Commission Briefing Paper 4C-01

Assessment of the Ability of Traditional and Unconventional Energy Sources to Meet the Demands of Transportation Systems

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Introduction

This paper is part of a series of briefing papers to be prepared for the National Surface Transportation Policy and Revenue Study Commission authorized in Section 1909 of SAFETEA-LU. The papers are intended to synthesize the state-of-the-practice consensus on the issues that are relevant to the Commission's charge outlined in Section 1909, and will serve as background material in developing the analyses to be presented in the final report of the Commission.

Background and Key Findings

If one were to ask simply, "will there be oil supplies available to the year 2030? …to the year 2050?" The answer would have to be, "Yes, but…" There's an "elephant in the living room" that many are ignoring. Oil supplies are not going to last through the end of this century, especially in light of the enormous new demands countries like China and India will put on supplies as their surging economies develop. IEA predicts a 50% increase in demand for oil between now and 2030, with China alone accounting for 30%. We need to begin to focus now on a possible transition from the Oil Age. What's going to replace it? How will that new energy source work? Where's the infrastructure going to come from? However, the question this paper seeks to answer is not simply, "Will petroleum-based fuels be *available*?" but rather, "Will they and other energy sources be available in *appropriate quantities* and at prices that will meet the demands of the Nation's transportation systems?"

- Petroleum will remain the primary source of transportation fuel at least until 2030. And supplies of petroleum-based fuels will be available. That's according to two reports from government agencies: the U.S. Department of Energy's Energy Information Administration's "Annual Energy Outlook 2007," and the International Energy Agency's, (IEA's) "World Energy Outlook 2006."

- Right now, most all the worldwide "plumbing" in transportation is geared for gasoline and diesel. And that plumbing has been built up over the past 150 to 200 years at a cost of trillions of dollars. It's not going to be replaced overnight. When will we have to start building a new infrastructure, so that when the oil finally does run out, we can, over time, smoothly segue over to the other approach?

- Alternative fuels hold promise, but based on the current level of research in those areas, we are several decades from the point that they can carry the load petroleum now handles. According to the World Energy Outlook 2006 report, the world's energy will remain carbon based until 2050.

- What is needed is a significant and persistent effort, aimed at the problem of energy supply. Pieces of the solution to the coming global energy crisis must include energy efficiency and conservation, development of renewable technologies, deployment of those technologies, and cooperative efforts among national governments.

- Therefore, the key findings of this paper are that although oil will be available through the year 2050, prices will escalate. And long before that end date, a significantly higher investment needs to be made toward moving away from a carbon-fuel dependant society.

- Short term efforts should include increasing incentives for alternative fuels and fuel economy, as well as policies that move us away from the use of single-occupant vehicles and toward increasing mass transit.

- A stronger emphasis should be placed on alternative work styles, working at home, telecommuting, and the like.

- There may be changes in funding levels for energy infrastructure creation and maintenance, development of renewable technologies, more energy efficiency and conservation, and policy changes that include carbon-fuel taxes.

- The dramatic cultural changes which may result from such a program need to be anticipated and responded to so that social order is maintained. For example, if a move away from gasoline- powered vehicles and toward, say, electric vehicles is anticipated, there should be a phasing in of the change so that people can plan ahead. If, for example, consumers are told that over the next six years, the tax on a gallon of gasoline will increase five cents a gallon per year, and then for the next six years after that, the increase will be ten cents a gallon per year, people will be able to anticipate that their next vehicle should probably be much more fuel efficient – maybe even electrically powered. Also, it would allow auto makers to phase out gas guzzlers, rather than be suddenly faced with a huge inventory of vehicle nobody wants to buy.

