OCS Report
MMS 2007-016

Energy Alternatives and the Environment

MMS
U.S. Department of the Interior
Minerals Management Service
Environmental Division

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Contents

Tables

Energy Alternatives and the Environment

1. Introduction

This report considers energy alternatives to the proposed action in the *Proposed Final Outer Continental Shelf Oil and Gas Leasing Program 2007-2012* (*Proposed Final Program*). The Minerals Management Service (MMS) is concerned with energy alternatives for three major reasons:

1. The National Environmental Policy Act requires consideration of a No Action Alternative to the proposed action when preparing an environmental impact statement (EIS). Examining other energy sources is an important aspect of the No Action Alternative for the *Proposed Final Program*.

2. Those commenting on previous 5-Year Programs have requested consideration of energy alternatives or have suggested that specific energy alternatives are superior to the proposed program.

3. The MMS believes that consideration of alternatives is an important basis for the ultimate decision about the proposed schedule in the *Proposed Final Program*.

The alternatives considered in this report extend beyond the Outer Continental Shelf (OCS) and even beyond the span of responsibility of the Secretary of the Interior. However, the report only considers environmental impacts associated with production and transportation of the alternative sources of energy. This limitation is chosen in order to keep the discussion parallel to that in the Final EIS accompanying the *Proposed Final Program*. The rationale for this decision is that OCS oil and natural gas are mixed with similar onshore products and become indistinguishable prior to refining, product transport, and final consumption. Any environmental analysis beyond the mixing point would become an analysis of the entire oil and natural gas industry, which is an insupportable expansion of the boundary of OCS activities. An exception to this bounding occurs in cases where compliance with environmental regulations affects the cost structure of an energy alternative. In those cases, environmental impacts from consumption of the alternative may be mentioned because those impacts may influence the financial viability of the alternative.

Understanding alternatives to oil and natural gas requires an appreciation of the complex nature of these materials. Both oil and natural gas are mixtures of many chemical compounds with different mixtures characterizing different geologic deposits. Crude oil, when processed through an atmospheric distillation column, and natural gas, when processed through a separation plant, break into numerous, identifiable categories of organic chemicals, each with a large number of sub-categories.

Natural gas, which is mostly methane, often includes heavier hydrocarbon compounds called “Natural Gas Liquids” or “NGL’s.” The majority of NGL’s are stripped from the “wet” gas at natural gas processing plants. A subset of the NGL’s, propane and butane, which remain gaseous at ambient pressures and temperatures, are also found in crude oil. Under pressure these substances form liquids and are known as liquefied petroleum gases (LPG's). Some of the heavy NGL's, which are liquid at ambient temperatures and pressures and are also found in crude oil, are referred to as "natural gasoline" or "pentanes plus" and are classified as lease condensate. Despite NGL's association with natural gas production, this report will follow the standard convention that combines NGL data with crude oil data.

An investigation into alternatives to OCS natural gas and oil needs to be built on the following types of information:

- the uses of natural gas and oil
- the alternatives that can be used to fulfill those uses
- the circumstances under which alternatives might be adopted
- the financial implications and environmental effects of adopting the alternatives

This report is organized around these types of information with emphasis on society's end uses for products derived from natural gas and oil and the alternatives to those end uses. This approach encourages consideration of a broad range of alternatives. It also opens up the possibility to identify creative solutions to the substitution question.

Products made from natural gas and oil permeate virtually every aspect of life in a modern industrial society. The next two sections identify the uses of these products.

2. Uses for Oil and NGL's

Society's end uses for oil and NGL's (referred to as oil for the remainder of this discussion) can be categorized into uses for:

- transportation vehicles and as fuel for similar machine engines
- industrial heat, steam, and cogeneration
- residential and commercial heat, hot water, etc.
- electricity generation
- non-energy uses

Table 1 provides statistics on quantities and percentages of oil-based products used in each energy category or sector. As the table shows, oil provides about 40 percent of our energy on a British thermal unit (Btu) basis. It dominates transportation to such an extent that it can be said that U.S. transportation runs on oil. Oil is an important, but not dominant, source of energy to industry. It makes a modest contribution to the residential and commercial sector and only a minor contribution in electricity generation.

Table 1. Uses of Oil by Major Sector

End-Use Sector	Transportation	Industrial	Residential and Commercial	Electricity Generation	Total
2005 Consumption (Quadrillion Btu)	28.065	8.530	2.307	1.230	40.442
The sector as a percentage of total 2005 oil consumption	67.69%	23.56%	5.70%	3.04%	100.00%
Oil as a percentage of the sector (2005)	97.54%	29.80%	5.70%	3.09%	40.48%

Source: U.S. Department of Energy, Energy Information Administration. Annual *Energy Review2005.* DOE/EIA-0384(2005) July 27, 2006.

Another way to categorize oil use is by the products into which the oil is refined and then sold. Table 2 shows statistics on sales of major oil refinery products. Gasoline constitutes over 58 percent of the total sales volume of oil-based refinery products, jet fuel makes up over 9 percent, and diesel fuel forms a large percentage of the distillate class. It is easy to see that fuels used primarily in transportation constitute most of the volume of refinery products.

Table 2. Sales Volume of Oil Refinery Products

Refinery Product	Sales Volume (2005) (MM gal/day)	Percent of Total
Gasoline	387.0	58.08%
Jet Fuel	60.7	9.11%
Propane (Consumer Grade)	37.4	5.61%
Kerosene & No. 1 Distillate	2.2	0.33%
No. 2 Distillate	162.2	24.34%
Residual Fuel Oil	16.8	2.52%
Total	666.3	100.00%

Source: U.S. Department of Energy, Energy Information Administration. *Petroleum Marketing Monthly:* March 2006. DOE/EIA-0580(2006/03) March 2006.

2.1. Transportation Vehicles

By far the largest and most important use for oil products in the U.S. economy is as transportation fuel. Oil products fuel a majority of vehicles in every major transportation mode.

2.1.1. Gasoline-Powered Vehicles and Engines

The automobile is the dominant icon of the American way of life. In a typical year Americans drive about 2.5 trillion miles and use over 120 billion gallons of gasoline going about their work and play (DOE2000). The flexibility, ease of operation and maintenance, performance, and relatively clean running of gasoline engines make them the choice for the vast majority of automobile owners. In addition to cars, gasoline is used to fuel:

- light trucks and buses
- small boats
- reciprocating engine aircraft
- light farm tractors
- small engines for many industrial, commercial, agricultural, and residential uses

2.1.2. Diesel-Powered Vehicles and Machinery

Diesel engines are the workhorses of the industrial world. Their efficiency and reliability make them the choice for firms and individuals with heavy-duty applications where long-run costs are an important consideration. In addition to the ubiquitous diesel truck, diesels are used to power:

- cars
- buses
- trains
- boats
- machinery

2.1.3. Jet Fuel-Powered Aircraft

Almost all large passenger airplanes, most large cargo aircraft, and many smaller planes and helicopters are powered by jet engines or use turbo jets for their propulsion. Jet airplanes are almost always faster than their propeller-driven counterparts and turboprop planes and helicopters are usually faster than reciprocating engine models. Because much of the point of flight is to travel faster, jet planes dominate the most important niches in the aviation industry.

Jet fuel lies between gasoline and diesel fuel in volatility. It comes in 2 grades; however, well over 90 percent of jet fuel sold in the U.S. is of the kerosene type.

2.1.4. Steam-Powered Ships

Ships generally use relatively crude steam boilers for their power. Virtually any combustible material can power these boilers although virtually all modern ships use oil-based products for their fuel. In the recent past, ships used some of the lowest grades of residual fuel oil and the heaviest distillates. More recently, air pollution restrictions while ships are in port have led shipping companies to switch to less polluting medium distillates.

2.1.5. Propane-Powered Industrial and Commercial Vehicles

Industrial and commercial establishments employ LPG's (usually referred to as "propane") powered vehicles and machinery, such as forklifts, primarily for off-road applications, because of the generally lower maintenance costs associated with this fuel and the better performance compared to similar electric machinery. Even though LPG is primarily used in off-road applications, LPG-powered vehicles constitute an important class of alternative-fueled vehicles on United States highways (EIA 1999).

2.2. Industrial Sector Uses

Next to the transportation sector, industry uses more oil products than other sectors. However, oil provides less than a third of industrial energy. This percentage has been relatively stable for many years.

2.2.1. Industrial Process Heat and Steam

Heat and steam perform a vast array of tasks for industry from melting metals to driving chemical processes to aiding the bonding of materials. Oil competes with other energy sources for this role and usually wins out in situations where coal produces unacceptable levels of air pollution, natural gas is unavailable in adequate quantities, or capital equipment was originally designed for oil and replacement is too expensive. Steam still powers some machinery, but either electric motors or diesel engines (which were covered along with diesel transportation equipment) now power most machines.

2.2.2. Air Conditioning and Drying

Air conditioning includes both heating and cooling. Oil products are used not only for raising the comfort level of industrial buildings, but also to create the right air temperature and humidity conditions to maximize the effectiveness of various processes or to minimize maintenance costs. Drying is a response to the many industrial processes involving wet materials. Oil successfully competes for industrial air conditioning and drying in many of the same situations as for industrial process heat and steam.

2.2.3. *Cogeneration*

Cogeneration is the process of using excess or exhaust steam from an industrial process for generating electricity or vice versa. The Public Utility Regulatory Policies Act of 1978 (PURPA) requires electric utilities to purchase available power from willing sellers at reasonable prices. Since the passage of PURPA, a large percentage of the potentially viable cogeneration sites have gone into service. Cogeneration now constitutes almost ten percent of U.S. electricity generation and the Department of Energy expects cogeneration to maintain this percentage in the future (EIA 1996b).

2.3. Residential and Commercial Sector Uses

The residential and commercial sectors use products made from oil for air conditioning (primarily heating), heating water, and running appliances (in locations not served by electricity). Natural gas and electricity dominate these sectors. Oil products compete best where natural gas is unavailable and the climate is sufficiently cold that electric heat pumps are inefficient. A broad range of oil products serves the residential and commercial sectors from LPG (propane)
through kerosene to fuel oil. Choice depends mostly on local availability and already-installed equipment.

