Special Feature

Oil is the lifeblood of war in our times. Without it a nation cannot fight. It is the basic munition. There is nothing else the deprivation of which would have so damaging an effect upon a country's prospect of achieving victory. The loss of it would mean, indeed, the certainty of defeat. However great the reserve of manpower and machine-power, however ample the armaments that have been amassed, a nation could not hope for victory if it lacked the oil-power without which its men, its machines, and armaments would be immobilized and powerless.

—James Molony Spaight, C.B., C.B.E., *The War of Oil*

Thinking about logistics

Air Force Munitions ISO Management: Logistics Enterprise for Containers
Strategic Energy Lessons: A Historical Perspective Applied to America's Source Issues
Integrating Air and Ground: Joint Theater Distribution System

This speial double edition of the Journal presents three featured articles: "Air Force Munitions ISO Management: Logistics Enterprise for Containers," "Strategic Energy Lessons: A Historical Perspective Applied to America's Source Issues," and "Integrating Air and Ground: Joint Theater Distribution System."

In "Air Force Munitions ISO Management: Logistics Enterprise for Containers," the author presents the results of an Air Force Logistics Management Agency (AFLMA) analysis comparing the use of the common commercial ISO (International Organization for Standardization) pool to total ownership of ISO containers to meet Air Force contingency munitions needs. This article documents the relevant background information, problem, objectives, methodology, research, and findings associated with this effort.

The second featured article investigates a past coal-to-liquids program (German efforts during WWII) to determine whether there are strategic lessons for the United States that can be applied to today's energy situation, seen particularly from the perspective of national security.

In the concluding article the authors make the case that a single command structure responsible for the movement control of the theater could better utilize available assets to meet mission requirements by selecting the mode that would be most effective for the mission.

Special Feature

Extending hope and opportunity depends on a stable supply of energy that keeps America's economy running and America's environment clean. For too long our nation has been dependent on foreign oil. And this dependence leaves us more vulnerable to hostile regimes and to terrorists—who could cause huge disruptions of oil shipments, and raise the price of oil, and do great harm to our economy.

—President George W. Bush, State of the Union Address, January 23, 2007[1]

Introduction

Energy is arguably the greatest national security issue for the United States (US). By late 2007, oil broke the $100 a barrel mark. Climate change is being blamed on ever increasing levels of energy usage, resulting in the inevitable conclusion that American national security strategy is being affected by long-term energy considerations.[2] Energy was a major section of the President's State of the Union speech in January 2007, where he outlined a proposal to reduce gasoline usage 20 percent in the next 10 years (*Twenty in Ten*).[3] This position was reemphasized in the 2008 State of the Union. According to the US Department of Energy's Annual Energy Outlook for 2008, oil prices are high enough to trigger the initiation of alternative energy processes in the $30 to $60 range (2006 dollars). These

Strategic Energy Lessons

A Historical Perspective Applied to America's Oil Source Issues

Michael E. Puckett, USAF

Article Highlights

Instead of debating what the parameters of a comprehensive energy security strategy should be, considerable time has been spent by the American government discussing the tactical details of industrial processes.

This article will focus primarily on the issues surrounding replacing imported crude oil as the strategic imperative. Alternative or synthetic fuel manufacturing is not a novel approach. The technical work started nearly a century ago in Germany was advanced considerably in the period of 1924 to 1945.

The United States' own shortages in domestic oil sources indicate sufficient similarity of circumstances to warrant seriously considering the lessons to be learned from the German experience over 60 years ago. They are simple, but still viable in today's world.

- Recognize and admit you have a problem
- Commit to a course of action
- Support the existing developmental and technology efforts
- Emphasize conservation
- Establish a strategic framework focused on successful results

When a comparison is made to the actions taken to date it indicated that America may have admitted it had a problem over 30 years ago, but has been very slow to commit to a long-term course of action to address the problem. The extensive current activity around biofuels is foundational, but the nation's resources have not been sufficiently committed. Congressional funding does not appear to be robust enough to encourage the capital investment needed to ensure long-term success. The current administration's efforts and those of Congress are a good start, but a start only. America imports nearly 66 percent of its petroleum needs every day. Biofuels will replace about 30 percent of current US petroleum consumption. The remaining 36 percent will have to be addressed as well—renewable sources may be preferred, but if those renewable sources are incapable of freeing the US from its imported oil include oil sands, ultra-heavy oils, gas-to-liquids, and coal-to-liquids (CTL).[4] This article investigates a past CTL program to determine whether there are strategic lessons for the United States that can be applied to today's energy situation, seen particularly from the perspective of national security.

Given energy's ability to touch everybody and everything in modern life, there are a myriad of topics to consider in the energy realm—social, economic, strategic, ecological, and political. Some are very personal, such as when people are told they may not be able to drive their favorite vehicle, or the prospect of a new energy production plant being considered for construction in the neighborhood. Energy issues also affect the ability of the state to project power in order to protect and defend its citizens or influence its relationships within the global community.

Instead of debating what the parameters of a comprehensive energy security strategy should be, considerable time has been spent by the American government discussing the tactical details of industrial processes. Discussions today are reminiscent of the Japanese debate regarding the decision to attack Pearl Harbor—allowing the argument itself to divert from the central issue of "what should be done" to "how it should be done."[5] The debate approach taken by America has allowed for recurring politicized arguments covering the same issues such as the oil peak question, greenhouse gas (CO_2) emissions, climate impacts, and economic impacts to local constituents.

Meanwhile, the American and world economy continues to be affected by the surging price of oil. Energy prices have a direct impact on the consumer price index (CPI), and are a key cause of inflation. Long-term and sustained price increases impact other commodity prices and further impact the economy through a lagging effect on CPI inflation. Historically, the pressures of energy prices on aggregate prices in the economy have created problems for the economy as a whole, occasionally driving a downward adjustment to expected growth projections. Continued economic recession is a distinct possibility in the current economic climate due in part to the cost of oil.[6] According to the Energy Information Agency, a $25 per barrel increase in the price of crude oil results in a 1 percent drop in American Gross Domestic Product. The trade imbalance provides oil supplying countries potential leverage over US capital markets. Energy dependency influences foreign affairs and reduces American freedom of action; and it can empower countries such as Iran and Venezuela to pursue policies hostile to the US.[7] This dependency will be a continuing issue as the energy demands of China, India, and the rapidly industrializing third world continue to accelerate.

US oil imports started exceeding oil production in the 1990s (see Figure 1). A General Accountability Office (GAO) report in February 2007 yet again articulated a policy perspective repeated from the Nixon administration on imports that in some respects dates back to Franklin Delano Roosevelt's administration—the requirement for a cohesive approach to meeting the oil needs of the United States.

With respect to the peak oil issue, the report stated the following:

> While the consequences of a peak would be felt globally, the United States, as the largest consumer of oil and one of the nations most heavily dependent on oil for transportation, may be particularly vulnerable. Therefore, to better prepare the United States for a peak and decline in oil production, we are recommending that the Secretary

of Energy take the lead, in coordination with other relevant federal agencies, to establish a peak oil strategy. Such a strategy should include efforts to reduce uncertainty about the timing of a peak in oil production and provide timely advice to Congress about cost-effective measures to mitigate the potential consequences of a peak. In commenting on a draft of the report, the Departments of Energy and the Interior generally agreed with the report and recommendations.[9]

From a strategic perspective it is irrelevant whether the oil peak is 1 or 10 years away. It is prudent for the US as the biggest global consumer to develop a policy to account for the issues that can be anticipated on the other side of peak oil, whenever it might come. Indeed one can take from the failure to find *significant* oil fields since the 1960s, combined with drastically increased demand in Asia, that the peak is now an academic point and strategically irrelevant in terms of justification for policy planning action.

This article will focus primarily on the issues surrounding replacing imported crude oil as the strategic imperative. Alternative or synthetic fuel manufacturing is not a novel approach. The technical work started nearly a century ago in Germany was advanced considerably in the period of 1924 to 1945. It was strongly considered by the Allies both before and during the Second World War and actually used by the British at a Billingham plant to produce 100,000 tons of high quality synthetic gasoline a year for the Royal Air Force.[10] Much can be learned from the German experience which should be investigated when discussing any synthetic fuel approach to changing the source of US energy supplies.

Put to one side the character of the Nazi regime and its atrocities. There is a great deal to be learned from some of the strategic decisions and the scientific or engineering accomplishments of German synthetic fuel programs. This study will therefore identify the German causes for action, examine the impact that action had on Germany's ability to pursue its national goals and objectives, and outline several strategic lessons that can be applied to the current energy situation. It will then look at American policy efforts over the past few decades and compare those efforts to the lessons and observations regarding their effectiveness in meeting the needs of US energy policy. The huge difference in the political nature of the national system of wartime Germany and that of modern US government urge caution in such an analysis. This article seeks to learn from the German technical capabilities and the role of the state in planning and pursuing energy policy for strategic purposes.

