ENERGY OUTLOOK

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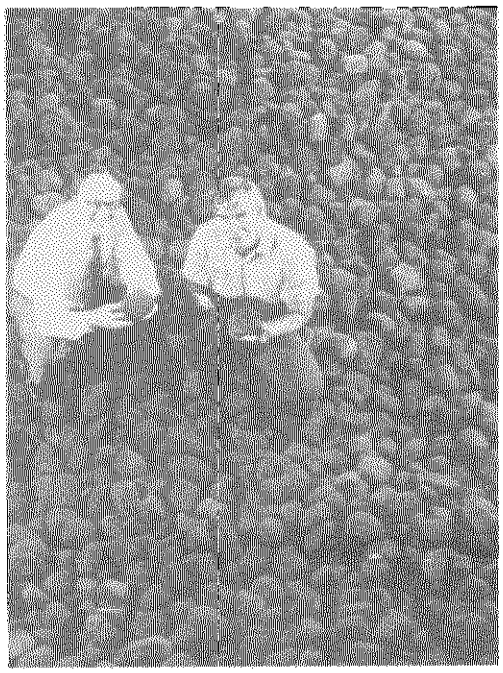
GOOD NEWS FROM CTC:

An Update on the Continuous-Formed Coke Process

On February 29, 1996, the Radford, Virginia, Shell Division of Intermet Corporation successfully completed the largest test in the U.S. of coke produced by the Coal Technology Corporation (CTC) of Bristol, VA. Readers of this publication may remember that CTC is the developer of - and holds the sole patent on - a revolutionary new continuous-coking technology with the ability to create high-quality, uniform coke in a mere two hours or less ("Being the First: Continuous Coking Gets Ready to Take on the World," *Energy Outlook* v.IX, n.1). A blend of 50% CTC coke with conventional coke-oven-foundry coke was tested in the production of grey iron at Intermet; preliminary results showed positive impacts upon the operation, and company officials were pleased by and supportive of the results. As a result of this test at Radford, a much larger test - utilizing 20 tons of the same 50/50 blend - is scheduled to be conducted by General Motors at their Defiance, Ohio plant in April.

In this issue

CTC is now in the process of designing and financing the first commercial CTC continuous coking plant - a state-of-the-art facility to be located at the Norfolk Southern Railroad in Princeton, West Virginia. During the first year of operation, the plant is expected to utilize about 75,000 tons of both Virginia and West Virginia coal. Once the first CTC coke reactor is operating successfully, the plant will rapidly be expanded to utilize over 750,000 tons of coal per year, producing coke for sale to the entire U.S. steel industry.



Richard Wolfe, CTC President, and Michael Henkelman, Coking Engineer, demonstrate the uniform quality of CTC coke

Dr. Richard A. Wolfe, President of CTC and a member of the Virginia Center for Coal and Energy Research Advisory Board, recently presented the first technical paper on the continuous coking process at the international conference of the Ironmaking and Steel Society in Pittsburgh, Pennsylvania. "The continuous coking process has numerous benefits over the existing coke-oven technology in use today," Wolfe explains, enumerating both economic and environmental factors. "And also, we're using Virginia coal." For those with an interest in the state's coal industry, this may be the best news of all.

Virginia Tech

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY

THE FUTURE OF ELECTRIC VEHICLES

For many years, Americans have been hearing about the electric car - that mysterious vehicle that will move silently along the highway, no pollution rising from its absent exhaust pipe. An unlikely automobile, maybe too expensive or not reliable enough, and certainly not ready for public consumption. Electric vehicles, however - EVs - are no longer only a rumor. A two-seat GM sports car will be sold at Saturn dealerships in southern California and Arizona in the fall of this year, has a top speed of 80 mph, a range of between 60 and 90 miles per charge, and will cost between 30 and 40 thousand dollars. And for those who want something a little more substantial, an electric Chevrolet pickup truck is due by the beginning of next year.

For Virginia Power, though, the EV has been around for a while, at least in the form of high-powered electric race cars built by high school and university students. Since 1994, the utility has been responsible for the EV Grand Prix, an exciting competition in which "Indy-style" cars compete in categories which include handling and braking, acceleration, range, speed, and design. Last spring, participants came from high schools from up and down the east coast, as well as universities from as far away as Indiana and Arizona, to race cars converted from gasoline power at speeds of up to 100 mph.

