The Competition Between Coal and Natural Gas: The Importance of Sunk Costs
by
A. Denny Ellerman

MIT-CEEPR 96-005 WP        July 1996
THE COMPETITION BETWEEN COAL AND NATURAL GAS: THE IMPORTANCE OF SUNK COSTS

A. Denny Ellerman
Center for Energy and Environmental Policy Research
One Amherst Street (E40-279)
Massachusetts Institute of Technology
Cambridge, MA 02139-4307
Tel: 617-253-3551
Fax: 617-253-9845
ABSTRACT

This paper explores the seeming paradox between the predominant choice of natural gas for capacity additions to generate electricity in the United States and the continuing large share of coal in meeting incremental generation, despite little new coal capacity and the aging of existing plants. The explanation offered here relies upon a consideration of the factors which affect fuel choice in new and existing plants, and decisions about retirement and the expansion of capacity to meet load growth. The sunk costs of past investment are an important unifying theme in the explanation.

KEYWORDS: Natural Gas, Coal, Electricity, Fuel Choice

ABBREVIATED TITLE: Competition Between Coal and Natural Gas

ACKNOWLEDGMENTS

Financial support from the Center for Energy and Environmental Policy Research at the Massachusetts Institute of Technology and the U.S. Environmental Protection Agency is gratefully acknowledged.
INTRODUCTION

This paper explores a paradox concerning coal and natural gas in the electric utility fuels market in the United States. Almost all new additions to generating capacity are fired by natural gas, yet there is little increase in the generation of electricity by natural gas. In contrast, capacity additions for coal have ceased, yet coal-fired generation continues to increase and accounts for a large percentage of observed and projected incremental generation.

That natural gas is competing with coal is in itself remarkable given not-so-distantly-past views of the availability and expected price of natural gas. This competition is one aspect of the new economics of natural gas which is fully manifest in North America and increasingly so in Western Europe, particularly in the United Kingdom.

The next section of this paper touches briefly on the recent changes in the economics of natural gas and presents the paradox arising from the competition between coal and natural gas in the electric utility fuels market. Subsequent sections discuss the economic considerations governing fuel choice, the replacement of aging capacity, and the choice of generating unit to meet load growth. Sunk costs are a unifying theme in this discussion. Although economically irrelevant for current fuel choice, the influence of sunk costs, like so much that is past, strongly affects the present.
THE NEW ECONOMICS OF NATURAL GAS

Over the past few years, it has become obvious that natural gas is not a fuel so scarce that it is too valuable to burn under a boiler, much less one that would sell at a premium to distillate because of its environmental qualities. The reason is simply that natural gas is more abundant than was believed to be the case as little as ten years ago. Since the deregulation of wellhead prices in the late 1980s, U.S. reserve estimates for natural gas have more than trebled (Fisher, 1994); and the price of natural gas has settled at levels that would have been viewed earlier as unrealistically low.

The lower actual and expected price for natural gas has coincided with a technological innovation that favors natural gas: aero-derivative combined-cycle combustion turbines. An important aspect of this technology is that the fuel must be in liquid or gaseous form. Although a combined cycle facility can be based on coal, the coal must be gasified first; and the cost of coal gasification renders IGCC (integrated gasification and combined cycle) uneconomic when compared with the same turbine using newly abundant natural gas. This innovation in generation technology has reduced the initial capital outlay in comparison both with coal and with the gas-fired steam cycle and improved the efficiency of converting primary energy into electricity.

For coal, the new economics of natural gas introduce a competitor for the electric utility fuels market. The combination of lower actual and expected prices, lower capital cost, and improved efficiency has made natural gas the economic
choice for new generating capacity in most regions of the United States. This is not
the first time that coal has faced serious competition in this market, but the
circumstances are now very different from the preceding, almost halcyon years when
high oil prices, opposition to nuclear power, and the earlier view of natural gas
availability, (enshrined temporarily in legislative bans of natural gas use) made coal
the only alternative for electric utilities.

The change in the economics of natural gas has had a marked effect on the
choice of new generating capacity. Figure 1 presents intended ten-year forward
capacity additions in the United States as projected each year from 1987 through
1995 by electric utilities and reported to the North American Electric Reliability Council
(NERC). Over these years, the share of projected coal and nuclear additions has
fallen from 74% to 8%, while that for oil and gas has risen from 4% to 59% and the
non-utility generator (NUG) share from 18% to 30%.\(^2\) Not only is there a notable
change of intentions, but actual capacity additions observed in the 1990s reflect the
same economics. From 1990 through 1994, coal capacity actually declined slightly,
by 4.0 GW\(^e\), while gas and dual-fired capacity increased by 12.1 GW\(^e\) and NUG
capacity increased by 13.5 GW\(^e\).