Assumptions

The following assumptions are used in this article:

- Access to oil is the number 1 critical, strategic, and economic imperative of the United States.
- The United States is not self-sufficient in oil. Coal and nuclear fuel reserves exist for US use into the foreseeable future.
- Technical and ecological concerns in coal and nuclear power generation can be overcome with emerging technologies and processes.
- The worldwide oil peak is not an accurate trigger for action. The peak discussion is almost immaterial at this point. Oil reserve data is extremely questionable.[11] Worldwide demand is ballooning due to China, India, and the developing third world.[12] Global oil demand is accelerating (see Figure 2).

Article Highlights

dependency, other methods are clearly available and in most cases commercially viable with today's volatile oil prices. Also remaining are residential and commercial power issues and whether this will be addressed by clean-coal technology or by nuclear power stations.

Timing is also an issue. The extended time frame being used with the current efforts, especially conservation, may only cover future growth in national energy demands. This means current plans would only preclude additional large crude oil import requirements—not necessarily drive import reductions in the near term. Building a new infrastructure for biomass based fuels may take some time, but conservation efforts in the transportation sector would be of greater immediate benefit. New corporate average fuel economy standards were overdue, but are not aggressive enough to be of any near-term assistance to alleviating oil import-imbalance-driven inflation on America's economy or improving national security.

Finally, improving current processes, exploring other existing technologies, and developing new ones should be continued and nurtured. Biomass fuels need cheaper enzymes to help break down the cellulose for processing. Nanotechnology might be used to develop artificial enzymatic biomass factory processes to manufacture ethanol or other petroleum products. Some commercial use could be found for all the carbon dioxide to be produced by clean-coal technology. Other energy renewables such as wind, tidal, and solar show potential as the technology evolves.

Article Acronyms

CAFE – Corporate Average Fuel Economy
CO_2 – Carbon Dioxide
CPI – Consumer Price Index
CTL – Coal-to-Liquids
FT – Fischer Tropsch
GAO – Government Accountability Office
GWOT – Global War on Terror
H.R. – House Resolution
MYPP – Multi-Year Program Plan
R&D – Research and Development
STL – Solid-to-Liquid
US – United States

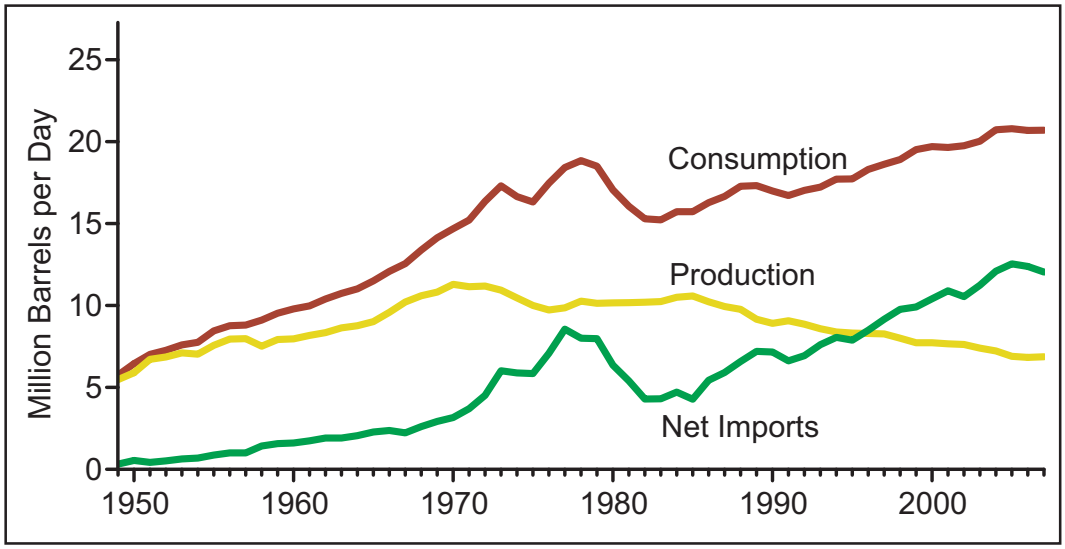

Figure 1. US Consumption, Production, and Imports of Oil, 1949-2005[8]

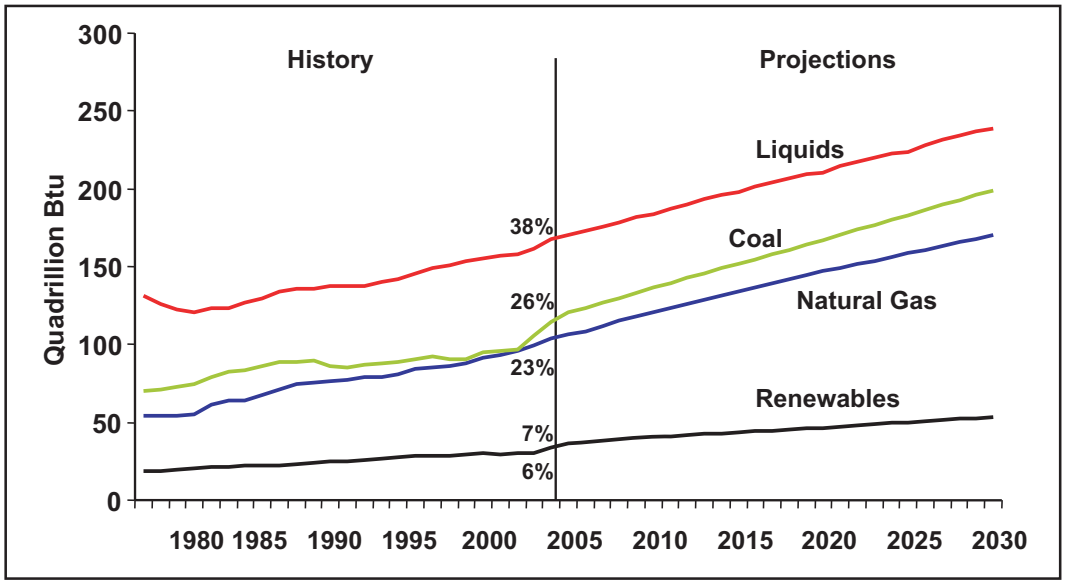

Figure 2. World Marketed Energy Fuel Use by Fuel Type 1980-2030[13]

- Global warming and climate change is a real issue.
- Solid-to-liquid (STL) alternatives must be part of the energy supply solution. The technology is mature enough to be used as a midterm solution and then retained as part of a diverse energy policy. Continuity of supply is vital. STL does come at an environmental cost from a CO_2 output perspective which has to be addressed to achieve viability. An attempt at addressing this is in the recently signed *Energy Independence and Security Act of 2007*[14] and other pending legislation.[15]
- Oil alternatives, such as shale oil/sand show promise, but they are beyond the scope of this investigation.
- Renewable energy is a better all-around, long-term solution. The technology and manufacturing processes are quickly evolving to both manufacture and utilize the resultant products in vehicles. At worst it is environmentally neutral with regard to atmospheric carbon emissions—essentially recycling existing carbon.
- Time terminology used: near-term, 3 to 5 years; midterm, 5 to 10 years; long-term, greater than 10 years.

The German Historical Perspective

In the early years of the twentieth century, German scientists and engineers recognized that Germany's energy requirements were changing for two reasons: 1. Germany was becoming increasingly dependent on internal combustion engines and 2. Germany's continuing industrialization and urbanization magnified the shortcomings of coal as an energy source. Petroleum was clearly the fuel of the future and Germany needed to ensure that it was never without it.[16] The breakthrough came in 1914 with the development of a continuous hydrogenization of coal process by Frederich Bergius. The start of World War I revealed Germany's critical need for petroleum as nearly all oil was imported. Bergius did attempt to establish a commercial hydrogenization facility at Rheinau during the period of 1915 to 1918, but technical start-up issues, along with Germany obtaining access to the Romanian oil fields resulted in minimizing the importance of converting coal to petroleum. The first hydrogenization plant was not completed until 1924 following research and development by Bergius and other German scientists.[17] Frederick Bergius and Carl Bosch received the Nobel Prize in 1931 for their contributions to high-pressure methods in chemistry—a key methodology in hydrogenization's success.[18]

Research and development did not stop with the success of Bergius' method. During the 1920s and 1930s, another CTL petroleum process was developed in Germany by Franz Fischer and Hans Tropsch (FT)—the indirect synthesis of petroleum from carbon monoxide and hydrogen, known as the FT method. The two methods were not in direct competition, as coal hydrogenization was more advanced and better suited to high quality aviation and motor fuel, while the FT process gave high quality diesel, lubricating oil, waxes, and lower quality motor fuel.[19]

Following the First World War in the early 1930s, Germany was struggling with rebuilding its economy, suffering from the worldwide depression, and continued looking for alternatives that either limited or eliminated their dependency in imported resources. The Allied blockade and attacks on critical resources during the war had taught them how dependent they were for

critical materials such as oil. Increasing their concerns was an imbalance of trade, leaving them with a severe shortage of hard currency, and rumors that worldwide oil reserves were about to run out.[20] Germany was dependent on fuel imports for greater than 90 percent of their national requirements.[21] They had a strategic problem of the first order.