This year, the Grand Prix's 35 laps around the Richmond International Raceway (and other events) will take place on April 26 and 27, and the sixteen competing high-school teams will represent Virginia, North Carolina, Maryland and the District of Columbia. Virginia Power will sponsor eleven of these teams, and other utility sponsors include Carolina Power and Light, Potomac Electric Power Company, Dominion Electric Cooperative and Northern Virginia Electric Cooperative. This spring, too, teams will be asked to submit 60-second videotapes describing their vehicles and promoting EV technologies. These will be judged by a panel that includes television and other media professionals, and shown to the public at the Science Museum of Virginia on April 26.

The EV Grand Prix is an important event to officials at Virginia Power, which already has approximately 40 electric trucks and cars in its fleet, and plans to have over 400 by the end of the decade. "This is the one event we have to show new electronic technology to a new age," says the company's Manager of Conservation Dave Roop. He adds that the motivated young people involved in the Grand Prix will come away with more than awards and memories. "Those who participate in this year's event will get a good look and gain valuable experience in the area of electronic automobiles." Adds Cindy Dickerson, Electric Vehicle Promotions Coordinator for Virginia Power, "[This race] gets hundreds of high school students involved in building electric vehicles. And it is proving the viability, and reliability, of electric vehicles in a real-world environment."

Outside of Richmond's race track, however, EVs continue to experience setbacks. The problems with these so-called "zero-emission vehicles" are well-known - their cost is high, their heavy lead-acid batteries can be dangerous, and they tend to need recharging every 60 - 100 miles. And until recently, the largest auto manufacturers were all designing different and incompatible charging systems for their cars. (In the fall, Chrysler and Ford unveiled an electric minivan and a small pick-up truck, respectively, agreeing to use the same type of charging system for the batteries of each. General Motors will use a different charging system for its upcoming, all-electric EV-1 sports car, described above.) Finally, the "zero-emission" moniker given to electric vehicles is actually a myth; electricity for the cars would be generated at the same power plants that deliver energy to homes and businesses, so their ability to mitigate pollution is only as adequate as utility controls.

In addition, after several years of speculation about how it was to be achieved, California in December elected to rescind its requirement that 2% of all cars sold in the state by 1998 must be powered by electricity. The original proposal called for 60,000 electric cars to be produced from 1998 through the year 2000, and was the state's response to the federal Clean Air Act. New policies are being enthusiastically supported by auto manufacturers, who had insisted that electric cars would not be ready for the mass consumption by 1998. These policies require a gradual increase in production of electric vehicles to comprise up to 10% of all cars manufactured in California (by companies manufacturing over 3,000 cars annually) by the year 2003 - a fraction of the 60,000 such vehicles that were originally expected to roll off the assembly lines.

But meanwhile, closer to home, the Departments of Energy and Transportation and the Electric Transportation Coalition have recently instituted a program to place at least 5,000 electric cars on America's roads in the near future, 500 of them in the Richmond, Virginia area. And last November, that city put into operation what is thought to be the first electrically powered school bus on the east coast. As quoted in *The Richmond Times-Dispatch* (1/7/96), Central Virginia Electric Automobile Association president James Robb foresees a day when Richmond will be seen as a particularly "electric vehicle-friendly community." One obvious benefit of such a community is that emissions can be dealt with not at thousands of tailpipes, but at a single source.

One final note about EVs involves the Ozone Transport Commission, an organization comprised of representatives from the District of Columbia and twelve eastern

states, including Virginia, which had petitioned the U.S. Environmental Protection Agency to allow for more stringent state pollution limits than those set by the federal government. Part of this plan involved the use of EVs to lower automobile-emissions levels. During the recent meeting of the Virginia General Assembly, however, a bill was passed which stipulated that neither the Department of Environmental Quality nor any other agency of the Commonwealth is not to enter into any interstate agreement related to ozone transport exceeding the directives of the federal Clean Air Act. But those interested in electric vehicles still find them attractive for a variety of reasons. Electricity is cheaper than gasoline, proponents like to point out, and - to quote a patron at a recent EV display in Roanoke - "these cars are exciting because they're new, and it's clear that they're improving all the time."

THE NEWEST COAL-TAX CREDIT

After heated debate, the 1996 session of the General Assembly approved a bill that would more than double a tax credit for coal companies by investing $188 million in southwestern Virginia's flagging coal industry. Although the impact of the bill will not be apparent until the next two-year budget cycle - and the tax credit itself will be phased in over a five-year period - this is seen as an extremely positive development in Virginia's coalfields, where thousands of jobs may be saved over the next ten years as a result of the legislative action.

Spurred on by an economic analysis prepared by the Virginia Coal Association, which indicated that the Commonwealth's high-quality, low-sulfur coal costs three-to-five dollars more per ton to mine than does coal in neighboring states, coal company representatives have been agitating for the passage of this bill - not as the industry's salvation, but as an opportunity for the coalfield region to stay economically afloat as it looks for ways to diversify its economy. While the tax credit adds an incentive for the production of thinner-seam, more-difficult-to-mine coal, it is clear that Virginia's production peak is past, and the resource is no longer plentiful.