2.4. Electricity Generation

2.4.1. *Steam Boilers*

Most electricity is generated by heating water to the boiling point and directing the expanded volume of steam through a turbine. The rotating shaft of the turbine connects to the shaft of a generator that produces electricity. Virtually any fuel can be used to fire the steam boilers. Until very recently, oil-based products, even relatively cheap residual fuel, had been more expensive per kilowatt of electricity produced than other fuels such as natural gas and coal. Recently, gas prices reached or exceeded the prices per unit of energy of oil-based fuels. Oil-fired steam boilers tend to be used in situations where conversion to natural gas is impractical due to unavailability of gas or where it would be too expensive to convert.

2.4.2. *Diesel Generators*

Diesel engines can also be used to turn the shaft of a generator to produce electricity. Diesels are usually only used in remote sites where the electricity demand is too small to justify the expense of installing a steam boiler and transportation of diesel fuel is relatively inexpensive.

2.5. Non-Energy Uses

2.5.1. *Chemical Feedstock*

The chemical industry converts NGL's and oil refinery products into a vast array of goods for industry and final consumers. Plastics, artificial fibers, paints and preservatives, agricultural chemicals, and many pharmaceuticals are all made primarily from NGL's and oil refinery products. Although our economy consumes large quantities of these products, the amount of oil going into them is much less than that which goes into energy applications, especially transportation.

2.5.2. Solvents, Lubricants, Asphalts, and Waxes

Several other groups of chemicals are made from oil and LPG's but retain much of their original characteristics even after chemical conversion. These are solvents, lubricants, asphalts, and waxes. The properties of the various types of LPG and oil used in these products are enhanced in the chemical conversion process but retain much of their original nature.

3. Uses for Natural Gas

As table 3 shows, the industrial, residential, and commercial sectors are the largest consumers of natural gas. Electricity generation uses less gas than the preceding sectors; however, it is the fastest growing major use of natural gas. The figure shown for transportation refers only to the use of natural gas in pipeline transportation.

Table 3. Uses of Natural Gas by Major Sector

End-Use Sector	Industrial	Residential and Commercial	Electricity Generation	Transpor-tation	Total
2005 Consumption (Quadrillion Btu)	7.941	8.128	5.965	.600	22.634
The sector as a percentage of total 2005 gas consumption	35.08%	35.91%	26.35%	2.65%	100.00%
Gas as a percentage of the sector (2005)	24.83%	20.40%	14.97%	2.14%	22.66%

Source: U.S. Department of Energy, Energy Information Administration. Annual *Energy Review 2005*. DOE/EIA-0384(2005) July 27, 2006.

3.1. Industrial Sector Uses

On a Btu basis, the percentage of energy industry derives from natural gas surpassed oil-derived products in 1987 making it the largest source of energy for this sector. However, in 2001 natural gas fell behind oil in response to the relative rise in natural gas prices on a Btu basis. Natural gas maintains an important position as a source of industrial energy for two major reasons:

1. Burning natural gas produces less air pollution, including greenhouse gases, than any other fossil fuel. This allows industry to use natural gas burning technology without expensive pollution control equipment that might be required for other energy sources.

2. The cleaner burning and handling character of natural gas tends to keep maintenance costs

low.

Further adoption of natural gas is limited by relatively high prices, the unavailability of secure supplies, and by equipment designed for other energy sources which has not yet reached the replacement point.

Industry uses natural gas for the same purposes as it uses oil-based fuels:

- industrial process heat and steam
- air conditioning and drying
- cogeneration

These industrial processes use much the same technology for both natural gas and oil-based fuels. Differences derive mostly from the gaseous nature of natural gas versus the liquid nature of most oil-based products. Of special note is that a majority of United States cogeneration is fueled with natural gas.

3.2. Residential and Commercial Sector Uses

Natural gas performs much the same role in the residential and commercial sectors as oil: to condition air (primarily to heat it), to heat water, and to run appliances in locations not served by electricity. Natural gas and electricity dominate these sectors. The residential and commercial sectors favor natural gas because of its low cost and low maintenance. Recent relative price increases and lack of access or the expense of access to gas pipelines limits the further penetration of natural gas into these sectors.

3.3. Electricity Generation

The natural gas industry considers electricity generation to be its growth sector. In recent years electric utilities have been slow to add new generating capacity. However, rapidly increasing electricity demand, most notably in California, has forced electric utilities to consider adding significantly to their generating capacity. Natural gas will fire most new power plants under construction and probably those in the planning stages as well.

3.3.1. Turbines

Much new and planned electricity generating capacity consists of gas turbines. Gas turbines operate by directing the hot gases from burning natural gas into a turbine. As in a steam boiler, the rotating shaft of the turbine connects to the shaft of a generator that produces electricity. Electric utilities have to deal with vast swings in the demand for their power. So-called peaks in demand occur on summer afternoons when air conditioning reaches its maximum and on winter evenings when electric ranges and other appliances add their draw to heating. Peaking power is the most expensive power for utilities to produce. Gas turbines, because of their very rapid fire-up capability, along with hydroelectric and pump storage capacity, constitute the equipment of choice for peaking.

In addition, their low initial capital cost, relatively low maintenance, and efficiency make gas turbines highly competitive with coal-fired plants, which require expensive pollution control technology.

3.3.2. Steam Boilers

Gas-fired steam boilers are very similar to oil-fired models; indeed, some boilers are designed to use either fuel with only minor adjustments. Most duel-fuel boilers and most boilers that can be inexpensively converted to gas already use gas because of its reduced air pollution and less expensive maintenance.

3.3.3. Combined Cycle

Combined cycle plants first use natural gas to fire gas turbines, then they use the hot gases from the turbine exhaust to create steam which is used to generate electricity in the same way as in normal cycle steam generation. The cost of electricity generated using combined cycle technology compares favorably with that produced using other fuels in conventional plants. The possibility also exists to use the hot water remaining when the steam condenses in a cogeneration mode.

3.4. Transportation

The 2004 transportation sector consumption of natural gas reported in table 3 consists entirely of gas used to power the pumps and other machinery that moves natural gas across the country via pipelines. Any natural gas used in motor vehicles is reported in the residential and commercial sector because almost all the natural gas vehicles in service in the United States are fleet vehicles operated by commercial establishments. Vehicular use of natural gas is growing rapidly (see table 6). Nevertheless, natural gas accounts for only a small percentage of the highway fuel used in the United States.

3.5. Non-Energy Uses

Natural gas, primarily methane, is also used as a chemical feedstock. Among the products made from natural gas are chemicals like methanol, ammonia, and formaldehyde that are converted into final products like fertilizer, detergents, and glues.

4. The No Action Alternative

The National Environmental Policy Act requires consideration of a No Action Alternative to every major Federal action significantly affecting the environment. In the case of the *Proposed Final Program*, no action means that the MMS would hold no OCS oil and gas lease sales during the 5-year period covered by the Program. An absence of lease sales means production firms do not obtain rights to new oil and natural gas resources on the OCS. As a result, the oil and natural gas that would have been produced as a consequence of sales over that 5-year period would not be available to consumers.

This section reports the results of an investigation into the most likely response of oil and natural gas markets to a curtailment of their supplies from the OCS and the ensuing environmental impacts. Under these assumptions, markets would have to respond to a reduction in supply equal to the anticipated production from the 5-Year Program. Note that in a typical year almost two-thirds of OCS production on a Btu basis has consisted of natural gas (MMS 2001). The other one-third or so has been oil and NGL's. Recently, the percentage of oil has been increasing and in the near future OCS oil production is projected to surpass gas on a Btu basis (Farndon 2006).

4.1. Methodology

The MMS employs the MarketSim model to evaluate the impact of decreased OCS production resulting from no action. MarketSim estimates changes in quantities of alternatives to OCS natural gas and oil traded in domestic markets. This same model, which includes oil and gas submodels, also performs other analyses used in the development of the 5-Year Program. A more detailed description of the market simulation model can be found in a companion paper to this one (King 2007).

4.2. Market Response to a Reduction in OCS Production

The MMS ran MarketSim for low and high cases chosen to bracket the most likely range of future conditions. The purpose of these runs was to demonstrate the response of oil and gas markets to a reduction in OCS production under a variety of circumstances. The MMS has chosen to base its analysis on an oil price of $46 per barrel (bbl) and a natural gas wellhead price of $6.96 per mcf. While these prices are somewhat below recent open market prices, they are thought to represent a realistic estimate of the kind of long-term prices the oil and gas industry will be using for making its development decisions.

4.2.1. Results for Oil

Table 4 shows the most important results of runs comparing the Proposed Program to no action under the low and high cases. The percentage estimates, which are almost identical for the low and high cases, are the most interesting and useful numbers in the table. They imply that for each hundred barrels of OCS oil not produced:

- onshore U.S. oil production will increase by about 3 barrels
- U.S. oil imports will increase by about 88 barrels
- conservation will account for a decline in U.S. oil consumption of about 5 barrels
- switching to gas will amount to the equivalent of about 4 barrels

In absolute terms expectations are for:

- onshore production to make up 200 million of the 5.7 billion barrels lost through no action at the low price and 300 million of the 12.1 billion barrels of OCS production lost at the high price
- imports to account for 5.1 billion barrels at the low price and 10.7 billion barrels at the high price

Table 4. Results of the No Action Alternative

Sector	% of OCS Production		Quantity Involved	
	Low	High	Low	High
Oil				
OCS Production (BBO)	-100%	-100%	-5.7	-12.1
Onshore Production (BBO)	3%	3%	0.2	0.3
Imports (BBO)	88%	88%	5.1	10.7
Conservation (BBOE)	5%	5%	0.3	0.6
Switch to Gas (BBOE)	4%	4%	0.2	0.5
Gas				
OCS Production (TCFG)	-100%	-100%	-20.7	-36.4
Onshore Production (TCFG)	28%	28%	5.8	10.3
Imports (TCFG)	16%	16%	3.3	5.9
Conservation (TCFGE)	16%	16%	3.4	5.9
Switch to Oil (TCFGE/BBOE)	40%	39%	8.2/1.5	14.3/2.5
Induced Oil Imports (BBO)	NA	NA	1.2	2.2

BBO = billion barrels of oil, BBOE = the Btu equivalent of billion barrels of oil, TCFG = trillion cubic feet of natural gas, TCFGE = the Btu equivalent of trillion cubic feet of natural gas

- conservation to total the equivalent of 300 million barrels at the low price and 600 million at the high price
- switching to gas the equivalent of 200 million barrels at the low price and 500 million at the high price (MarketSim deals with the oil and gas markets in isolation. In reality, if OCS production were curtailed, less OCS gas would lead to more imported oil, conservation, and domestic onshore oil and gas production than the model shows.)

