ENERGY OUTLOOK

VIRGINIA CENTER FOR COAL & ENERGY RESEARCH — WINTER 1998-99 / VOL. XVIII, NO. 1

Global Warming
Our two cents worth—after 1998

So here we are, six years after the Earth Summit in Rio de Janeiro and the signing of the Framework Convention on Climate Change. Four conferences of Parties to the Convention are behind us (the last two in Kyoto, Japan, December 1997 and Buenos Aries in November, 1998)—and 1998 saw a hot summer in the US.

Although El Niño diverted our attention somewhat over the past year, the debates over global warming continue, becoming more strident again as differing models predict widely varying economic consequences of reducing carbon dioxide emissions in the United States. Is an increase in global warming really occurring? If it is real, what effects will it have on our climate, our safety and our way of life—and how much of it is caused by human actions as distinct from natural phenomena? These are the questions that are argued vigorously.

The problem is that the responses to these questions so often seem to be based on less than rational perceptions. Charges of "industrial irresponsibility" are met with railings against "junk science." The arguments have become so polarized that there seem to be relatively few who remain truly objective. The most strident voices appear to be driven by motives other than scientific objectivity. In fact, it often seems that the further away the advocate is from the science, the stronger the opinion.

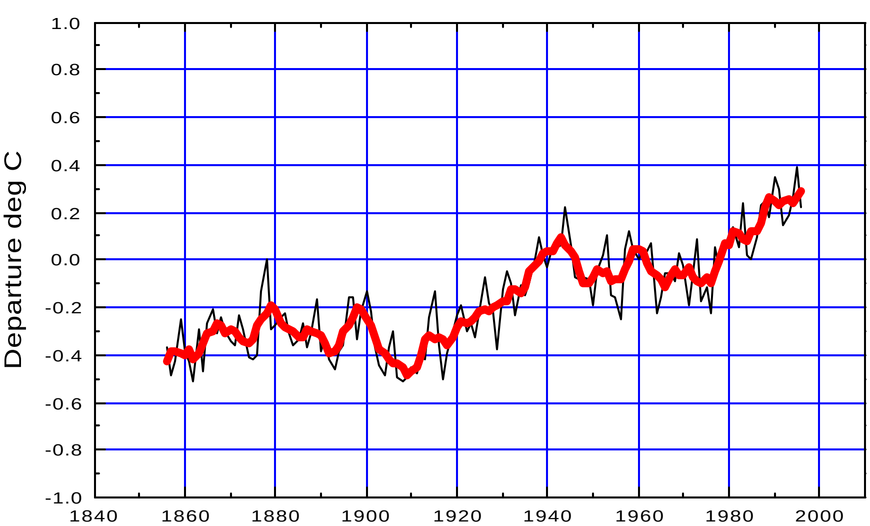

Figure 1. Trend of global average air temperatures measured at the surface of the earth. Results are given as differences from the 1960 value

Can the VCCER with its mandated interests in coal and energy be any different? Well, we do try to be fair and balanced in our output, sometimes to the chagrin of those we serve as well as our critics. So, following the warmth of 1998, here are our two cents worth on global warming, written in the knowledge that the manner in which it will be received will depend, to a large extent, on the preconceptions of the reader.

Climate Change

Is the climate changing? Sure it is, just as it has throughout the entire history of the earth. Sometimes the rate of change has been slow. Other periods have experienced more rapid transients and, very occasionally, there have been catastrophic events that produced step changes in the atmosphere, resulting in sudden redirections in the evolution of life-forms on the earth. Compared to many past millennia, we are currently experiencing a period of relatively quiescent climate, but changes will go on occurring whether we are here or not.