Congressman Rick Boucher has called economic development "our top priority" for southwestern Virginia, and notes the approval of $96.5 million for a new federal prison in Lee County and the creation of a Commission on the Future of Southwest Virginia. Boucher also co-hosted a "Coal Counties Summit" with Lt. Governor Don Beyer in November, in which over 200 community leaders discussed the roles of government in advancing the economic needs of the coalfields region.

For now, however, the infrastructure in place in these counties is dedicated to the mining of coal - just as it has been for many of the last hundred years. And the question in the coalfields remains that of James W. McGlothlin, Chairman and CEO of The United Company in Bristol (quoted in *The Richmond Times-Dispatch*, 2/28/96): "What can we do to allow us to continue to mine coal?" The answer, at least for the present, may well be the newest coal tax credit.

COALBED METHANE

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From the earliest days of the Industrial Revolution, methane emitted from carbonaceous strata was a constant source of danger in underground coal mines. The horrific fires and explosions caused by methane resulted in the development of the flame safety lamp and mechanical fans to replace the earlier shaft-bottom furnaces.

The organized drainage of methane from coal seams commenced in the Ruhr Coalfield of Germany in 1943 as a means of reducing emissions of this flammable gas into mine workings. The practice spread to other European countries during the 1950s. In the United States, the techniques of methane drainage were investigated by the Bureau of Mines in the mid 1960s, not only to improve mine safety but also to produce the gas as a fuel in its own right. Throughout the 1980s, drilling for coalbed methane saw an upsurge within this country, encouraged by tax credits, environmental concerns with conventional fossil fuels and the potential of significant financial return.

The predominant methods of extracting coalbed methane involve drilling boreholes into the coal seams or associated gas-bearing strata, either from surface rigs or from locations in underground mines. In the United States, there are two favored techniques associated with coal mines. One of these utilizes boreholes drilled through the coal seam from current mine workings. Long-hole directional drilling has enabled this method to be used to pre-drain methane from some areas of coal seams that are subsequently to be mined. The other technique involves boreholes drilled from the surface into the roof beds above coal that is to be mined by the longwall method. The relaxation of these strata caused by mining allows methane to desorb from coal seams that lie within those upper beds, and also creates fracture networks in which the gas can collect. Low pressure pumps may be used to extract the gas.

Both of these methods are employed to reduce emissions of gas into mine ventilation systems and, also, to produce methane in commercial quantities and purity. However, coalbed methane is also being extracted in increasing quantities as a fuel resource where, because of geological structure, thin seams or poor quality of coal, there is no intention to mine the coal. In this case, holes are drilled from surface rigs to intersect the coal horizons.

The potential is absolutely enormous. Estimates of recoverable coalbed methane in the United States have varied between 400 and 1,100 trillion cubic feet. The