All these amounts would substitute for the 5.7 billion barrels of oil lost through no action at the low price and 12.1 billion barrels at the high price. The distribution of conservation and switching to gas by sector depends on the amount of consumption in each sector and the price elasticities of demand in each sector. Transportation accounted for 68 percent and industrial consumption 24 percent of U.S. oil use in 2004. Residential and commercial consumption accounted for about 6 percent (EIA 2006).

Other forms of energy cannot readily substitute for most of this oil in the near term. In the U.S. transportation sector, a consumption decline would probably involve a reduction in miles traveled, the purchase of more fuel-efficient cars, or both. Most energy projections show relatively little alternative fuel, such as ethanol, entering the transportation sector for many years (EIA 2001b). However, ethanol consumption in the transportation sector increased 350 percent from 1996 to 2005 (EIA 2006). Significant additional fuel substitution in response to the relatively small price increase implied by the model would be unlikely. In addition to the modest price increase associated with these scenarios, the costs of replacing the present transportation fuel infrastructure further hinders efforts to extend the use of alternative transportation fuels.

In the industrial sector most uses for which there exists a ready substitute for oil have already converted to the substitute. Many industrial uses such as for products like asphalt and lube oils have few comparable substitutes. Oil use in the residential and commercial sectors is forecast to occur principally at locations without access to natural gas, so little fuel substitution can be expected.

The only applications where significant substitution is likely are industrial heat and steam and electricity generation. The degree of substitution in these sectors depends on whether oil is competing directly with gas for market share. In the recent past, natural gas and oil did not compete in the boiler market because gas was significantly cheaper. Recently, as gas prices rose past the level of oil prices in these sectors, only a modest amount of fuel switching took place. Because of gas's greater efficiency and environmental superiority, only moderate switching will likely occur unless gas prices rise significantly higher than oil.

4.2.2. Results for Natural Gas

Table 4 also reveals that for each thousand cubic feet (Mcf) of OCS gas not produced because of no action, MMS anticipates the following results:

- U.S. onshore gas production will increase by 0.28 Mcf
- imports will increase by 0.16 Mcf
- conservation will account for about 0.16 Mcf
- switching to oil will amount to the equivalent of about 0.39 or 0.40 Mcf

In absolute terms in the low case this amounts to:

- 5.8 trillion cubic feet (Tcf) of onshore gas
- 3.3 Tcf of gas imports (mostly from Canada)
- conservation equivalent to 3.4 Tcf of gas
- switching to oil equivalent to 8.2 Tcf of gas

substituting for the 20.7 Tcf of OCS natural gas lost through no action.

In absolute terms in the high case this amounts to:

- 10.3 Tcf of onshore gas
- 5.9 Tcf of gas imports (mostly from Canada)
- conservation equivalent to 5.9 Tcf of gas
- switching to oil equivalent to 14.3 Tcf of gas

substituting for the 36.4 trillion cubic feet of OCS natural gas lost through no action.

Of the reduced consumption of natural gas in the low case, the equivalent of about 8.2 Tcf of gas would consist of switching to oil. This means that an additional 1.5 billion barrels of oil would clear the market. Assuming that imports constitute 88 percent of any additional oil traded in the U.S. market, this adds another 1.3 billion barrels of oil to imports. Thus, as a result of no action, an additional 6.4 billion barrels of oil would have to be imported by the U.S. The corresponding import estimate for the high case is 12.9 billion barrels of oil.

4.3. Environmental Impacts from the Market Response to a Reduction in OCS Production

4.3.1. Onshore Oil and Gas Production

Onshore oil and gas are often produced together from the same wells; furthermore, the impacts from efforts to recover the two resources are almost identical even in those cases where production from a given location is entirely oil or entirely gas. Onshore oil and gas production has notable negative impacts on surface water, groundwater, and wildlife. Onshore oil and gas production can also be expected to cause negative impacts on soils, air pollution, vegetation, noise, and odor.

Surface water could incur increased turbidity, salinity, and sedimentation caused by runoff from road, drilling pad, and pipeline construction. Other sources of water pollution include discharges of drilling muds, other toxic chemicals, and engine fuels and lubricants. Although holding ponds or reserve pits for produced waters and other process waste are required to retain any environmentally hazardous substances, spills of such materials into surface waters are a risk.

Groundwater can be contaminated from puncture of the aquifer or from leaching down from improperly sealed surface holding ponds or overflow of those ponds onto permeable surfaces. In many areas, sufficient interchange occurs between surface and groundwater sources that pollution of one leads to the contamination of the other.

For the most part, surface disturbance from oil and gas development is sufficiently limited that it causes relatively minor negative impacts on wildlife. A large portion of the negative impact on wildlife comes through water pollution and the impacts on wildlife living in or drinking from a water supply contaminated by oil and gas extraction activities. However, holding ponds can pose a significant threat to birds, especially waterfowl. Improperly safeguarded holding ponds can prove attractive to waterfowl and other birds looking for a safe resting and feeding location. Birds landing on these ponds may drown when the action of solvents in the pond material destroys the buoyancy of their feathers.

Soil and vegetative disturbance is mostly a result of construction activities. However, soils can become contaminated and vegetation killed by spills of herbicidal chemicals.

Diesel engines employed in construction, drilling, and production contribute to air and noise pollution. Chemicals used in drilling and production can create noxious odors. Local standards may partially control these impacts, but oil and gas production adds to the cumulative burden of these pollutants.

4.3.2. Imports

Environmental impacts associated with expanded importation of oil include:

- generation of greenhouse gases and regulated air pollutants from both transport and dockside activities (emissions of NO_x, SO_x, and VOCs having an impact on acid rain, tropospheric ozone formation, stratospheric ozone depletion, and global climate change)

- degradation of water quality from oil spills associated with accidental or intentional discharges or tanker casualties
- possible destruction of flora, fauna, and recreational and scenic land and water areas in the instance of oil spills
- public fear of the increased likelihood of oil spills

Air pollution and oil spills vie for the dubious distinction of being the most important of these classes of impact. Oil spills are certainly the negative events most people associate with oil importation. Table 5 shows by region the estimated additional spills greater than 1000 barrels associated with the no action alternative, along with their probabilities.

Table 5. No Action Alternative—Large Oil Spill Estimates

Variables	Gulf of Mexico	Alaska	Pacific
Additional Imports (BBO)	1.4 - 2.8	0.2 - 0.4	3.5 – 7.5
# of spills ≥ 1000 bbl	0.47 - 1.02	0.07 - 0.15	1.24 - 2.74
Probability of 1 or more spills ≥ 1000 bbl	37% - 64%	7% - 14%	71% - 94%
Imports Induced by Switching from Gas to Oil (BBO)	1.3 - 2.2	-	-
# of spills ≥ 1000 bbl	0.44 - 0.80	-	-
Probability of 1 or more spills ≥ 1000 bbl	36% - 55%	-	-
Total Imports (BBO)	2.7 – 5.0	0.2 - 0.4	3.5 – 7.5
# of spills ≥ 1000 bbl	0.91 – 1.83	0.07 - 0.15	1.24 – 2.74
Probability of 1 or more spills ≥ 1000 bbl	60% - 84%	7% - 14%	71% - 94%

The environmental impacts from oil spills are well documented in the EIS for the 5-Year Program. Tanker spills tend to be larger events than those from OCS pipelines. While it is uncertain where the spills associated with additional imports will occur, the majority of tanker spills occur in port or near shore where the potential environmental impact is more severe.

This report does not address environmental impacts outside the United States. In the case of imported oil, negative environmental impacts in producing countries and in countries along trade routes can be significant, especially where environmental protection standards are lower than those in the U.S.

4.3.3. Conservation

As shown in table 4, the price increase induced by the no action alternative will lead people to conserve about 6 percent of expected oil consumption and 16 percent of expected natural gas consumption. This conservation is composed of two major components:

- substituting energy saving technology, often embodied in new capital equipment, for energy resources (for example, adding to home insulation)
- consuming less of an energy using service (for example, turning down the thermostat in an office during the winter)

This paper discusses the environmental impacts from oil and gas conservation in sections 6 and 7, respectively.

4.3.4. Fuel Switching

Table 4 shows people switching 4 percent of their consumption from oil to gas and 40 percent from gas to oil. This seemingly anomalous result is a function of the two submodels used to estimate the oil and gas market responses. To keep the analysis simple, the two submodels account for the price change in their market in isolation from the other market.

In reality, there would probably be no switching from oil to gas. Because it is much easier to increase oil imports than gas imports, the price of gas would rise relative to the price of oil and people would switch to oil. This would shift the demand for oil at the same time the supply was being restricted. The major source to satisfy this increased demand would be imports that would add to the imports induced by the initial oil supply decrease.

5. Government Imposition of Energy Alternatives

In the U.S. economy, market forces make most decisions about the allocation of resources. However, government sometimes chooses to override market decisions in order to change the economy’s energy mix. This section will investigate specific forms of energy government might choose as substitutes for OCS natural gas and oil and some of the consequences of those choices.

Even if leasing on the OCS proceeds, government can choose policies having the effect of imposing various energy alternatives on society. These policies may be chosen to:

- minimize reliance on imports, such as oil, from unstable regions
- encourage the use of a politically favored fuel, such as ethanol
- reduce air pollution, such as by mandating electric vehicles
- conserve energy

Among the policy tools government can use to encourage or force the adoption of a desired energy mix are:

- taxes
- subsidies
- performance standards

5.1. Taxes to Achieve a Desired Energy Mix

Government can impose either broad-based or narrowly focused energy taxes. A broad-based energy tax would tax all or a broad spectrum of energy alternatives. An example, which has been discussed at considerable length, is the carbon tax. The carbon tax would impose a levy on all hydrocarbon materials used as sources of energy in proportion to the amount of carbon the material contains. The carbon tax is aimed at controlling the sources of greenhouse gases that have been found to contribute to global warming. The increased cost of fuels containing carbon would encourage consumers to switch to non-carbon sources of energy such as wind, solar, hydroelectric, and nuclear. It would also encourage conservation both through the substitution of capital for energy and through reduced use.

