TOWARD A RATIONAL ENERGY POLICY

John Huppler November 2006

Executive Summary:

John Huppler Updated December 2006

This paper addresses four matters within the broad energy arena:

1. The need to prevent rampant escalation of energy costs during the next decade. This requires a rational energy policy. The first step for such a policy is for the government to accept reality and commence to pitch the need to control our energy use. It must also act to ease the economic pain of our market-driven transition to higher costs and less desired fuels. The marketplace is making modest progress; for example, during 2005/2006 gasoline consumption has been rising at 0.5%/yr, down from the 1.4%/yr pattern. But the marketplace alone will be economically punitive.
2. The need to dramatically reduce airborne pollutants. The technology exists to do this. Such an effort will raise the cost of products such as delivered electricity but not unacceptably. The cleanup devices consume energy so any mandate for cleanup is unlikely until after a rational energy policy is in place.
3. The need to reduce greenhouse gas emissions. This will require an enormous effort and consume substantial energy. A rational energy policy that starts to get us using less energy and promotes both wind power and nuclear power will be a first step.
4. The route to eliminating energy imports. This is a Herculean task.

Any practical energy policy must be premised upon three unassailable observations:

1. Worldwide, *supplies* of crude oil have permanently ceased to be abundant.
2. Worldwide, *deliverable supplies* of natural gas have permanently ceased to be abundant.
3. Worldwide, *economically deliverable supplies* of energy have permanently ceased to be abundant.

There is a core message in the above observations: **We have entered the second epoch for energy**. *From now on, supply will be less than unconstrained demand.* The US has enjoyed the lowest energy costs with minimal taxation. Consequently, it appears likely that the *US will bear an entirely disproportionate amount of the ongoing demand destruction* needed to balance worldwide supply and demand.

A rational energy policy must embrace today's needs and those actions required today to set plans in motion for future activities. Let us now outline the ten-point policy in specific terms. Each element plays a critical role in controlling near-term energy price rises and setting the stage for future decades. The sum of the realizable targets for reducing crude oil imports over the next decade is in the range of 3 mmb/d.

POLICY

Immediate needs

- Embrace a public awareness campaign to get the public on board as to the state of energy supply, and to get the public attuned to conserve.
- Encourage energy conservation and fuel switching from oil to natural gas in homes, businesses, and industry.
- Raise the light-vehicle fleet mileage.
- Encourage renewable energy supply with tax credits.

Bridging needs

- Permit LNG offloading sites.
- Fast-track permitting for North Slope gas pipelines.
- Open ANWR and other off-limit areas to exploration.

Longer-term needs

- Permit new coal-fired electrical generating facilities with rules to reduce overall emissions from coal-fired plants.
- Permit new electrical facilities using nuclear fuel.
- Permit shale-oil test sites and establish a viable permitting process for commercial ventures.

Once the energy policy is in place, we can look to reducing or even eliminating crude oil imports and reducing carbon dioxide emissions. These are subjects broader than energy policy. They are each Herculean in scope and will require a decades-long national commitment with attendant enormous costs.

Key facts are:

- We must dramatically raise fleet-average vehicle mileage, perhaps using a multi-pronged approach. *For the market to effect changes in driving habits may take something above $5 per gallon gasoline This level for gasoline implies crude at well above $100/b and such prices will hurt other sectors of the economy, especially the less well off.*
- Coal is the principal alternate hydrocarbon fuel. The nation has abundant supplies. Recent energy price increases allow economic room to construct new coal-fired facilities that include good clean-up of pollutants.

- Manufacture and use of ethanol actually increases our use of crude oil and when the cycle for ethanol is considered, it is our dirtiest fuel.
- Hydrogen will not be a viable player until such time as all of our electricity is generated by coal, nuclear and renewables.
- Wind-power is economic.
- Solar-power is far from economic and requires a major technology breakthrough before becoming viable.
- Drilling in the coastal plain of ANWR could provide the linchpin to keep crude oil prices in check for the next decade.
- To reduce our crude oil imports will require conservation, better vehicle efficiency, using electrical plug-ins to shift vehicle fuel use to electricity, and fast-tracked construction of coal-fired power plants and wind facilities followed by a large number of new nuclear plants.
- Our shale oil reserve is massive and is our only route towards energy independence in the next three decades. We will need to develop a shale oil supply of eight to ten million barrels per day.
- If we decide to move towards dramatically lowering carbon dioxide emissions, the top priority must be limiting world population growth. Beyond that we must move towards an electricity-driven society.

Toward a Rational Energy Policy

A rational energy policy needs only two basic elements. It will frankly lay out the energy situation to the public, and it will attempt to ease the economic pain of our market-driven transition to higher costs and less desired fuels.