Figure 2 shows that the projected changes in incremental generation are not
as pronounced as the change in net capacity additions. In this figure, incremental
generation is the expected change in generation by source for the next ten years as
predicted in each of the years indicated. For instance, in 1986, coal and nuclear
power were predicted to contribute 42% and 44%, respectively, of incremental
generation over the next ten years, electric utility oil and gas-fired generation, 2%, and non-utility generation, 19%. Since about 50% of NUG capacity is gas-fired, the predicted contribution of natural gas to incremental generation in 1987 was probably slightly above 10%. In 1994, the corresponding percentages of projected 10-year-ahead incremental generation are: coal, 45%; nuclear, 7%; electric utility oil and gas, 23%; and non-utility generators, 22%. Expected electric utility use of oil and gas has increased markedly, but what is particularly notable is that coal’s share is so large when there is projected to be so little new coal capacity. With a 45% expected increase in generation and only 8% more capacity, a 34% increase in average utilization is implied despite what will be considerably older stock of coal-fired powerplants.

The contrast between capacity additions and incremental generation is even greater when actual experience in the years 1990 through 1994 is observed. Figure 3 shows the percentage changes in capacity and generation by source during these years for the United States. The increase in NUG and electric utility oil/gas capacity is greater than the total addition to generating capacity at the expense of coal and hydro/geothermal/other. In generation, coal accounts for 40% of incremental generation and nuclear plants for another 30%. Electric utility oil and gas use is slightly negative, but when the likely natural gas component of the NUG contribution is taken into account, about 20% of the increase in generation over these four years can be attributed to natural gas.
It bears noting that the challenge presented by natural gas to coal has little to do with environmental considerations. Natural gas is an attractive choice today because of its lower price (compared with earlier prices and expectations) and the reduced capital cost and greater conversion efficiency of combined cycle technology. Undoubtedly, environmental regulation has some effect on the choice between coal and natural gas, but that effect is small in comparison with fuel prices, capital costs, and heat rates, or the basic factors that govern fuel choice in existing and new plants.

THE FUNDAMENTALS OF FUEL CHOICE

The choice of fuel depends both on the price of the competing fuels and on technical considerations that influence how those fuels can be used to produce electrical energy. When compared with petroleum products or natural gas, coal has a considerable technical disadvantage. It is a less concentrated form of energy so that more elaborate combustion equipment and processes are required to handle the larger amount of non-combustible matter and water that is bundled with the hydrocarbon content. As a result, coal-fired generating units will have higher capital cost and higher non-fuel operating cost than competing gas- or oil-fired units.

The economic magnitude of this technical disadvantage is shown in the first two columns of Table 1 which provides a representative comparison of expected unit costs for generation from a new coal-fired powerplant with flue gas desulfurization and from a new gas-fired combined cycle combustion turbine. With comparable assumptions about utilization and capital charge rates, the non-fuel costs of coal-fired
generation are more than three times that of the gas combined cycle plant. This ratio can vary reflecting location and plant-specific factors, but the non-fuel component in the total cost of a coal-fired kilowatt-hour will always be considerably higher than the same cost component from a generating unit fired by oil or natural gas.

While coal suffers from this fundamental cost disadvantage whenever the choice involves new generating capacity, the disadvantage is much less once the plant is built and the capital costs have been sunk. For instance, in the example provided above, approximately five-sixths of the disadvantage in non-fuel cost is fixed cost that does not figure in decisions about the choice of fuel or the dispatch of generating units once the investment of capital has been made. At the fuel prices given, the variable generating cost of the new coal plant (with scrubber, as required by new source performance standards) is about a mill cheaper than the comparable cost for the higher efficiency combined cycle plant. Thus, when the capital is in place and where the fuel price relation is similar to this example or more favorable to coal, a coal plant will be dispatched ahead of a combined cycle gas plant.

The effect of sunk costs is also evident in the comparison of the new green-field plants with the estimates of the cost of generation from fully refurbished and life extended brown-field plants as shown in the last two columns of Table One. Although a new gas-fired plant is typically cheaper on a total cost basis than a new coal-fired plant, a fully-life-extended existing coal-fired plant is cheaper still on the same basis. Because of sunk costs, a much smaller investment is required to make
an existing plant like new than is necessary to build an equivalent new plant from the ground up.