Narrowly focused energy taxes include the taxes imposed by national and state governments on vehicle fuels. These fuel taxes have the primary purpose of raising money to pay for highway, road, and bridge construction and maintenance. Theoretically, they also have the effect of discouraging people from using automobile transportation and substituting trains, planes, or buses.

By their nature taxes distort market signals in the economy. In the case of energy taxes, they impose a direct cost on energy consumers and producers (who suffer a loss of profits).

5.2. Subsidies for Energy Alternatives

Many governments subsidize favored energy sources, actions usually justified as a temporary aid to start an infant industry. Recent examples in the U.S. are tax rebates for ethanol used as a gasoline additive and the subsidy extended to coal bed methane extraction for addition to the natural gas system. Subsidies that reward production of an energy product serve to reduce that product's unit costs and thus lower the supply curve for the product leading to increased use and enhanced profits for producers.

Subsidies can also take the form of grants to consumers. Home heating subsidies for the poor in the U.S. are an example of this approach. Consumer energy subsidies tend to raise the effective demand curves for the fuels involved leading to greater sales and profits. This type of subsidy tends to apply to a range of different energy sources capable of performing the function being supported, such as heating homes in winter. Although home heating subsidies tend to increase fuel use, subsidies for things like insulation and weatherization are sometimes used to encourage fuel conservation.

On the cost side, taxpayers must pay for the subsidies, further distorting market signals. In addition, unintended consequences may result from imperfect government decisions.

5.3. Energy Performance Standards and Regulations

Energy performance standards and the regulations developed to implement them are one of the cornerstones of U.S. energy policy. The best known set of energy performance standards are the Corporate Average Fuel Efficiency (CAFÉ) standards that set the average fleet vehicle miles per gallon of gasoline that each automobile manufacturer must meet with the set (fleet) of vehicles the manufacturer produces in a year.

6. Alternatives to Oil and NGL's and Their Environmental Impacts

Primary alternatives to OCS oil are imported oil and oil from onshore production. In addition to these primary alternatives, other materials and forms of energy can be substituted for oil to provide the services consumers demand. However, only five basic ways exist to replace the oil society decides not to obtain from the OCS: import, produce onshore, switch fuel, substitute oil saving technology, or accept less service. The total number of specific alternatives fitting within these broad categories appears almost endless. Nevertheless, the basic approaches to replacement are limited. The same point holds true for natural gas.

Importation and onshore production are covered in section 4.3. This section will review the other potential substitutes for OCS oil. The discussion will cover the potential future market and the environmental impacts from the production and transportation of the original energy resource for each specific energy alternative.

6.1. Transportation Vehicle Fuel

Table 1 shows the transportation sector to be by far the largest user of oil and oil products being the overwhelmingly dominant transportation fuels in the U.S. economy. Thus, the transportation sector is the first place to look for ways to replace oil. In the words of the 1991 *National Energy Strategy* (DOE 1991), "The transportation sector offers the best available opportunity to reduce U.S. dependence on oil, improve the quality of air in metropolitan areas, and spur the development and use of new, more efficient, environmentally superior vehicle and fuel technology."

Oil can be replaced by switching to other fuels, adopting more efficient vehicles, implementing more efficient transportation systems, and accepting less motorized transportation. The latter three of these alternatives are examples of conservation.

6.1.1. Alternative Fuels

Table 6 lists the consumption of alternative fuels and the number of alternative-fueled vehicles in the United States for 2000 estimated by the U.S. Department of Energy, Energy Information Administration (EIA 2000). LPG powers more of these vehicles than any other alternative fuel. This is an oil product so it is not relevant to this discussion.

Clearly the most popular non-oil-based alternative fuels are compressed natural gas and ethanol. Other fuels may have future potential, but none is a viable presence yet.

Table 6. Estimated Consumption of Vehicle Fuels and Number of Alternative-Fueled Vehicles in the United States, 2000

Fuel	**Consumption** (Thousand Gasoline-Equivalent Gallons)	**Alternate-Fueled Vehicles**
LPG	242,695	268,000
Compressed Natural Gas (CNG)	97,568	100,530
Liquefied Natural Gas (LNG)	6,847	1,900
Methanol, 85 Percent (M85)	996	18,365
Methanol, Neat (M100)	437	195
Ethanol, 85 Percent (E85)	3,344	34,680
Ethanol, 95 Percent (E95)	54	13
Electricity	1,819	8,661
Non-LPG Alternative Fuel Subtotal	111,065	164,344
Gasoline	124,651,000	
Diesel	36,779,340	
Total	161,784,100	

Source: U.S. Department of Energy, Energy Information Administration. *Alternatives to Traditional Transportation Fuels, 2000, Volume 1.* DOE/EIA-0585(2000).

6.1.1.1. Natural Gas

Two forms of natural gas can be utilized as transportation vehicle fuel, compressed natural gas (CNG) and liquefied natural gas (LNG). The use of LNG is limited to a few heavy-duty trucks and, primarily, passenger buses in three large programs (Houston, Seattle, and Los Angeles). The CNG's easier and cheaper conversion and handling give it the lead in current applications to transportation. The recent growth in the number of CNG vehicles has greatly exceeded that of all other types of alternative fuels. Montgomery and Sweeney (1991) explain this growth,

> "Compressed natural gas is now the alternative fuel with the lowest net cost, considering all factors, and appears to be finding its way into the market under current policies. Its role may be greatest in fleet operations, especially those involving large vehicles, where central refueling and some loss in vehicle space is not important, and where the low cost of natural gas fuel is important."

EIA (1996) adds that other factors promoting the growth of CNG are "support from natural gas utilities, relatively greater availability of vehicles and fuels compared to most other alternative fuels, and continued public and private sector enthusiasm for the fuel." The technical problems with CNG fuel cylinders have apparently been solved. Furthermore, some cities, like New York and Washington, DC, are turning to natural gas to power their urban buses as a method of reducing air pollution (Layton 2000).

The natural gas to be utilized as a transportation fuel in the form of CNG can be supplied from OCS, domestic onshore, pipeline imports from Canada, or imported LNG sources. Environmental impacts from domestic OCS production are covered in the 5-Year EIS. Domestic onshore production is covered in section 4.3.1. of this paper.

Additional pipeline imports from Canada would require additional pipelines. Associated construction would lead to temporary increases in water pollution from unstable construction sites and spills of construction-related fuels and other chemicals.

LNG imports experienced a record high of 507 Bcf in 2003. Although that only amounts to 2.7 percent of U.S. consumption and 13 percent of imports, this form of importation is expected to rise dramatically. As of 2004 applications had been filed or prefiled for 19 new LNG terminals to join the four already in operation. Five of the filings were for offshore LNG terminals in the Gulf of Mexico. The increased interest in LNG is driven by new technology making the method more efficient, the growth in LNG export terminals throughout the world, and the price advantage of foreign natural gas over increasingly expensive domestic sources.

The LNG imports introduce a new form of environmental impact. In addition to the risk of fuel spills from LNG ships, there is a slight risk of an LNG leak. Because it is super cold, as LNG vaporizes, the cold vapors gather close to the ground where they smother any animal inhabitants. If a large quantity of the vapors could be ignited, they would produce a violent explosion. Fortunately, the risk of such an occurrence is very low.

6.1.1.2. Methanol

Two forms of methanol find application as transportation fuels: M85, which is 85 percent methanol and 15 percent gasoline, and M100, which is pure (neat) methanol. Apparently, M100 use has peaked. Because of the poor performance and maintenance record it has compiled, little additional M100 use is expected in the future (EIA 2000).

Adoption of M85 as a transportation fuel seems to be governed by the cost of methanol. Four variables go into the price of methanol as a transportation fuel: 1) the price of natural gas because virtually all commercial methanol is made from natural gas, 2) the cost of building the very large conversion plants needed to capture economies of scale, 3) the cost of developing the necessary new distribution system, and 4) the demand for methanol for other purposes. Methanol is a raw material in the creation of methyl tertiary butyl ether (MTBE), a major constituent of reformulated gasoline. Recent demand for reformulated gasoline has driven up the price of methanol and it is still uncertain where the price will eventually settle. Nevertheless, the use of M85 has declined from its high in the late 1990's. There remains a question about whether M85 will ever find a larger niche in the transportation sector.

Conversion of gasoline and diesel powered vehicles to methanol is relatively inexpensive; however, dual powered vehicles capable of using either gasoline and methanol or diesel and methanol seem to encounter technical problems. The process of conversion from gasoline to methanol entails the development of a new fuel distribution network. The implication of this requirement is that a major conversion effort must be launched to make this alternative viable. However, the effort need not be nationwide. A regional market, if it were large enough and well enough defined, could be converted without involving the rest of the nation.

Because most commercially available methanol is made from natural gas, the extraction step in the process has been covered in the 5-Year Program EIS and section 4.3. of this paper. Production of methanol from natural gas, depending on the precise technology used, may lead to additional discharges of atmospheric pollutants with resultant impacts on local air quality, acid rain, stratospheric and tropospheric ozone, and greenhouse gasses. The production process may also lead to discharges of contaminated and heated water into streams, rivers, and lakes.

6.1.1.3. Ethanol

In addition to its use as a gasoline additive, two different forms of ethanol are potential alternative fuels. E95 is 95 percent ethanol and 5 percent gasoline. Like M100, users are showing little interest in E95. E85 consists of 85 percent ethanol and 15 percent gasoline. Through 1995 users have shown only modest interest in E85 vehicles. However, beginning in 1997, Chevrolet S-10 and GMC Sonoma pickup trucks produced by General Motors have been flexible fuel vehicles that can use either gasoline or E85 (EIA 2000). More recently, General Motors has expanded the list of flexible fuel vehicles it manufactures.

The principal problem with ethanol is its high cost. Present interest undoubtedly stems from subsidies in the form of exemptions from Federal and some state excise taxes.

