic crude oil (syncrude).[62]

In 2005, mining oil sands production was 572,000 bbl/d with the heating extraction process producing 528,000 bbl/d. The heating process production is expected to increase even further to 926,000 bbl/d by 2012. Oil sands production is expected to rise from 1.2 mbd to 2.8 mbd by 2015, which could easily compensate for the loss of 704,000 barrels of Venezuelan oil.[63] Most forecasters of world oil markets estimate that Canadian oil sands will become an increasingly important component of the world supply and by 2030 will be producing almost 3.4 mbd, accounting for 30 percent of U.S. oil imports.[64] The U.S. infrastructure is currently well-positioned to receive Canada's oil sands. Using pipelines originally created to carry U.S. oil to Canada, oil sands are now moving in the opposite direction and reaching as far as southeast Texas, where a large majority of petrochemical plants and refineries are located.[65] The U.S.

refinery capacity is expected to increase from 16.9 mbd in 2004 to 19.3 mbd in 2030, which still may not be enough to handle the expected increased amounts of Canadian oil.[66]

While Canada's oil sands appear to be a panacea for a loss to Venezuelan oil, its importation poses significant political and environmental problems for the U.S. Oil sands, when refined, produce three times more carbon dioxide per barrel than contained in a barrel of conventional oil.[67] The refining of oil sands in Canada is expected to account for half of its carbon dioxide emissions by 2010.[68] Importing and refining Canadian oil sands will only increase the amount of greenhouse gases emissions produced by the U.S. Due to concern over greenhouse gases, the 2007 Energy and Independence Security Act (EISA) included a provision which prevents the U.S. Air Force from developing coal to liquid fuels. Authors of the bill categorize Canadian oil sands under the same provision, which would prevent the U.S. military from purchasing Canadian oil sand syncrude.[69] With the U.S. military being the largest domestic consumer of oil, purchasing 136 million barrels worldwide in fiscal year 2007, the impact of EISA will present challenges for the U.S. if ever placed in a position of supplanting Venezuelan oil.[70]

Mexico

Mexico currently ranks second behind Canada in U.S. oil imports. Since 2003, Mexico exported an average of 1.5 mbd in crude oil (less refined products) to the U.S.[71] Like Venezuela, the oil relationship between the U.S. and Mexico is one of mutual convenience. Over eighty percent of Mexico's total crude oil production is located on its Gulf Coast and the close proximity of U.S. refineries provides both countries an opportune client.[72] The Cantarell oil field, located in the Gulf of Campeche, is considered one of the largest oil fields in the world.

Cantarell began production in 1979 and levels immediately began to decline due to lowering reservoir pressure. In 1997, after injecting nitrogen to raise extraction pressure, oil production temporarily increased with production levels in 2004 doubling the 1995 levels.[73] However, this year also marked a peak of its production at 2.1 mbd.[74] The same nitrogen extraction method used in Cantarell was tried on Mexico's other oil fields with some success. The Ku-Maloob-Zaap oil complex increased oil production by 120,000 bbl/d and Mexico expects to increase production from 403,000 bbl/d to 800,000 bbl/d by 2010.[75] However, this level of increased production would only be offsetting the declines in the Cantarell field and does not contribute to an overall increased production capacity.

The biggest obstacle to Mexican oil production is the government control of the oil sector. In 1938, the Mexican government nationalized the U.S., British, and Dutch oil companies into Petroleos Mexicanos (PEMEX), and today turns 61 percent of its revenues over to the government, accounting for 40 percent of Mexico's budget.[76] Despite the high gasoline prices during the first half of 2008, PEMEX reported a $1.7 billion dollar loss.[77] Even if Mexico identified additional oil reserves, PEMEX's dilapidated infrastructure cannot support an increase in oil production. In order to modernize its refineries and pipelines, PEMEX requires $9 billion dollars before it can even consider exploration.[78] Additionally, the Mexican Constitution prevents foreign oil companies from investing in PEMEX. Proponents of privatization, including President Felipe Calderon and former President Vicente Fox, argue that unless the government acts now to amend the Constitution, Mexico's oil reserves will only last seven more years.[79]

The current political situation in Mexico does not bode well for increased oil production despite the opportunities of untapped oil reserves. Only 20 percent of Mexican territory has been comprehensively explored with a majority located in deep waters of the Gulf of Mexico.[80] While there has been a public call to explore these deep water areas, experts agree that PEMEX does not have the technical expertise or capital to drill these areas. PEMEX has identified a region north of Mexico City as another area for future production. The Chincontepec project is estimated to have 6.5 billion barrels in reserves, but the area is still in the early stages of development with no firm date for production.[81] Additionally, there is debate as to the validity of PEMEX's estimation of oil. Therefore, the prospect of Mexico increasing its oil production looks bleak. While the U.S. could turn to Mexico to increase production in the past, this is not the case today. Opportunities due exist in offshore oil areas and the Chincontepec projects, but their future production is uncertain and years from becoming a reality. The U.S. cannot rely on these projects as viable solutions to a loss of Venezuelan oil. Unless immediate and radical changes to PEMEX and the Mexican Constitution are implemented, the U.S. should not depend on Mexico to increase its oil production in order to supplant a Venezuelan loss. In fact, a future long term loss of Venezuelan oil would only be exacerbated as Mexico's imports to the U.S. will likely decline.

Brazil

Brazil is the second largest producer of oil in South America after Venezuela. With 12.2 billion barrels of proven oil reserves, Brazil is currently producing 1.75 mbd of crude oil.[82] Brazil's crude oil fields are located offshore in water as deep as 18,000 feet. Brazilian oil (known as Marlim crude) is similar to Venezuelan oil in terms of API (19.6 degrees,) yet its sulfur content is lower. Recent discoveries in the Campos and Santos Basins are projected to lead to additional production increases in the long term. The deepwater Santos basin contains the Tupi, Iara, and Guara fields and expects to be producing a combined 300,000 bbl/d by 2012.[83] These fields are expected to produce oil and natural gas equivalent to 56 billion barrels of crude oil.[84]