Onto the stage stepped Adolph Hitler. Obsessed with many things following the Great War, Hitler outlined his beliefs in his book *Mein Kampf*.

> The foreign policy of a People's State must first of all bear in mind the duty of securing the existence of the race which is incorporated in this State. And this must be done by establishing a healthy and natural proportion between the number and growth of the population on the one hand and the extent and resources of the territory they inhabit, on the other. That balance must be such that it accords with the vital necessities of the people.
>
> What I call a *healthy* proportion is that in which the support of a people is guaranteed by the resources of its own soil and subsoil. Any situation which falls short of this condition is none the less unhealthy even though it may endure for centuries or even a thousand years. Sooner or later, this lack of proportion must of necessity lead to the decline or even annihilation of the people concerned.[22]

One of his eight key goals for Germany was identified as economic sufficiency through a large area autarky.[23] German self-sufficiency was not the goal.

> Sensible autarky called for a fundamental turn in foreign-trade policy; in the final analysis it implied that no more should be exported than was required for the importation of indispensable raw materials and foodstuffs and of such commodities as were 'unavailable or available in insufficient measure' or could not be manufactured in Germany in sufficient quantity.[24]

Hitler essentially wanted reciprocal-bilateral economic agreements with his trade partners to establish a barter mechanism—to eliminate trade imbalances creating hard cash issues.[25] The desire was for a friendly and neutral ring of trade partners within easy reach of Germany. Being close made it possible for the Nazis to easily reach out and *negotiate* with their military should a partner decide to terminate their trade agreement before Germany was ready to do so.

The role of oil and fuel cannot be understated when talking about German and Nazi views regarding their national economy or their military plans for the future. Hitler was obsessed with oil. To Hitler, it was the vital commodity of the industrial age and for economic power.[26] The Germans had a large growing population and needed mechanical farming systems fueled by oil products to help feed them. They also knew they had a crucial need for oil products to rebuild and fuel German military forces for the upcoming struggle Hitler had planned to achieve his expansionist aims. The war of 1914 to 1918 taught him that it was imperative to have sufficient economic resources. In 1934, Hitler assigned Wilhelm Keppler, his personal economic advisor, to find replacements for imported resources. Keppler had been working closely with big business since Hitler's rise to power, creating a working group known as the Keppler Circle whose task was to develop alternative economic programs.[27] The result was the inclusion in a Secret Four Year Plan memorandum of a strategic objective to increase domestic mineral oil production to self sufficiency within 18 months and to satisfy lubricant requirements by processing coal.[28]

The Nazis never quite reached the 3.8M ton goal they set for themselves as can be seen in Table 1.[30] Contrary to the almost mythological stories of Teutonic efficiency, the Germans were not a totalitarian state in regard to everything in their economy. The business economy was capitalistic in nature, although strongly monitored, encouraged and incentivized by supportive government contracts.

> The economic system introduced step by step after 1933 may be assigned to the 'guided-market economy' or 'organized capitalism' type: the state set the economic goals, it laid down the economic priorities, it even acted on a considerable scale as the customer, i.e. generally as a directing agency, while entrepreneurs managed their business on their own responsibility in line with the state's directives. The National Socialists felt under an obligation to 'observe the intrinsic laws of all economic matters' because they feared that any violation of these might have to be paid for dearly in economic terms.[31]

By the time the war started in 1939, the incentives allowed the development of an additional 14 FT and Bergius plants, with 6 more under construction.[32] These plants provided a key edge to the German economy and to the Luftwaffe in particular.[33] About 95 percent of Germany's total aviation gasoline for the Luftwaffe was provided by the Bergius hydrogenization plants during the war. Without them the Luftwaffe could not have gotten off the ground.[34] Toward the end of the war, these plants were key in keeping Germany in the war. By 1943, synthetic fuel production had doubled from 1942 levels, producing 124K barrels a day. By early 1944 it was providing 57 percent of the total oil supply and 92 percent of aviation fuel. All told, synthetic fuels would account for half of all of Germany's oil production.[35]

Another interesting myth regards Germany's *total war* effort; namely that they sacrificed everything for the fatherland. During the war, all the Allies made this assumption because of their own conservation efforts. While some sacrifices were made by the Germans, analysis after the war revealed a very different picture.

> Germany did not fight a total war; despite all the propaganda talk, she made no serious attempt to exploit her own war potential fully, except perhaps for a brief period in August and September 1944, when it was too late to be of any consequence. Whatever ruthlessness she may have shown towards vanquished enemies, there is no evidence of ruthless sacrifices having been imposed upon her own people for the sake of victory; in terms of the thoroughness of the war effort, Germany lagged well behind not only Britain or Russia in the present war, but also behind her own showing in the First World War. Whatever else may be said about the German economy it certainly was not *totalitarian*.[36]

Some of the potential to conserve can be seen in the split between civilian and military consumption (see Table 2). The military would never have been given 100 percent, as some amount is always needed in the logistical tail supporting production and transportation, not to mention essential civilian

Years	Tons (millions)
1939	1,091.8
1940	1,430.2
1941	1,994.0
1942	2,603.2
1943	2,913.7
1944	1.673.4

Table 1. German Synthetic Oil Production 1939-1944[29]

usage. Nonetheless, there was a considerable amount available to further bolster the military war machine in its strategic and operational efforts. It can only be imagined what Germany would have done and what battles could have been changed with more fuel for its blitzkrieg style of warfare. The military constantly adjusted its pattern of behavior and consumption to match the available fuel supply situation of the moment. This meant reducing its usage of fully motorized units and heavy bomber forces, thus reducing its strategic and operational capability.[38]

Destruction of Germany's oil production capability played a crucial role in the demise of the Third Reich. Once the Allies had destroyed much of the German airpower, it turned its attention to oil production facilities, making them a priority target. Starting in April 1944, the attacks grew. On May 12, the Eighth Air Force attack with 935 planes hit the fuel plants in central and eastern Germany. The bombing results rocked the Nazi production czar Albert Speer. "The enemy has struck us at one of our weakest points. If they persist at it this time, we will soon no longer have any fuel production worth mentioning. Our one hope is that the other side has an Air Force staff as scatterbrained as ours!"[39] On June 8, 1944, attacks on the German oil industry commenced with a vengeance when General Carl A. Spaatz sent his historic cable to his Air Force commanders: "Primary strategic aim of US Strategic Air Forces is now to deny oil to enemy air forces."[40] German synthetic production dropped from its average 316K ton monthly production before the start of Allied bombing in April 1944 to 5K tons in September.[41] The loss of fuel during this time period seriously hampered everything from pilot training to the movement of Panzer divisions in the field. "[Speer's] visit to the Ruhr during early November, coming on the heels of a new wave of allied air strikes against Germany's synthetic fuel plants and its railways and canals, rocked his confidence."[42] By December, Albert Speer, the Nazi Minister of Armaments, stated that the fuel shortage had reached catastrophic proportions. The lack of fuel continued hampering the German army for the rest of the war, debilitating their ability to either attack (Battle of the Bulge) or defend (Baronov bridgehead at the Vistula).[43] After the surrender, Field Marshal Milch stated "If the synthetic oil plants had been attacked 6 months earlier Germany would have been defeated 6 months earlier."[44]

The Allies saw synthetic fuel as so vital to Germany's ability to wage war that German synthetic fuel production was prohibited by the Potsdam Conference on 16 July 1945.[45] Fuel processing facilities were a critical vulnerability for Germany's support of its center of gravity—the Wehrmacht.[46] The investment in synthetic fuels undertaken by Germany allowed it to continue fighting years longer than reasonably expected for such an isolated and resource *poor* nation.

Years	Gross-Deutsch-land and Occupied Countries* Production (000 tons)	Total German Consump-tion (000 tons)	Portion Used by Armed Forces (000 tons)
1049	3,963	5,856	3,005
1941	4,839	7,305	4,567
1942	5,520	6,483	4,410
1943	6,563	6,971	4,762
1944	4,684	-	-
* does not include the Axis *satellites, such as Romania*			

Table 2. German Petroleum Production and Use 1940-1944[37]

Strategic Lessons

There are five key lessons that can be learned from the German experience. They should be recognized as paramount to developing an alternate energy strategy.