Because ethanol is corrosive and an absorbent of water, it cannot be transported through conventional pipelines. These characteristics make it incompatible with present liquid fuel distribution systems. A viable, large-scale ethanol industry requires a new infrastructure including new transportation, storage, and dispensing equipment.

Distillers produce ethanol through the fermentation of a sugar-containing biological product. Corn is the feedstock most widely used for ethanol production in North America. Research into the use of cellulose as a feedstock for ethanol production has opened up the possibility of using wood fiber, grasses, and other woody vegetation as a cheap raw material (Lovins 2006).

Farmers may grow additional corn needed to meet expanded ethanol demand principally on land now considered marginal for crop production. They will have to remove land from less intense uses to devote to this intensively cultivated row crop. This action will result in significant increases in soil erosion, fertilizer runoff, and systemic effects through expanded uses of pesticides and herbicides. The net effect will be deteriorated water quality through siltation, eutrophication, and chemical toxicity. Upland wildlife habitat will be diminished through loss of cover and the effects of chemical toxicity. Wildlife will also be adversely affected by the additional rural activity associated with the more intense agriculture.

Production of ethanol uses great quantities of water and leads to releases of large quantities of oxygen depleting materials into streams and rivers. The net effect is significant further deterioration of water quality. Ethanol production also has deleterious impacts on local air quality through hydrocarbon releases and on greenhouse gases through copious CO_2 releases.

6.1.1.4. Electricity

The future of electric vehicles is dominated by state mandates for zero emission vehicles (ZEV's). Starting in 1998, California, New York, and Massachusetts require that 2 percent of the vehicles sold in the state be ZEV's. The requirement increases incrementally to 10 percent in 2003 (EIA 1996). Electric vehicles are the only ones that have zero emissions (at the point of use).

Electric vehicles suffer from some performance problems; however, the ultimate limitations on electric vehicle acceptance revolve around technical problems with batteries. Batteries are too heavy, take too long to recharge, do not hold sufficient charge, and (most important) are much too expensive. Until these problems are solved, or at least ameliorated, consumers are unlikely to freely choose electric vehicles over vehicles powered with internal combustion engines or hybrids. The only way to overcome this rejection would be to induce consumers to take electric vehicles or to do as the three states above are and force the automobile companies to offer consumers incentives.

If the battery technology problems are overcome, or if ZEV mandates are effective, the substantial adoption of electric vehicles will greatly increase the demand for electricity. Meeting increased demand for electricity will lead to the kinds of environmental impacts noted in section 7.1, which deals with electricity generation.

6.1.1.5. Hydrogen

Hydrogen powered fuel cells could be used in a new generation of vehicles designed to minimize final use air pollution in urban areas. One article put it this way, "One day, many experts believe, the auto industry could virtually wean itself completely from fossil fuels with so-called fuel cells that use hydrogen. But that day is at least 20 years away (BusinessWeek 2001)."

Hydrogen fuel cell technology faces three major impediments:

- hydrogen production using present technology is expensive—requiring large amounts of electricity
- no distribution network exists
- hydrogen is relatively hard to transport over long distances

If the U.S. Government decided to pursue hydrogen fuel cell vehicles on a large scale, we would have to develop major additions to the electricity production infrastructure. The impacts of this development are discussed in the section on electricity generation (7.1).

Research on the use of enzymes found in organisms growing in extreme conditions has found a way to produce hydrogen from glucose and presumably other sugars and similar materials including perhaps even cellulose. If this approach proves to be financially feasible, it may become a major source of energy for the future. It will be decades before this technology is implemented on a broad scale. Nevertheless, hydrogen powered fuel cells have the potential to eventually replace the internal combustion engine as the primary transportation engine. The resulting "hydrogen economy" could revolutionize the world fuel mix (EREN 2001). MMS is studying the potential for hydrogen production as a means of transporting energy produced from advanced technologies on the OCS.

6.1.2 More Efficient Vehicles

One good way to conserve energy, or in this case to substitute for OCS oil, is to adopt more efficient transportation vehicles. Essentially this can be accomplished either by improving the efficiency of engines and transmissions or by adopting lighter and more streamlined vehicle bodies. Government interference in the market place often leads to unintended consequences. Potentially, that could be the case with more fuel-efficient vehicles and other government energy programs. For instance, more fuel-efficient cars might encourage car owners to drive more. This would partially negate any fuel savings. In addition, greater automobile efficiency might discourage use of even more efficient alternative modes of transportation such as mass transit or ride sharing. Nevertheless, more efficient vehicles are likely to be a highly effective way to decrease the aggregate demand for oil in the transportation sector.

6.1.2.1. Improved Engines and Transmissions

Automobile manufacturers have responded to the CAFE standards by steadily increasing the fuel economy of cars sold in the United States market. Major contributors to this increased efficiency have been more efficient engines and transmissions. Although more efficient engines and transmissions presumably burn gasoline for fuel, the potential exists for this alternative to decrease further the amount of oil consumed in automobile transportation. The problem with this alternative is that it increases the cost of new automobiles. No negative environmental consequences stem from this alternative. This desirable outcome is undoubtedly the basis for the current Government-private industry partnership to produce a more fuel-efficient automobile.

Several auto makers have introduced hybrid gasoline-electric vehicles in the American market. These automobiles use small, efficient gasoline engines for cruising. While the cars are cruising or braking, they charge specially designed batteries attached to highly efficient and powerful electric motors. The electric motors take control when needed for extra power and during stop and go driving while the gasoline engine waits in reserve until it is needed when the batteries run down or for sustained high speed driving. Virtually all hybrid vehicles qualify as ultra-efficient vehicles.

Diesel engines tend to be more efficient than gasoline engines for any particular application. Diesel engines dominate markets for trucks, buses, and trains. Consumers resist diesel engines in cars because:

- their performance characteristics are poorer than gasoline engines
- they are more expensive
- they are harder to start
- older models were smelly and smoky and the perception persists
- diesel fuel is less widely available than gasoline

However, if car companies choose to market the cleaner burning diesel engines currently popular in Europe and consumers can be convinced to accept them, diesels could effect a major decline in oil use. Diesel hybrids could be even more efficient.

6.1.2.2. Lighter, More Streamlined Vehicle Bodies

Vehicles with lighter, more streamlined bodies would also save additional fuel. Manufacturers have made significant progress in this direction, but more is still possible. One study reached the conclusion that decreasing the weight of automobiles would result in about two-thirds of the potential increase in fuel efficiency that could be expected using state-of-the-art design (Lovins 2006). Increasing the proportions of aluminum and plastic composites could reduce vehicle weights. Lightweight steel can be almost as light and cheaper than the other alternatives. Lighter weight vehicles have several problems:

- they are more expensive
- they are thought to be less safe
- they may be more expensive to repair in case of collision damage
- they may be less acceptable to buyers looking for a “solid” steel car or truck

More streamlined cars may be less acceptable because buyers find the style of such cars too extreme for their taste. More streamlined bodies should have few negative environmental consequences. Environmental consequences of lighter bodies would depend on the materials of which they are made. Plastic composites usually use oil as a raw material so the amount of oil embodied in the construction of lighter vehicles based on plastic is likely to increase. However, the life cycle oil use of the lighter vehicles is likely to decrease. Similarly, aluminum requires more energy to produce than the amount of steel needed to perform the same function; nevertheless, life cycle oil savings are likely to accrue to an increase in the proportion of aluminum.

6.1.3. More Efficient Transportation Systems

The United States has the least energy efficient transportation system among the major industrialized countries. Improving the efficiency of this system would reduce the single largest source of oil demand in our economy. Among the possible approaches for achieving this end are:

- using more mass transit and car pools
- increasing the percentage of rail transport
- designing and building more efficient road systems

6.1.3.1. More Mass Transit and Car Pools

A large portion of automobile use is for commuting to and from work. A large percentage of workers commute alone in their automobiles. Enticing commuters to use mass transit and car pools on a large scale would save vast quantities of oil. Although such a switch in transportation mode should save money for commuters, a majority are unwilling to make the switch because they like the freedom and convenience afforded by driving one's own car. The environmental consequences of switching to mass transit and car pools would be entirely positive. Air, water, land, noise, and visual aesthetics would all be improved.

6.1.3.2. Greater Use of Rail Transportation

Trains are more energy efficient than trucks, buses, cars, or planes. Increasing the portion of goods and passengers traveling by rail would save oil. Train travel is avoided because it tends to be slower, door-to-door, than the other modes listed and it often entails mode changes to reach destinations not served by railroad lines. Increased rail travel would tend to have positive environmental consequences although there could be negative impacts from construction if rail transportation became sufficiently popular to require additional rail lines. However, net impacts to air, water, land, and noise would all decline.

6.1.3.3. Improved Road Systems

Road systems can be designed to handle the same volume of traffic more efficiently. Adequate road space to handle peak loads at normal speeds is one way to do this. Timing traffic lights and installing more "smart" traffic lights to keep high volume traffic moving are others. Building more free flowing highways is a third way to increase efficiency. Unfortunately, these alternatives tend to be expensive and to lead to higher use by motorists abandoning mass transit for the freedom and speed of individual commuting. The environmental consequences of more efficient roads depend on the impacts of construction and the space usurped by increasing the land area devoted to roads.

6.1.4. Less Motorized Transportation

Another way to save oil currently going into motorized transportation is to do less of it. People would tend to use less transportation if its price increased. Taxes could be used to decrease transportation use. Given the unpopularity of increasing taxes, it is unlikely that this alternative will be used to any great extent. Other approaches to less motorized transportation include telecommuting and non-motorized vehicles.

6.1.4.1. Telecommuting

Allowing workers to use computers and to perform other work-related activities in their homes saves the oil that would be used in commuting. Telecommuting is limited by:

- work unsuited to the home environment
- difficulty supervising workers
- interruptions from other family members

Negative environmental consequences of telecommuting are virtually nonexistent.

6.1.4.2. Non-motorized Transportation

Adopting non-motorized forms of transportation provides another approach to reducing the oil consumed by motorized transportation. In practical terms this means bicycles and walking. Both modes tend to be more time consuming and limited in flexibility compared to automobiles. However, with more jobs being located in suburban campuses near workers' homes, non-motorized transportation has become more practical for more people. Using bicycles and walking have only the most minimal negative environmental consequences.