Atmospheric temperatures measured at the surface of the earth have been trending upwards for the past century. Figure 1 shows the record with an averaging curve added to highlight the trend. The overall increase has been about 0.7 Celsius degrees (1.26

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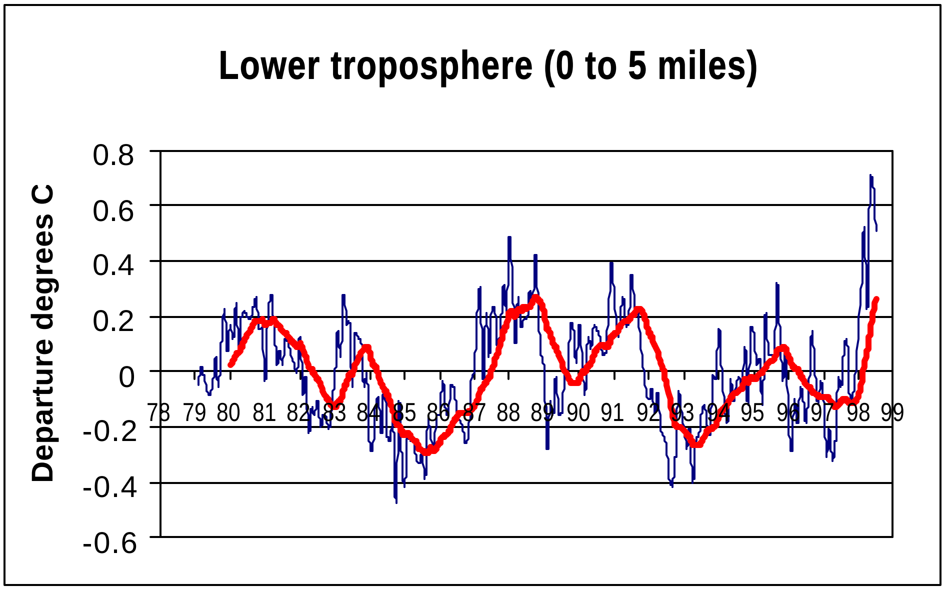


Figure 2. Temperature departures in the lower troposphere

Fahrenheit degrees) concentrated into the periods 1910 to 1944 and 1975 to the present time. The decline during the 1960s and into the '70s gave rise to a concern about global cooling[1,2,3] while the rise over the past two decades has produced the alarm of global warming. There is no doubt that surface temperatures have shown a net increase in the 20th century. The pertinent question is, "Why?" Is this the result of an enhanced greenhouse effect encouraged by burning fossil fuels, or merely the continuance of completely natural phenomena about which we can do very little?

Much has been written about the basic physics of the greenhouse effect, the absorption of reflected radiation from the earth by compound gases in the atmosphere, in particular, water vapor and carbon dioxide. The concentration of atmospheric carbon dioxide has been increasing at an accelerating rate over the past century. It is, therefore, an understandable reaction to correlate this with the increased utilization of fossil fuels (coal, petroleum products and natural gas). It would also seem to be a reasonable extrapolation that the increase in carbon dioxide, a radiation-absorbing gas is, at least, partly responsible for the rising air temperatures.

Atmospheric Temperatures

The greenhouse effect is very real. If it were not for our blanket of atmosphere, the surface of the earth would be about 33 Celsius degrees (59 Fahrenheit degrees) cooler and have a mean temperature of some -18°C (0°F). However, only about 22.5 percent of atmospheric warming (7.4 Celsius degrees) is caused by reflected radiation. The remaining 25.6 degrees arises from evaporation and convective heat transfer, and is independent of the greenhouse effect[4]. In the lower atmosphere, water vapor and carbon dioxide account for 7.0 and 0.4 degrees, respectively, out of the total 7.4 Celsius degrees.

Changes in the carbon dioxide concentration will, therefore, have a very limited effect on the warming caused by absorbed radiation. At higher altitudes (above 15km or 9.3 miles) there is much less water vapor and the relative effect of carbon dioxide becomes more significant. So let us take a look at the record of atmospheric temperatures at those higher altitudes.

Since 1979, orbiting satellite observations have allowed atmospheric temperatures to be measured on a global basis and at selected altitudes rather than at fixed surface locations, and have been confirmed by balloon measurements to an accuracy of three hundredths of a degree Celsius. As with almost everything in the global warming debate, the reliability of satellite observations has been challenged. However, the arguments are over a few hundredths of a degree and do not substantially alter the trends indicated by Figures 2 and 3.