Calculating the Prospects of Long-Term Fuel Supplies

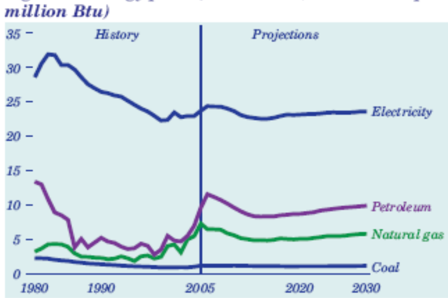
To project transportation energy demands and supplies fifty years into the future requires more than simply looking at the availability of fossil fuels. Other issues, many of them seemingly disparate, are involved. These include the economic development of China and India, technological developments in energy production and vehicle fuel efficiency, civil wars in Africa (where a major oil deposit exists), the impact of the cost of traditional fuels on the viability of developing non-traditional ones, and many, many more.

Two highly respected organizations -- the Office of Integrated Analysis and Forecasting of the U. S. Energy Information Administration, and the International Energy Agency, an affiliate of the Paris-based Organization for Economic Co-operation and Development (OECD) – have developed scenarios which include consideration for these and other issues. The reports are the International Energy Agency's (IEA's) June 2006 report, "Energy Technology Perspectives: Scenarios and Strategies to 2050," and the U.S. Energy Information Administration's (EIA's) "Annual Energy Outlook." The EIA is an independent statistical and analytical agency within the U.S. Department of Energy. The agency's 2007 report (AEO 2007) is due out in February 2007, but released its overview of that report in December 2006.

In using the two governmental reports noted above to anticipate the fuel availabilities until 2050, there are limitations. The EIA report focuses much of its attention on the United States but looks forward only to 2030. The IEA report reaches to the year 2050, but is global in scope. And both look at a wide range of energy applications, not transportation alone. The following statements were pulled from the two reports:

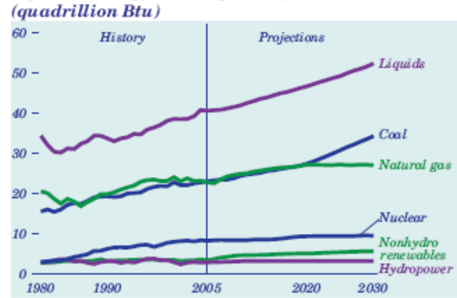
- OPEC is expected to keep its average oil prices in the range of \$50 to \$60 per barrel (in 2005 dollars) through 2030. (EIA Annual Energy Outlook 2007)

Figure 1. Energy prices, 1980-2030 (2005 dollars per million Btu)



(Source: U.S. Energy Information Administration)

Figure 3. Energy consumption by fuel, 1980-2030 (quadrillion Btu)



(Source: U.S. Energy Information Administration)

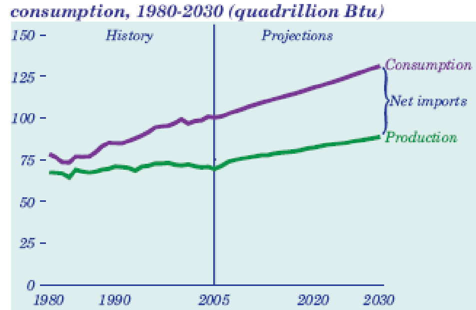
- Significant long-term supply potential is anticipated from non-OPEC producers. Several major areas of renewed or new production include Angola, Azerbaijan, Kazakhstan and Brazil. Canada's oil sands have increased in economic viability with higher world oil prices and advances in production technology. (AEO 2007)

- Production of oil, coal, and natural gas will provide the same 86% share of the total U.S. primary energy supply in 2030 that they did in 2005…assuming no change in existing laws and regulations occurs (AEO 2007)

- Global primary energy demand will increase by just over 50% between now and 2030. Over 70% of that increase comes from developing countries, with China alone accounting for 30%. (World Energy Outlook IEA)

- By 2050, most energy will still be derived from fossil fuels. (IEA)

Figure 6. Total energy production and consumption, 1980-2030 (quadrillion Btu)