6.2. Industrial Sector Uses

Natural gas constitutes the primary alternative to oil in the industrial sector. Environmental consequences of expanded natural gas production are covered in section 4.3. and the 5-Year Program EIS. The other alternatives to oil in the industrial sector tend to be identical to those for natural gas. These other alternatives are discussed in section 7.2. because natural gas is a more important fuel in the industrial sector than oil.

6.3. Residential and Commercial Sector Uses

As is true in the industrial sector, natural gas constitutes the primary alternative to oil in the residential and commercial sectors. Similarly, environmental consequences of expanded natural gas production are covered in section 4.3. and the 5-Year Program EIS. The other alternatives to oil for the residential and commercial sectors tend to be identical to those for natural gas. These other alternatives are discussed in section 7.2. because natural gas is a more important fuel in the residential and commercial sectors than oil.

6.4. Electricity Generation

Natural gas is also one of the major alternatives to oil for electricity generation. Environmental consequences of expanded natural gas production are covered in section 4.3. and the 5-Year Program EIS. The other alternatives to oil for electricity generation tend to be identical to the alternatives to natural gas. These other alternatives are discussed in section 7.1. because natural gas is a more important fuel for electricity generation than oil.

6.5. Non-Energy Uses

The major non-energy uses of oil and NGL's are as a feedstock for chemicals and as a raw material for solvents, lubricants, asphalts, and waxes. The alternatives for both types of non-energy use tend to be identical so they are discussed together.

6.5.1. Alternative Raw Materials

Oil and NGL's consist of hydrocarbons of varying complexity. Substitutes must be hydrocarbons with roughly similar chemical compositions. Thus, the list of substitute raw materials is limited to coal and biological sources.

6.5.1.1. Coal

For the most part, coal is suitable only for the chemical feedstock uses of oil. Although coal is a cheap and abundant raw material, it tends to require more (and more expensive) conversion before it is suitable as a substitute for oil and NGL's. In a nutshell, coal can be converted into most chemicals presently processed from oil and NGL's; however, it is usually much more expensive to do so. The environmental consequences of increased coal extraction are discussed in section 7.1.1.1., where coal is considered as an alternative fuel for generating electricity.

6.5.1.2. Biological Products

Products from living biological entities can be used for most non-energy uses of oil and NGL's. The important thing to understand is that very large quantities of oil and NGL's are used to produce non-energy products. To harvest enough of a biological product to make an important contribution to this industry would require a large-scale production system. Presently, some biological products do compete as feedstocks and for such products as waxes. Soybeans are the most obvious domestic example. The vast acreage committed to soybean production is an example of the kind of commitment that would have to be mounted to substitute for a meaningful percentage of oil and NGL's. The major impediment to such conversion is its cost.

Greatly increasing the harvest of biological resources would mean conversion of significant land area to this new use. The result would depend on the biological source and the region chosen to provide that source. Regardless of the option chosen, consequences would almost undoubtedly include:

- loss of habitat for many species of wildlife, including those that are threatened and endangered
- increased soil erosion
- water quality degradation
- added dust and related forms of air pollution
- increased use of insecticides, herbicides, and other potentially harmful agricultural chemicals

6.5.2. Using Less of the Products

Among the major forms of conservation is using less of the oil-based products. In the case of chemicals, lubricants, etc., this would entail lowering our standard of living. It would mean things like painting our houses less frequently, cutting back on consumption of pharmaceuticals, and not cleaning clothes and houses so often. A major future use of plastics made from oil and NGL's is as lighter-weight major parts for automobiles. Cutting back on plastic parts for automobiles would make the autos heavier, which would expand their need for oil products as fuel. Meaningful reduction of these non-fuel uses would lead to a lower standard of living with questionable positive impacts on the natural and human environments.

6.5.3. Recycling

Plastics are easily recycled although only a small percentage of plastics are recycled in the U.S. Recycling solvents, lubricants, and other oil-based chemicals would also seem to be an ideal way to save some of the raw material input. Unfortunately, used chemicals of these types are often contaminated with dangerous and environmentally damaging materials. Removing these contaminants is often more expensive than the cost of virgin raw materials. For example, recycled motor oil from automobiles has mostly been mixed in with residual oil and burned in boilers.

Disposing of the contaminants can lead to processes that add to air and water pollution. Where processes can be developed to reprocess these types of chemicals in an environmentally acceptable manner, the result could be a saving of oil and NGL's with relatively benign environmental consequences.

7. Alternatives to Natural Gas and Their Environmental Impacts

The same five basic ways exist to replace either OCS gas or oil: import, produce onshore, switch fuel, substitute fuel-saving technology, or accept less service. The principal alternatives to OCS natural gas are oil and gas from onshore production. Oil importation and onshore gas production are covered in section 4.3. This section will review the other potential substitutes for OCS gas.

7.1. Electricity Generation

Electricity generation is the fastest growing use of natural gas. As discussed in section 3.3., natural gas is especially well suited to producing ramping power to meet peak loads. This is the most expensive and valuable type of power production. However, combined-cycle gas plants are finding more frequent application to base-load and intermediate power supply.

7.1.1. Alternative Sources of Electricity

Table 7 provides statistics on utilities' capability to generate electricity using different fuels and the amount of electricity generated using the various fuels in 2004.

7.1.1.1. Coal

As table 7 makes clear, the United States generates more electricity using coal than any other fuel. Coal is best suited to base-load and slowly ramping power production because coal-fired power plants are relatively slow to bring on and off line. For the proper application, coal-fired power plants compete reasonably well with other generators. However, in order to be efficient, coal plants must be large. In addition, air pollution control regulations require the installation of expensive pollution control equipment. As a result, building a new coal plant entails a very significant capital investment with interest costs that can become prohibitive if the cost of money rises. Thus, utilities have completed few coal-fired electric generating plants in recent years. Nevertheless, in the face of rising gas prices, utilities are planning the construction of many new coal plants. It remains to be seen whether the plants will be built.

Coal extraction may cause especially severe impacts on water resources that are degraded by acidic drainage from active and abandoned mines and by silt from earth movement, which is especially serious in strip and auger mining. Ground water is often polluted or disrupted by coal extraction because coal seams serve as the aquifer in many locations. Coal mining also is associated with air pollution from dust and machinery exhaust. The machinery also produces noise pollution. Coal's impact on visual aesthetics is especially severe because the surface scars from strip mining and the mountainside cuts from auger mining have an especially significant effect on scenic mountain areas.

Table 7. U.S. Electric Utilities 2004 Generating Capability and Net Generation

Fuel	Generating Capability (megawatts)	Net Generation (billion kilowatt-hours)
Coal	335,243	1,978
Petroleum	37,970	121
Gas	256,627	709
Nuclear	105,650	789
Hydroelectric	96,699	260
Other*	23,648	114
Total	639,143	3,971

Source: U.S. Department of Energy, Energy Information Administration. *Electric Power Annual with Data for 2004*,. DOE/EIA-0348(2005).

*Includes wind, geothermal, solar, biomass of various kinds, and other gases.

7.1.1.2. Nuclear

Nuclear power plants are almost exclusively used for base-load power production. Although nuclear power was originally promoted as a very cheap form of electricity generation, it has proven to be quite expensive. Providing the margin of safety society expects from a nuclear plant requires safety systems that multiply by several times the cost of building a nuclear plant. Similarly, safe operations cost many times the operating costs originally envisioned. Finally, finding a socially acceptable location for disposing of the spent nuclear fuel cells is much more difficult and expensive than originally expected.

In table 7 one can see that nuclear plants have the highest ratio of generation to capacity of any major category of electric generation. Where they are installed, they are usually the base-load workhorses of the utilities' generation systems. Nonetheless, the lack of any planned nuclear capacity addition demonstrates their prohibitively high costs (EIA 2005). In the next 15 or 20 years many presently operating nuclear units are scheduled for decommissioning. If this occurs on schedule, it will lead to a significant increase in the demand for other forms of electricity generating capacity. Development of ultra-safe standardized units and greater creativity in siting are the keys to an expanded future role for nuclear power plants.

Compared with other forms of large-scale electricity generation, nuclear power has relatively minor environmental impacts. Mine tailings from uranium mining have caused radioactive water pollution in the West, but this is more a result of formerly inadequate regulation or lax enforcement than it is a problem with present production. The tremendous cooling needs of nuclear reactors can lead to abnormal temperature increases in bodies of water used for plant cooling. The size of the containment vessels can also cause visual aesthetic degradation. Recent events have dramatized the vulnerability of nuclear plants to acts of terrorism that could lead to the release of radioactive material.

7.1.1.3. Hydroelectric

Many of the best hydroelectric sites in the U.S. have already been utilized or set aside for aesthetic reasons. In addition hydroelectric dams in several parts of the country have been breached to provide pathways for anadromous fish and for other environmental purposes. As a result, hydroelectric power won't make a significant contribution to additional domestic electricity generation. Pump storage, which is a method for storing less expensive base-load power from off-peak hours for meeting peak demand, could substitute for some natural gas-fired turbines used for peaking power. Environmental impacts from pump storage facilities tend to be localized and to consist of destruction of wildlife habitat and, in open systems, disruption of stream flows. At this time no pump storage projects are being planned for the United States (EIA 2005).

7.1.1.4. Geothermal

Geothermal electricity generation is limited by the availability of geothermal resources and the inadequate technology to take advantage of many forms of geothermal energy. Geothermal generating stations may create air pollution, water pollution, and land disturbance. Water discharged by geothermal developments is often highly corrosive and full of rocks (Hazen 1996).

7.1.1.5. Biomass

Next to wind and geothermal, biomass makes a larger contribution to U.S. electricity generation than any other non-conventional power source. Most of the biomass burned for power is wood or specific types of waste wood products. Obviously, this power source is dependent on a large supply of low-cost wood.

At some point trees must be cut to obtain the wood for generating power with this form of biomass. Cutting trees can lead to additional water pollution from soil erosion caused by timber road construction and skidding the fallen trees. Ground without the protection of trees, especially if it is burned, may also be subject to increased erosion. The logging also creates a location unsuitable for wildlife requiring trees for food, cover, and protection. Some of the displaced wildlife could be endangered species.