For decades our government has been unable to come to grips with a meaningful energy policy. Successive administrations have pitched the dream that abundant supply and perhaps even energy independence lay just around the corner. The only significant item in the energy arena is that in 1973 our rapacious growth in per-capita energy use stopped abruptly and has since stayed flat. This change was brought about not by policy but by OPEC's first price leap coming just as we were realizing that we had lost our energy independence.

Today the administration is still telling us supply will grow and costs will come down. Senator Kerry wants to stop us importing crude from the Middle East and produce 20% of our energy from renewable sources. These are not responsible statements! But, they may serve political ends.

We, the voters, do not help. We may want to improve things, but we find this difficult for our emotions get in the way. The three barriers we put up are: NIMBY, or "Not In My Backyard", cause-driven efforts, and economic self-interest.

Politicians live to be re-elected. They have perceived that a realistic energy outlook is inimical to their constituents. So, a rational energy policy has not been possible. Voters now view the need to reduce crude imports as their top issue. The stage is set for a bold policy.

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These statements are not doomsday cries. To cease to be abundant does not preclude further rise in supply; it merely precludes sufficient rise in supply to overbalance price-unconstrained demand.

The Navy projects that world crude supply has already peaked. The EIA takes the view that worldwide crude oil supply rates will continue to grow and could double over the next several decades. It seems more likely that crude oil supplies will continue to rise modestly for several years and then plateau for a number of years before commencing a long slow decline.

On the demand side, virtually everyone missed the impact of the burgeoning economies in China and India and was caught by surprise at how soon crude supply fell below unconstrained demand. China and India are early in their dramatic rise in energy use. Demand for crude oil would like to increase rapidly world-wide and supply cannot accommodate this.

Worldwide natural gas supply remains abundant, albeit in remote locations. For the US, indigenous supply and imports are nominally in balance with demand. Delivered natural gas sells at parity with its competing refined liquid fuels. Any supply addition will simply back off liquid hydrocarbon use. New supplies must come from North Slope pipelines or from imported LNG. Any such supplies will be insufficient to create a surplus of combined gaseous and liquid fuels so it too will sell at parity. Other nations are ahead of us in contracting for available LNG supply, so in that market each player will raise their share of fees to parity.

Coal represents the potential US fuel to reduce our energy dependence in the mid-term. For all new coal-based facilities each member of the chain, that is the mine, the railroad, and the power plant, will attempt to garner an added profit. Layered onto this the government will take this opportunity to require stack-gas cleanup and such implementation will absorb most of the prospective added profits. The net result is that power generated from new coal-fired facilities will sell into the market at parity with power from oil or gas-fired facilities.

There is a core message in the above observations: **We have entered the second epoch for energy**.

Until now supply was abundant. For the last seven decades production was controlled to manage price, first by the Texas Railroad Commission in cooperation with counterparts in Louisiana and Oklahoma, and then by OPEC.

From now on, supply will be less than unconstrained demand. In recurring cycles demand will creep ahead of supply, prices will rise rapidly, marginal demand will be destroyed, and prices will fall back somewhat. Over a planning horizon prices will trend upwards. Demand destruction will maintain the supply/demand balance. Prices will cycle wildly since the marketplace is less efficient at price stabilization than a cartel.

The rest of the world has a history of accommodation to high energy costs. They have fuel-efficient vehicles, viable public transportation, and low per-capita energy use. In Europe high existing taxes of up to $3 per gallon on fuel moderate the relative impact of energy cost increases. In China and India governments will want to maintain their burgeoning economies and will likely subsidize as needed to offset rising prices; they have such low per-capita energy use that they may hardly notice price rises.

The US has enjoyed the lowest energy costs with minimal taxation. We use twice the per-capita energy as Europeans. We will feel about double the relative impact of energy cost increases as in Europe. Consequently, it appears likely that the *US will bear an entirely disproportionate amount of the ongoing demand destruction* needed to balance worldwide supply and demand.

Here is an optimistic near-term model. Suppose that over the next ten years we hold oil imports flat and worldwide production growth is sufficient to satisfy demand growth for the rest of the world. This will stabilize pricing in the $50 to $80 per barrel range, our economy will remain healthy without high inflation, and we gain time to get new technologies underway; clean-coal power, shale-oil, and wind-power are viable. Our imports have been rising at somewhat over 300,000 b/d yearly which implies that over the next ten years we need to destroy demand or add domestic production of about 3 million barrels per day. This is an attainable target!

Beyond ten years any model is dicey. World crude oil production is likely to have peaked and prices will be rising. Over a reasonable planning horizon, say thirty years, our energy supply will trend as follows:

1. The two preferred fuels, oil and natural gas, will satisfy a declining fraction of needs.

2. Three less preferred fuels will play a larger role. Initially coal use will increase. Eventually, nuclear will play a larger role and shale oil will become a fuel.

3. Hydro will remain flat.

4. Renewables will continue to grow but will likely not merit a separate line on a chart, except possibly for wind-power.

