Chapter 7

Stationary Uses of Petroleum

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Stationary Uses of Petroleum

INTRODUCTION

Stationary users–buildings, industry, and electric utilities—consumed about 8.1 million barrels per day (MMB/D) of petroleum products in 1980. While the potential for reducing oil use by these sectors is well recognized, it has not received as much attention as oil reduction opportunities in transportation. Indeed, U.S. energy policies in the 1970's implicitly encouraged increased oil use for stationary purposes. Lately, however, policy objectives have been set to encourage reduction in oil use by fuel switching and conservation. These objectives include conservation goals and incentives to increase energy use efficiency by buildings and industry, and fuel-switching goals to convert utility and large industrial boilers from oil and natural gas to coal.

This section examines the current mix of petroleum products used in the stationary sector and recent trends. A Department of Energy forecast of stationary demand on petroleum products was selected to serve as a baseline. This will be used to provide estimates of the volume of fuel oil that can be saved by either conservation or conversion to new natural gas and electricity. Readers should note that these estimates only describe reductions in oil use that are technically and economically plausible. Whether the estimated reductions are actually realized depends on how numerous energy users and producers react to economic incentives and other factors affecting their choices. Some of these factors are discussed at the end of this section.

Photo credit: Department of Energy

Cracks and very narrow spaces, such as those around window framing are insulated to increase energy use efficiency

CURRENT SITUATION

Table 51 shows petroleum use by the stationary and transportation sectors since 1965.

Stationary sectors have accounted for 45 to 48 percent of total petroleum demand over this period. Demand growth has occurred in industry and electric utilities as a result of natural-gas curtailments during the 1970's, environmental restrictions on coal, and the rapid increase in electricity demand since about 1973. The type of petroleum product used is also important, since we are primarily concerned with products most readily converted to transportation fuels. Table 52 shows the distribution of major petroleum products for 1980 among the stationary and transportation sectors.

As fuel, the stationary sectors consume principally middle distillates and residual oil. The major components of the other category includes petrochemical feedstocks, asphalt, petroleum coke, and refinery still gas. These are unlikely

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Table 51 .–U.S. Petroleum Demand (MMB/D)

	Stationary				Transportation
Year	Industry	Buildings	Utilities	Total	Total
1965	2.2	3.0	0.3	5.5	6.0
1970	2.5	3.5	0.9	6.9	7.8
1975	2.8	3.2	1.4	7.4	8.9
1980	3.6	2.9	1.6	8.1	8.7

SOURCE: Department of Energy, Energy Information Administration, *1980 Annual Report* to Congress, vol. II.

candidates for conversion to transportation fuels because modifications to refineries would be required far beyond those needed to convert residual fuel oil.[1] Further, some of these products, such as the petrochemical feedstocks and asphalt, could only be replaced by synthetic liquids. The liquefied petroleum gases (LPGs) can be used directly as a transportation fuel, as is the case with cars and trucks that have been modified to run on propane. Widespread adoption will depend principally on the relative cost of propane compared with gasoline, diesel fuel, and methanol when the cost of motor vehicle conversion is included.

Since the current price of natural gas liquids–the major source of propane–is and is likely to remain as high as the price of domestic crude oil, a significant shift to propane-powered vehicles is not likely. Therefore, LPG was not considered in this analysis of stationary fuel use. The major target of fuel switching and conservation, then, is the 4.4 MMB/D of distillate and residual fuel oil in current use. They can be used as a transportation fuel, although it will be necessary to upgrade residual fuel to gasoline and middle distillates by modifying the refinery process. Such modification is under way but will require considerable time and investment.[2]

[1] Refining Flexibility (Washington, D. C.: National Petroleum Council, 1980).

[2] *Oil and Gas Journal,* Jan. 5, 1981, p. 43.

Table 52.—1980 Petroleum Demand (MMBD)[a]

	Stationary				Transportation
Product	Buildings	Industry	Electricity	Total	Total
Gasoline	0	0	0	0	6.3
Distillate	1.0	0.7	0.2	1.9	0.95
Residual	0.5	0.65	1.3	2.45	0.4
Jet	o	0	0	0	1.1
LPG	0.3	0.7	0	1.0	0
Other	0.7	2.0	0	2.7	0.2

[a] Given in terms of product equivalent–5.5 million Btu per Barrel.