(Source: U.S. Energy Information Administration

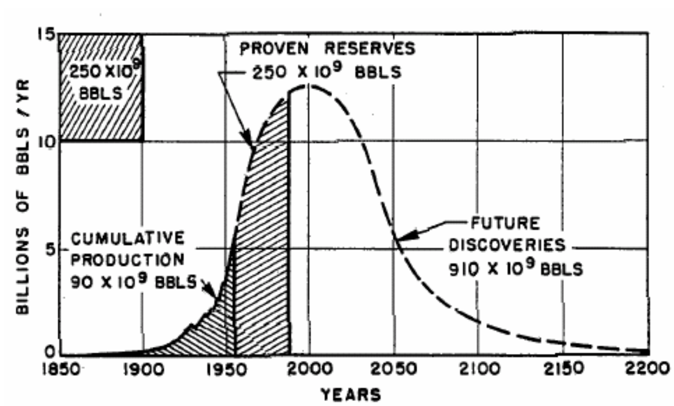
- "De-carbonizing" (reducing the reliance of carbon-based fuels) will take longer than many anticipate, but must be achieved in the second half of the 21st century for environmental and supply reasons. Hydrogen and fuel cells are anticipated to hold the most promise in this area. (IEA)

- Substantial development of unconventional energy sources is expected over the next 25 years. Anticipated prices of energy will be high enough to trigger entry of some alternative energy supplies into the market. (AEO 2007)

Based on these points, it would appear that the future thirty or even fifty years out is predictable, bright, and consistent with the current status. However, another viewpoint says that within the next ten to twenty years, the situation will begin to change dramatically for the worse, and will initiate a decline in our oil-based society.

The seeds of this other viewpoint go back fifty years. In 1956, a Shell Oil geologist named M. King Hubbert had calculated that production of oil in the Continental United States would peak in 1971. Hubbert had found, through a variety of calculations based on past experience, that oil exploration takes the form of a bell curve when plotted on a graph. Early discoveries go slow for a short while, but as the resource enters increasingly common use, and people learn how to find it, the upside of the bell curve steepens quickly as it rises. In the case of oil in the U.S., Hubbert knew the speed of that rise: the production rate had doubled every ten years from 1859 to 1956. At that point, the U.S. was pumping oil at a rate of 2.5 billion barrels a year. But if the resource is indeed finite, there had to come a day when it is half used up.

Importantly, Hubbert was aware that the annual rate of discovery of oil in the U.S. had peaked in the 1930s. He couldn’t see it going back up again once it started falling, and he figured production had to follow essentially the same bell shape.



M. King Hubbert’s 1956 curve
(from “Nuclear Energy and Fossil Fuels,” by M. King Hubbert, presented March, 1956)

Based on estimates of the total amount of oil that would ever be produced, Hubbert estimated that the peak of oil production would be 1971. Hubbert presented a paper with his findings to the American Petroleum Institute. His concept was believed by almost nobody, and he was widely ridiculed. In fact, Shell censored the written version of Hubbert’s address to API, changing the wording of his conclusion to read that “the culmination should occur within the next few decades.” In 1961, the US Geological Survey said the US had 590 billion barrels of recoverable oil, meaning the industry had another thirty years of growth ahead. Ultimately, Continental US production did, indeed, hit its topping point, but it was 1970, a year early, at 3.5 billion barrels.

Hubbert's Curve later was found to be applicable to other countries, as well as to specific oil fields. Over and over, it proved effective. One should note that the curve can be influenced by wars, weather, recessions, and other items which can affect oil exploration and production. But with the impacts of those things calculated in, the curve still has been shown to be accurate. And the feeling among many is that it is applicable to worldwide petroleum production. And it is this concept that forms the foundation of the peak oil theory.

"Conventional oil" is the substance for which most of the world's liquid fuel "plumbing" has been installed. Through this plumbing, the world's extraction and use is close to 85 million barrels per day. And conventional petroleum is the substance that "Peak Oil" predicts will be available in lower and lower quantities, starting at some time in the future, sooner or later, depending on whom you believe.