Anything that can be done to facilitate domestic crude and natural gas supply during the next decade will ease the transition into use of less desirable fuels.

A rational energy policy must embrace today's needs and those actions required today to set plans in motion for future activities. Let us now outline the ten-point policy in specific terms. Each element plays a critical role in controlling near-term energy price rises and setting the stage for future decades. The sum of the realizable targets for reducing crude oil imports over the next decade is in the range of 3 mmb/d. Following the outline, each item will be discussed. The Appendix enumerates potential and realistic limits to changes in energy use.

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Bridging needs

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As used here, the term “permit” is meant to include whatever federal actions are required to remove bottlenecks currently in place which are allowing interest groups to stall or prevent implementation. A typical tactic would be litigation claiming that an Environmental Impact Statement was wrong or incomplete, or that the provisions of the Clean Air Act might be violated, or that persons and wildlife might be adversely affected. Different actions will be called for with each item.

Further, whenever excise taxes are proposed it is assumed that such revenues will be redistributed in a fashion to mitigate the burdens placed on the less advantaged. Such is a matter of tax policy.

Once the energy policy is in place, we can look to reducing or even eliminating crude oil imports and reducing carbon dioxide emissions. These are subjects broader than energy policy. They are each Herculean in scope and will require a decades-long national commitment with attendant enormous costs.

Awareness and Conservation

Government should stop decrying high fuel costs, make the public fully aware that costs will, over time, go higher, press drivers to conserve, and press the public to undertake conservation measures. The government cannot expect the public to embrace conservation and efforts to lower energy use unless it accepts reality. Americans have responded in the past to sobering facts.

If the government shirks this burden, the marketplace will in due course make the situation clear by dramatic price rises. If such a route is taken, the populace is likely to be angry with the then-current administration.

The government should offer larger credits for better insulation and other energy-saving devices. There should be a campaign to have thermostats in both public and private buildings set no lower than 75 degrees for cooling and no higher than 68 degrees for heating. To encourage smaller dwellings and energy conservation, there should be a graduated excise tax on electricity use.

The government should offer credits for switching from oil to natural gas for space heating and, to further encourage this, impose taxes on fuel-oil use; if half the residential and commercial users and one-fourth the industrial users of oil switched to natural gas, this would reduce oil use by 1.1 mmb/d, a target worth going after; a realizable target is more likely to be half this amount.

Crude oil currently used to generate electricity should be reduced by either or both of, a large tax on such use, or credits for switching to another fuel supply. To avoid increased pollution from greater use of older, coal-fired power plants some mandate/credit will be needed for such plants to reduce emissions; they can affect this either by switching to less-polluting supply or by retro-fitting cleanup devices. Present crude use for power generation is 0.6 mmb/d; it is infeasible to eliminate all such use due to peaking demands but a reduction of 0.4 mmb/d is prospective.

The government should press for greater public transportation use, possibly increasing subsidies for this. Our light-vehicle annual miles-driven is rising by 2% each year. If a conservation mindset can be established such that this rise is halved, that alone would save 750,000 barrels per day of imports by the end of a decade.

<u>Light-vehicle fleet mileage</u>

America's fleet-average mpg is 20.2 and has been declining for fifteen years. Advances in technology have been used to add weight (from 3200# to 4000#) and performance (0 to 60 mph times declined from 12 sec to 10 sec); new vehicles average about 24.9 mpg. These compare with a European fleet average around 34 mpg and new vehicle average of 43 mpg.

Americans like speed, size, and power. We will not readily give these up and go to more fuel-efficient vehicles. In the US we have seen the citizenry modestly cut gasoline consumption as prices rose and then resume prior patterns as prices fell back; at $3.00 per gallon there was a great wailing but no meaningful habit change. We essentially sloughed it off. This suggests that *for the market to effect changes in driving habits may take something above $5 per gallon gasoline This level for gasoline implies crude at well above $100/b and such prices will hurt other sectors of the economy, especially the less well off.*

A wise government will act now to force better fuel economy. Three options are:

- Provide a sliding-scale tax credit for higher-mileage new vehicles and a sliding-scale tax for low-mileage new vehicles. Set the null point at 40 mpg.
- Dramatically toughen CAFÉ standards.
- Impose a substantial gasoline tax, of say $2/gal.

Technology exists for 50 to 70 mpg vehicles. A target for fleet-average of 40 mpg in twenty years is not unreasonable. Improving fleet-average to 30 mpg (still below Europe today) in ten years would save 2.8 mmb/d of crude imports. Even raising the fleet-average to 24 mpg would save 1.1 mmb/d, and if Americans simply drove 5% less, this would save 400,000 b/d.