SOURCE: Department of Energy, Energy Information Administration, *1980 Annual* Report to Congress, vol. II.

FUTURE DEMAND

Over the next decade some of this 4.4 MMB/D will be eliminated by fuel switching and conservation as the price of oil rises. Indeed, a decline of 1.1 MMB/D took place between 1979 and 1980.[3] How much more is possible by 1990 depends on future oil prices, the costs of alternatives, the ability to finance these alternatives, and environmental and regulatory factors. The 1980 Energy Information Administration (EIA) estimate of 1990 demand is shown in table 53. This fore-

[3] *1980 Annual Report* to Congress, *Vol.* 2, DOE/EIA-01 73(80)/2 (Washington, D. C.: U.S. Department of Energy, Energy Information Administration, 1980).

Table 53.—1990 EIA Petroleum[a] Demand Forecast for Stationary Fuel Uses (MMB/D)[b]

Product	Buildings	Industry	Electricity	Total
Distillate	0.9	0.1	0.15	1.4
Residual	0.3	0.2	0.9	1.15
Total	1.2	0.3	1.05	2.55

[a] The "other" and LPG category of stationary petroleum demand is forecast to remain at its 1980 level of 3.8 MMB/D. This category, however, would then increase from 48 percent of all stationary uses in 1980 to 60 percent In 1990. It has proven to be much less elastic to fuel price increases since 1973 than the distillate—residual fuel category.
[b] Barrel of product—5.5 MMBtu per barrel.

SOURCE: Department of Energy, Energy Information Administration, *Annual* Report to Congress, vol. III.

cast is based on a 1990 oil price of $45 per barrel (bbl) (in 1980 dollars).

The forecast reduction of 1.8 MM B/D over the next 10 years (from 4.4 MMB/D in 1980 to 2.6 MMB/D in 1990) would be accomplished by more efficient use, and by conversion to coal, electricity, and natural gas. Beyond 1990, continued reduction can be expected, particularly in the electric utility sector, if the economic advantages of alternate fuels and conservation continue.

For the purpose of this study, OTA determined the technology (alternate fuels, conservation) and investment necessary to eliminate this 2.6-MMB/D usage during the 1990's. This is about the same level of reduction that can be achieved by going from a new-car fleet average of 30 miles per gallon (mpg) in 1985 to an average of 65 mpg in 1995, * and is close to the target synthetic fuels production level by 1992 set forth in the Energy Security Act.[4] Therefore, it provides a good comparison for the remainder of the study. The rest of this chapter describes how this elimination might be achieved and what it might cost.

*See ch. 5, p. 127.

[4]42 USC 8701, Energy Security Act, June 30, 1980.

First, fuel switching alone is considered, and second, conservation. OTA did not attempt to estimate a timetable other than to assume that the reductions take place throughout the 1990's. This is consistent with the time needed to introduce similar savings from increased auto efficiency or from synthetic fuels production. * Where possible, serious time constraints that may appear are mentioned. The focus, however, is on investment costs and resource requirements. It is important to emphasize that because OTA's calculations were based on the EIA 1990 forecast, costs of fuel switching and conservation necessary to go from the 1980 to 1990 levels of fuel oil consumption were not counted. This somewhat arbitrary decision will bias against conservation and fuel switching, since the least costly steps are expected to be taken first, during the 1980's.

*See ch. 5, p. 127; ch. 6, p. 177.

FUEL SWITCHING

The prime candidates for eliminating this 2.6 MMB/D of fuel oil by fuel switching are natural gas, coal, and electricity from coal and natural gas. Indeed, a considerable amount of the oil now used by industry (about 20 percent) is a result of converting from natural gas to oil during the mid-l970's.[5] This was partially a result of the Federal curtailment policy for natural gas that gave low priority in many industrial applications (primarily boilers). Further, the uncertainty of supply that existed during that same period caused industry to switch other applications from natural gas to oil as well. In the buildings sector, "scarcity" of natural gas during the 1970's, combined with the rapid rise in its price, caused a temporary halt in the growth rate of natural gas use. There was no corresponding growth in petroleum use, however, unlike the case with industry, since electricity was the primary replacement energy.

[5]1980 Annual Report to Congress, Vol. 2, op. cit., pp. 65 and 107. This claim is inferred from these two tables which show a drop in natural gas consumption by industry between 1974 to 1979 of over 20 percent and a corresponding increase in industrial oil consumption.