Obviously, if the expected price of gas is high enough, gas-fired plants would not be the choice for new capacity, and conversely, if the price of gas is low enough, it can displace coal even from existing plants. The current situation in North America falls between these two extremes. Although there are always exceptions, in general, gas-fired generation is less expensive than coal on a total cost basis, but more expensive on a variable cost basis. Accordingly, natural-gas fired plants are typically the choice in new plants, where capital costs must be considered; but coal remains the fuel of choice in existing plants, where capital costs are sunk.

The implications for the demand for generating fuel of this intermediate case are less clear than if natural gas prices were either very high or very low. Nevertheless, as the maintenance cost for aging plants rises and as load growth continues, the demand for new capacity, and by extension incremental generation and fuel demand, might be expected to follow the simple schematic presented at Figure 4. Natural gas capacity and generation would increase over time, and coal capacity and generation diminish, as determined by the rates of retirement for the aging plant and the rate of load growth.

THE ECONOMICS OF PLANT REPLACEMENT

The rate of replacement of existing plant is not predetermined by physical decay or accounting rule, but depends on an economic comparison of the avoidable
costs associated with continued operation and with replacement. In general, a plant will be replaced when the maintenance requirements are such that the variable cost of its output is greater than the total (including capital) cost of similar output from a new plant.

The difference between the total cost of a new replacement plant and the non-maintenance operating cost (principally fuel) of the existing plant, including any option value, will govern how much maintenance expenditure can be justified. The greater this difference, the greater the incentive to keep the existing plant in service. Where the fuel is the same for the existing and the replacement plant, this difference is roughly equal to the capital cost associated with the new plant; but where the fuels are different, any savings in fuel cost associated with the existing plant justifies more maintenance and a longer life for the existing plant. Furthermore, anything that makes the new plant more costly, such as differential environmental standards or a NIMBY-inspired resistance to new facilities, retards the rate of replacement and has the effect of extending the life of the existing plant; and conversely, anything that reduces the cost of new plant, such as technological advance, increases the rate of replacement and shortens the life of the existing plant.

The relation between time or cumulative use and maintenance will also be important. If maintenance cost rises linearly as a function of time or cumulative use, then replacement will occur inevitably. However, if the relationship is asymptotic, in that there is a level of expenditure that will maintain the existing plant indefinitely, replacement is not inevitable, but will depend on the comparison between the total
cost of the new plant and the variable costs associated with the perpetually life extending asymptote for maintenance cost. If the asymptote is such that the cost of continued operation is less than replacement, existing plant would become like the woodsman's axe that was the same though the head and handle had been replaced many times.  

There is little evidence in the United States that existing coal-fired capacity is being retired. Figure 5 gives the age distribution of electric utility coal-fired capacity at the unit level in 1985 and in 1994. Total coal-fired capacity in 1994 is 295.8 GW, only 0.5 GW less than the sum of the 274.6 GW existing in 1985 and the 21.8 GW of new additions in the intervening years. The effects of the renewed attractiveness of natural gas can be seen in the sharply reduced increments of capacity in the recent years of the 1994 age profile, but otherwise the 1985 age profile has shifted out nine years. The shift can be expressed in terms of the amount of existing capacity in plants older than thirty-five years. In 1985, only 1% of coal-fired capacity was more than 35 years old, but that percentage had risen to 12% by 1994.

Current indications of retirement decisions imply that the ratio will become even larger over the next ten years. Table 2 shows projected unit retirements by source of generation as reported to NERC for the 1995 ten year forward forecast and compares the retirements to the capacity in place in 1994. The retirement rate of 0.6% for all plant, regardless of fuel source, is exceedingly low. Seventy percent of those retirements are oil and gas units, but even as a percentage of that capacity, the rate of 1.73% is low, particularly when the age of the oil and gas-fired generating stock
is considered. For the coal-fired plant, the rate of replacement is negligible. Given the age distribution in 1994, this forecast indicates that the percentage of coal-fired plant older than 35 years will have risen to about one-third by the year 2004, and that more than ten percent of that capacity will be in excess of 45 years old.