The marketplace must decide if hybrid vehicles make economic sense. We can say with certainty that we will trend towards smaller, sleeker, more fuel-efficient vehicles; these will increasingly be powered by small four cylinder gasoline and diesel engines. Hybrid vehicles will succeed if they become reliable and if the public perceives the savings in lifetime fuel costs to justify the higher purchase cost.

If hybrids succeed, a further hybrid variant may arise, namely one that can be plugged into the home electricity grid to be charged at night using off-peak power to provide, say, up to 20 miles of power each day. Once there is progress in expanding use of coal-fired power facilities, then tax credits to encourage plug-in style electricity-powered vehicles makes sense. In effect, such vehicles would be using indigenous coal for their fuel. Such a program has many merits: Not only would it reduce use of imported oil, it would facilitate emission cleanup at large central facilities, and would as an adjunct mean smaller vehicles. The potential is meaningful but not huge; if one-fourth of the fleet got 10 miles per day through the plug-in route, this would account for seven percent of driving, and with these being higher fuel efficiency vehicles of say 40 mpg, would reduce crude use 300,000 b/d.

Parenthetically, the route to achieve higher mileage might be via the war on terror. The President could make a bold statement along lines as follows: "Our level of crude oil imports threatens our nation's security. It is unacceptable! If we are to win the war on terror, we must dramatically reduce our dependence on Middle East oil. We must use less gasoline by changing our habits; we must start driving less and using more fuel-efficient vehicles. To that end I am today imposing a tax of $0.50 per gallon on gasoline. If this is insufficient to start changing our habits, I am prepared to raise those taxes further, all the way to the $3 level prevalent in Europe. I am also establishing tax credits for those that purchase fuel-efficient vehicles. And, to insure we move in the right direction, I am raising our CAFÉ standard for the year 2015 to 35 mpg and including light trucks."

Renewable energy supply

In the near term, renewable energy will not play an important role. Government should continue to support research as part of its public awareness campaign. Tax subsidies should be continued and perhaps increased to encourage investors in the sector. Overall, we must not conceptually lean on renewable fuels as the route to salvation. It will be many decades before these have impact. In the coming decades we must lean on our other available energy supplies and apply significant conservation measures.

Wind

Wind turbines appear viable. Over the past twenty years turbines have grown as much as fifty-times more powerful while costs have dropped as much as 90%. They pay back their construction energy cost in 3-8 months, an acceptable figure. They are economical, at least with their 1.5 cents per kwh subsidy. Wind turbines currently produce 0.4% of our electrical energy and have potential to get to 5% (or about 2% of total supply). Objection to new wind turbines is abating although NIMBY continues to be a strong factor. Perhaps the greatest obstacle to growth is that the wind blows in unpopulated areas and wheeling the electricity to users adds too much cost.

Solar

Solar has not yet proved viable in large applications. Solar generates less than 0.01% of electricity. It is not economical even with subsidies. (In Germany to encourage solar such power is sold, per policy, into the grid at ten times what conventional power receives.) It has long payback times to recoup the energy cost of creating and installing the facility, perhaps ten or more years.

If a solar cell takes ten years to pay back the hydrocarbon energy used to build it; and continues to operate for another 15 years, it does net 60% renewable energy. But how do we get there? Let us say we want to build each year enough solar cells to have them provide 1% of the total energy supply. Then in the first year we must consume 10% of available energy to build these cells. Total energy available to the end user drops to 90% of what it was before and does not return to base level for ten years. If we continue the process, we do get to a 15% increase in total available energy after 25 years and from then on we stay flat as we replace failing cells. This is not going to happen!

What needs to happen with solar is continued progress in technology towards the point where less than three-years of solar output is required to repay the energy to create the cell. Research should be heavily supported in hopes of a breakthrough.

Home units affixed to existing structures can pay back in about four years. These are useful in remote locations and as a means to focus attention on conservation of energy.

Ethanol

We should abandon efforts to expand ethanol use. More hydrocarbon energy is consumed in creating ethanol than is produced by burning the resulting ethanol. As to pollutants and carbon-dioxide production, the ethanol cycle makes ethanol our most polluting fuel!

Ethanol is touted by proponents as a renewable liquid fuel. Estimates of net energy gain from ethanol relative to the hydrocarbon energy consumed in creating it range from about +30% to -30%. Proponents tend to use high crop yield, low fertilizer requirement, highly efficient process operation and high waste-product credits; they tend to overlook a significant portion of the energy requirements for the farming and processing. A detailed study by Pimentel and Patzek, professors at Cornell and Berkeley with no personal interest in the nature of their findings, concludes that corn requires 29% more fossil energy than the ethanol fuel produces. They are careful to include all energy cost for the cycle. Even taking their data and applying the most optimistic values for process efficiency and credits, leads to a negative balance. They use 12 % lower crop efficiency than some. This is appropriate, and may even be too high. For, if the US should undertake a major program to expand corn-growing for ethanol manufacture, such corn would need to be grown on currently fallow land, and surely our farmers are clever enough that the land they are already using is the most fertile.