Since 2000, Brazil's oil exports to the U.S. have increased from 51,000 bbl/d to almost 200,000 bbl/d.[85] The rise in Brazilian oil imports is due to Petrobras, the Brazilian state-owned oil company, bringing three oil projects online in 2007 from the shallower Campos Basin, contributing to an increase production of 460,000 bbl/d.[86] Non-OPEC countries conventional liquid production is expected to increase from 50 mbd by 2015 to 55 mbd by 2030.[87] Brazil's contribution to this production (crude oil and ethanol) is projected to grow at an average annual rate of 4.4 percent from 2005 to 2030, resulting in a production level of 3.8 mbd.[88] Brazil's future oil consumption is expected to increase from 2.57 mbd in 2015 to 3.68 mbd by 2030, leaving little available for export.[89] Most likely, the amount available for export will be less than 1.6 mbd and current importers of Brazilian oil like China, Europe, and the U.S. will be vying for their portion. However, the U.S. is in a better position to receive a larger share due to its ability to refine Brazilian oil.[90]

Ecuador

Ecuador ranks twelfth in U.S. oil imports but is the next largest Latin American exporter behind Brazil.[91] Ecuadorian exports to the U.S. have fluctuated since 2002 illustrating the volatility and uncertainty of its crude oil. U.S. crude oil imports account for 50 percent of Ecuador's exports and have varied as low at 100,000 bbl/d in 2002 to as high 276,000 bbl/d in 2005.[92] The largest and most productive oil fields are located in the northeast part of the country providing heavy to medium sour crude varieties. These oil fields have been completely explored with no new discovered areas of production.

There is one region, located in the Amazon, which provides an opportunity of additional reserves. The Ishpingo-Tapococha-Tiputini (ITT) oil field has been estimated to have between 900 million and 1.2 billion barrels of oil and if fully developed could produce at least 190,000 bbl/d.[93] The oil field is sparking domestic and international protests because it is located in Yashuni National Park, a United Nations Biosphere Reserve, and home to some of the last uncontacted indigenous people in the world, whose cultural survival may depend upon its protection.[94] Due to the outcry for preservation, Ecuadorian President Rafael Correa is willing to prevent ITT's development and forfeitures in an estimated $9 billion in revenues, so as long as the international community compensates for this loss through measures such as debt cancellation.[95] Correa's proposal has been met with mixed results but countries such as Spain, Norway, and Belgium have helped in sponsoring the initiative.[96] Currently, ITT remains off-limits to drilling.

If Ecuador did decide to reverse its decision and allow drilling of ITT, do not expect the U.S. to reap any benefits from increased production. Brazil's Petrobras and Andes Petroleum, a consortium of China's National Petroleum Company, China Petrochemical Corporation and their subsidiary PetroOriental, have expressed an interest in ITT if Ecuador decides to reverse its decision.[97] Additionally, the government controlled oil company, Petroecuador, seized production assets of the U.S. oil company, Occidental Petroleum Corporation in 2006. The U.S. company has launched an arbitration claim against the government in hopes of seeking compensation for the takeover. The Occidental case complicates the United States' relationship with Ecuador. Regardless of the outcome, any increased oil production available will not likely reach U.S. shores and provide no compensation for a loss in Venezuelan oil.

Domestic Production

Between 2006 and 2030, U.S. crude oil production is expected to increase from 5.1 mbd, peak in 2018 at 6.3 mbd, and then decline to 5.6 mbd.[98] However, U.S. consumption is expected to increase from 20.7 mbd to 22 mbd by 2020.[99] While nowhere near being energy independent, the increase in domestic production is expected to maintain oil imports approximately steady until 2030. U.S. petroleum import dependence will fall from nearly 60 percent in 2006 to 54 percent by 2030.[100] The bulk of domestic production increase is expected from the Gulf of Mexico offshore drilling, along with increasing bio-fuel coal-to-liquid (CTL) production.[101]

Oil production in the Gulf of Mexico is expected to increase from 1.3 mbd to 2.2 mbd by 2030. Deepwater oil production will have the most significant contribution to the increase reaching a peak of 2 mbd in 2019.[102] Production in the shallower Gulf waters will decline from 350,000 bbl/d to 230,000 bbl/d in 2030.[103] Alaska is an area where future U.S. production will see increases in offshore production, but overall the production will decline by 2030. Alaska crude oil production is expected to decline from 741,000 bbl/d to 520,000 bbl/d by 2014.[104] After 2014, offshore development off Alaska's North Slope is expected to increase total crude oil production from 520,000 bbl/d to 700,000 bbl/d by 2020, before declining to 300,000 bbl/d by 2030.[105]

Alaska's future oil production does not include the Arctic National Wildlife Refuge (ANWR). Oil production in ANWR has long been debated as a possible source of oil. Federal law currently prohibits the development of oil and natural gas within ANWR. Due to public concerns over a perceived over-reliance on foreign oil, Senator Ted Stevens requested the EIA to assess crude oil production if ANWR was immediately opened to drilling.[106] Assuming that enactment of legislation in 2008 would allow drilling, EIA anticipated the first production would begin in 2018.[107] The EIA estimates there is between 5.7 and 16.0 billion barrels of recoverable oil available in ANWR.[108] Using the mean case in the analysis, EIA predicts that by 2020, oil production in ANWR would be 200,000 bbl/d increasing Alaska's crude oil production to 900,000 bbl/d.[109] Oil production in ANWR would be expected to increase to 780,000 bbl/d by 2027 before declining to 710,000 bbl/d by 2030.[110] If ANWR is included in future U.S. production, then U.S. imports of crude oil falls to 48 percent by 2024 before increasing to 51 percent by 2030 (compared to 54% without ANWR oil).[111]

In addition to ANWR, there are other areas in the U.S. that can provide additional oil. The National Petroleum Reserve Alaska (NPRA), located in the northwest part of the state, is estimated to have between 6.7 and 15.0 billion barrels of oil.[112] In July 2007, the U.S. Bureau of Land Management opened the northeast portion of NPRA to drilling. It is estimated that production in NRPA could begin as early as 2012.[113] However, no analysis has been conducted to date on estimated daily production levels and like ANWR are not included in future oil production forecasts. Additionally, the United States Geologic Survey (USGS) also revised its estimates on oil reserves located in Montana and South Dakota. When compared to ANWR and NPRA, the Bakken Formation would provide an insignificant amount of oil, with the USGS assessing only 3.65 billion barrels of undiscovered oil.[114]

Any forecasted increase in U.S. crude oil production will only meet the demands of domestic consumption and will not provide a surplus to compensate for Venezuelan oil. ANWR, with a projected production level of 900,000 bbl/d, is a credible solution to a loss of Venezuelan oil. However, if ANWR were immediately opened to permit drilling, then the U.S. could possibly begin to compensate for a loss of Venezuelan oil, but not until at least 2025. With considerable public and congressional opposition to drilling in ANWR because of its impact to the environment, the likelihood of ANWR contributing to U.S. production within the next two decades is unlikely.