It bears noting that these very low projected rates of retirement apply to all plants; and that the highest (but still very low) rates of retirement are observed for the plants which are not only older, but also have the highest fuel cost. The retirement intentions revealed by these forecasts suggest that the continued use of existing plant compares favorably with the cost of a new plant, regardless of the fuel used in the existing plant.\(^1\) A similar conclusion is suggested by the data on Table One which indicate that it would be cheaper to refurbish and life extend existing units, whether coal or gas, than to build a new, more efficient combined cycle unit.\(^2\) In view of this evidence, it appears unlikely that demand for new plant as a replacement for aging plant will be significant, and we must look to load growth as the source of demand for new plant and the associated demand for natural gas.

**THE ECONOMICS OF MEETING LOAD GROWTH**

The substantial seasonal and diurnal variation of electricity demand permits a distinction between peak and off-peak periods. Load growth typically raises both peak and off-peak demand, but the peak is what requires new capacity since off-peak is a period of idle capacity by definition. The most obvious way to accommodate the peak is to build peaking capacity for which economic considerations will dictate as
little capital expenditure as possible since utilization will be low. With the current set of technological possibilities and fuel price relationships, such capacity will be older units that can be cheaply maintained and rapidly brought on and off line or combustion turbines fueled by natural gas or distillate.\textsuperscript{13}

The need for new off-peak capacity is never as urgent, technically, as that for peak capacity; but the peak constraint can be and has been relieved by building new baseload capacity. If greater efficiency or cheaper fuel costs are associated with the new baseload capacity, such that there are savings in the cost of generation in the off-peak periods, it may make sense to build new baseload plant to reduce costs as well as to relieve the peak. More generally, the decision about meeting the increase in off-peak demand depends on the comparison between the cost of increased utilization (as distinct from continued use) of existing capacity and the cost of a new plant. New plant will be built to meet load growth when the total cost of generation from the new plant will be less than the avoidable costs of increased utilization at existing facilities less some credit for not having to build additional peaking capacity.

The considerations involved in deciding upon capacity to meet load growth are similar but not identical to those which apply to the replacement of existing facilities. In both instances, the critical comparison is between the variable cost of existing facilities, without consideration of already sunk capital cost, and the total cost, including capital cost, of a new plant. Furthermore, the decision to add new capacity is triggered not so much by any engineering, technical or system considerations, as arguably exists with peak demand, but by the extent of the increase in the cost of
generation from the existing facility as utilization is increased. By the same token, anything that raises the cost of new capacity will justify higher utilization of the existing plant, as well as continued use; and facilities that can use lower cost fuel than the new plant will justify higher utilization and longer use.

Decisions to build new plant to meet load growth and to replace aging plant are not only formally similar but they may be practically inseparable. If maintenance cost is monotonically rising with cumulative use, more intensive utilization would only hasten replacement, since greater utilization necessarily increases cumulative use. This connection may be broken however, if maintenance cost rises to some asymptote and the higher cost of increased utilization is caused by reasons other than wear and tear. In such a case, there would be no demand for new plant as replacement, but new plant would be needed when load growth pushes utilization to the point where the cost of generation from the existing plant is more than that from a new baseload plant.

The economic considerations concerning decisions about how to meet load growth help to explain why coal figures so prominently in observed and projected incremental generation while new capacity is overwhelmingly gas-fired. In fact, the new gas-fired capacity put in place over the past two years consists mostly of combustion turbines as shown by Figure 6. Electric utilities are building new capacity principally to accommodate the ever rising peak, but are meeting growth in off-peak demand by increased utilization of existing plant. Figure 7 presents observed and projected capacity utilization for coal-fired generating units.¹⁴ Utilization in 1994 is
substantially above the 1986 expectation for 1994, and above the prediction for 1994 in every subsequent year, and it is now projected to rise to nearly 75% by the year 2004. The steady shift in actual and projected utilization effectively substitutes for new capacity to meet load growth. Evidently, for the next decade, utilization can be increased without generation cost rising sufficiently to call for new baseload or cycling capacity.

CONCLUSION

The paradox of the continuing growth in the use of coal for the generation of electricity despite the marked shift to natural gas for new capacity additions is largely explained by the economic considerations which govern replacement and utilization decisions. The trends now manifest can be viewed as paradoxical only when compared with the patterns that prevailed prior to the 1970s when the utilization of existing plant diminished with age and old plants were replaced.