The ethanol cycle essentially doubles the carbon-dioxide production per unit of energy delivered. First the fossil fuels are burned to create the ethanol and then the ethanol is burned. This is offset only to the extent that corn growth consumes more carbon-dioxide than native prairie grasses would if the field were left fallow.

An ethanol manufacturing effort would not create renewable fuel and would, in fact, modestly increase our hydrocarbon use. To the extent we continue to subsidize corn-growing and produce excess corn piled on the ground, it is clearly better to turn that surplus into ethanol than to let it rot.

Presently 13% of the corn crop is excess and converted into ethanol. Over 90% of the $1.3 billion in subsidies to grow this corn go to agribusinesses and these are for the most part the same entities that enjoy further subsidies to convert the corn into ethanol.

Further, and quite aside from hydrocarbon consumption in creating ethanol, should the government decide to expand ethanol production beyond current levels, impossible physical barriers would arise. For, to supplant just one-fourth of the nation's gasoline with ethanol would require additional corn to be planted on over 40% of the nation's arable land, an area larger than Illinois, Wisconsin, Iowa, and Indiana. Such a landmass is unavailable. Moreover, the nation has little fallow acreage suitable for growing corn.

Ethanol will continue to be pitched so long as it makes good advertising copy and serves political ends. The agribusinesses will happily lobby to continue their profitable subsidies.

Other renewables

Biomass, geothermal, and wave power are still in the curiosity stage. They hold little chance of becoming meaningful in the coming decade.

Natural gas supply

Additional natural gas supply is needed to supplement developable domestic production. In the near-term any reduction in crude supply for electrical generating and space heating will need to be filled via natural gas.

LNG offloading sites

Multiple additional LNG offloading sites need to be fast tracked. We need an additional 3.5 bcf/d (600,000 boe/d) within ten years. This wants immediate attention. Whatever is done will face delay from legal challenges. The NIMBY factor is dominant in opposition. There is added international natural gas supply available for LNG production. There will be three to ten-year time delays to affect contracts, build liquefaction facilities and construct ships. Other gas-hungry nations are busy contracting new LNG supplies so we are likely to have the more remote and costly supply available to us by the time our government facilitates this route. On the positive side, industry seems to be progressing its permitting; sites along both the east and west coasts will likely not materialize while sites along the gulf coast face much less opposition.

<u>North Slope Gas Pipelines</u>

The government must fast-track approval and construction of natural gas pipelines from the Alaskan north slope and from the Mackenzie Delta on the Canadian north slope to bring an added natural gas supply of 2.5 Billion cubic feet per day, the energy equivalent of about 400,000 barrels per day of crude oil; this added supply will be necessary to offset declines in domestic natural gas production and cover increasing natural gas demand; absent such supply, an equivalent added demand for crude oil will ensue. Issues to be addressed are political and environmental. While the sea-route may be safest and cheapest, it employs fewer Alaskans; the government needs to see to resolution of the wrangling and then address limits to environmental litigation.

<u>ANWR</u>

Drilling in ANWR should be immediately approved. ANRW represents part of a bridging solution while we transition to other fuels. It has potential to provide up to 1.5 mmb/d (with 0.5 to 1.0 mmb/d more likely) within seven to ten years after drilling approval. It can play an important role in reducing our dependence on Middle East oil. It is more important to our security to develop this native fuel supply for our use over the next thirty years than it is to keep all of the area in its pristine state. The government needs to look beyond the clarion-call that ANWR is our last pristine wilderness, and ask, who is served by retaining an unvisitable wilderness and having larger dependence on imported oil? Experience in the Prudhoe Bay area demonstrates that no adverse long-term impact is made upon the environment by oilfield activity, and even the short-term impact is restricted to deminimus acreage. Opening the coastal part of this wilderness area will subsequently allow a few very interested scientists and tourists to have a look at the area.

ANWR is a *cause celebre.* Public statements have high emotional content and few facts, or facts badly used.

The anti-drilling group argues:

1. ANWR needs to be saved!
2. We can't "hand over this precious natural treasure to big oil companies – even though they know full well that it won't make a dime's worth of difference in making America more energy independent."

3. ANWR is our nation's last undisturbed wilderness.
4. Drilling in ANWR will destroy the ecology, kill the migratory birds, and destroy indigenous wildlife.
5. Oil produced from ANWR will have no effect on America's oil independence.
6. There is only a limited amount of oil to be found within ANWR.

The pro-drilling group argues:

1. America needs the oil from ANWR.
2. ANWR oil can help America reduce dependence on imported oil until new energy sources can be developed.
3. Drilling in ANWR will not harm the environment or the wildlife.