Chapter 5

Ethanol

Ethanol and biodiesel are expected to comprise a larger percentage of transportation fuels over the next two decades. By 2030, ethanol and biodiesel are forecasted to contribute an equivalent 2.05 mbd of crude oil to the United States' 21.6 mbd consumption of liquid fuels.[115] Ethanol and biodiesel consumption will increase to 3.4 quadrillion BTUs by 2030 growing 3.3 percent per year.[116] Ethanol blended fuel comprised 4 percent of the motor gasoline pool in 2006 and is expected to increase to 15.8 percent of the total motor gasoline pool in 2030.[117] Ethanol is a fuel made from almost any plant material such as corn, sugarcane, even yams and contains the same chemical compound that is found in alcohol.[118] Over 99 percent of ethanol produced in the U.S. is mixed to make E10, a fuel containing 10 percent ethanol and 90 percent gasoline.[119] E85, a fuel containing a mixture of 15 percent gasoline and 85 percent ethanol, is also available in the U.S. .[120] However, E85 can only be used by flex fuel vehicles (FFV) which engines are specifically designed to handle the higher concentration of ethanol.[121] FFVs vehicle sales are expected to increase from 454,600 vehicles in 2006 to 2.7 million vehicles by 2030.[122]

The U.S. is the world's largest producer and consumer of ethanol blended fuel consuming approximately 5.4 million gallons in 2006.[123] The Energy Policy Act of 2005 established a Renewable Fuel Standard (RFS) requiring a dedicated amount of renewable fuel be blended with gasoline such that by 2012, 7.5 billion gallons of fuel meet this requirement.[124] The majority of this fuel was expected to be made from corn ethanol.[125] The Energy Independence and Security Act (EISA) of 2007 expanded the requirement such that by 2022, 36 billon gallons of transportation fuel will require domestically produced renewable fuels.[126] Of the 36 billion gallons, 21 billons gallons must be "from feedstocks other than corn starch and having 50% lower lifecycle emissions than petroleum fuels."[127] While there may be an increase in U.S. produced renewable fuels, the expected U.S. liquid energy consumption of 21.6 mbd in 2030 includes the EISA 2007 requirements for increased renewable fuels such as ethanol and biodiesel.[128] Therefore, to account for the loss of Venezuelan oil, a solution would require the U.S. to produce more renewable fuels than 36 billion gallons or look for non-domestic sources.

The United States and Brazil together produce 70 percent of the world's ethanol.[129] The overwhelming majority of ethanol produced in Brazil is from sugarcane. Brazil is forecasted to produce 530,000 bbl/d of ethanol in 2009 but currently exports 86,000 bbl/d.[130] In 2007, the U.S. imported 12,000 bbl/d of pure ethanol down from the previous year's 30,000 bbl/d.[131] In 2006, members (Costa Rica, El Salvador, Jamaica, and Trinidad and Tobago) of the Caribbean Basin Initiative (CBI) exported 15,000 bbl/d of ethanol to the U.S.[132] The CBI permits these same nations to export a maximum 7 percent of U.S. daily ethanol consumption without a $0.54 per gallon tax.[133] A major obstacle to increasing Brazilian ethanol imports is that all ethanol exports leaving directly to the U.S. are subject to a 2.5 percent tariff in addition to the $0.54 per gallon tax.[134]

A gallon of gasoline contains an average 124,000 BTUs of energy. A gallon of E100 contains approximately 66 percent the amount of energy as a regular gallon of gasoline or 81,400 BTUs.[135]

	Energy Content (BTUs)
Gasoline	124,000
Diesel	139,000
E100	81,400
E85	92,830

Table 2: Energy Content Comparison per Gallon (BTUs)[136 137]

Using the amount 3.8 trillion BTUs per day of Venezuelan oil that needs to be replaced, the U.S. would need to import the equivalent of 1.1 mbd of ethanol from Brazil and other nations. The EIA's Annual Energy Outlook 2009 Early Release Report forecasts that in 2020 the U.S. will import 40000 bbl/d of ethanol and will increase to 490,000 bbl/d by 2030.[138] These amounts contribute to the 21.6 mbd of daily U.S. consumption in 2030. Assuming the U.S. would substitute all 3.8 trillion BTUs of energy with ethanol, the U.S. will need to import 1.2 mbd of ethanol in 2020 and 1.6 mbd by 2030.

By looking at Brazil's expected ethanol production in 2020 and 2030, it is theoretically possible that importing ethanol alone can overcome a loss of Venezuelan oil. Oak Ridge National Laboratory conducted an assessment on the future of biofuels. The 2007 assessment, titled "Biofuel Feedstock Assessment of Selected Countries," identified several Latin American and Caribbean countries based on the ability of their traditional crops to produce biofuel.[139] The report projected crop productions in sugarcane, corn, wheat, soybeans, and palm oil in 2012, 2017, 2027 for each country and the expected percentage available for export.[140] The report did not differentiate between the type of export available, such as the crop itself or as a converted biofuel, but only the total amount of the crop available for export.

The report projected that Brazil will produce 594.4 million metric tons (mmt) of sugarcane in 2017 and increase to 1053.1 in 2027.[141] During the same years, 82 percent of the sugarcane produced per year is expected to be available for either export or biofuels.[142] Therefore, if Brazil decided to convert all of its exported sugarcane to ethanol, the amount of ethanol produced would be 1.0 mbd in 2017 and 1.44 mbd in 2027. Recalling that 1.1 mbd of ethanol is required to overcome the 704,000 bbl/d of Venezuelan oil, Brazil cannot produce enough sugarcane in 2017 to overcome the required 1.1 mbd of ethanol. In 2027, Brazil would have to convert 78 percent of its sugarcane exports to ethanol in order to replace Venezuelan oil with an ethanol-only solution. While Brazil alone is not be the solution to a loss of Venezuelan oil, combining ethanol imports with other Caribbean nations is a feasible substitute.