The difference in the role of aging plant prior to the 1970s and now can be explained by the comparison between the variable cost of existing plant and the total cost of new plant. Although regulatory incentives may have created a bias for new plant prior to the 1970s, the most obvious explanation for the diminishing use and replacement of aging plant in those years was the continuing cost-reducing improvements embodied in new plant that made the existing plant technologically obsolescent and economically inefficient. When these improvements came to an end in the 1970s, the value of existing plant was enhanced. Other developments also
increased the incentive to maintain and to utilize existing coal-fired plant more intensively. Mention has already been made of the explicit and implicit bias of environmental legislation and regulation against new facilities. A further factor increasing the utilization of coal-fired plants has been the pronounced and continuing decline in the delivered price of coal since the late 1970s, due both to rail deregulation and to productivity improvements in coal mining. Although gas prices have also fallen, the decline has not been nearly as great or as persistent as the reduction in the price of coal.

The new economics of natural gas mean that coal will no longer be the bridge to the future, to use a metaphor from an earlier era. The idea that synthetic fuels from coal would provide a substitute for petroleum products has long since faded from view. Now, in coal's last redoubt, the electric utility fuels market, the new economics of natural gas will create a future that will be shared, but emphasis must be placed on the sharing. With present price relations, new generating capacity will be mostly gas-fired, whether for peaking duty or baseload generation, but coal use will not fade away because of low fuel cost and the fact that the capital is already in place, and coal use appears likely even to increase because of the favorable economics for more intensive utilization of existing plant.

Sunk costs largely explain the apparent paradox between current and projected additions to capacity and incremental generation. The importance of sunk costs resides not in any present cost that figures in economic calculations, but in the way that those past, sunk costs condition today's choices. Coal could not be used if the
capital required to convert this relatively unconcentrated form of energy into electricity were not in place. The fact that those costs are sunk means that coal's great disadvantage is removed. This capital stock is, like other inheritances, a gift that has value only to the extent that its use avoids other expenditure. Where greater expenditure is avoided, its employment is an efficient use of available resources, and a reminder of the enduring influence of the past on the present.
BIBLIOGRAPHY


__________________________, Monthly Energy Review, various editions, Washington, D.C.

__________________________, Electric Power Monthly, various editions, Washington, D.C.

Gas Research Institute, Baseline Projection Data Book, 1996 Edition, Washington,
D.C.

Joskow, Paul L. (1987), "Productivity Growth and Technical Change in the Generation
of Electricity," The Energy Journal, 8:17-38.

____________________ and Nancy Rose (1985), "The Effects of Technological Change,
Experience and Environmental Regulation on the Construction Cost of Coal-burning

____________________ and Richard Schmalensee (1987), "The Performance of Coal-
North American Electric Reliability Council, *Electricity Supply and Demand Database*, various years, Princeton, N.J.
ENDNOTES

1 Senior Lecturer, Sloan School of Management, Massachusetts Institute of Technology and Executive Director, Center for Energy and Environmental Policy Research. Financial support from the U.S. Environmental Protection Agency and MIT's Center for Energy and Environmental Policy Research is gratefully acknowledged. An initial draft of this paper was presented at an international conference on Competitiveness and Sustainability in Natural Resource Exploitation organized by the Economics Research Program at Lulea University, Lulea, Sweden on May 29-30, 1996. Comments from Rod Eggert, Robert Pindyck, and the discussants at the Lulea Conference, Patrick Soderholm and Olle Eklund, are gratefully acknowledged.

2 In 1993, 67% of existing NUG capacity was oil or gas-fired and 15%, coal-fired. In the same year, 53% of NUG generation was from oil or gas units, and 16% of NUG generation came from coal units. See GRI, 1996, vol. 1, p. 345.

3 Hydro and geothermal generation was forecast to decline by 7% of the expected increase in generation from all sources.
This difficulty in using coal exists independently of how the post-combustion residuals are treated. Environmental requirements to treat the impurities associated with coal only increase coal's disadvantage.

The estimates of capital and operating costs are what would be required to make the existing plant like new.

Plants built initially for coal can be converted to oil or gas use with relatively little additional capital expenditure, whereas the converse is not true.

See Joskow and Schmalensee (1987) for evidence that aging plants are characterized by increasing heat rates and declining availability.

See Bitros and Kelejian (1974) and Cowing and Smith (1977) for similar conclusions in an earlier debate on this point.

The acronym for "Not-In-My-BackYard," often used to describe local opposition to changes of land use and the siting of new facilities.

I am indebted to Richard Schmalensee for this apt metaphor.

Joskow and Rose (1985) and Joskow (1987) provide evidence of a significant increase in the cost of new coal-fired generating units through the early 1980s.
The estimates of capital and operating costs are what would be required to make the existing plant like new.

The middle column of Table One provides representative cost data for a new combustion turbine.

Capacity utilization is measured as the ratio of actual generation to what would be generated if summer capacity were available and fully used throughout the year.