Facts for ANWR and nearby areas are:

1. ANWR is 19.8 million acres.
2. It is uninhabited except for about 200 residents on an adjacent island.
3. If leasing occurred, it would be within the coastal plain encompassing 1.5 million acres.
4. The total land area affected in some fashion by successful exploration would be between 10,000 and 100,000 acres.
5. The energy industry estimates that with today's technology a Prudhoe Bay sized field could be developed with a footprint of 1600 acres.
6. Prospective reserve estimates range from 4 to 16 billion barrels with an average of around 10 billion barrels.
7. Prospective production estimates range from 1 to 1.5 mmb/d
8. In the Prudhoe Bay area the caribou herd has thrived and is continuing to expand and migratory birds are unaffected by operations.

<u>Coal</u>

New coal-fired power plants represent an important component in reducing crude oil and natural gas consumption during the timeframe beyond 2015. The resource and technology exist! TXU recently announced plans to construct 11 new coal-fired power plants during the next decade; these will burn Wyoming coal, which is inherently a cleaner coal, and include 60% emissions cleanup in each of the new plant and a comparable old plant; the plants will provide 8600 megawatts and effectively reduce consumption of oil, or natural gas equivalent, by about 170,000 barrels per day. If five other utilities do the same, the equivalent of 1,000,000 barrels per day of imported oil and natural gas will be saved. TXU is now embroiled in the criticism/litigation phase.

The government needs to stipulate required pollution cleanup. The government must avoid imposing so-called Best Available Control Technology (BACT) as such an approach will lead to endless litigation. The government should take a middle position beyond the initial TXU proposal but well within attainability. It should mandate a minimum 70% pollutant cleanup for all existing facilities in ten years; any facility cleaned to the 85% level would earn a credit; each new facility would be required to both clean to the 85% level, and obtain a credit from an existing facility. This will reduce total pollutants by 70% no matter how many new plants are built. This target is not out of reach. Germany has since 1983 mandated 85% cleanup of pollutants.

Coal is the principal alternate hydrocarbon fuel. The nation has abundant supplies. Recent energy price increases allow economic room to construct new coal-fired facilities that include good clean-up of pollutants.

Nuclear

This nation must return to building nuclear power facilities. Over a twenty-five-year timeframe enough nuclear plants can be constructed to reduce oil-fired and natural gas-fired power generation to zero and to reduce use of coal-fired power plants. With expected permitting obstacles, it is only feasible to project 10,000 megawatts of new nuclear power in the coming decade. Current permitting/construction time for a standard design reactor is about eight years. Litigation can add endlessly to this time; it is in the arena of such litigation that the government must focus.

Nuclear is nonpolluting and emits no greenhouse gases. These are sufficient incentives to put up with the worries over nuclear plants and the, as yet, unresolved waste disposal issues.

Hydrogen

Hydrogen is unlikely to be a player in the next several decades and the government should stop touting it. The hydrogen-fuel cycle is a very inefficient way to create an end-use fuel; any manufacture of hydrogen will simply increase our imported crude requirement. The hydrogen-fuel cycle is highly polluting and is at the high end for carbon-dioxide generation per unit of energy. Beyond that, using hydrogen to fuel vehicles will require new vehicles and an entirely new infrastructure; we are unlikely to embrace the attendant costs while more conventional options remain.

Hydrogen as a "new fuel" is a lie. While it is true that hydrogen per se is a clean burning fuel with no emissions except water and it is politically sexy, *it is an energy- inefficient use of hydrocarbon fuel and does not remove the emission of carbon dioxide but merely moves the emission point.* Hydrogen likes the married state! It mates either with oxygen in the form of water or carbon in the entire suite of hydrocarbon molecules. Energy runs down hill. Hydrocarbons react with oxygen when ignited, giving off heat and producing carbon dioxide and water (and, depending on the hydrocarbon molecule, a host of other oxidized waste products.).

The most common way to obtain hydrogen is to mix water and methane under high pressure and temperature in the so-called "reforming" reaction. This produces carbon monoxide and hydrogen. To get the energy to drive this reaction one burns additional methane and can burn the produced carbon monoxide to get it to carbon dioxide. So, energy is consumed to create the needed heat and pressure with the resultant hydrogen having considerably less energy available than the starting methane. And, the carbon in the methane was oxidized to carbon dioxide so there was no reduction of greenhouse gas production; in fact there was increased greenhouse gas in proportion to the net methane used to fuel the reaction. To a select group of advocates the greenhouse gases were created remote to them so they overlook them.

Another way to create hydrogen is via electrolysis of water. This process is extremely energy-inefficient and wasteful of hydrocarbon energy. First, the hydrocarbon is burned to create electricity, giving off its pollutants and greenhouse gases in the process. Then the electricity is used to reverse the water reaction and produce oxygen and hydrogen. Both these processes consume energy lost as heat, so once again, the energy available in the produced hydrogen is far less than the original energy contained in the hydrocarbons.