The hot summer months of 1998 were reflected in the temperature measurements of the lower troposphere (Fig. 2). However, the fluctuations over the past two decades, when such measurements have been possible, indicate no definite long-term trend so far. Temperatures in the lower stratosphere actually show a decreasing pattern (Fig. 3).

So what are we to make of this, rising surface temperatures since the late 1970s but no similar pattern at higher altitudes where the effects of increased carbon dioxide should be more pronounced? One response might be gleaned from those of us who have lain too long on a white sand beach on a sunny day. The radiant and reflected heat of the sun not only makes us hot, it also results in a layer of warm air over the land surface. A similar effect over the ocean is lessened by the evaporative cooling that takes place there. It is, in fact, these phenomena that result in air currents and meteorological effects.

Small oscillations in the solar energy that reaches the earth have a very significant influence on our climate. Such variations occur due to the changing characteristics of the earth's orbit around the sun, and inflections in the energy output of the sun itself. The correlation between sunspot activity and earth surface temperatures has been well-documented[5,6]. As we have entered into a period of increased solar output it might be expected that we experience increased surface temperatures. This also explains the overall increase in average upper oceanic temperatures that have been observed.

The classical carbon cycle indicates that carbon-based gases are emitted into the atmosphere from the dissolution of carbonate rocks, biological processes, volcanic activity, and the burning or oxidation of organic compounds. Atmospheric carbon dioxide is absorbed by the oceans to produce carbonate sediments, which become part of the crustal rocks, completing the cycle. A shorter cycle occurs as carbon dioxide is absorbed by vegetation and converted into organic matter, most of which decays subsequently to release carbon-containing gases back to the atmosphere.

Now let's think about this. Anyone who likes soda drinks knows that carbon dioxide dissolves quite readily in water. If you warm the water it becomes less capable of holding the gas. The oceans presently contain about 52 times as much carbon dioxide as does the atmosphere. It follows that a small increase in the temperature of the upper ocean will result in less carbon dioxide being absorbed—hence, more of the gas will remain in the atmosphere. It would seem that increasing atmospheric concentrations of carbon dioxide should be a *consequence* of enhanced global warming rather than the cause of it. In fact, the two are synergistic—they abet each other. This theory appears to be supported by past cycles of atmospheric temperatures and carbon dioxide concentrations over geological time. An even more potent result of a warmer air–ocean interface is that atmospheric concentrations of water vapor will increase, and we remember that water vapor is a much greater contributor to the greenhouse effect than carbon dioxide.

Effect of Fossil Fuels

The blanket of air surrounding the earth is effectively about 25 miles thick—very thin compared to the 7,900 mile diameter of the earth itself. Think of holding a 12-inch globe of the earth in your hands. On the same scale the atmosphere would be less than 0.04 inches thick. It is not difficult to believe that the 20 billion tons of carbon dioxide that we produce from burning fossil fuels each year would have an effect on that thin film of air. However, that 20 billion tons is quite small compared to the exchanges that take place between the air, land biota and the oceans. Assuming an average rate of activity, the human population of the earth, alone, contributes to the carbon cycle by expiring about 5 billion tons of carbon dioxide per year. It might be expected, therefore, that any perceptible effect of burning fossil fuels would also be small compared to natural variations.

Global Climate Prediction Models

Much of the alarm concerning climate change has arisen from the predictions of computer models. The problem was that those models consistently produced atmospheric temperatures that were several degrees above those actually measured. Over the past ten years or so, the models have been improved by including more variables. The effect of the cooling effects of aerosols was added. That helped. Then it was considered that cloud cover had a greater influence than had previously been thought. That also brought the predictions closer to reality. In 1990, the models were predicting a 3.3 degrees C increase by 2100. By 1995 this had reduced to between 1 and 2 degrees and has continued to decrease. Nevertheless, predictions of catastrophes resulting from global warming still generate media attention. Britain's Hadley Centre produced the latest—just in time for the Buenos Aries Conference.

In truth, the current models of global climate achieve nothing more than a gross approximation of the tremendous complexity and interactions of the earth's climate. Further development and tuning of climate prediction models should certainly continue in order to improve their reliability as research tools but they have, so far, a poor record of reflecting reality.