On December 7, 2005, the House Committee on Energy and Commerce held hearings on the subject of Peak Oil. Among the speakers was Robert L. Hirsh, a senior energy program advisor for SAIC. Hirsh said, "Over the past century, world economic development has been fundamentally shaped by the availability of abundant, low-cost oil. Previous energy transitions (wood to coal, coal to oil, etc.) were gradual and evolutionary; oil peaking will be abrupt and revolutionary. The world has never faced a problem like this. Without massive mitigation at least a decade before the fact, the problem will be pervasive and long lasting.

Hirsh provided a listing of several noteworthy oil executives, geologists, and others who had made projections as to exactly the peaking of world oil production would occur. They include the following:

Projected Date	Source of Projection	Background & Reference
2006-2007	Bakhitari, A.M.S.	Oil Executive (Iran)
2007-2009	Simmons, M.R.	Investment Banker (U.S.)
After 2007	Skrebowski, C.	Petroleum journal editor (U.K.)
Before 2009	Deffeyes, K.S.	Oil Company Geologist (retired, U.S.)
Before 2010	Goodstein, D.	Vice Provost, Cal Tech (U.S.)
After 2010	World Energy Council	World Non-Governm. Org.
2012	Pang Xiongqi	Petroleum Executive (China)
2010-2012	Laherre, J.	Oil geologist (ret., France)
2016	EIA Nominal Case	DOE Analysis/Information (U.S.)
After 2020	CERA	Energy Consultants (U.S.)
2025 or Later	Shell	Major Oil Company (U.K.)

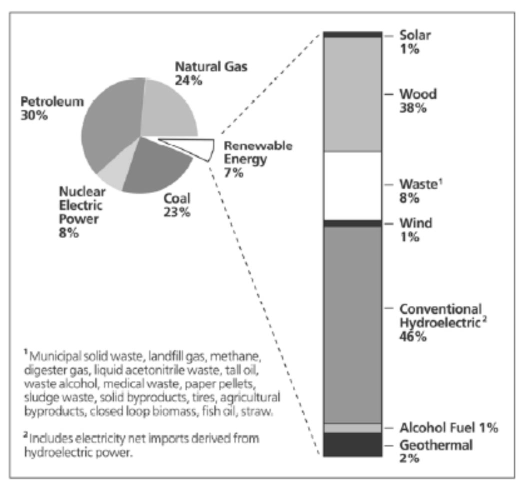
The difficulty in predicting the date with any certainty arises from the fact that many countries do not actually know how much oil is available within their borders, and others may have some idea but are not sharing those detailed numbers with others. Things like oil shale in Colorado and tar sands in Alberta, Canada appear to hold much promise, but the technologies currently available require more energy to mine than the resulting fuel provides. In other words, even if the value of the resulting petroleum product rises sharply, the energy cost of producing the non-conventional petroleum would rise just as fast. Plus, there's the problem of changing the necessary "plumbing" to meet those needs in some instances. The challenge, then is, how quickly can other sources of energy be developed? And can those sources be developed to the level needed in time to make a transition to them faster than conventional petroleum supplies are depleted?

Such a challenge, and the national will which would require meeting it, might be put in the context of such events as the anticipated bankruptcy of the Social Security System, or of global warming. Many times, the public has been told that unless hard choices are made, disastrous results will occur. And the public's response has not always been overwhelming in such instances. Often, it takes a major disaster to push action. It's been noted that most of the major inventions come during times of war, when the immediacy of demand is met with an appropriate level of funding and focused mind power. Yet, even after major disasters, such as the impact of Hurricane Katrina on New Orleans' insufficient levee systems, the national reaction to change has been slow. Add to that the fact that there is now no "silver bullet" out there, in the form of a single alternative energy source that can begin to take the place of oil within a few short years. Much has been said about hydrogen fuel cells as the ultimate energy source, but those, too, have challenges of energy return on investment, in that in many cases, more energy is required to power such cells and put them into place than the energy that they will expend.