1. Recognize and admit you have a problem. The earlier the better, especially if technology is involved. It takes time for a new technology to mature to the point where it is both dependable and economically viable.

It became apparent to Frederich Bergius and others at the start of World War I that oil and oil products were becoming a necessity for the machines of modern warfare. Bergius came to the conclusion that his coal hydrogenization process would address this critical requirement. As a result, he organized a group of investors to start commercial development. As noted earlier, technical difficulties, gaining access to the Romanian oil fields, and the end of the war prevented this enterprise from succeeding during the war.[47]

As Hitler came to power in 1932, a discussion with I. G. Farben (who controlled Bergius' hydrogenization process) brought the availability of a German domestic oil alternative to his attention. He immediately grasped the impact to his center of gravity—the Wehrmacht. Synthetic fuel production became one of the keystones of German economic plans between 1936 and 1945.[48]

Hydrogenization and the FT process both had sufficient time to develop and mature into viable commercial processes, capable of having a national strategic impact. Early problem recognition allowed this to occur.

2. Commit to a course of action. General George Patton's famous quote "A good plan violently executed now is better than a perfect plan executed next week"[49] could not be more true. Waiting until you are having a perfect plan to deal with an emergency before you take action will obviously put you behind the power curve. When a process must be done on a large commercial scale, it requires considerable capital investment and may take several years to build. Spending time arguing over the benefits of any particular technology is time wasted.

Hitler's 1932 commitment to commercial synthetic oil development was critical in the construction of 14 plants by September 1939 (6 more under construction). Were the processes involved perfect? Far from it! They were very inefficient using about 5 tons of hard coal or 10 tons of lignite to produce 1 ton of synthetic fuel.[50] More importantly, the processes worked on a commercial scale (Germany had plenty of coal). The synthetic fuel plants were vital to the German war economy supporting the Wehrmacht and Blitzkrieg. Blitzkrieg was a new warfare concept built on mechanical speed to outmaneuver its often numerically superior opponents, striking a knockout blow before their enemy was prepared.[51]

Before invading Russia in 1941, sufficient fuel reserves were available to allow the German military significant freedom of action and maneuver. As the war progressed, Allied attention began to focus more and more on the oil resource areas. When

Germany started losing the ability to maneuver freely due to lack of fuel, they lost their ability to take tactical advantage of a given set of circumstances. Oil became a critical limiting factor. Without the additional operational capability that 11,706.3M tons[52] of synthetic fuel brought to the German war machine from 1939 to 1944, the war could arguably have been over much sooner.

3. Support existing developmental and technology efforts. Everybody looks for the *silver bullet* to solve their problem—that one thing that makes the problem disappear. Mankind has been lucky with two energy sources—coal and oil. Both have worked in a fairly universal manner to meet mankind's energy needs in many ways. Future developments may not be so universal, but that is not necessarily bad. It just requires adaptation to what works for a particular set of circumstances.

Just as the Germans supported both the FT and hydrogenization in their quest to replace oil, the US should support multiple solution alternatives. Encouraging multiple techniques simplifies goal achievement by allowing a simpler technique to satisfy a simpler requirement. It diversifies the risk by isolating the possibility of failure to individual processes. Finally, diversification allows for increased opportunities to identify and implement tailored process efficiencies for a particular energy product.

The Germans did not launch a program to find a single replacement for oil. They moved forward from where they found themselves, taking advantage of both FT and hydrogenization processes to meet their strategic needs. Sounding similar in capability, the processes were actually complementary in that hydrogenization was better suited to the manufacture of high octane aviation fuel and FT for diesel and heavier petroleum products.[53] Each supported a highly important niche for the German Wehrmacht—aviation fuel for the Luftwaffe and diesel for the Panzer divisions and general transportation.

4. Conservation can make a difference. Conservation is recognized by most experts as the first course of action to increase availability of any scarce resource. It is usually the only alternative that can have nearly immediate results. In the short-term, rationing is typically the instrument used—ration books, limiting use to key people and industries, or some type of luxury tax. Long-term solutions to stretch existing supply levels or reduce overall consumption levels are usually associated with finding more efficient ways to utilize the resource or limit (or eliminate) the need for the resource.

Germany did not seriously begin considering conservation until 1942.[54] Considerably more fuel could have been made available to the German military (see Table 2). Some was certainly needed for military support infrastructure, but more could have been made available for direct military operations.

Studying the German fuel picture during World War II is fascinating. At most points in time, they never had more than a few months strategic reserve. Captured fuel from countries such as France (785K tons) and purchased fuel from their allies such as Russia (900K tons with the 1939 pact) allowed them to take the next operational or tactical step.[55] The Germans lived just ahead of their oil demand curve all through the war. Hitler did not believe in the necessity of stockpiling and "emphatically demanded that full economic mobilization should neglect long-term stockpiling and confine itself to sufficient armaments, equipment, and food supplies."[56] Hitler did not expect to fight a protracted war, but a series of small ones—if he could not intimidate his opponents by military threats alone.[57] The Wehrmacht also learned to live with this shortage, taking it into account in their tactical and strategic battle planning as any army would do. Although subject to much speculation, the lack of readily available fuel has to be assumed to have resulted in missed opportunities for battlefield success.

> The situation changed in 1941 with the German attack on Russia, an attack launched with the objective of obtaining the Russian oil resources for Germany. This attack failed mainly because of the slender nature of the German liquid combustible resources which only allowed for the concentration of three and a half million Germans for the initial attack. Had the Germans had the means in 1941 to throw against the Soviet Union at least 5 million men with their equipment, the German campaign in Russia in 1941, given the almost total Russian unpreparedness for the attack, would have achieved its purpose (another short war).[58]

The US is a major oil consumer with very (energy) inefficient cars and houses. American oil consumption history shows the effect of conservation after the start of corporate average fuel economy (CAFE) vehicle mileage standards in 1975. By about 1983 (see Figure 1), just a few years after the start of CAFE requirements, a 20 to 25 percent reduction in consumption was achieved. Unfortunately, this success was not followed by additional conservation accomplishments because of a lack of political support for continued CAFE mileage reductions.[59]

5. Establish a strategic framework focused on successful results. It is easy to get lost in the details, such as discussing how a technology works, arguing pros and cons, arguing the benefits or lack thereof for a particular constituency, location, or industry. It is just as easy when the next new technology or process comes along to repeat the same discussions all over again—hopefully reaching new decisions that do not contradict earlier efforts. What is more difficult, yet more beneficial, is developing and implementing a strategic framework focused on the desired results, not a desired technology. As an example, this framework must contain the following:
   - Identify the desired outcomes: internally sourced, renewable fuels
   - Establish desired control limits or mechanisms: minimized CO_2 emissions
   - Cultivate emerging technologies, encouraging source and process diversity: invest in research and development—multiple specialized processes for multiple materials
   - Nurture initial life cycle start-up success with economic support: research and development grants, tax incentives, purchase guarantees

Because of the economic and wartime nature of their oil requirement, Nazi Germany did not recognize the need for several of the elements of this framework. They were not concerned about the environment and, although cost was an issue, they recognized that Germany needed an internal source of oil. Further, higher than competitive costs within Germany helped with their balance of trade (hard currency) issues and assured a fuel supply in time of war or conflict.

Current US Energy Efforts

What has the US done to reduce its strategic dependency on foreign oil? The first significant national activity occurred after the 1973 Arab oil embargo. A public car mileage framework was established under CAFE standards in 1975. This did achieve improvements in overall consumption as was noted earlier, but continuing progress was not achieved after 1984. Congress did not require additional increases in vehicle mileage until 2008.[60] Overall consumption has continued to rise.

President Bush's administration has been formulating energy policy and supporting legislation since early in his first term. The President released his energy policy in 2001 and it included three principles:

- The policy is a long-term, comprehensive strategy. Our energy crisis has been years in the making, and will take years to put fully behind us.
- The policy will advance new, environmentally friendly technologies to increase energy supplies and encourage cleaner, more efficient energy use.
- The policy seeks to raise the living standards of the American people, recognizing that to do so our country must fully integrate its energy, environmental, and economic policies.[61]

The energy effort slowed down after 11 September 2001 as the United States found itself embroiled in the Global War on Terror (GWOT). Although Congress did try to develop energy bills in 2002 and 2003, the nation's focus was on the GWOT and the US-led invasion of Iraq. The bills died in conference before being offered to Congress for their consideration and the effort had to start over.