Complete replacement of fuel oil in buildings by natural gas alone would require about 2.4 trillion cubic feet per year (TCF/yr), assuming current end-use efficiency. If only electricity were used, 425 billion kWh/yr of delivered electric energy would be needed assuming an end-use efficiency increase of 67 percent. * By 1990, most of the industrial processes that can use coal (primarily large boilers) will have been converted because of the large difference in coal and oil prices that currently exists.[6] If all the remaining fuel oil

*Assuming heat pumps (water and space) with a seasonal performance factor of 1.25 compared to oil furnaces with a seasonal performance factor of 0.75.

[6]*Cost and Qua/@ of Fuels for Electric Utility Plants, February 1981,* DOE/EIA-0075(81/02) (Washington, D. C.: U.S. Department of Energy, Energy Information Administration, 1981), p. 3.

used by industry were displaced by natural gas alone, 0.6 TCF/yr would be required, assuming no change in end-use efficiency. If electricity alone were used, about 120 billion kWh/yr of delivered electric energy would be needed, assuming a 50-percent increase in end-use efficiency. *

For electric utilities, residual fuel oil is primarily used in baseload steam plants, while distillate oil is used for peaking turbines. To replace the former by coal would require 135 million tons, and to replace the latter by natural gas would require 0.3 TCF/yr. ** Table 54 summarizes the amount of energy needed to replace oil in each sector, assuming that each substitute energy source is used exclusively.

The first question to ask is whether these substitute resources will be available. Forecasts for domestic natural gas production during the 1990's by Exxon and EIA are about 14 to 16 TCF/yr.[7] Of this, about 70 percent will come from existing reserves, while the remaining will come from new reserves including so-called unconventional gas; i.e., gas from tight sands, geopressured brine, coal seams, and Devonian shale. These latter resources are of particular interest since they are the likely source of any domestic natural gas, above that now forecast, that would be needed to replace stationary fuel oil during the 1990's.

*Assuming an end-use efficiency of 100 percent for electric heat, compared with 67 percent for oil-fired units. If combustion turbines are replaced by electric motors for mechanical drive a similar increase will occur.

**It was assumed that there would be no change in conversion efficiency upon replacing the residual and distillate oil generation by coal and natural gas generation.

[7] *Energy Outlook* 19802&X.1 (Houston, Tex.: Exxon Co., U. S. A., December 1980), p. 10; 1980 *Annual* Report to Congress, *Vol.* 3, DOE/EIA 01 73(80)/3 (Washington, D. C.: U.S. Department of Energy, Energy Information Administration, 1980), p. 87.

EIA currently forecasts unconventional gas production increasing from 1.3 TCF in 1990 to 4.4 TCF in 2000 at a production cost of about $5.50 to $6.50/MCF (in 1980 dollars).[8] EIA predicts, however, that additional volumes of unconventional gas will become available in the 1990's if natural gas reaches what would then be the world price of oil (about $56/bbl in 1980 dollars). The National Petroleum Council recently made a similar claim, predicting as much as an additional 10 TCF/yr becoming available by 2000.[9] Therefore, it appears that production of an additional 3.3 TCF/yr (relative to that now forecast by EIA and Exxon) could be possible by the mid-l990's at gas production prices equivalent to about $56/bbl of oil (1980 dollars).

These cost estimates are subject to a great deal of uncertainty, however, and the actual cost of this unconventional gas could be considerably higher. There is less uncertainty about the ability to produce this gas increment from unconventional sources—particularly tight sands–but other alternatives, including synthetic natural gas from coal, may be cheaper.

Next, consider electricity. Current generation capacity in the United States is 600,000 MW (including 100,000 MW using oil) operating at an overall capacity factor of 45 percent.[10] Although increasing the capacity factor to 65 percent while concurrently converting all oil units to coal would provide the quantity of electricity needed (see table 54), that path may not be practical. The pro-

[8] 'i bid., p. 88.

[9] *Unconventional Gas Sources, Executive* Summary, (Washington, D. C.: National Petroleum Council, December 1980), p. 5.

[10] *Electric* Power *Supply and* Demand, 1981-*1990* (Princeton, N. J.: National Electric Reliability Council, July 1981).