Economic Consequences

Turning to other computer predictions, a variety of numerical models have been developed to predict the economic effects of given perturbations. So, we are able to produce forecasts of the costs to businesses and, hence, consumers, of carbon taxes, higher prices of fossil fuels, greater stringency in allowable emissions, international trading of carbon dioxide credits, and so on. The results that emerge are even more variable in their predictions than climate models, ranging from freefalls in national economies to greater job opportunities in environmental remediation and recreational industries. The problem here is not so much differences in the models themselves (they tend to be similar) but the assumptions that are made in selecting input data. As a developer of simulation models in engineering, I am well aware of how easy it is to choose data that will produce any desired result.

Unfortunately, there is an even greater quandary for those who believe that carbon dioxide from our use of fossil fuels will cause calamitous climatic effects. While most other pollutants can be removed or diminished, at considerable cost, from the emissions of fossil fuel combustion, removing carbon dioxide on the scale necessary appears to be infeasible with current technology. So if we are to satisfy the increasing demands of ever-larger populations for fossil fuel–based energy then the production of carbon dioxide will also, inevitably, increase. The alternatives do not look at all promising. Nuclear energy, currently supplying about 21 per cent of our electricity, is currently unpopular because of concerns over safety, nuclear proliferation and waste disposal, and is declining in use at the present time. Large hydroelectric schemes have just about reached their limit of technically viable sites in the United States and also impose their own environmental problems. That leaves us with the other forms of non-hydrocarbon renewable energy, including solar, wind, tidal and geothermal sources. Despite all of the research, these renewable resources still provide less than one per cent of our energy demands. While developments in renewable energy must continue, such sources are unlikely to provide for more than fringe demands in the foreseeable future. No matter how unpalatable, these are the realities that result in India and China, with their growing populations and economies, refusing to curtail the use of fossil fuels. These are also the realities that cause Congress to draw back from ratifying treaties or adopting

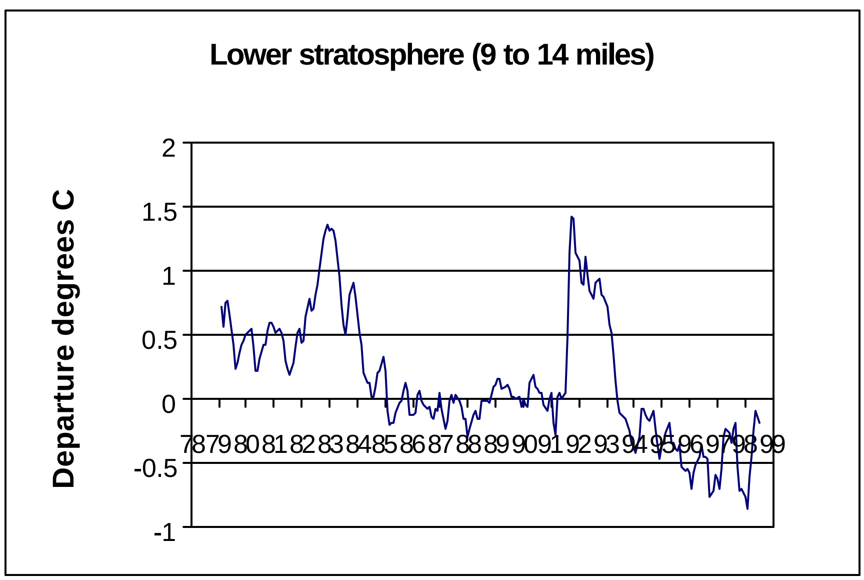
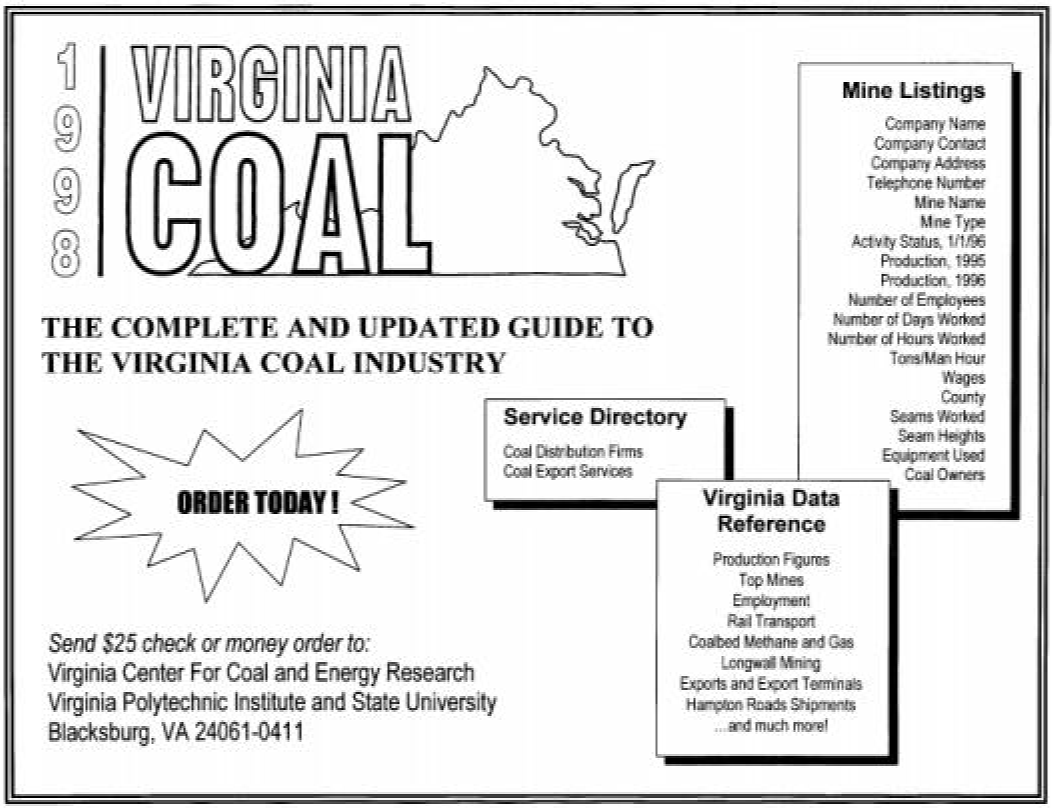