Chapter 6

Fuel Conservation

By 2020, U.S. consumption of liquid fuels is expected to increase 1.3 mbd to 22 mbd while earlier estimates were as high as 24 mbd.[143] The lower estimate is based upon predicted higher energy prices and the impacts of the 2007 Energy Independence and Security Act (EISA).[144] EISA directed the Secretary of Transportation to establish fuel economy standards for passenger cars and light trucks beginning with Model Year (MY) 2011 such that by MY 2020, the average fuel economy is 35 miles per gallon (mpg).[145] The National Highway Transportation Safety Administration (NHTSA) also projected that by MY 2015, the average fuel economy will increase from 27.8 mpg in MY 2011 to 31.6 mpg.[146] These higher fuel standards are known as the Corporate Average Fuel Economy (CAFE) and are set at the "maximum feasible level," based upon four major criteria: technological capability, economic practicability, effects on other standards of fuel economy, need of nation to conserve more energy.[147]

By comparing the amount of fuel provided from Venezuelan oil to the expected savings from new CAFE standards, the impact of fuel conservation on a loss of Venezuelan oil is illustrated. The NHTSA has predicted long term U.S. conservation trends based upon the set CAFE standards in EISA. The NHTSA prepared an Environmental Impact Statement (EIS) to determine the potential effects of EISA on the imposed CAFE standards. The EIS used the four major criteria to develop several alternative CAFE standards. These standards varied in degree from no change in the current standard (Alternative 1), to one that optimized the benefits in all four criteria (Alternative 3), to an even higher fuel standard in which vehicle manufacturers applied all available technologies (Alternative 7), but yielded negative net benefits.[148]

Table S-1 Reference Case Alternative CAFE Standards in MY 2015 MPG							
	Alt. 1	Alt. 2	Alt. 3	Alt. 4	Alt. 5	Alt. 6	Alt. 7
	No Action	25% Below Optimized	Optimized	25% Above Optimized	50% Above Optimized	Total Costs Equal Total Benefits	Technology Exhaustion
Cars	27.5	33.3	33.4	33.5	33.7	33.9	47.1
Trucks	23.4	25.8	26.0	26.2	26.5	27.0	37.2

Table 3: Reference Alternative CAFE Standards in MY 2015 (mpg).[149]

The EIS also used an economic model against the alternative CAFE standards resulting in two overarching scenarios (Reference and High Scenarios).[150] These scenarios were based upon three major factors. The first factor determined the damage done by emitting carbon dioxide, known in economic terms as the social cost of carbon. The second factor was oil externalities, which is a cost not reflected in the price of oil that is incurred by the U.S. due to the negative effects of importing oil like its associated air and water pollution. The final factor is the EIA's predicted average fuel price for the years 2011-2030 based on 2007 dollars.[151]

Table S-2 Reference Case and High Scenario Economic Model Inputs				
	Value of Carbon Dioxide (CO_2) (2007 $/ton)	Oil Import Externalities (2007 $/gallon)	*Annual Energy Outlook 2008* a/ Fuel Price	Discount Rate
Reference Case	$2.00 (domestic)	$0.326	$2.41 (reference)	3% CO_2 – 7% Other
High Scenario	$33.00 (global)	$0.116	$3.33 (high)	3% CO_2 – 3% Other

a/ Both the Reference and High *Annual Energy Outlook* fuel price vary by year. Price shown is the average 2011-2030 price for gasoline expressed in 2007 dollars.

Table 4: Reference Cases and High Scenario Economic Model Inputs (dollars).[152]

Table S-3							
High Scenario Alternative CAFE Standards in MY 2015 MPG							
	Alt. 1	Alt. 2	Alt. 3	Alt. 4	Alt. 5	Alt. 6	Alt. 7
	No Action	25% Below Optimized	Optimized (Preferred)	25% Above Optimized	50% Above Optimized	Total Costs Equal Total Benefits	Technology Exhaustion
Passenger Cars	27.5	37.2	37.7	38.2	38.8	39.8	47.1
Light Trucks	23.4	28.9	29.6	30.3	31.0	32.3	37.2

Table 5: High Scenario Alternative CAFE Standards in MY 2015 (mpg)[153]

Through modeling the alternative CAFE standards in the Reference and High Scenarios, the NHTSA predicted future U.S. annual fuel consumption and potential fuel savings. The resulting fuel consumption and fuel savings are based upon MY 2011-2015 CAFE standards and are compared against a No Action alternative, in which the CAFE standard remained at pre-2007 EISA approved levels. Using the Optimized Alternative and Reference Scenario, the results show that by 2020 the U.S. will save 2.6 billion gallons of fuel. When compared with the High Scenario, the Optimized Alternative increases fuel savings to 6.7 billion gallons.

Table S-4							
Reference Case Passenger Car and Light Truck Annual Fuel Consumption and Fuel Savings (billion gallons)							
	Alternative CAFE Standards for MY 2011-2015						
	Alt. 1	Alt. 2	Alt. 3	Alt. 4	Alt. 5	Alt. 6	Alt. 7
Calendar Year	No Action	25% Below Optimized	Optimized	25% Above Optimized	50% Above Optimized	Total Cost Equal Total Benefit	Technology Exhaustion
Fuel Consumption							
2020	151.8	149.4	149.2	148.7	148.4	147.8	134.9
2030	172.4	167.7	167.2	166.5	165.8	164.9	141.8
2040	198.5	192.8	192.1	191.3	190.4	189.3	161.1
2050	229.7	222.9	222.2	221.2	220.1	218.7	185.9
2060	264.9	257.1	256.3	255.1	253.8	252.3	214.3
Fuel Savings Compared to No Action							
2020	--	2.4	2.6	3.1	3.4	3.9	16.9
2030	--	4.7	5.2	5.8	6.6	7.5	30.5
2040	--	5.8	6.4	7.2	8.2	9.2	37.4
2050	--	6.8	7.4	8.5	9.5	10.8	43.8
2060	--	7.8	8.6	9.7	11.0	12.5	50.5

Table 6: Reference Case Passenger Car and Light Truck Annual Fuel Consumption and Fuel Savings (billions gallons)[154]

Table S-5 (cont'd) High Scenario Passenger Car and Light Truck Annual Fuel Consumption and Fuel Savings (billion gallons)							
	Alternative CAFE Standards for MY 2011-2015						
	Alt. 1	Alt. 2	Alt. 3	Alt. 4	Alt. 5	Alt. 6	Alt. 7
Calendar Year	No Action	25% Below Optimized	Optimized	25% Above Optimized	50% Above Optimized	Total Cost Equal Total Benefit	Technology Exhaustion
Fuel Savings Compared to No Action							
2020	--	5.6	6.7	7.8	8.6	9.4	15.5
2030	--	11.0	12.8	14.6	15.9	17.2	27.5
2040	--	13.5	15.6	17.8	19.4	20.9	33.4
2050	--	15.5	18.0	20.6	22.5	24.2	38.6
2060	--	17.8	20.6	23.4	25.6	27.6	44.1

Table 7: High Scenario Passenger Car and Light Truck Annual Fuel Consumption and Fuel Savings (billions gallons).[155]

Assuming that Venezuelan imports remain constant through 2020, the total amount of gasoline and diesel produced daily is 29.7 million gallons. While the fuel savings by 2020 vary from 2.4 to 6.7 billion gallons, these amounts conserve the equivalent of 80.8 days or as much as 225 days of Venezuelan imported fuel. Comparing these values illustrates that through conservation programs alone, the U.S. likely will not be able to overcome a sustained loss of Venezuelan oil.