Table 54.-Summary of Energy Requirements for Displacing 1990 Fuel Oil

	1990 petroleum forecast (EIA) (MMB/D)	Replacement energy sources: Natural gas (TCF)	Electricity (billion kWh)	Coal (million tons)
Buildings.	1.2	2.4	425	—
Industry.	0.3	0.6	120	—
Utilities	0.9 (residual)	—	—	135
	0.15 (distillate)	0.3	—	—
Total	2.55	3.3	545	135

SOURCE: Office of Technology Assessment.

file describing the fuel oil load of buildings for heating peaks rather sharply during the winter, and nearly all of the electric energy required to replace fuel oil would need to be generated during the 5 months of the heating season. Since the load profile is the primary determinant of the capacity factor, conversion to electric space and water heating will likely do little to increase the overall capacity factor. Therefore, as much as 120,000 MW of new capacity may be needed.*,

The ease with which this much capacity could be added depends on the growth rate for electricity for the remainder of the century in the absence of this oil-to-electricity conversion (underlying rate), and the financial health of the electric utility industry. These two points are obviously related because an industry which has difficulty raising capital, as is now the case,[11] will have difficulty meeting new generation requirements of any kind. Currently forecasts of the electric demand growth rate range from near zero (by the Solar Energy Research Institute (SERl))[12] to about 3.8 percent per year (by the National Electric Reliability Council).[13]

In the latter case, capacity additions become so great during the 1990's that the full increment of capacity needed for fuel oil replacement (120,000 MW) could be met if the underlying rate dropped to 3.2 percent per year but the utilities continued building at 3.8 percent per year. If growth of electricity demand in the absence of our hypothetical fuel switching dropped to 2 percent per year, a capacity addition rate of 3 percent per year would meet both underlying demand and the fuel-switching demand. Under these conditions, annual capital requirements would be approximately $25 billion to $35 billion (1980 dollars) and annual capacity addition would average about 27,000 MW. These are values below those attained by the utility industry during the early 1970's.[14] This is manageable provided the current financial problems are solved. If not, providing the replacement electricity from new capacity is unlikely.

Finally, there is the question of conversion of the electric powerplants that will still be burning oil in 1990 to other fuels (primarily coal). There should be little difficulty producing the extra coal for conversion of the plants burning residual fuel oil.[15] Further, as seen above, the natural gas could be available as a fuel in those plants burning distillate. There are barriers to converting existing plants including environmental problems of coal, the technical problems in actually converting many of these powerplants, and difficulties in financing the conversion projects. In many cases it may be less costly to build a new powerplant at a different site and retire the existing oil-fired plant.

Considering the physical requirements alone, however, there could be adequate supplies, during the 1990's, to replace 2.6 MMB/D of distillate and residual fuel oil by some combination of natural gas and electricity along with coal (or possibly nuclear) to replace the oil-fired electric utility boilers.

Although the cost of this process is difficult to calculate, it is possible to make an estimate by making several arbitrary, but plausible assumptions based on the above analysis and current operating conditions. First, it is assumed that natural gas replaces all of the fuel oil used by industry and utility combustion turbines, and half the heating oil used by buildings. Second, it is assumed that electricity is used to replace the other half of the heating oil used by buildings. Finally, all electric powerplants using residual fuel oil are replaced by coal conversions or new coal-fired powerplants. Table 55 summarizes the replacement energy requirements for this scenario.

To estimate the costs of eliminating this 2.6 MMB/D of fuel oil by fuel switching, the following costs (in 1980 dollars) for the replacement energy were used:

*This is the capacity required to produce 545 billion kWh operating at the current coal-fired average capacity factor of 52 percent.

[11] "The Current Financial Condition of the Investor-Owned Electric Utility Industry and Possible Federal Actions to Improve It, " Edison Electric Institute before the Federal Energy Regulatory Commission, Mar. 6, 1981.

[12] *Building a Sustainable Future*, Vol. z, prepared by the Solar Energy Research Institute, Committee on Energy and Commerce, U.S. House of Representatives, Washington, D. C., April 1981, p. 837.

[13] *Electric Power Supply and Demand, 1981-1990*, op. cit.

[14] *Electrical World*, Sept. 15, 1980, P. 69.

[15] *The Direct Use of Coal*, OTA-E-86 (Washington, D. C.: U.S. congress, Office of Technology Assessment, April 1979).