Alternative fuels have been around for decades. Steam and electric powered cars date to the early days of the 20th century. Often, alternative fuels have been used when conventional fuels were unavailable. Toward the end of World War II, for example, Germans with no conventional fuels converted their Volkswagens to run on wood, rather than petroleum.

Alternatives to Traditional Energy Sources

Michael Pacheco, director of the National Renewable Energy Laboratory's National Bioenergy Center, noted in an article in *Consumer Reports* magazine, "The big challenge is that we are going to reach a peak in world oil production. We need to start working toward replacement fuels 20 years before that peak."



Renewable energy as share of U.S. energy comsumption, 2000
(Source: U.S. Energy Information Administration)

Alternative fuels of today have come a long way, but they are still a long way from providing a substantial percentage of the nation's energy, and an even smaller percentage of its transportation energy sources. And both the Energy Information Administration and the International Energy Agency predict that that situation will not change significantly for several decades. Major breakthroughs will have to come about first.

So what are the most promising major alternative transportation fuels now being developed?

Ethanol has had its drawbacks in the amount of land and crops required to provide sufficient ethanol to make a dent in the amount of fuel Americans use. But thanks to advances in biotechnology, researchers can now use straw and other plant wastes as feedstock for the manufacture of ethanol. Such cellulosic ethanol exhibits a net energy content three times higher than corn ethanol and emits a low net level of greenhouse gases. Use of certain agricultural methods and native plants may actually increase carbon sequestration while producing feedstock for cellulosic ethanol, resulting in even greater reductions of greenhouse gas emissions.

Solar energy has always been an ultimate energy source for transportation. Having a vehicle that could transfer energy from the sun directly into electrical energy would eliminate, not just pollution but also the need for a non-renewable fuel such as oil. The problems have always centered on cost and the size of solar panels and batteries. The use of nanotechnology is now being employed in this field with a lot of great potential for smaller, cheaper cells – again, years away.

Hydrogen fuel cells are seen by the International Energy Agency as being the next key energy source after carbon-based energy becomes prohibitively expensive, sometime in the second half of this century. Currently, however, hydrogen is impractical as an alternative. It is inefficient to produce, has low energy density, and is expensive to transport and convert back to electricity. In concentration, Hydrogen is also hazardous, so storage will tend to be expensive as well.

Thus, the big questions to be answered are:

1) How can we extend the existing petroleum supplies for as long as possible?
2) How can we get alternative fuel sources on line to handle some of petroleum's load?

Scenarios for 2050

A number of organizations, including the International Energy Agency, the National Commission on Energy Policy, the World Energy Council, and the United Nations Development Programme, have offered scenarios on the future of transportation energy between now and 2050.

The International Energy Agency, after prompting from the G-8 world leaders at their Gleneagles, Scotland Summit in 2005, developed what may be the most comprehensive - a 500-page set of scenarios and strategies to the year 2050. The innovative work, entitled *Energy Technology Perspectives 2006: Scenarios and Strategies to 2050* notes that the world is facing twin energy-related threats: that of not having adequate and secure supplies of energy at affordable prices, and that of environmental harm caused by consuming too much of it. It looks at five scenarios, ranging from continuing the current approaches to energy policies and consumption to dramatic changes from the status quo, such as increased emphasis on energy efficiency, development of new technologies, and policy changes that promote low-carbon energy options. The other organizations' scenarios carry much the same recommendations as the IEA's. Therefore the following recommendations are offered:

Recommendations

A comprehensive energy program with a focus on the transition to renewable energy may be necessary. Several months back, the President sought recommendations for major national initiatives on the order of the NASA Mission to the Moon. A highway comparison might be the Interstate Highway System, the largest manmade structure in history, built over a period of around four decades. Comparisons to the Marshall Plan or the Manhattan Project have also been made, but the level of this effort may need to go well beyond the scope of any of those efforts. Here are some aspects