Another source of biomass for power is municipal solid waste. Burning solid waste without creating air and water pollution problems is costly. This means such systems usually cannot compete with other sources of power without sizable subsidies. However, in locations where suitable sites for landfills are becoming inaccessible, subsidies may be appropriate. Some individual solid waste incinerators, for example the Lancaster County (Pennsylvania) Resource Recovery System, can solve the solid waste disposal problem; generate electricity; and produce negligible air, water, and land pollution. Unfortunately, the combination of cost and technical sophistication makes waste to power systems unlikely sources of significant electricity generation in the near future.

7.1.1.6. Wind

The amount of electricity generated by wind power has expanded greatly over the last decade driven in part by significant technological improvements. During 1998 and 1999, 925 megawatts of wind-powered generating capacity were added in the U.S., mostly on Iowa and Minnesota farmland (AWEA 2006). Much of the expansion in wind generating facilities has been fueled by generous subsidies for building and operating these generators. Nevertheless, wind power contributes less than one percent of present-day U.S. electricity generation. The wind power industry projects that wind could provide six percent of U.S. power production, about 24.8 billion kWh, by 2020. A major source of this optimism is the 90 percent drop in wind energy costs over the last 20 years (AWEA 2006).

The main problem with wind powered electricity generation is wind availability. Most wind systems only operate 25 percent of the time at 50 percent or less of capacity. The lack of wind constancy causes system stress and difficult voltage regulation. Early problems with noise and interference with television, radio, and other media transmissions have largely been solved through better designs and non-metallic wind vanes (Hazen 1996).

Recently, planning has begun on two projects offshore the U.S. coast. One is off Nantucket and the other off Long Island. The relative constancy of winds in these areas and their proximity to areas of high demand were important attractions to the developers. Although some European studies have shown the structures to lead to relatively large areas avoided by sea birds, the environmental impacts have not yet been shown to be significantly negative.

However, wind-powered generating equipment must be carefully sited. Construction of the pads and access roads for wind farms located in arid, mountainous country can disturb large areas of sensitive land. The result is greatly increased soil erosion compared with what it would be from more traditional land uses leading to siltation in nearby streams. The Altamont Pass wind resource area in California has been associated with high levels of raptor mortality (Audubon 1991). Thus, wind energy development sites must consider the locations of major migration routes and areas that might funnel birds into the machines. Appalachian wind farms have experienced relatively high numbers of bat deaths. The industry is studying this problem with the hope of remedying the situation in the future. The most modern wind generators are very large and revolve relatively slowly. These slower generators may partially alleviate the impacts to birds that have been noted with older models.

Visual aesthetics must also be considered in wind energy siting decision. The crests of ridges and the sides of canyons are often the highlights of scenic areas. Generators in stark relief against the sky could create a devastating loss of aesthetic value to some observers. On the other hand, wind generation equipment may be aesthetically compatible with farmland in the Plain States that have some of the most reliable wind resources in the U.S.

Wind generation in shallow waters offshore entails similar technology to that used onshore except that a structure must be built to raise the generating equipment above the level of the water. However, unlike parts of Western Europe, 90 percent of U.S. offshore wind resources lie in deep water. Deep water entails much more elaborate and expensive structures to protect the generators. Estimates of shallow water cost lie in the range of $.08 to $.15 per kwh. Deep-water costs are expected to be double those figures although technological improvements and economies of scale could lower that number significantly. Offshore environmental impacts include visual impacts; noise and vibrations; collisions, habitat dislocation, and navigational disorientation for birds; alterations of natural underwater environments; and impacts on fisheries and marine traffic. Potential siting constraints include water depth, migration routes, shipping lanes, pipelines, and military operations.

7.1.1.7. Solar

Solar energy is converted to electricity primarily through solar thermal or photovoltaic technology. Solar thermal conversion uses three types of conversion technology: parabolic troughs, parabolic dishes, and heliostat/central receiver systems. The parabolic troughs and dishes collect solar energy as part of distributed collection systems that transmit solar heat via a fluid system to a point where the heat creates steam to power a turbine. Heliostats are mirrors mounted on an axis maneuvered by a mechanism that focuses the reflected solar energy on a single receiving point. The energy from many heliostats at the central receiver heats water there to drive a turbine. Although research continues, major breakthroughs in solar thermal conversion have been limited of late (Hazen 1996).

Photovoltaic technology on the other hand has been a hotbed of recent technological improvement. Photovoltaics create electricity directly through the activity of solar energy on semiconductors. Cells of the semiconducting material are arrayed on trays that may be stacked to maximize solar capture. Alternatively, the material may be laid out in a thin film that should be relatively inexpensive to manufacture and deploy. Photovoltaic systems are finding increased use as power facilities far from existing power lines. As the cost of photovoltaic cells has declined and their reliability improved, in many cases it has become cheaper to install photovoltaic cells than run a long-distance power line (EREN 2001). For instance, a program has been initiated on the Navajo Indian Reservation to install photovoltaic solar electric generating systems on scattered homesites throughout the reservation (Rushlo 2000).

Nevertheless, solar powered electricity remains a high cost alternative. Indeed, the cost for thin film technology for large-scale power production is still based on estimates and models. A relatively reliable study suggested that solar energy costs would have to decline tenfold in order to compete with present commodity electricity costs (Zweibel 1999). It is fair to say that for the foreseeable future solar energy will not make a major contribution to electricity generation because of its cost. MMS is investigating the use of solar energy to produce electricity on the OCS.

Photovoltaic electricity generation has virtually no negative environmental impacts in the power production process itself. Production of the equipment may entail environmental degradation associated with the manufacturing process, although this should be localized and controllable. However, if solar thermal power were ever to make a measurable contribution to national electricity generation, vast areas of land would have to be given over to this technology. Although the areas best suited to solar energy tend to be arid and thus fragile, many areas might be flat or on gentle slopes and not especially susceptible to wholesale erosion. Nevertheless, large-scale loss of vegetation and wildlife habitat, soil erosion, and resulting water pollution can be expected from large-scale solar thermal generating facilities. Such facilities could also be aesthetically displeasing.

7.1.1.8. Advanced Technologies

Ocean currents. Submerged turbines similar to wind turbines can extract energy from ocean currents. The system for producing energy from ocean currents would consist of the rotor blade turbine, a generator for converting the rotational energy into electricity, and a means of transporting the electrical current to shore for incorporation into the electrical grid. Problems attendant on this technology include the necessity of maintaining corrosion resistance and prevention of marine growth buildup. Marine current energy is likely to have minimal negative environmental impacts; however, fish, marine mammals, shipping routes, and recreational fishing and diving will need protection. Risks may also be encountered from slowing the current flow by extracting energy. One study suggested that if 10% of the Gulf Stream's energy were extracted near Florida, there could be significant climate changes in northwestern Europe.

Wave action. The energy from waves can be captured using a variety of technologies. The cost of energy produced by wave action depends on technological, physical, and economic factors. One study found the cost in areas with relatively high wave energy was in the range of \$0.09 to \$0.11/kWh after tax incentives. However, expanded production volume can significantly reduce equipment costs. The eventual cost of wave-generated electricity with mature technologies has been estimated to be competitive with wind-generated electricity. Wave energy may have environmental impacts on marine habitat, lead to releases of toxic hydraulic fluids, cause visual disturbances and noise pollution, and conflict with commercial shipping and recreational boating.

Other. Tidal energy and ocean thermal gradients are other potential sources of generating capacity. These sources often rely on relatively unique circumstances to justify their construction. For the most part, these exotic sources lack the potential to make a serious contribution to U.S. electricity supply. In most situations these alternatives are too expensive, lack feasible technology, or both. It is extremely unlikely that any exotic form of electricity generation will make even a one percent contribution to the U.S. electricity supply during the planning period for this program

MMS is preparing a separate Programmatic EIS for OCS renewable energy. This document will include an assessment of hydrogen production, solar, wind, current, and wave energy sources. It will assess the technical status, economic viability, and potential environmental impacts of each of these sources on the OCS.

7.1.2. More Efficient Electricity Generation

Using more efficient generating equipment to produce the same amount of electricity as now could save a meaningful amount of natural gas and oil. Examples of how this could be done include:

- replacing aged equipment with modern conventional equipment
- replacing straight turbines with much more fuel efficient combined cycle systems
- adopting the next generation of nuclear reactor should they become available
- building one of the new generation of coal-fired generating plants such as atmospheric fluidized bed, pressurized fluidized bed, or limestone injection

The problem is that modern, efficient generating plants are very expensive. Power companies may have trouble justifying the expenditures to their stockholders on a financial basis. Furthermore, state regulatory agencies may be unwilling to allow additions to rates for plant construction while they allow standard rate adjustments for fuel costs. Saving natural gas and oil through more efficient generation would reduce the incidence and risk of all the environmental impacts associated with the natural gas and oil production saved. Some of the conserved resources would have come from the OCS.

7.1.3. More Efficient and Less Electricity Consumption

By using less electricity and by using it more efficiently, the industrial, commercial, and residential sectors could save the fuels used to generate that electricity. These types of savings will be discussed in sections 7.2 and 7.3.

7.2. Industrial Sector Uses

7.2.1. Alternative Fuels

The trend in the industrial sector is to switch to natural gas or electricity. This means that other fuels are less suitable for industrial applications, more expensive, or both. Oil is the most likely alternative fuel that most industries would choose as a substitute for natural gas. Impacts from oil production are covered in section 4.3. and the 5-Year Program EIS.

7.2.1.1. Coal

Coal can be an effective alternative to natural gas in industrial applications where rapid peaking is not a requirement. However, it is an expensive alternative in all but the largest new applications. Among the characteristics that add to the cost of new coal plants are:

- the expense of efficient-sized coal-burning facilities
- the need for expensive air pollution control equipment
- the expense of transporting and handling coal

The environmental impacts associated with coal are covered in section 7.1.1.1.

7.2.1.2. Electricity

Electricity can be substituted for natural gas (and oil) in many industrial applications. Although electricity tends to be more expensive than the use of a raw fuel, it moves the source of air pollution to another location that may have less stringent pollution control regulations than the industrial site. Furthermore, an electric utility can achieve economies of scale in pollution control that might not be available to the individual firm. The environmental impacts attributable to the generation of electricity are dependent on the fuel used and these are covered in section 7.1.1.