Chapter 7

A Long-Term U.S. Energy Policy Without Venezuelan Oil

A long-term strategy to overcome 704,000 bbl/d of Venezuelan oil spans the next two decades based upon forecasts projecting to 2030. The comprehensive strategy is described through four 5-year periods. Within each period, sources of additional foreign and domestic oil production, availability of additional ethanol, and impacts of fuel conservation are summarized. The strategy also identifies possible energy sources that can compensate for the loss of Venezuelan oil. It is important to note that the strategy is based on current projections of the world's future oil production and consumption as well as the predicted sources of available oil.

2010-2015

If Venezuela stops exporting oil to the U.S. during this period, the U.S. has few options available. Increased domestic production will likely not be available other than deep-water offshore production in the Gulf of Mexico. This offshore production will not provide any surplus capacity but rather help to counter production declines in other regions, primarily in Alaska. The U.S. also cannot expect to find an increase capacity in foreign oil production. Mexico's oil production will continue to decline so long as PEMEX remains nationalized. During this period, Brazil will be a net exporter of oil but imports to the U.S. will remain at current or lower levels. By 2015, Brazil's oil consumption is expected to increase by more than 300,000 bbl/d, leaving approximately 135,000 bbl/d available for export.[156]

Between 2010 and 2015, Canadian oil sands will become an increasing player on the international market by increasing production from 1.91 mbd to 2.34 mbd.[157] Canada's total exports (conventional and oil sands) will increase from 1.44 mbd in 2010 to 1.56 mbd in 2015.[158] Lower transportation costs and its refinery capability places the U.S. in an excellent position to receive the oil sands. However, the projected amount of Canadian exports during this period is similar to what the U.S. currently imports today. Brazil and Canada exemplify the expected trend that while production may increase during the period, consumption levels will also rise, and thus will negate any surplus capacity. Therefore, by 2015 there is no surplus capacity of 704,000 mbd of crude oil available in the Western Hemisphere markets.

U.S. ethanol production and consumption will expand and importation of Brazilian and Caribbean ethanol will also increase during this period. Ethanol production will increase from 810,000 bbl/d in 2010 to 1.04 mbd in 2015.[159] However, this increase in production is accounted for in projected U.S. consumption of 21.74 mbd by 2015.[160] There will not be a surplus of ethanol available for the U.S. to compensate for any portion of Venezuela's lost 704,000 bbl/d. Fuel savings, as a result of the CAFE standards implemented under the 2007 EISA, have little or no effect on domestic consumption since the first projected savings are not expected until 2020.

A loss of Venezuelan oil during this period will likely require expending at least a portion of the U.S. Strategic Petroleum Reserve. The U.S. Strategic Petroleum Reserve is 700 million barrels of light crude oil available for major disruptions in the oil supply.[161] Using the 704,000 bbl/d as the amount, the Strategic Reserve can offset the loss of Venezuelan oil for approximately 30 months. Additionally, the U.S. could pursue other nations' stockpiles by coordinating through the International Energy Agency (IEA). Members of the IEA are required to maintain stocks equal to at least 90 days of its net imports.[162] The IEA members must release their reserves, restrain demand, and share available oil during times of oil disruptions.[163] The difficulty of expending these strategic reserves is that it would be expected these nations and the

U.S. would replenish their stockpiles at a time when there is a limited amount of excess oil available. In addition, the U.S. must encourage energy efficiency and conservation programs although its mitigating effects would be minimal. The largest effect on reducing consumption would likely be the rise in gasoline prices due to the loss in Venezuelan oil. As a result, gasoline shortages would also occur across the country requiring fuel rationing in order to meet domestic demand.

Despite the gloomy outlook, Venezuela is not likely to permanently sever oil imports to the U.S. during this period, because the U.S. refines a significant amount of Venezuela's heavy sour crude oil. Venezuela could not easily divert the 704,000 bbl/d to other countries since a significant portion of the refineries specifically designed to handle Venezuelan oil are located in the U.S. and Virgin Islands.[164] Venezuela does partially own refineries in Europe capable of producing a maximum 291,000 bbl/d.[165] Venezuela would suffer economically as a large portion of its crude oil exports would remain in country and likely cause production levels to drop off forcing worker layoffs. With the oil sector as the most critical component of its economy, internal conflict would likely occur placing the Venezuelan government in a difficult position. The Venezuelan owned refineries in the U.S. would likely cease operations causing additional losses in revenues. The U.S. could seize these refineries and divert the imported Canadian oil sands to blend with the remaining Venezuelan crude as well as the U.S. Strategic Petroleum Reserve.

A plausible scenario is that Venezuela may discontinue exports to the U.S. but still send its oil to refineries located in the U.S. Virgin Islands and Netherlands Antilles. The U.S. Virgin Islands' refinery currently refines 300,000 bbl/d but has a capacity to refine 495,000 bbl/d.[166] Venezuela may then divert a portion of the 704,000 bbl/d that is normally intended for U.S.

refineries and send to the U.S. Virgin Islands. This scenario still does not prevent expending at the U.S. Strategic Petroleum Reserve but does extend the stockpile to almost 44 months.

2015-2020

The U.S. will have more options available during this period but overall access to additional oil sources will remain limited. Domestic deepwater oil production increases and peaks in 2019 at 2 mbd. However, this increase only offsets declines in the shallower Gulf waters and production on Alaska's North Slope. Overall, the domestic crude oil production increases by 300,000 bbl/d between 2015 and 2020.[167] Domestic oil consumption does lower from 21.59 mbd to 21.47 mbd over the same period,[168] but oil imports remain steady.[169] Canada's oil production increases to 4.17 mbd by 2020 with 68 percent coming from Canadian oil sands.[170] Canada's oil consumption also increases slightly from 2.34 mbd to 2.36 mbd.[171] During the five year period Canadian net oil exports increase from 1.56 mbd to 1.81 mbd, resulting in an additional 250,000 bbl/d of Canadian oil available for export to the United States.