A third route to hydrogen is via the so-called coal-synthetics process using Lurgi technology. Here lignite is reacted in pressure vessels to create varying hydrocarbon end products which can include hydrogen. The process frees the same suite of pollutants and greenhouse gases as would ensue had the lignite been used to generate electricity and cleanup of such gases is the same as at a generating facility. This cycle is less efficient than electricity generation.

Some may say let's create our hydrogen using renewable electrical sources. That is not how things work. Until such time as <u>all</u> of our electricity is generated by nuclear or renewables, the incremental demand for electrolysis must come from incremental use of fossil fuels.

<u>Shale Oil</u>

The government should place strong emphasis on rapidly developing this resource. About 80% of this resource lies on federal lands. Issues to be dealt with include permitting for test facilities as well as for subsequent commercial facilities plus the spectrum of environmental matters, many of which will only become evident as the test projects proceed.

Our shale oil is a huge potential resource with in-place reserve estimated at up to 2.6 trillion barrels. At current oil prices this resource should be commercially developable. Recoverable reserve estimates range from 750 to 1000 billion barrels. Until extraction processes are perfected, the economic reserve will be unclear. But, if reserves prove to be 800 billion barrels, then ***at a delivered production rate of 10 mmb/d, plus 3 mmb/d loss for extraction, this resource represents a 170-year supply***.

What needs doing immediately is to get a number of test projects underway. Our only previous attempt at such projects were mothballed over twenty-five years ago when oil prices dropped below $35 per barrel. For surface extraction, the resource suffers from having the powdery shale residue occupy a larger volume that the starting oil-rich shale. For in-situ extraction the new extraction schemes are untested in large scale.

Without government emphasis we are likely to be just entering the commercial phase in twenty years. With strong government emphasis, including fast-tract permitting once the environmental issues are clearer, a growing commercial industry of around one to two million barrels per day is reasonable in twenty years. Only with Herculean efforts by both government and industry can a ten million barrel per day operation be realized, and that will likely take more than twenty years.

Parenthetically, the Canadian tar sands represent a resource of at least 175 billion barrels, with extraction issues comparable to our shale oil, and they have a thirty-five-year head start on commercial production. A policy option to reduce Middle East oil dependence is to encourage more joint ventures with Canadian companies to develop these tar sands to the 10 mmb/d range and import the produced crude from a friendly country.

Manage and ultimately reduce pollution from our fuels

Until nuclear power is re-established, coal will provide the bulk of added energy supply. As noted above current fuel supply prices will allow emissions cleanup both of new facilities and of existing facilities. There are over fifty processes in use to remove sulfur and nitrogen oxides; most common processes for sulfur produce either gypsum or sulfuric acid. Over 85% cleanup is commercially feasible. This area demands appropriate government action.

Smaller vehicles getting better gas mileage will abate emissions from our vehicle fleet. As emissions are reduced at power stations, plug-in nightly electrical recharging will further reduce emissions.

Other emissions also need to be curtailed, such as those of cement plants and industrial operations. The government should apply similar cleanup standards as proposed above for coal-fired generating facilities. And, we must not backtrack by allowing high emissions from new ventures such as demonstration or commercial biomass-burning facilities.

It is in vogue to pitch coal-to-synthetic oil or coal-to-natural-gas as the panacea to eliminating emissions from using coal. The marketplace will decide this issue. It seems likely that no such synthetics industry will materialize as a consistently more economical route is to use the coal to generate electricity and clean the emissions there. This is the most economical use of coal energy; logic says that if we are energy-short, don't waste it.

Previously there were plans to create onsite synthetics plants to convert lignite to either natural gas or crude oil. One plant was built in the Dakotas and in the 1970's produced natural gas at a subsidized cost of about $7/mcf, well above a market clearing level. Exxon among others did pilot plant work and had full-size plants in the planning phase in the late 1970's under a then-current 35$/bbl pricing scenario. For the lignite reserves in Texas and Arkansas it now appears the more energy-efficient process of mine-mouth electricity generation has won over synthetics. North Dakota is more remote to electricity markets so the economics are less clear but the best route is still likely to be to generate electricity.

Carbon Dioxide Emissions

Carbon dioxide is created by combustion of any hydrocarbon fuel. Natural gas provides the most energy per unit of emitted carbon dioxide, followed by crude oil and finally coal. Hydrogen is below coal because of the hydrocarbons consumed in its creation. Ethanol follows last. A step in the near-term is to focus on natural gas use. As noted above the necessary incremental supply must come from either the North Slope or imported LNG.

We can get rid of carbon dioxide in stack gases at large facilities for an added energy consumption cost. We can either sequester it or separate it from the rest of the stack gas and inject it underground. Will we want to use the added energy to accomplish this in an environment of limited energy supply? This will increase crude oil imports and drive energy prices incrementally higher. And what will we do with the solid refuse from sequestering? These are tough political and economic issues.