7.2.2. More Efficient Energy Usage

Although the industrial sector as a whole spends a considerable amount of time and money developing methods for using energy more efficiently, opportunities remain for saving vast quantities of energy in the industrial sector. Many consulting firms make it their business to help firms use energy more efficiently, but they tend to help only those firms with high enough levels of inefficiency to pay a portion of efficiency savings to a consultant. Many smaller opportunities for improvements go unaddressed. This is true for the use of natural gas, oil, electricity, and even other energy inputs such as coal.

One way firms in the industrial sector can improve their energy efficiency is by adopting state-of-the-art equipment. In many cases, a new process or new space heating and cooling equipment can save enough in energy costs to pay for itself in a reasonably short payback period. Choosing equipment that is the right size in terms of energy efficiency for the task at hand can reap related savings.

Another way firms can save energy is through improving the energy efficiency of their industrial processes. Although most “reengineering” activities in industry are aimed at using labor more efficiently, the same approach can be used to save on the use of energy. Combinations of new processes with new, properly sized equipment can lead to especially significant energy savings. Although some negative environmental impacts may be associated with the production of materials or equipment installed in the process of achieving greater energy efficiency, these impacts tend to be negligible. Thus, improvements in the efficiency with which the industrial sector uses energy are almost entirely beneficial to the environment.

7.3. Residential and Commercial Sector Uses

7.3.1. Alternative Fuels

Just as in the industrial sector, the trend in the residential and commercial sectors is to switch to natural gas, when it is available, or electricity. Residential and commercial facilities have relatively many alternative fuel options.

7.3.1.1 Electricity

When gas is unavailable, electricity is the fuel of choice for new residential and commercial facilities in all but the coldest parts of the country. Heat pumps are the technological breakthrough that has allowed electricity to compete with products made from oil. Environmental impacts from the production of electricity are covered in section 7.1.

7.3.1.2. Oil

Among the products made from oil and available to the residential and commercial sectors are fuel oil, kerosene, and Liquefied Petroleum Gas (LPG). Each of these products can be competitive with natural gas under certain circumstances, the most common of which is expensive access to a natural gas pipeline. Oil-based products are also well suited to areas where it is too cold for electric heat pumps to operate effectively. Impacts from oil production are covered in section 4.3. of this paper and in the 5-Year Program EIS.

7.3.1.3. Coal

Coal is still burned in many older houses. Even in modern houses, coal is still used as an auxiliary source of heat, sometimes switching off with wood depending on relative costs or availability. The environmental impacts associated with coal mining are enumerated in section 7.1.1.1.

7.3.1.4. Biomass (Wood)

Wood is burned for heat in many houses. Cutting firewood in moderation may cause little negative environmental impact and may even serve to open up forests to let the remaining trees develop and to provide some ecological diversity. Where such cutting is carried to an extreme it may destroy forest habitat and lead to soil erosion resulting in long-term damage to the land and waters. In addition, habitat for tree-dependent wildlife may be lost with resultant loss of the wildlife population, which may include endangered species. Other forms of biomass can be burned or they can be processed into methane gas for use in a similar manner to natural gas although these alternatives see little application in the residential and commercial sectors.

7.3.1.5. Solar

Solar energy is almost exclusively an auxiliary source of heat to the residential and commercial sectors. However, especially in sunny areas, the contribution of solar energy can be significant. Simple approaches to letting the sun warm parts of a dwelling, especially those made of heat retaining materials, work especially well. Such passive solar systems can reduce heating bills as much as 50 percent (EREN 2001). Solar energy also works effectively as an auxiliary water heating system. A typical solar water heating system will reduce the need for conventional water heating by two-thirds (EREN 2001). The problem is that these auxiliary systems need a main or a backup system including an alternative source of energy. Where the alternative source is electricity, the demand during times of low solar radiation could force electric utilities to provide relatively expensive peak demand at a cost to all customers whether or not they used solar heat.

Recently, photovoltaics for residential and commercial applications have come on the market that can compete with other sources of energy in certain situations. The use of photovoltaic films has been a major breakthrough in helping to make these systems more economical. The solar powered systems still need expensive and complex storage systems or connections to the electric power grid.

Manufacturing solar energy capturing material could lead to environmental deterioration; however, that environmental cost is likely to be minor. Environmental impacts of residential and commercial solar energy use at the point of capture are likely to be negligible.

7.3.2. More Efficient Energy Usage

As is true of the industrial sector, the residential and commercial sectors can use correctly sized state-of-the-art equipment to increase the efficiency of their energy usage. However, in terms of more efficient use, these sectors have some specific steps open to them that have broad application across the sectors. Most important is the use of better designs and materials. Better designs can take advantage of passive solar energy, minimize openings to the outside, and take into account airflow as well as temperature to maximize comfort. Better materials include multi-paned glass, insulated sheathing, and more effective insulation materials.

Insulation and weatherization can be especially effective in the residential sector. Programs to subsidize insulation and weatherization sponsored by electric utilities have cost-effectively spared the utilities from having to install expensive new generating plants. In more sophisticated applications, zoning and time-of-day controls can be used to hold down unnecessary energy usage in large residences and commercial establishments. More efficient appliances and appliance usage can also add to the efficiency of the residential sector.

Any negative environmental impacts from increased production of more energy efficient heating and cooling equipment and appliances would be only marginal. Therefore, almost all the improvements in energy efficiency in the residential and commercial sectors would have positive impacts on the natural environment.

7.3.3. Less Energy Usage

In the industrial sector, any decrease in energy usage not associated with increased energy efficiency would lead directly to a decrease in production. In the residential sector, less energy usage might lead to lower utility; however, the tradeoff might be a reasonable one. For instance, less heating and cooling might lead people to change their dress habits without causing much inconvenience. Everyday decisions like this could lead to positive impacts on the natural environment.

8. A Note on “Conservation”

The two types of energy conservation, substituting energy-saving technology and using less of the energy service, share two important characteristics:

1. There may be some negative environmental impacts associated with any new equipment required to achieve the efficiency, but these impacts will tend to be marginal.

2. The net effect of these measures will generally be positive from an environmental point of view, even though they could lead to unintended consequences.

Furthermore, there is ample opportunity in our society to provide cost-effective subsidies to entice people to implement various conservation measures. However, for any given level of technology the opportunities are not unlimited. Enticement to conserve will have to be constant. After an initial period of success, each additional unit of conservation at a given technological level will become incrementally more expensive. In other words, absent technological change, conservation has an upward sloping supply curve just as most other goods and services do. Thus, our society could decide to save energy and save money in the process, but only for a while. Eventually, saving more energy would become too expensive to continue, unless breakthrough technology can come to the rescue.

Some energy analysts believe that society has within its power the ability to implement technological improvements that could change the nature of our energy system. The Rocky Mountain Institute has published a volume titled, *Winning the Oil Endgame*, in which the authors detail just such a system of change based partially on already available technology and partially on technological improvements that they believe are well within the capabilities of modern science and engineering. Their focus is on substituting conservation and other fuel sources for the vast quantity of oil imported by the U.S. from unstable foreign sources. They offer the possibility of achieving these goals in the not too distant future (Lovins 2006).

9. Conclusion

In the short run, oil and natural gas are essential elements in the U.S. energy equation. Within the next few years, even vigorous government action can only shift the mix of energy alternatives to a minor degree. Any major change in the energy mix will also require changes in behavior by individuals and institutions not under direct control of the government in the U.S. system. In an intermediate time period, other energy options like wind powered electricity generation and hybrid-electric cars can begin to make inroads on hydrocarbon use if government gives these alternatives a sufficient boost. In the longer run, new generation nuclear electricity generation and fuel cell powered transportation could revolutionize the energy picture.

These long run possibilities won't come to pass until most of the development associated with the present 5-Year Program has peaked out and been decommissioned. Until such a time as the U.S. economy can rely on alternatives with less serious environmental impacts, especially in the area of greenhouse gases, oil and natural gas will remain key interim fuels. Even in the foreseeable future, oil will be needed to power airplanes, to provide heat in cold rural locations, and for non-energy uses. Natural gas will likely still be the fuel of choice for peaking electric power.

Alternatives likely to help minimize environmental impacts in the long run are topped by conservation, the least polluting, most cost-effective option up to a point. However, without revolutionary technological changes, conservation benefits are limited, as noted in section 8 of this paper. Other comers include hybrid cars and fuel cells in the ground transportation sector. New generation nuclear backed up with wind may power baseload electricity. Finally, hydrogen for urban industrial, commercial, and residential heating and related uses rounds out the list of potential minimum polluters likely to populate the energy economy. Oil and natural gas will be needed in the interim to power an economy that can generate the capital needed to implement these less polluting alternatives. The most likely and largest available alternatives to OCS production are imported oil and LNG. The environmental impacts associated with these alternatives represent important considerations when weighing the no action alternative.

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The Department of the Interior Mission

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering sound use of our land and water resources; protecting our fish, wildlife, and biological diversity; preserving the environmental and cultural values of our national parks and historical places; and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

The Minerals Management Service Mission

As a bureau of the Department of the Interior, the Minerals Management Service's (MMS) primary responsibilities are to manage the mineral resources located on the Nation's Outer Continental Shelf (OCS), collect revenue from the Federal OCS and onshore Federal and Indian lands, and distribute those revenues.

Moreover, in working to meet its responsibilities, the **Offshore Minerals Management Program** administers the OCS competitive leasing program and oversees the safe and environmentally sound exploration and production of our Nation's offshore natural gas, oil and other mineral resources. The MMS **Minerals Revenue Management** meets its responsibilities by ensuring the efficient, timely and accurate collection and disbursement of revenue from mineral leasing and production due to Indian tribes and allottees, States and the U.S. Treasury.

The MMS strives to fulfill its responsibilities through the general guiding principles of: (1) being responsive to the public's concerns and interests by maintaining a dialogue with all potentially affected parties and (2) carrying out its programs with an emphasis on working to enhance the quality of life for all Americans by lending MMS assistance and expertise to economic development and environmental protection.