Brazil's deepwater oil production will help to maintain the country as a net oil exporter. However, the overall net imports available over this period reduce from 135,000 bbl/d to 110,000 bbl/d.[172] With multiple countries vying for Brazil's limited amount of exported oil, it will be difficult for the U.S. to receive any additional portion. Ethanol from Brazil has the potential to contribute to the solution, although ethanol in itself will not be sufficient to overcome the Venezuelan loss. While it would be unlikely for Brazil to convert all of its exported sugarcane into ethanol, it is feasible for Brazil to convert at least half of the estimated 1 mbd of ethanol that is expected to be grown in 2017. Therefore, 500,000 bbl/d of Brazilian ethanol is equivalent to 320,000 bbl/d of Venezuelan oil. The U.S. is forecasted to import an average 30,000 bbl/d of ethanol during this period so any additional imported ethanol could be considered a surplus. What may limit the amount exported to the U.S. are the current tariffs imposed on Brazilian ethanol.

To overcome a loss of Venezuelan oil, an energy strategy should incorporate the surpluses in Canadian oil sands and Brazilian ethanol that are forecasted to be available. Assuming the 250,000 bbl/d of oil sands and 500,000 bbl/d of ethanol from Brazil are available for importing, these imports would equate to approximately 575,000 bbl/d of Venezuelan oil. There still would be 125,000 bbl/d that requires attention. Combined with the 250,000 bbl/d of Canadian oil sands, Brazil would have to export 690,000 bbl/d of ethanol to the U.S. in order to compensate for the 704,000 bbl/d of Venezuelan oil. If Brazil converted all their sugarcane exports to ethanol during this period, then the amount of ethanol available would be 1.0 mbd. It is unlikely that Brazil would convert 70 percent of its exported sugarcane to meet this U.S. requirement. However, the U.S. could negotiate to increase the additional amount of Brazilian ethanol closer to 500,000 bbl/d.

The proposed energy strategy results in a likely shortage of 200,000 bbl/d of oil. With the imposed CAFE standards not having an impact until after 2020, the U.S. will be forced to make a decision on using the U.S. Strategic Petroleum Reserve. It would take over fifteen years to deplete the U.S. stockpile at rate of 125,000 bbl/d. At such a slower rate, the U.S. could expend the strategic reserve in order to bide time until more Canadian oil sands and ethanol are available.

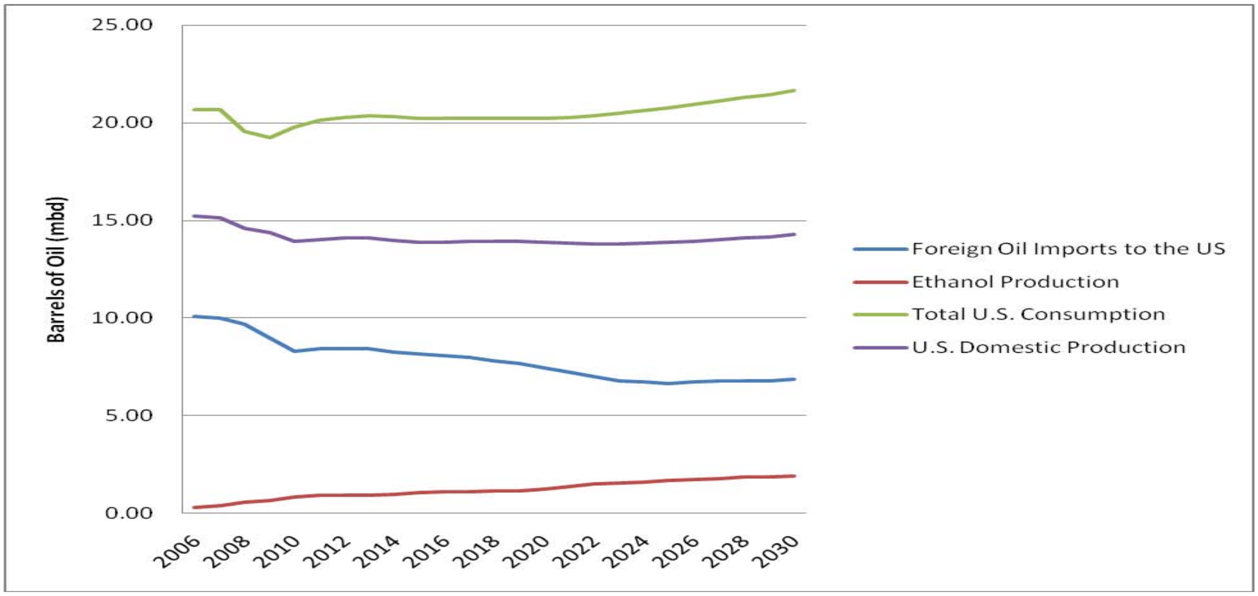

Figure 3: U.S. Production and Consumption Levels 2006-2030 (mbd)[173]

2020-2025

This period marks the first time where the U.S. can overcome the 704,000 bbl/d of Venezuelan oil without using the U.S. Strategic Petroleum Reserve. Domestic oil production will peak in 2018 at 6.3 mbd and continue to decline. Canada's oil production increases from 4.17 mbd to 4.57 mbd between 2020 and 2025 with oil sands accounting for 72 percent.[174] Canada's oil consumption is expected to increase by only 200,000 bbl/d, which results in 2.2 mbd of oil available for export.[175] When compared to the previous period, the amount of surplus oil available increases to 630,000 bbl/d. Canadian oil sands stand to be a significant player in solving the loss of Venezuelan oil. The Venezuelan owned refineries in the U.S. are available to refine the oil sands which properties are similar to Venezuelan crude oil.

The number of oil exports available from Brazil will continue to decline during this period. However, ethanol surpluses from Brazil will still be available and are forecasted to increase. The U.S. is expected to import an average 150,000 bbl/d of ethanol between 2020 and 2025 but Brazil will have the ability to export 1.2 mbd of ethanol. The U.S. could combine the surpluses in Brazilian ethanol and Canadian oil sands to overcome a Venezuelan loss of oil. With the amount of ethanol available for export increasing to 1.2 mbd, 500,000 bbl/d of ethanol seems much more plausible. With 500,000 bbl/d of ethanol the equivalent to 320,000 bbl/day of Venezuelan oil, the ratio of Canadian oil sands to ethanol used could be much more balanced. Using increasing amounts of Canadian oil sands will likely create public opposition due to its large contribution to greenhouse gases.