In 2005, Congress did pass a fairly comprehensive energy bill which was signed into law by President Bush on August 8th. The bill which provides for $88.9B over 10 years[62] was primarily focused on continued use of fossil fuels, but it did include several provisions totaling nearly $13.8B regarding the area of renewable fuels, including about $5.3B for hydrogen-related production research. Although some provision was made for fuel efficiency tax credits, the bill failed to strengthen fuel economy standards (CAFE). It has been noted by the Union of Concerned Scientists that this decision will increase US gas consumption by 10 billion gallons through 2015 and will ironically wipe out the gains to be realized by the President's proposed changes to the fuel economy regulation.[63]

The President continued to push energy in his 2006 State of the Union address with the Advanced Energy Initiative proposal. This initiative called for reduced dependence on foreign energy, improvement in energy efficiency, and enhanced energy security by changing the way America fuels its vehicles.[64] The Initiative's goals covered vehicles and homes-business energy usage.

Fueling Our Vehicles

- Develop advanced battery technologies that will allow a plug-in hybrid-electric vehicle to have a 40-mile range operating solely on battery charge
- Foster the breakthrough technologies needed to make cellulosic ethanol cost-competitive with corn-based ethanol by 2012
- Accelerate progress towards the President's goal of enabling large numbers of Americans to choose hydrogen fuel cell vehicles by 2020

Powering Our Homes and Businesses

- Complete the President's commitment to $2B in clean coal technology research funding, and move the resulting innovations into the marketplace
- Develop a new Global Nuclear Energy Partnership to address spent nuclear fuel, eliminate proliferation risks, and expand the promise of clean, reliable, and affordable nuclear energy
- Reduce the cost of solar photovoltaic technologies so that they become cost-competitive by 2015, and expand access to wind energy through technology[65]

This initiative was followed in early 2007 with Executive Order 13423, mandating US agencies to decrease petroleum consumption 2 percent each year through 2015 and increase alternative fuel use by 10 percent each year. At the 2007 State of the Union speech, the President announced his *20 in 10* goal. Recognizing America's addiction to oil, he asked that the US reduce its gasoline use by 20 percent over the next 10 years.[66] A major part of the program is to increase the supply of renewable and alternative fuels by 35 billion gallons per year by 2017. The effort includes additional requests for research and development funding to evaluate the Biomass Program and intermediate ethanol-gasoline blends such as E15 (15 percent ethanol) and E20 (20 percent ethanol) to accelerate gasoline displacement.[67]

The President continued pushing the Energy Security Program with his 2008 budget submission. His request to Congress included provisions for alternative fuels for cars and trucks, improving and reforming CAFE standards, accelerating the Advanced Energy Initiative, expanding the Strategic Petroleum Reserve, accelerating the American Competitiveness Initiative (supports basic research to enable future technology breakthroughs), and strengthening American nuclear weapons storage and nonproliferation capabilities.[68]

In November 2007, The US Department of Energy's Energy Efficiency and Renewable Energy Division, Office of the Biomass Program, released a comprehensive plan regarding the development of a renewable energy source, the "*Biomass Multi-Year Program Plan.*" The comprehensive nature of the plan should not be understated. It covers all aspects from production of feedstocks (raw material inputs), feedstock logistics, biofuel production, distribution, and biofuels end use technologies.

The approach pictured in Figure 3 allows for a lot of flexibility and diversity of use, yet each supply chain element must be addressed to meet the target outcomes. Each element is summarized as follows:

- Feedstock Production. Produce large, sustainable supplies of regionally available biomass
- Feedstock Logistics. Implement cost-effective biomass feedstock infrastructure, equipment, and systems (biomass harvesting, collection, storage, preprocessing and transportation)
- Biofuels Production. Deploy cost-effective, integrated, biomass-to-biofuels conversion facilities
- Biofuels Distribution. Implement biofuels distribution infrastructure (storage, blending, transportation, and dispensing)
- Biofuels End Use. Expand public availability of biofuels-compatible vehicles offering the same performance as vehicles using traditional fuels[70]

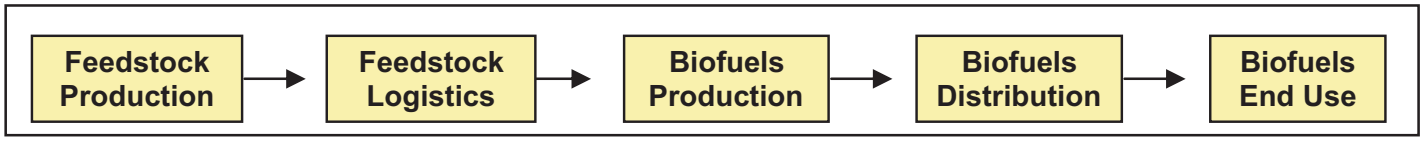

Figure 3. Biomass to Biofuels Supply Chain[69]

What might seem to be *government overkill* in such a comprehensive plan is, in this writer's opinion, a well thought out approach to covering all the critical aspects of standing up a new, emerging fuel source to start replacing a highly entrenched supply and utilization chain for imported oil related products. As noted in the Multi-Year Program Plan's (MYPP) executive summary:

> This approach ensures development of required technological foundation, leaves room for pursuing solutions to technical barriers as they emerge, enables demonstration activities that are critical to proof of performance, and lays the groundwork for future commercialization without competing with or duplicating work in the private sector. The plan addresses important technological advances to produce biofuels, as well as the underlying infrastructure needed to ensure that feedstocks are available and the products can be distributed safely with the quality and performance demanded by end consumers.
>
> The Biomass Program's MYPP is designed to allow the program to progressively enable increasing amounts of biofuels, bioproducts, and biopower to be deployed across the nation from a widening array of feedstocks. This approach will not only have a significant impact on oil displacement at the earliest opportunity, but will also facilitate the paradigm shift to renewable, sustainable energy in the long-term.[71]

December 2007 saw considerable energy related activity in the US capital. The House of Representatives initiated House Resolution (H.R. 6), a bill that would have considerable impact on the US energy source structure and which supported many of the President's biofuel efforts. But, proposed financing for the effort would come from seriously restructuring current tax law to tax American oil companies at a higher rate, due to the very high profit level they have been experiencing in recent years. It also proposed a Renewable Energy Portfolio Standard (RPS) that required electric utilities to provide a minimum amount of electricity from renewable energy resources—15 percent by 2020. While the President mostly welcomed the proposed bill, he would not support such changes. The Senate, through Senate Amendment 3850, designed a compromise essentially eliminating both oil company taxation and the RPS to ensure the bill was not vetoed by the President. The House approved the Senate bill on 18 December 2007 and the President signed the bill into law (Public Law 110-140) on 19 December 2007.

The highlights of key provisions enacted into law are as follows:

- Corporate Average Fuel Economy (CAFE). The law sets a target of 35 miles per gallon for the combined fleet of cars and light trucks by model year 2020.
- Renewable Fuels Standard. The law sets a modified standard that starts at 9 billion gallons in 2008 and rises to 36 billion gallons by 2022.
- Energy Efficiency Equipment Standards. The adopted bill includes a variety of new standards for lighting and for residential and commercial appliance equipment. The equipment includes residential refrigerators, freezers, refrigerator-freezers, metal halide lamps, and commercial walk-in coolers and freezers.
- Repeal of Oil and Gas Tax Incentives. The enacted law includes repeal of two tax subsidies in order to offset the estimated cost to implement the CAFE provision.[72]

While the signed bill left much of what the democratic House of Representatives and environmental advocates wanted on the table, it was a big step in the right direction for the United States and was landmark legislation. The bill's impact regarding fuel economy and biofuel are designed to weaken the country's exposure to volatile oil prices.[73]

Comparisons and Observations

Are the actions being taken by the United States in its pursuit of synthetic fuel to replace oil appropriate? Looking at the activities to date with regard to the five strategic lessons identified earlier, the following observations can be made.

- **Recognize and admit you have a problem.** The United States recognized the imported oil problem in 1975, but failed to continue CAFE-like efforts that would have provided some relief. Between the early 1980s and 2001, little significant activity affecting change on a national level can be noted. President Bush's administration recognized in 2001 through the National Energy Policy that the US had energy issues that needed to be addressed as a strategic imperative.[74]

  Problem recognition has *intensified* as oil prices have increased since 2001. Foreign energy dependency has become an ongoing topic of discussion within the current government and among the 2008 presidential candidates. The need to reduce or eliminate American dependency on foreign oil by finding domestic alternatives—preferably renewable and environmentally friendly has been publicly admitted.
- **Commit to a course of action.** Although the President's energy policy covers all aspects of America's energy usage profile, considerable progress has been made with regard to the potential reduction of oil imports and the strategic impact it has on the US. The President set a strategic goal for the United States in his 2007 State of the Union Address to reduce gasoline consumption by 20 percent in 10 years (20 in 10). Supporting this strategic goal, he has also set other objectives that must be achieved in order to be successful.