Table 55.—Annual Replacement Energy Requirements[a]

	Buildings	Industry	Electric utilities	Total
Natural gas (TCF) . . .	1.2	0.6	0.3	2.1
Electricity (billion kWh)	225	[b] –	—	225
Coal (million tons) . .	–	–	135[c]	135

[a]Assumes an increase in end-use efficiency of 67 percent when switching from fuel oil to electricity for space or water heating and no change when switching from fuel oil to natural gee in any of the three sectors.
[b]Requires 50,000 MW operating at a 50 percent capacity factor.
[c]Assumes the 1990 oil-fired capacity, which is now forecast to operate at a 35 percent capacity factor (NERC), can be replaced by 55,000 MW of coal-fired capacity operating at 57.5 percent capacity factor.

SOURCE: Office of Technology Assessment.

1. New coal-fired electric powerplants cost $900/kW, including all necessary environmental controls.[16]
2. Investment costs for natural gas from unconventional sources (tight sands) are approximately $16,500/MCF per day.[17] Operating costs, including transmission and distribution, are about $1.30/MCF.[18]
3. The investment cost for new coal surface mines is approximately $9,000/ton of coal per day. Operating costs are about $6.50/ton.[19]
4. The cost to convert oil fired capacity to coal is estimated at $600/kW.[20]

All of these costs are in 1980 dollars. Therefore, they will underestimate the actual costs of conversion in the 1990's to the extent there are real increases in these costs between new and the mid-1990's. Cost estimates are also needed for the end-use equipment. This was simplified by assuming no change is needed for industry and combustion turbines in converting from distillate to natural gas. For buildings, heat pumps are used when electricity is the new energy source, and new gas furnaces are used for natural gas. Based on current retail estimates these costs are $2,000 and $1,200, respectively (1980 dollars), for units capable of delivering 100 million Btu of heat per heating season, and having the capacity to meet the peak-hour heating load.[21] Table 56 summarizes the investment costs per barrel per day replaced for each sector.

The total investment, obtained by multiplying the per unit investment (table 56) by the amount of oil replaced (table 55), is about $230 billion (1980 dollars). These estimates include production of the energy resource (electric generating plants, natural gas, and coal mines) and end-use equipment when needed. They do not include costs to construct new transmission and distribution facilities that might be needed. This omission will be discussed below.

[16]*Technical Assessment Guide,* EPRI PS-1 201 -SR (Palo Alto, Calif.: Electric Power Research Institute, July 1979), pp. 8-11.
[17]*Unconventional Gas* Sources, Tight Gas Reservoirs, Part 1, op. cit., pp. E-1 15.
[18]" Natural Gas Issues" (Arlington, Va.: American Gas Association, May 1981), p. 8.
[19]"Comparative Analysis of Mining Synfuels" (Los Angeles, Calif.: Fluor Corp., 1981).
[20]"The Regional Economic Impacts on Electricity Supply of the Powerplant and Industrial Fuel Use Act and Proposed Amendments" (Washington, D. C.: Edison Electric Institute, April 1980), p. 37.
[21]Academy Airconditioning Co., Rockville, Md., private communication.

Table 56.—investment Costs For Fuel Oil Replacement Energy[a b]

	Buildings	Industry	Utilities
Natural gas	121,000	100,000	90,000
Electricity.	110,000	–	–
Coal.	–	–	54,000

[a]Dollars per barrel of oil replaced per day.
[b]Includes investment cost necessary to upgrade the replaced residual fuel oil to gasoline and diesel where applicable. Cost is $14,000/bbl of residual per day on the average, Purvin and Gertz, Inc., An Analysis *of Potential* for *Upgrading Domestic Refining* Capacity, prepared for the American Gas Association, Arlington, Va., March 1960.

SOURCE: Office of Technology Assessment.

CONSERVATION

The other major alternative for reducing oil use in the stationary sectors is conservation. Conservation cannot completely eliminate fuel oil use by itself–but it can reduce it, and possibly free enough natural gas and electricity to substitute for the remaining fuel oil. There have been numerous estimates of conservation potential for buildings and industry in the past several years.