Figure 3. Temperature departures in the lower stratosphere

measures that will increase costs of living perceptibly in the United States.

So here is the quandary. We seem to be stuck with fossil fuels for most of our power generation and transportation needs, but fossil fuels are a contributor to atmospheric carbon dioxide. Are there any other alternatives? Yes, there are. First, as we are necessarily committed to using fossil fuels until, at least, well into the next century, surely it makes sense to concentrate our attention on means of improving the efficiency of the systems that use these fuels, as well as reducing further the pollutants that remain in the emissions. Secondly, our experience of the '70s showed that we do have the capability of reducing energy demand when we become convinced of the need. These are measures that stand the tests of technical feasibility as well as political and social acceptability.



Final Word

So what are we left with? Our modest conclusions are that atmospheric concentrations of carbon dioxide, and near-surface average air temperatures are both increasing. Which is cause and which is effect is not at all clear. The changes are much more likely to be caused by natural rather than man-made influences. The effect of fossil fuels, said by some to be just perceptible within the climatic "noise," is small. Any attempts we make to combat natural changes in earth's climate will be like trying to hold back the tide with an open fence. If we become convinced that average atmospheric temperatures will continue to rise then we should engage in measures to adapt to, and benefit from, that change rather than in ineffective and very costly attempts to prevent it.

There are many very serious environmental problems in our world that demand attention—toxic pollution of land, air and water, looming shortages of potable water, endemic poverty, the political and military barriers against the distribution of food and medicines, and the destruction of rain forests to name just a few.

So why do we spend so much time worrying about a problem that may well prove be a non-problem, and about which we can do very little? There are large numbers of people who have become genuinely alarmed at the predicted consequences of enhanced global warming. We do not doubt their sincerity and we understand their concerns. However, it does seem that such widespread anxiety has enabled the development of a self-sustaining cycle. Very large sums, including taxpayers' money, are expended on funding organizations that have a vested political, monetary or reputational interest in maintaining that alarm. Some of these organizations are lobbying agencies engaged in generating yet more funds—and so the cycle perpetuates[7]. But perhaps the story is becoming stale. The media appear to be showing some interest in the opinions of those many scientists who question the extent of human influence on our climate[8]. Perhaps we might hope for the emergence of a more rational outlook based on true science, meticulous observation and unbiased interpretation, and unfettered by political or institutional propaganda from both sides of the question.