> To reach this goal, we must increase the supply of alternative fuels by setting a mandatory fuels standard to require 35 billion gallons of renewable and alternative fuels in 2017—nearly five times the current target. At the same time, we need to reform and modernize fuel economy standards for cars the way we did for light trucks—and conserve up to 8.5 billion more gallons of gasoline by 2017.[75]

The renewable fuels goal of the President's program appears to be most challenging as it is an emerging technology. To that end, the Department of Energy released the *Biomass*

Multi-Year Program Plan in November 2007 to enable the deployment of biomass as a renewable energy source. A good question on renewables is "How much of current American needs can it replace?" The Department of Energy and Department of Agriculture in their *Biomass as Feedstock* study is looking at about 30 percent replacement and the renewable biomass raw material is potentially there; over a billion tons annually with judicious use of technology and agricultural acumen (see Figure 4).

The other synthetic fuel source, coal, is also a potential, albeit a nonrenewable alternative, but has not been included in a similarly detailed plan at this time. Funding has been provided for continued research and development into the FT hydrogenization process as it is expected to be used in both coal and renewable biomass synthetic fuel efforts.

A defined course of action, at least with regard to importing oil for gasoline, has been identified and enacted by way of H.R. 6 through the new CAFE standards and the Renewable Fuels Standard for use of increasing amounts of ethanol. A focus on the transportation sector is needed (see Figure 5) since it uses nearly 75 percent of total daily petroleum flow. In particular, the personal transportation sector which is responsible for 50 percent of the imported oil in the form of motor gasoline.

- **Support the existing developmental and technology efforts.** The Biomass Program is a collaborative effort with industry to advance both biomass feedstock and conversion technologies. It will involve public-private partnerships to demonstrate the large-scale, integrated biomass technologies involved and will accelerate market deployment infrastructures to make the products commercially available.[78] The program is intended to build on existing technologies, improving and making them economical for large scale, long-term production efforts. It will also be taking similar technologies and integrating them in a new way called a biorefinery (see Figure 6) that can convert any number of biomass feedstocks into fuels, power, and chemicals. This new concept can be compared to today's petroleum refineries which produce multiple fuels

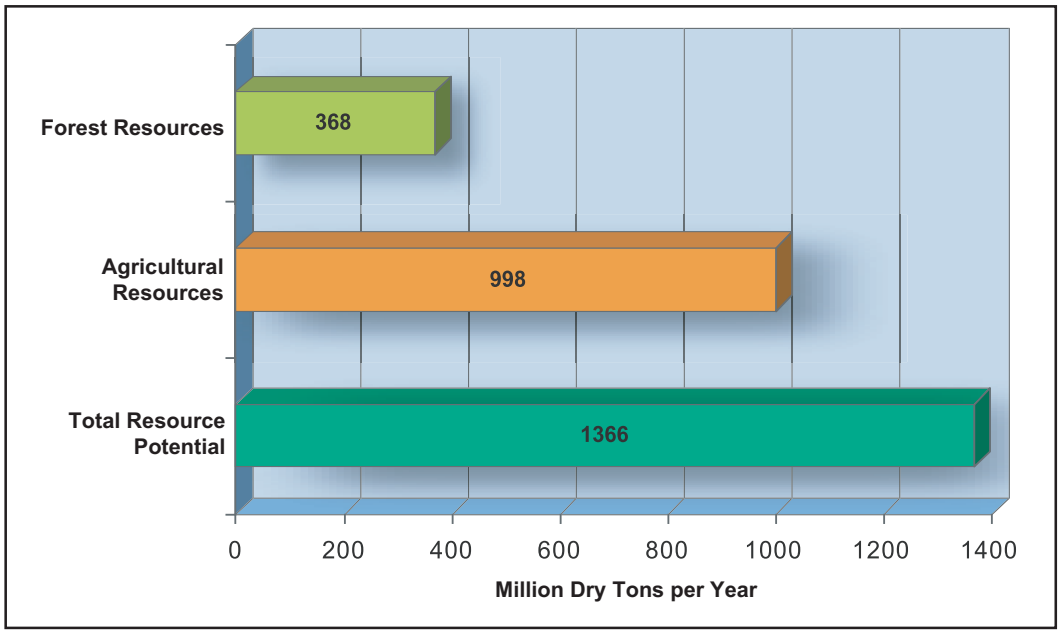

Figure 4. Annual Biomass Resource Potential[76]

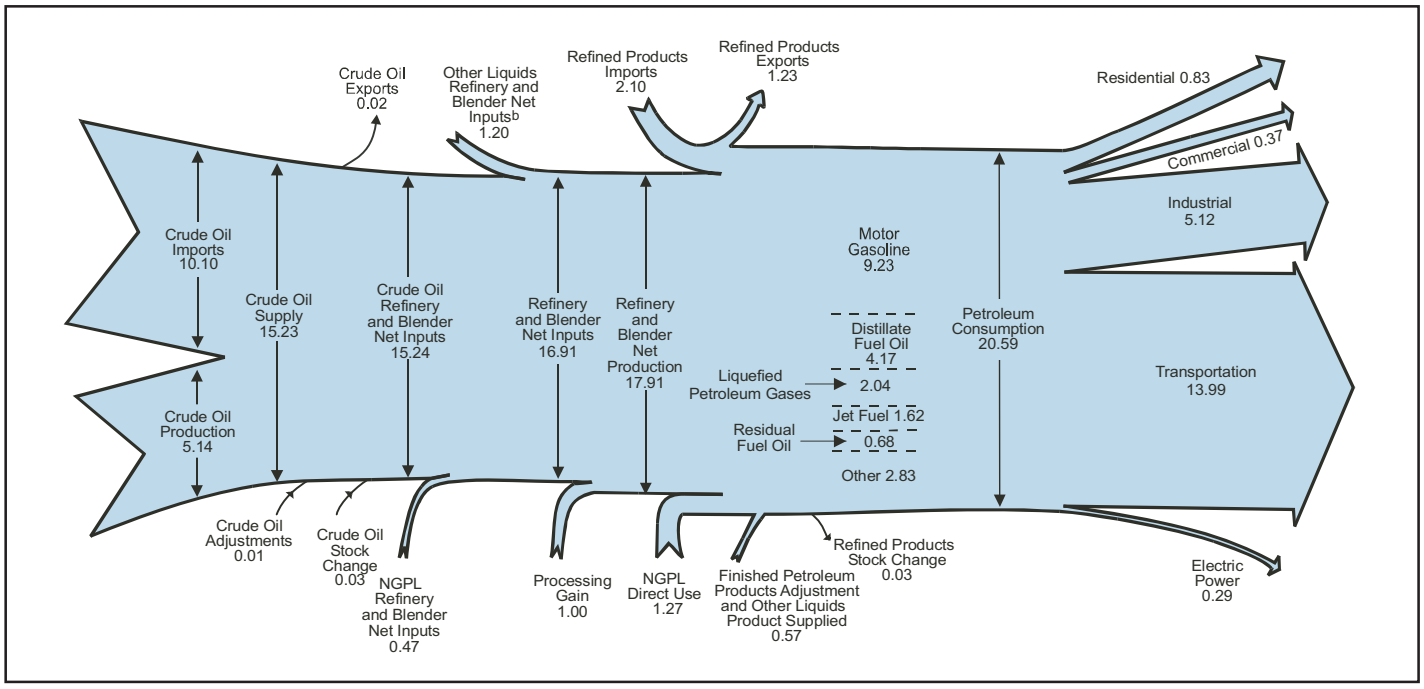

Figure 5. Petroleum Flow 2006[77]