Starting in 2020, the CAFE standards will begin to reduce domestic consumption. As stated previously, the CAFE standards are expected to create fuel savings of 2.6 billion gallons in 2020, equating to 80 days of Venezuelan oil. EIA forecasts do include the impacts of CAFE standards using the nominal reference values (Alternative 3). However, if the U.S. were able to reach the more technological advanced alternatives (Alternatives 3-7), the fuels savings could increase as high as 16.9 billion gallons, equating to 520 days of Venezuelan oil.[176] Fuel savings above and beyond the expected 2.6 billion gallons could reduce the required amount of Canadian oil sands and Brazilian ethanol.

2025-2030

The United States maintains its ability to overcome a loss in Venezuelan oil during this period. Domestic production is forecasted to decline from 6.3 mbd in 2018 to 5.6 mbd in 2030.[177] Canada's oil production increases from 4.57 mbd to 5.01 mbd between 2025 and 2030 with oil sands accounting for 79 percent.[178] Canada's domestic consumption increases slightly from 2.38 mbd to 2.40 from 2025 to 2030 and thus increases oil exports by 420,000 bbl/d to 2.61

mbd.[179] When compared to the amount of oil available in 2015, Canada now has an 800,000 bbl/d surplus available for export.

Brazil's oil production will decline such that by 2030 it will become a net importer. Domestic oil consumption will increase to 3.42 mbd to 3.68 mbd while Brazil's oil production increases only 100,000 bbl/d to 3.66 mbd.[180] Ethanol surpluses from Brazil will increase even further than the previous period to 1.44 mbd available for export. This increase in ethanol imports allows an increase to 700,000 bbl/d of ethanol or the equivalent of 448,000 bbl/d of Venezuelan oil. The end result is more oil sands and ethanol available to overcome the Venezuelan loss of oil but allows the opportunity for ethanol to comprise a higher percentage of the total amount.

The CAFE standards will help in maintaining overall U.S. consumption around 22 mbd between 2020 and 2030. By 2030, fuel savings double from 2.6 billion gallons to 5.2 billion gallons which is equivalent to 179 days of Venezuelan oil. However, using other technology driven alternatives could increase fuel savings as high as 30.5 billion gallons by 2030, resulting in 1051 days of Venezuelan oil. Higher CAFE standards would allow less importing of oil sands or ethanol during this period.

Chapter 8

Recommendations

The gap between world energy production and consumption will remain small over the next two decades, limiting the availability of oil surpluses. However, there are opportunities available to the U.S. that could lead to additional liquid fuels above and beyond its projected consumption. Some of the recommendations offered for consideration are separate from the long-term comprehensive strategy because they are not derived from the long-term forecasts of available energy. These recommendations identify possible sources of oil not considered in the forecasts. All recommendations are not in themselves a combined or single solution to obtaining additional oil. Almost all the recommendations have associated political, economical, and environmental issues that have positive and negative ramifications. These factors are often in conflict with each other and must be identified and balanced before choosing an option. The expectation is that if any of these recommendations are considered a viable option, they should be acted upon as early as possible since it takes time for implementation and much longer before their impact will be felt.

1. **The U.S. must encourage the Mexican government to privatize portions of PEMEX that would open exploration and production to Mexico's deep offshore oil fields.** The Mexican Constitution declares oil as property of the state and prevents contracts with foreign companies.[181] The proponents of excluding foreign oil companies are the result of a strong sense of nationalism and a perceived threat to its sovereignty. With proven

reserves expected to only last nine years, opponents, including, President Felipe Calderon, believe now is the time to take a pragmatic approach and reform the constitution.[182] In May 2008, Calderon proposed changes to the Mexican Congress that would allow foreign companies in a limited scope into Mexico's oil industry. After five months of debate, the Congress did pass limited energy reform giving PEMEX more budgetary freedoms and transparency, but did not open PEMEX to foreign investment.[183]

Mexico's national debate over privatization of its energy sector is an internal debate over which the U.S. has no direct influence. Any overt or public encouragement by the U.S. would likely be viewed as a threat to Mexico's sovereignty and kindle anti-U.S. sentiment. However, the U.S. should still work with the proponents within the Mexican government that support privatization of Mexico's oil industry. The U.S. should also sponsor economic and political incentives that could entice opponents of privatization to compromise. As Mexico's oil production continues to decline, it is likely that over the next decade the debate will intensify and ultimately the Mexican Congress will be forced to amend the constitution to allow foreign oil investment. The U.S. is a logical customer for Mexico due to their close proximity and should position itself to be the largest importer of untapped offshore oil fields.

2. **The U.S. should consider raising CAFE Standards higher than the current 31.6 mpg for MY 2015 and beyond.** Technology currently exists that allows automobiles to achieve at least 10 mpg more than current standards.[184] The concern for American automakers is that early increases in the CAFE standards, as the result of installing this technology, will increase unexpected manufacturing costs and cause severe financial losses and lost jobs.[185] The U.S. government should work closely with the auto industry

to create feasible economic solutions that allow the incorporation of improved fuel efficiency technologies and the economic success of the industry. One study concluded that if a gallon of gasoline costs $2.30, then technologies that increased overall fuel efficiencies to 33 mpg would pay for themselves in three to four years.[186] While the amount of fuel savings in gallons is relatively small, raising the CAFE Standards is nonetheless an important component of a U.S. energy policy towards Venezuela. A raise in the fuel efficiency standards could be the tipping point of U.S. dependency on Venezuelan oil. Instead of the U.S. overcoming its reliance on Venezuelan oil sometime after 2020, raising CAFE standards could shift the balance to the left such that the U.S. is free before the end of the next decade.

3. **The U.S. should remove tariffs on imported Brazilian ethanol.** There is substantial opposition to reducing or eliminating the tariff on imported Brazilian ethanol by U.S. corn-ethanol producers.[187] The longer the tariff remains in place the likelihood Brazil will turn to other countries to export its ethanol increases. Japan, a country with no domestic ethanol market, is negotiating with Brazil to import 800 million gallons of ethanol annually starting in 2011.[188] Due to its proximity and demand, the U.S. will likely remain the number one importer of Brazilian ethanol. However, the U.S. must take action now to eliminate the tariff or risk losing accessibility to larger shares of Brazilian ethanol exports, which is expected to increase significantly over the next two decades. Brazilian ethanol is vital to a U.S. policy aimed at removing dependency on Venezuelan oil.