Well, there you have it, our two cents worth.

Malcolm J. McPherson

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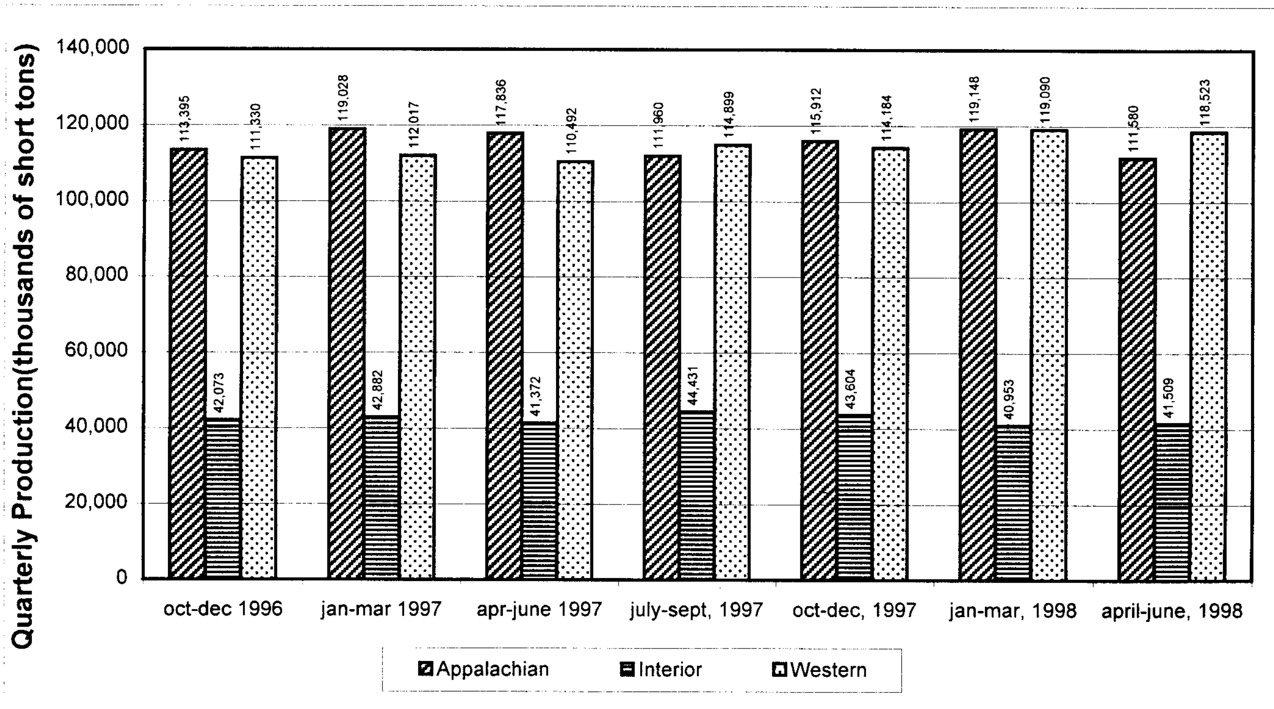
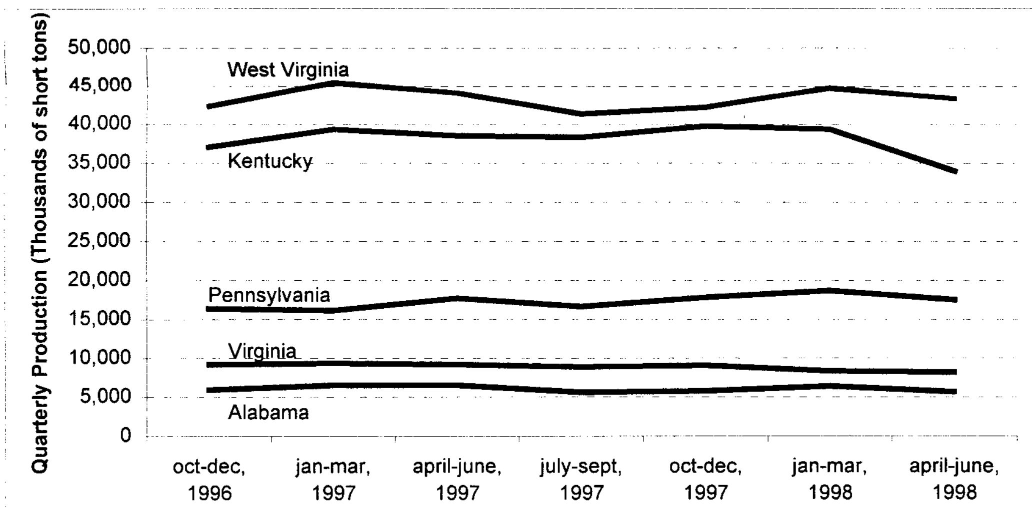
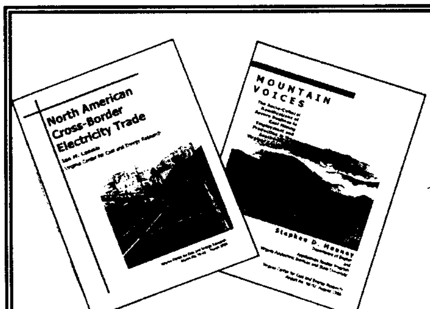
Quarterly Coal Production