1) Political leaders must play a significant role. They must recognize that the problem is on a scale of an international disaster, except that it will occur much more slowly than any hurricane or earthquake. But the impact will be more severe. Also, leaders should give consumers advance knowledge of what is to come. If, for example, a decision is made to push toward use of electric vehicles and away from gasoline-powered ones, policies might be set up whereby gasoline taxes increase by, say, five cents a gallon each year for the first six years, then ten cents a gallon per year the next six years, and so forth. A consumer who had recently purchased a gas guzzler would know that gasoline prices would be rising, but he or she could anticipate when to purchase an electrical vehicle. Auto manufacturers wouldn't be stuck with huge inventories overnight, but would rather be able to reduce manufacturing of gas guzzlers over time. Such a phased approach would allow the consumer to be in charge of what he does, yet provides him with the information he needs to make informed decisions.

2) The public needs to be engaged. During World War II, citizens were asked to sacrifice for the war effort, using ration stamps, donating scrap metal, and buying war bonds. Movie stars donated their time to USO shows, average people brought food to train stations for soldiers passing through on troop trains. As a result, the country united in the effort to defeat the enemy. Similar cooperative efforts and programs may be necessary for such an effort to succeed.

3) A massive amount of funding is required to develop the necessary technology that can take the place of petroleum in the transportation area. Not in the millions, but billions or even trillions of dollars could be focused in this area. There are many alternative fuels and renewable energy sources being touted now, but none are a safe, affordable, easily transportable alternative. In addition, aspects such as energy conservation and energy efficiency may require either new funding or refocusing of some previously heavily funded areas, such as highways, onto areas such as mass transit, in order to move people away from single-occupancy vehicles.

4) Energy conservation measures should be implemented. IEA's *Energy Technology Perspectives* notes that energy efficiency and conservation is indispensable. New vehicle construction materials, more compact engines, lighter vehicles, are examples.

5) Greater emphasis needs to be placed on mass transit and alternative work styles.. The idea of millions of vehicles going to and from the workplace every day with only a single person in them is the ultimate in inefficiency. Creativity should be employed to make mass transit more appealing in the places where it functions best, and long-range planning should include factors that reduce transportation energy consumption. Also, funding levels for highway and transit infrastructures may need to be switched in order to focus more appeal on transit than passenger car travel. According to the IEA, "If modal shift policies were to transfer 10% of the total passenger miles in 2003 from light-duty vehicles to buses (with unchanged load factors) the net energy savings on a global basis would amount to…about 5% of total transport energy demand."

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CONSOLIDATED COMMENTS FROM MEMBERS OF THE BLUE RIBBON PANEL OF TRANSPORTATION EXPERTS - PAPER 4C-01

One reviewer commented as follows:

On page 5, the bottom paragraph states: “Things like oil shale in Colorado and tar sands in Alberta, Canada appear to hold much promise, but the technologies currently available require more energy to mine than the resulting fuel provides.” This reviewer would suggest that the pertinent issue is not energy balance, but economics: specifically, whether the costs (capital and operating) of extracting and processing the oil exceeds what the oil will bring in the marketplace. At high enough oil prices, shale and tar sands certainly are viable, which is why oil from them is being produced today.

On page 6, the paper states: “But thanks to advances in biotechnology, researchers can now use straw and other plant wastes as feedstock for the manufacture of ethanol.” No doubt at some point this “cellulosic” ethanol will be cost effective, but this reviewer does not believe we are at that point now and it is not at all clear when we will be.

The discussion of “Hubbert’s Curve” should note the serious disagreement experts have on its validity. Cambridge Energy Research Associates (CERA), for example, wrote in November 2006 that “the ‘peak oil’ argument is based on faulty analysis which could, if accepted, distort critical policy and investment decisions and cloud the debate over the energy future.” CERA’s projected date for the peaking of world oil production is some time after 2030, not 2020 as the table on page 5 indicates.