The most detailed analysis is that recently completed by SERI.[22]

The SERI estimates are used to examine the possibility of and potential costs for eliminating stationary uses of fuel oil over the period 1990-2000. OTA has used the SERI analysis of conservation measures in the buildings sector to obtain an approximation of the costs of eliminating the remaining stationary uses of fuel oil in all sectors in the 1990-2000 period. These conservation measures reduce the use of fuel oil, electricity, and natural gas. The electricity and natural gas saved is used to replace the fuel oil remaining after the conservation. In table 57, the SERI projection for 2000 is given, by fuel, along with the savings obtained relative to the 1990 baseline demand (EIA forecast). The savings are the difference between the SERI 2000 projection and the EIA 1990 forecast. * As shown in table 57, conservation could eliminate 67 percent of the fuel oil used by buildings and provide more than enough natural gas to eliminate the remaining fuel oil used in both buildings and industry, as well as distillate used by electric utilities. Finally, enough electricity would be saved to replace the electricity produced by oil-fired generation (see table 54). The amount of natural gas and electricity needed to do this are given in the last column of table 57. About 65 percent of the SERI estimated savings for the buildings sector alone will achieve the goal.

The SERI study estimated an investment cost of $335 billion (in 1980 dollars) to achieve their savings goals for 2000. *[23] If we arbitrarily allocate these costs to the portion of the savings needed solely for fuel oil elimination, the cost investment for the scenario is about $215 billion (65 percent of total). In addition, investment is needed in converting end-use equipment from fuel oil to natural gas in buildings for oil not eliminated by conservation. Using the procedure described in the previous section, this amounts to about $10 billion. The total investment for these measures is $225 billion–equivalent to $88,000/bbl of oil replaced per day.

[22]*Building a* Sustainable Future, op. cit., pp. 5 and 6.

*By using the 1990 EIA forecast rather than the 1990 SERI projection as the starting point, we have compressed some of the savings calculated by SE RI. They assumed that much of the savings would occur between 1980 and 1990 with a result that their 1990 projection of fuel oil use is considerably below the EIA forecast. Our calculation does not change the net savings but only the period in which they could occur.

*Adjusted to reflect savings not accounted for by OTA's choice of base case.

[23]Ibid.

Table 57.—Energy Made Available by Conservation

Energy source	SERI demand estimate (2000)	EIA demand estimate (1990)	Savings by 2000	Savings used for oil substitution
Fuel oil (MMB/D)	0.4	1.2	0.8	—
Natural gas (TCF/yr).	4.5	7.8	3.3	1.7
Electricity (billion kWh/yr). .	1140	1580	440	250

SOURCE" Office of Technology Assessment.

DISCUSSION

The analysis described gives a plausible estimate of the technical and investment requirements of eliminating stationary uses of oil between 1990 and 2000. These requirements are not forecasts, as mentioned above, but only describe what is technically and economically within reason. There are several items, however, that were not considered in the calculation that will affect these costs somewhat. In this section some of the more important points are briefly discussed.

In calculating the costs of conversion to natural gas and electricity the possibility was ignored that new transmission and distribution equipment would be needed. This also holds for the conservation case, since natural gas freed by conservation would need to be delivered to sites formerly using fuel oil, and it is likely that new transmission and distribution facilities would be needed for some of those locations. A transmission and distribution operating cost for all the natural gas conversions was included but this is not likely to cover new construction where it is needed.

Similarly, the electricity made available by conservation may not be able to substitute for oil-fired capacity without the construction of new transmission lines. In a previous OTA study on solar energy,[24] the construction and operation costs of both electric and natural gas transmission and distribution systems were calculated. Using those values updated to 1980,[25] it was found in the worst case–electricity used to replace oil for heat in buildings—that the cost of oil replaced should be increased by about 20 percent. In all other cases the adjustment is less than 10 percent under the unlikely assumption that all the replacement energy requires new transmission and distribution facilities.

Another point concerns the choice of conservation estimates. The SERI study is the most optimistic of several analyses which attempt to calculate the potential for conservation under least cost conditions. The calculations in the SERI study, particularly for buildings, are based on the most complete analysis to date of the thermal characteristics of buildings, and include extensive experimental data. Therefore, these engineering and cost estimates can be considered as attainable.

Though the SERI calculations were used, it is not explicitly or implicitly claimed that SERI conservation targets will be reached. In an OTA study on building energy conservation recently completed it is estimated that only about 40 percent of the targets will be reached under current conditions.[26] A number of economic constraints and choices—including restrictive financial conditions, uncertainty of results, and high owner discount rates—will reduce the probability that these goals can be met. Even though it was not necessary to use the entire SERI estimate of savings to achieve OTA's hypothetical goal of eliminating stationary fuel oil use, more than two-thirds was still required. Therefore, while it is technically possible to eliminate all stationary fuel oil use through conservation, this is not likely to happen under current conditions.