4. **Drilling in Alaska's ANWR is a viable option.** While exploratory drilling has begun in Alaska's NPRA, both ANWR and NPRA do not contribute to future U.S. oil production

estimates located in the EIA's Energy Outlooks. NPRA's future production levels are uncertain although it is expected that production can begin as early as 2012. However, the earliest time production could commence in ANWR is ten years after drilling commences. It will take 12 years from the commencement of drilling before ANWR can produce 200,000 bbl/d. Therefore, if the government approved the drilling of ANWR in 2009, then the earliest time production occurs is 2019, with any considerable amount unavailable until 2021. The earlier the start date for drilling, then the earlier ANWR can contribute to long-term U.S. energy policy. Drilling of ANWR and NPRA will only then begin to contribute to U.S. oil production at a time when other solutions, such as ethanol and Canadian oil sands, are more readily available.

ANWR, with a projected production level of 900,000 bbl/d, is a credible solution to a loss of Venezuelan oil. There is considerable opposition to drilling in ANWR due to over its impact to the environment, but when compared to Canadian oil sands, ANWR's contribution to greenhouse gases and soil or ground water contamination is considerably less. Therefore, a balance of Brazilian ethanol and ANWR is a much more desirable mix than any mixture involving oil sands. Until ANWR reaches its maximum capacity of 900,000 bbl/d, which would fully supplant a loss of Venezuelan oil, a combination is required.

5. **The U.S. should temporarily rescind the ban on Canadian oil sands for military use during severe oil shortages that would occur between 2010-2020.** In 2007, the U.S. military consumed 330,000 bbl/d of oil or about 1.5 percent of total U.S. oil consumption.[189] Assuming military consumption levels stay constant, restricting the military to conventional oils during periods such as a 704,000 bbl/d loss of Venezuelan

oil would only exacerbate the shortage crisis. In the next decade, a Venezuelan loss of oil will force the U.S. to rely heavily on the Strategic Petroleum Reserve and likely cause significant fuel shortages. As the dependency on the Strategic Petroleum Reserve lowers between 2015 and 2020, the necessity of rescinding the ban diminishes. The use of oil sands does raise significant environmental concerns but its impact would only be temporary for the period in question. The law requires changing such that Congress or the President has the authority to temporary repeal and then reinstate the ban during times of severe oil shortages.

Chapter 9

Conclusions

The U.S. can meet its oil consumption needs without Venezuelan oil beginning around 2020. A U.S. energy policy dealing with a permanent loss of Venezuelan oil will initially rely heavily on the Strategic Petroleum Reserve. Towards the end of the next decade, Canadian oil sands and Brazilian ethanol are possible alternatives sources that can reduce a reliance on the Strategic Petroleum Reserve. Beginning in 2020, the U.S. no longer would require the exhaustion of the Strategic Petroleum Reserves as fuel savings due to CAFE standards, increased Brazilian ethanol production, and Canadian oil sands could supplant a loss of Venezuelan oil. Additional sources of oil are available such as ANWR and Mexico's offshore fields, but these options have significant political hurdles to overcome before than can even be considered a possibility. Additionally, any measurable amount of oil produced from these areas will not be available until after 2020.

The challenges of an energy policy that shift away from Venezuela illustrate a much larger, world-wide problem that all countries will experience in the next two decades and beyond. Even if additional sources such as ANWR, Canadian oil sands, Mexico's offshore oil fields, or ethanol become available to the U.S., this does not necessarily equate to a readily available international surplus. Venezuela's 704,000 bbl/d of oil will quickly be consumed by countries such as China or Japan that heavily rely on foreign oil imports to sustain their economies. The U.S. must tap into these possible additional oil sources in the near-term, otherwise in a moment of crisis the likelihood of increasing Brazilian ethanol imports or

Canadian oil sands to the U.S. is low. The U.S. cannot turn to Canada, Brazil, or even Saudi Arabia and expect to easily or readily increase production levels in order to meet U.S. consumption in times of prolonged crisis.

The U.S. should assess its economic and political relationship with Venezuela over the next two decades. If the U.S. has significant concerns about the future security and accessibility of Venezuelan oil, then now is the time for the U.S. to develop an energy policy that does not include Venezuelan oil. The economics behind such a shift is dramatic and a swap of Venezuelan oil for another energy source oversimplifies the challenges involved in shifting to new energy sources. Transportation costs could change dramatically causing gasoline prices to rise or fall. The U.S. would need to determine how to handle the stateside Venezuelan-owned refineries. The U.S. could shutdown these refineries or seize them and at the same time must ensure the right mixture of oil reaches them. The U.S. would need to increase and upgrade its oil infrastructure to handle Canadian oil sands or larger numbers of Brazilian ethanol. An increase in Canadian oil sands introduces additional environmental concerns that would likely spur public debate and additional regulations that increases its costs.

The complexity of changing energy sources where a worldwide oil surplus is estimated to be less than 1 mbd imposes challenges when creating a no-Venezuelan oil policy. Suppose Canada has an additional 100,000 bbl/d of Canadian oil sands available and is willing to export it to the U.S. The U.S. would have to decide whether or not it wants to start replacing the Venezuelan oil with 100,000 bbl/d of Canadian oil. The U.S. could decide not to import the 100,000 bbl/d. With such a small surplus capacity available on the world markets, other countries would then quickly consume it. The U.S. may also incorporate the oil sands into the domestic market while maintaining Venezuelan oil at current levels. Since this option would increase the amount available, then demand would lower resulting in lower fuel prices. The challenge for such a policy is that any supplanting of Venezuelan oil will likely increase fuel prices which is largely unpopular domestically. The difficulty in creating such a policy is balancing consumer wants against national security needs. Regardless, the U.S. must further expand its energy partnerships with Mexico, Canada, and Brazil in the near-term so that their energy resources can be guaranteed for the long-term. If the U.S. does not develop these partnerships now, then the U.S. will be unprepared to handle a loss of Venezuelan oil. The U.S. will have no access to these small surpluses because other counties would have already developed the energy relationships with Canada, Mexico, and Brazil in order to meet their domestic consumption needs.

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