See Joskow (1987) for a discussion of the technical improvements in new coal-fired plants prior to the 1970s, the increase in costs thereafter and the resulting productivity trends.
FIGURE 2

U.S. ELECTRICITY GENERATION
PROJECTED 10 YEAR INCREMENTAL GENERATION

<table>
<thead>
<tr>
<th>Year</th>
<th>Nuclear</th>
<th>Coal</th>
<th>Hydro, Geo</th>
<th>OilGas</th>
<th>NUG/Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>1989</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1991</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1993</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1995</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Terawatt-hours
FIGURE 3

FUEL SHARES OF CAPACITY ADDITIONS AND INCREMENTAL GENERATION
U.S. ELECTRIC UTILITY INDUSTRY, 1990-94
FIGURE 4

New Capacity

Load Growth

Replacement

Existing Capacity

$to$ to $t$
# TABLE 1

**REPRESENTATIVE COST CALCULATIONS FOR GENERATING CAPACITY**

<table>
<thead>
<tr>
<th>Input Data</th>
<th>New Plant</th>
<th>Existing Plant</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coal Bit MS w/FGD</td>
<td>Combust Turb</td>
</tr>
<tr>
<td>Overnight K Cost ($/Kw)</td>
<td>$1,400.00</td>
<td>$564.00</td>
</tr>
<tr>
<td>Fixed O&amp;M ($/Kw)</td>
<td>$29.00</td>
<td>$8.00</td>
</tr>
<tr>
<td>Var O&amp;M (mills/kwh)</td>
<td>6.7</td>
<td>2.1</td>
</tr>
<tr>
<td>Heat Rate (Btu/kwh)</td>
<td>9,281</td>
<td>8,149</td>
</tr>
<tr>
<td>Cap Factor</td>
<td>68%</td>
<td>68%</td>
</tr>
<tr>
<td>K Charge Rate</td>
<td>15.0%</td>
<td>15.0%</td>
</tr>
<tr>
<td>Fuel ($/mmBtu)</td>
<td>$1.36</td>
<td>$2.25</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Per kWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>K Cost</td>
<td>$0.0353</td>
</tr>
<tr>
<td>Fixed O&amp;M</td>
<td>$0.0049</td>
</tr>
<tr>
<td>Var O&amp;M</td>
<td>$0.0067</td>
</tr>
<tr>
<td>NON-FUEL COST</td>
<td>$0.0468</td>
</tr>
<tr>
<td>FUEL COST</td>
<td>$0.0126</td>
</tr>
<tr>
<td>TOTAL COST</td>
<td>$0.0594</td>
</tr>
</tbody>
</table>


FIGURE 5

AGE PROFILE OF U.S. COAL-FIRED CAPACITY: 1985

AGE PROFILE OF U.S. COAL-FIRED CAPACITY, 1994
## TABLE 2

U.S. GENERATING CAPACITY
PROJECTED RETIREMENTS, 1995-2004, BY FUEL

<table>
<thead>
<tr>
<th>Planned for Retirement (MWe)</th>
<th>OIL/GAS</th>
<th>COAL</th>
<th>NUCLEAR</th>
<th>HYDRO/OTH</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage of Total</td>
<td>3,406</td>
<td>838</td>
<td>67</td>
<td>10</td>
<td>4,321</td>
</tr>
<tr>
<td></td>
<td>78.8%</td>
<td>19.4%</td>
<td>1.6%</td>
<td>0.2%</td>
<td></td>
</tr>
<tr>
<td>1994 Capacity (MWe)</td>
<td>196,173</td>
<td>289,647</td>
<td>99,124</td>
<td>86,406</td>
<td>671,350</td>
</tr>
<tr>
<td>Percent to be Retired</td>
<td>1.74%</td>
<td>0.29%</td>
<td>0.07%</td>
<td>0.01%</td>
<td>0.64%</td>
</tr>
</tbody>
</table>

Source: North American Electric Reliability Council 1995 Electricity Supply & Demand Database
FIGURE 6

U.S. ELECTRIC GENERATING CAPACITY
ADDITIONS BY TYPE, 1994-95

MWt

Coal   1151
Hydro  1008
Waste Heat  393
NG Turbine  3215
NG Comb Cycle  844
FIGURE 7

PROJECTED AGGREGATE UTILIZATION
U.S. COAL-FIRED GENERATING CAPACITY


1987
1988
1989
1990
1991
1992
1993
1994
1995

Actual