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Average Price of Gas for United States and Virginia, by Consumer

With 1997 Deliveries and Market Value in Virginia

	1997 - $ per thousand cubic feet[1]		1997 Deliveries (million cubic feet)[2]	1997 Market Value (millions of dollars)
	U.S. Average	Virginia	Virginia	Virginia
Wellhead	2.23	N/A		
City Gate	3.61	4.13		
Residential	6.93	7.88	73,716	580.9
Commercial	5.76	5.60	61,430	344.0
Industrial	3.53	3.64	84,644	308.1
Electric Utility	2.81	2.99	11,571	34.6
1997 Totals for Virginia:			231,361	1267.6

[1] Department of Energy, Energy Information Administration, Natural Gas Monthly, Publication DOE/EIA-0130(98/06) pp. 50-62.
[2] op. cit. pp. 31-43.

Total Gas Deliveries in Virginia for 1997

With Virginia Production, by Conventional and Coalbed Sources

	(million cubic feet)	(million cubic feet)
Total Gas Deliveries (1997)[3]		231,361[1]
Virginia Production		58,249
Conventional	18,167 (31%)[2]	
Coalbed Methane	39,779 (68%)[2]	
Dual Completion	302 (1%)[2]	
Net Gas Imported		173,112

[1] Department of Energy, Energy Information Administration, Natural Gas Monthly, Publication DOE/EIA-0130(98/06), p. 47.
[2] Department of Mines, Minerals and Energy, Division of Gas and Oil, Commonwealth of Virginia, 1997 Gas and Oil Report, June 1998, p. 11.
[3] Includes only gas deliveries; does not include gas used as lease and pipeline fuel. Quantity of lease and pipeline fuel for 1997 not available at this time.

ENERGY OUTLOOK (ISSN 0279-6635) is a publication of the Virginia Center for Coal and Energy Research (0411), 217 Femoyer Hall, Virginia Polytechnic Institute and State University, Blacksburg, VA 24060. Telephone: 540/231-8108. Fax: 540/231-4070. Email: vccer@vt.edu. World Wide Web: http://www.energy.vt.edu. Director: Malcolm J. McPherson. Publications: Margaret K.K. Radcliffe. *Virginia Tech does not discriminate against employees, students, or applicants on the basis of race, color, sex, sexual orientation, disability, age, veteran status, national origin, religion, or political affiliation. Anyone having questions concerning discrimination should contact the Equal Opportunity and Affirmative Action Office.* ENERGY OUTLOOK is printed on recycled paper.