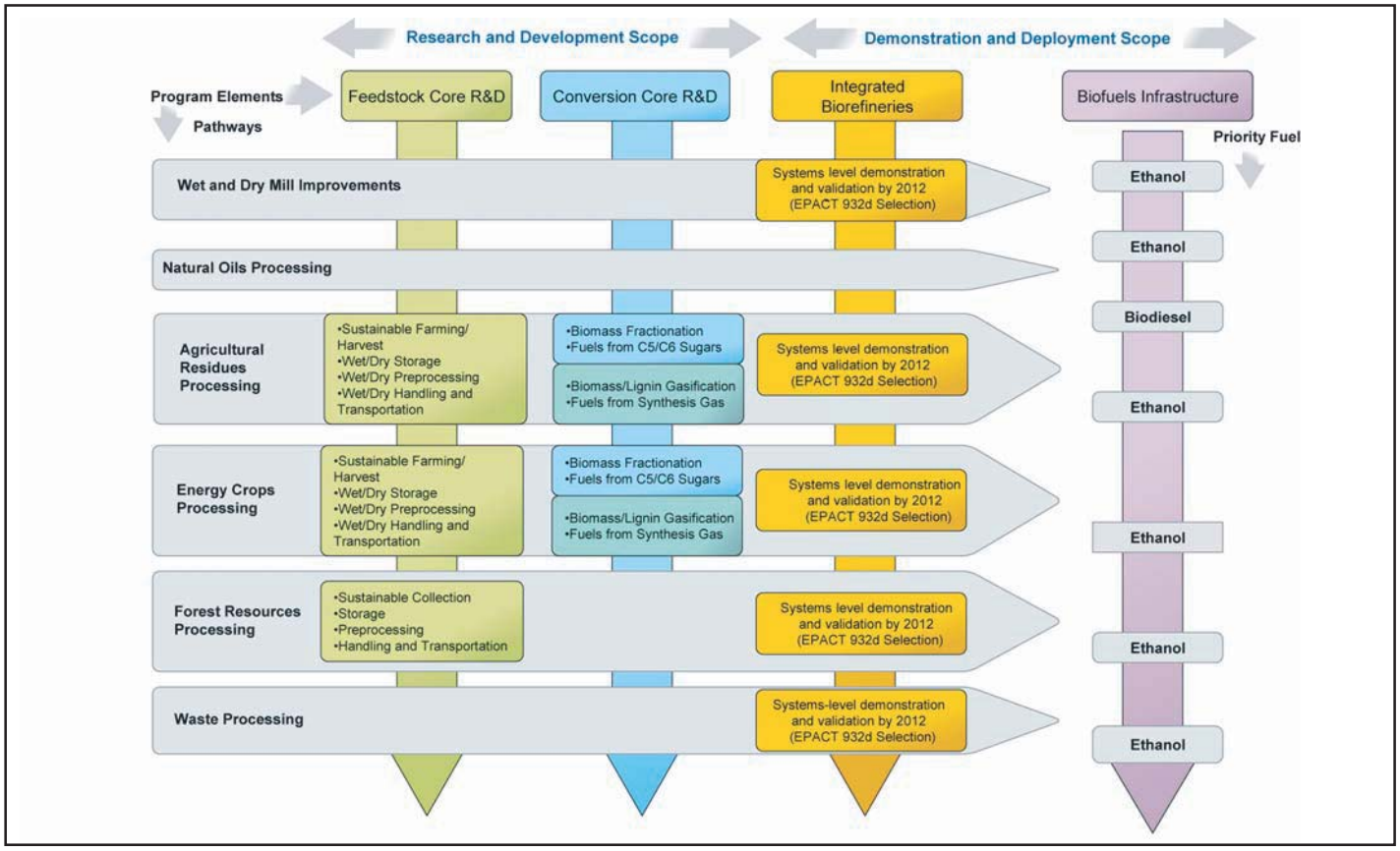

Figure 6. Technical Element Links to Biorefinery Pathway Framework[79]

and products from crude oil.[80] The difference here will be multiple input source materials rather than one, each going through their own *independent* conversion process, converging where the process and technology allow.

At the time of this writing, it is difficult to determine the true impact H.R. 6 will have on biofuels and cellulosic ethanol production in particular. The funding for research and development (R&D) in the bill is minimal ($25M for biofuel grants and $2M for renewable energy technologies), but the requirement to use 21 billion gallons of cellulosic ethanol by 2022 puts most of the R&D onus on industry.

- **Conservation can make a difference.** New CAFE standards have been legislated in H.R. 6, along with new energy efficiency standards for lighting and for residential and commercial appliance equipment. Each of these actions will reduce overall energy consumption in the long-term. As was shown earlier in this article, conservation could be making a *significant* contribution to reducing American oil imports within just a few years. With oil prices continuing to rise, conservation should be able to provide relief in the relative near-term. The potential can be seen looking at the nominal price per barrel over time and the total import cost for the United States as of 2006 (see Figures 7 and 8). Immediate gasoline conservation is called for, but no immediate action is being taken. Achieving a fleet average of 35 miles per gallon by 2020 will be a significant accomplishment but does very little to provide near-term relief to the import oil issue or help the current economic issues driven by imported oil costs.
- **Establish a strategic framework focused on successful results.** The Biomass Program has three broad areas: core research and development; industrial scale demonstration and validation; and cross-cutting market transformation activities. The program has taken the wide variety of biomass feedstocks and conversion technologies and placed them into seven plausible pathway options within the biorefinery construct. The approach taken is intended to streamline evaluation of opportunities, establish priorities for R&D, and measure commercialization progress. Although not shown as milestones in Figure 9, life cycle cost-benefit analysis and environmental impacts will also be addressed.

The most interesting thing about the MYPP may be the infrastructure transformation activities. A considerable amount of change management thought has gone into this particular area to help move toward a successful outcome. It addresses everything from the environment to the consumer to international partnerships.

With regards to renewable biofuels, a starting point, a strategic framework focused on successful results, has been defined. This is the crucial first step in American politics, defining a proposed policy. The next crucial step is funding the policy to a successful conclusion. However, that appears to be a potentially critical shortcoming of the current effort.

Conclusion

German scientists developed synthetic fuel processes before World War I and early oil shortage recognition by Bergius led to starting commercial development. Prior to World War II, Germany saw the Wehrmacht sustainment possibilities of synthetic fuel and the government incentivized a considerable number of commercial plants to provide internal sources of oil

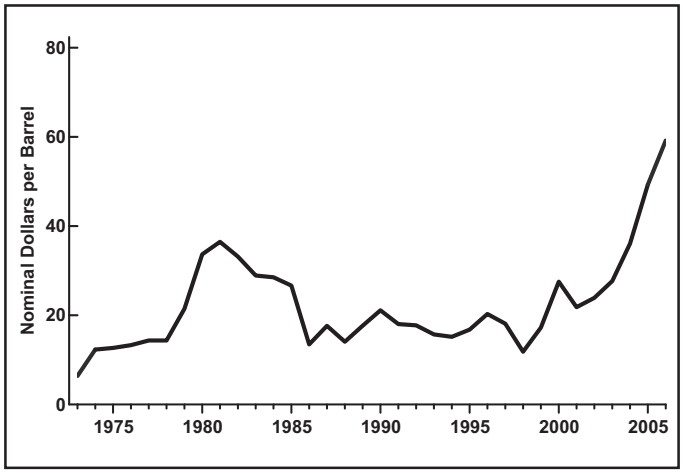

Figure 7. Nominal Crude Price 1973-2005[81]

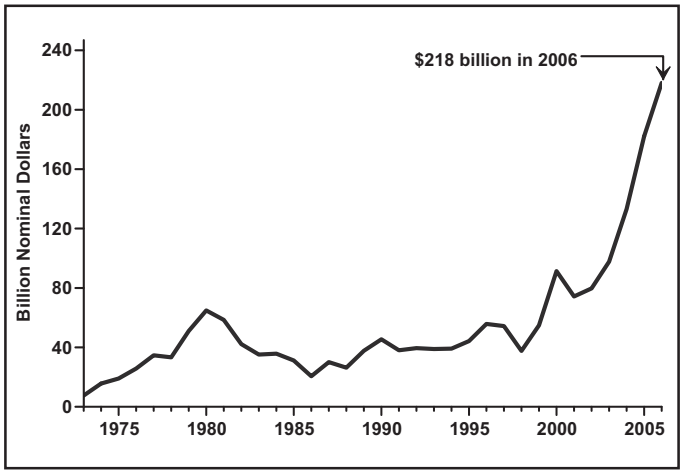

Figure 8. Nominal Crude Cost 1973-2005[82]

products. These synthetic fuel plants provided sufficient products for Germany to fight far beyond what was expected, given their lack of internal oil resources.

The United States' own shortages in domestic oil sources indicate sufficient similarity of circumstances to warrant seriously considering the lessons to be learned from the German experience over 60 years ago. They are simple, but still viable in today's world.

- Recognize and admit you have a problem
- Commit to a course of action
- Support the existing developmental and technology efforts
- Emphasize conservation
- Establish a strategic framework focused on successful results

They have great applicability to determining if the United States is moving in the right direction with regard to its energy program. When a comparison is made to the actions taken to date it indicates that America may have admitted it had a problem over 30 years ago, but has been very slow to commit to a long-term course of action to address the problem. The extensive current activity around biofuels is foundational, but the nation's resources have not been sufficiently committed. Congressional funding does not appear to be robust enough to encourage the capital investment needed to ensure long-term success. The current administration's efforts and those of Congress are a good start, but a start only. America imports nearly 66 percent of its petroleum needs every day. Biofuels will replace about 30 percent of current US petroleum consumption.[84] The remaining 36 percent will have to be addressed as well—renewable sources may be preferred, but if those renewable sources are incapable of freeing the US from its imported oil dependency, other methods are clearly available and in most cases commercially viable with today's volatile oil prices. Also remaining are residential and commercial power issues and whether this will be addressed by clean-coal technology or by nuclear power stations.