The best we can do now is move boldly towards nuclear and renewable power generation and achieve substantive conservation across all walks of energy use. Individually, citizens can see to the planting of more trees, and even grasses and shrubs, all of which consume carbon dioxide. There is little else to be done today except to progress the technology for carbon dioxide removal.

If we decide to move towards dramatically lowering carbon dioxide emissions, the top priority must be limiting world population growth. Beyond that we must move towards an electricity-driven society. Generation will be via coal with stack-gas CO_2 removal, nuclear, wind, and hopefully solar. Buildings will go exclusively to electrical for heating and cooling. Small vehicles will use mainly electrical power. Mass transit will return to favor. Population will tend towards re-urbanization. All this will require a societal mind-change. Before we can contemplate addressing this, we must deal with our energy issues for the next several decades.

APPENDIX

To frame the viable scope of energy policy recommendations, we need to know some limits. While it would be nice to talk of immediately eliminating all crude imports (which would reduce our per-capita energy use to levels of 1962 and still leave us one-third above Europe), our present mix of energy uses can not accommodate this. Our total light-vehicle energy use is only two-thirds of crude imports. Within the planning horizon, we will continue to require substantial supply of oil both to fuel moving vehicles and as feedstock. Indigenous added oil supply will arise from shale oil or coal liquefaction.

Near-term prospects for reducing crude oil imports

The table below shows potential to lower crude oil imports during nominally the next ten years by a combination of conservation/fuel-switching measures and added domestic supply from ANWR.

Potential to reduce crude oil use during the next decade (MMB/D}

USE	2004 demand per (EIA)	reasonable reduction	potential reduction	
light vehicles	8.5	1.1	2.8	raise fleet mpg to 24 or 30mpg
heavy vehicles	3.9	0	0	
airplanes	1.4	0	0	
residential	0.9	0.2	0.4	shift 1/4 or 1/2 heating to natural gas
commercial	0.4	0.1	0.2	shift 1/4 or 1/2 heating to natural gas
industrial heating/fuel	2.1	0.3	0.5	shift 1/8 or 1/4 heating/fuel to natural gas
industrial feedstock	2.9	0	0	
electricity generation	0.6	0.4	0.6	shift 2/3 or all to natural gas
rounding	0.2		0	
total	20.9	2.1	4.5	
SUPPLY				
Domestic	7.3	1.0	1.5	ANWR
Imports	13.6			
Total	20.9	3.1	6.0	

The potential in electricity generation is to back out all oil use, going initially to natural gas and subsequently to coal or nuclear. In time, as coal, nuclear and wind are used for all electrical generation, natural gas demand will come down by 21 bcf/d; this will offset demand increases for natural gas in other sectors and declines in domestic production.

Energy Independence

Suppose we determine that in the interest of national security, and to reduce terror threats, we are going to set out to eliminate crude oil energy imports. Can this be done? The answer is "yes" over time. The technology exists or is being developed. Cost will be enormous. A complete national commitment will be required and the process will likely take three decades.

First, we must generate all of our electricity using indigenous sources, coal, nuclear, wind and water; if a breakthrough in solar technology has occurred, we can add solar to the list. Just as with eliminating greenhouse gases, we must move towards an electricity-driven society. Buildings will go exclusively to electrical for heating and cooling. Mass transit will return to favor. Population will tend towards re-urbanization.

We must have dramatically increased our light vehicle fleet-average fuel economy to at least 30 mpg and reduced miles driven compared to today by 10%. It will help if we have constructed enough generating capacity so that the light vehicle fleet can be plugged in to charge batteries at night.

And, most critically, we must produce at least eight million barrels per day of shale oil or a combination of shale oil and liquids from coal. An illustrative balance sheet would look as follows:

CRUDE OIL IMPORT ELIMINATION (mmb/d)

Area	current crude use	Oil import savings	
Electrical generation	0.6	0.6	eliminate all oil use
Residential, commercial, Industrial	6.3	1.1	fuel switching/conservation
Light vehicles	8.5	2.8	30mpg fleet average
		0.8	10% less miles driven
ANWR production		1.5	
Shale oil production		8.3	
Total		15.1	
Current imports		13.6	
25% of EIA forecast growth		1.5	
Total		15.1	

It is impossible to call the investment to develop shale oil production when we have not yet determined which alternates are environmentally acceptable, but scaling from old coal-gasification costs and prospective operating revenue and acceptable payout times, a range of $500 to $1500 billion seems reasonable. Further the table above should be viewed only as a **scoping** model. It is crafted using current demand and makes no detailed attempt to project the level and mix of fuel uses that will be extant in the time frame when an effort is made to become energy-independent.