The final point concerns conversion of oil-fired electric generation capacity to coal. Although the high end of the range of estimates for conversion costs was used, in some instances even this will be insufficient. There will be sites where conversion is impossible because of lack of coal storage facilities or inadequate coal transportation, or where excessive derating of the boiler would be necessary. In such cases, it will make more sense to retire the plant and replace it with new capacity built elsewhere. For these cases, the replacement cost will equal the cost of new capacity, including any needed transmission costs. It should be expected, however, that new coal or nuclear generation will have a much higher capacity factor than current oil generation because of the former's lower cost of producing energy.

it should be remembered, however, that the load profile will dictate the capacity factor to a great extent. With the large amount of capacity under discussion, it can be expected that there will be sufficient load diversity so that power transfers between regions will allow for an increase in capacity factor to a level that now exists for coal-fired powerplants (about 57 percent).

The possibility of power transfers was assumed and accounted for in the calculation by assuming the 57-percent capacity factor. The result is that less capacity is needed to replace the electricity produced by the oil-fired generation that is expected to be on-line in 1990. To some degree this capacity reduction will take care of some of the site-specific problems described above.

Another point to be considered is whether coal-fired electricity will be less expensive than that generated from residual fuel oil in the 1990's. Because of the continuing decline in crude oil quality[27]—i.e., lower gravity—it will be increasingly

[24] *Application* of solar Technology to Today's *Energy* Needs, *Vol.* 1, OTA-E-66 (Washington, D. C.: U.S. Congress, Office of Technology Assessment, June 1978), p. 140.

[25] *Oil and* Gas *Journal,* Aug. 10, 1981, p. 76.

[26] *The Energy Efficiency* of Buildings in Cities, OTA-E-168 (Washington, D. C.: U.S. Congress, Office of Technology Assessment, March 1982).

[27] *Oil and Gas Journal,* Apr. 20, 1981, p. 27.

more costly to refine this oil up to the point where no residual oil remains. Currently, the average cost of converting residual fuel oil to middle distillates and gasoline is about $10,000 to $14,000/bbl/d.[28] The marginal cost, however, is much higher and will grow as more and more residual oil is transformed and as the crude oil feed becomes heavier.

[28] *An Analysis of Potential* for Upgrading Domestic Refining Capacity, op. cit.

Consequently, it is possible that it would be cheaper to use the residual oil directly in boilers, as it is used now, and produce the lighter fuels from oil shale or by way of methanol from coal. To reach that point, residual fuel oil would have to be priced below coal as a boiler fuel because the residual oil would have no other market. No attempt was made to determine when or to what extent this may occur.

SUMMARY

Elimination of fuel oil use in the stationary sectors (buildings, industry, electric utilities) appears to be technically plausible by 2000. The cost for either the conservation or fuel-switching scenario would be high. As shown, the total cost for the 1990-2000 period would be about $225 billion to $230 billion to eliminate the 2.6 MM B/D forecast still to be in use by 1990. These costs are consistent with estimates for synthetic fuels production and automobile efficiency improvement that would produce about the same amount of oil. * In addition, reduction from current use of 4.4 MMB/D to the 1990 level will also require several tens of billions of dollars. As noted earlier, the 1980-90 costs were not taken into account in the calculations.

Uncertainties about these estimates for stationary fuel oil elimination by conversion arise from changes in powerplant construction costs, in coal prices, in the cost of producing natural gas from tight sands, and in the discovery rate of new natural gas. All or any of these could cause significant swings in the cost of displacing oil, most likely upward. In the absence of information about these uncertainties, the estimates given here, which represent the best analyses to date, can be considered as reasonable. Similarly, for conservation, uncertainties about the conservation potential of buildings exist which can only be cleared up as more and more buildings are actually retrofit. Preliminary audits of buildings already retrofitted have indicated a range of energy savings from 80 percent less than predicted to 50 percent more.[29] The sample for this measurement was small, but it does indicate the level of uncertainty.

The estimates that were derived are plausible targets. They are not forecasts or even necessarily desirable goals. That will have to be decided within the context of all the economic choices possible and within the country's policy objectives about oil imports.

*See ch. 5, p. 139; ch. 6, p. 172.

[29] *Energy Efficiency* of Buildings in Cities, op. cit.