Timing is also an issue. The extended time frame being used with the current efforts, especially conservation, may only cover future growth in national energy demands. This means current plans would only preclude additional large increases in crude oil import requirements—not necessarily drive import reductions in the near-term. Building a new infrastructure for biomass based fuels may take some time, but conservation efforts in the transportation sector would be of greater immediate benefit. New CAFE standards were overdue, but are not aggressive enough to be of any near-term assistance to alleviating oil import imbalance driven inflation on America's economy or improving national security.

Finally, improving current processes, exploring other existing technologies, and developing new ones should be continued and nurtured. Biomass fuels need cheaper enzymes to help break down the cellulose for processing. Nanotechnology might be used to develop artificial enzymatic biomass factory processes to manufacture ethanol or other petroleum products. Some commercial use could be found for all the carbon dioxide to be produced by clean-coal technology—possibly in a new build material such as current concrete or wall board or bricks. Other energy renewables such as wind, tidal, and solar show potential as the technology evolves.

The bottom line is America has recognized the need and is beginning to transform its energy infrastructure. Now is the time to continue addressing the problem and finding true long-term solutions to assure national security and remove the volatility that importing vast amounts of oil has on the American economy. As Winston Churchill stated, "This is not the end. It is not even the beginning of the end. But it is, perhaps, the end of the beginning."[85]

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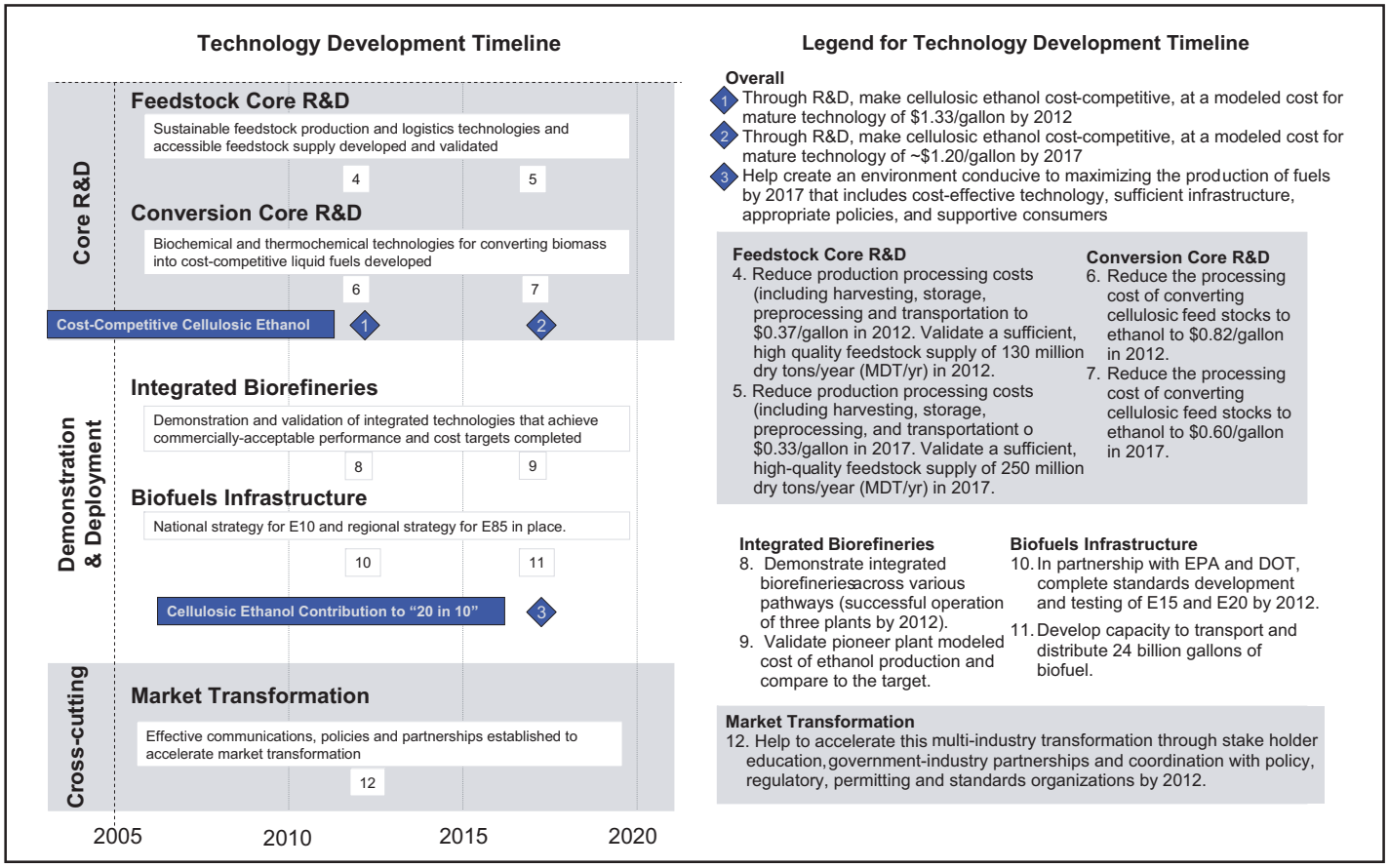

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    b. The agreement would guarantee loans of up to $25B for new nuclear plants and $2B for a uranium enrichment plant, something those industries had been avidly seeking. It would also provide guarantees of up to $10B for renewable energy projects, $10B for plants to turn coal into liquid vehicle fuel and $2B to turn coal into natural gas."
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He who will not apply new remedies must expect new evils; for time is the greatest innovator.

—Viscount Francis Bacon

The final dictum of history must be that whatever excellence Lee possessed as a strategist or as a tactician, he was the worst Quartermaster General in history, and that, consequently, his strategy had no foundations, with the result that his tactics never once resulted in an overwhelming and decisive victory.

—Major General J. C. Fuller, USA

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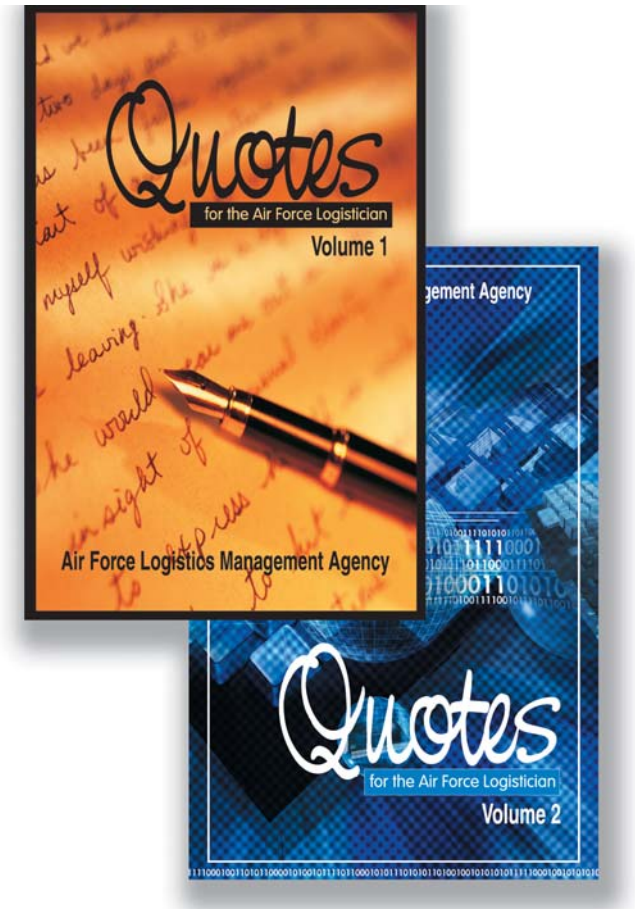

Why a set of quotations for Air Force Logisticians? An obvious answer is there isn't one. But that's not the only reason, and it's certainly not the most important reason. The primary reason for producing this set was to provide a teaching resource that can be used in classrooms, education, training, and mentoring programs for Air Force logisticians. It is a tool that can be used by instructors, teachers, managers, leaders, and students. It is also a tool that can be used in research settings and a resource that should stimulate comment and criticism within educational and mentoring settings. Copies of the set are provided free of charge to any Air Force logistician, educational institution, teacher, instructor, commander, or manager.

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Generating Transformational Solutions Today; Focusing the Logistics Enterprise of the Future