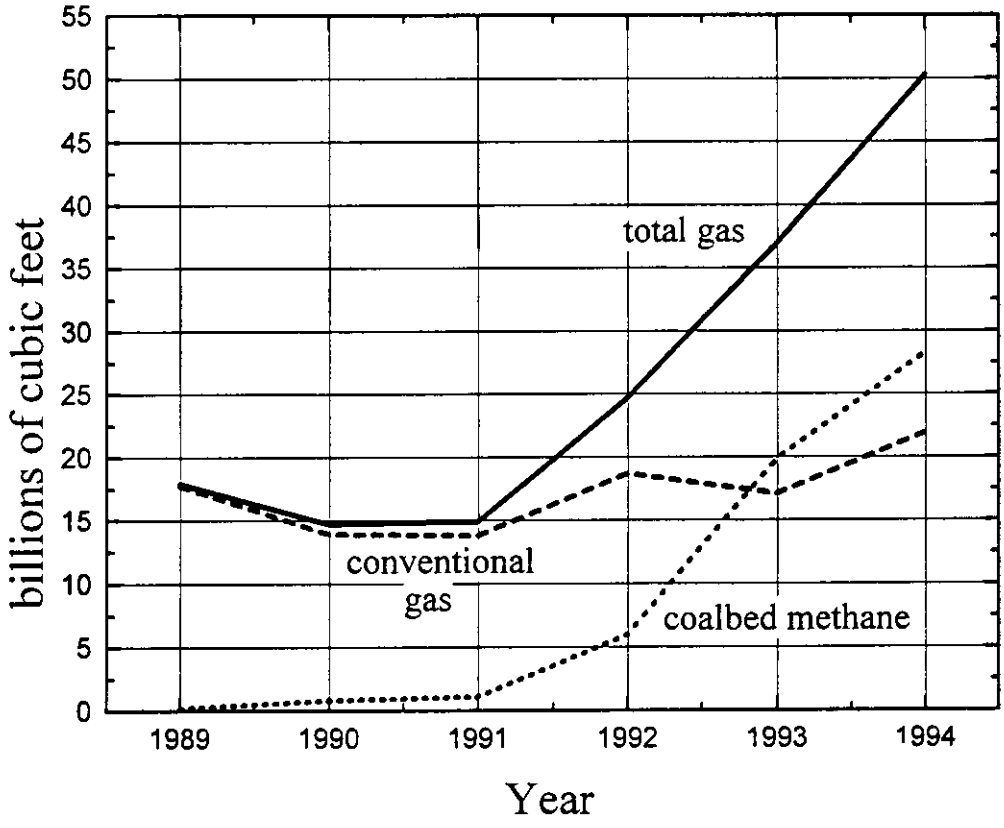

Figure 1. Gas production, southwestern Virginia

smaller of these two estimates is equivalent to a 6-foot-thick layer covering 2.4 million square miles. The seven counties of southwestern Virginia where gas is produced are Buchanan, Dickenson, Russell, Scott, Tazewell, Washington and Wise Counties. In addition to coalbed methane, natural gas associated with oil is produced from reservoirs of average depth exceeding some 5,000 feet. This is referred to as *conventional gas* to distinguish it from coalbed methane. Figure 1 illustrates the rapid rise in Virginia gas production since 1991, most of it due to the growth in coalbed methane extraction. By 1994, coalbed methane accounted for over 56 percent of the total production of Virginia gas. Although reliable estimates of gas resources are difficult to make, Virginia's recoverable coalbed methane reserves are clearly very high. The potential for further expansion in this state is tremendous.

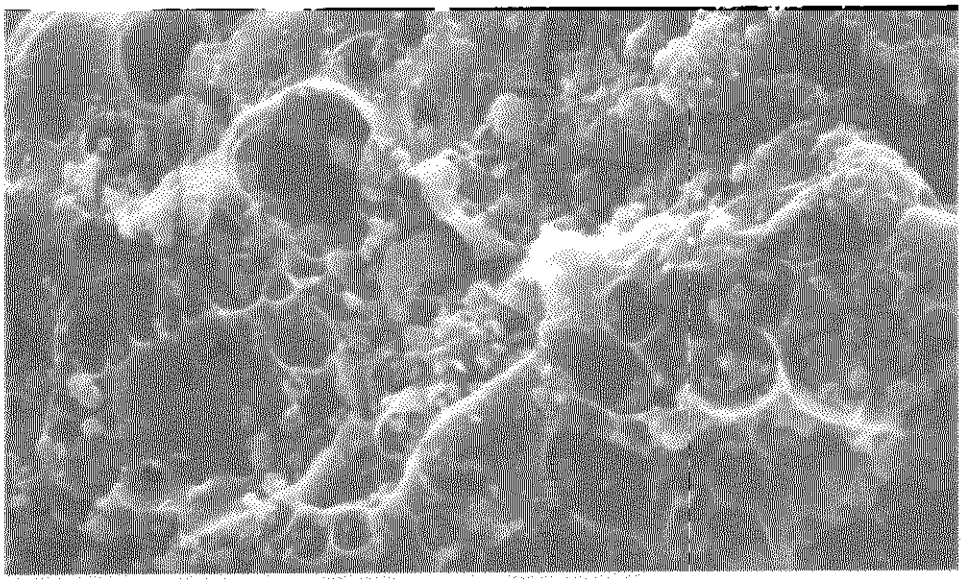

Figure 2. Electron micrograph of the cellular structure of coal

However, there are continuing technical problems that inhibit the effective extraction of much of this clean and efficient source of energy. Despite the research that has been conducted, drilling into virgin coal for methane extraction remains a hit-and-miss affair and largely dependent on the intuition of the drilling personnel. The basic problem is that although the amount of gas in the coal is large, the majority of it is attached by molecular attraction to the internal walls of pores within the coal which are so small they can be seen only with the help of an electron microscope. Figure 2 shows a micrograph taken of the surface of a fleck of coal dust at a magnification of 787. Even the largest of the pores shown is only about 20 microns (millionths of a meter) in diameter. Only when sufficiently large interconnections are made between those pores, and leading to a region of lower pressure such as a borehole, will gas begin to flow. The number and size of such interconnections that occur naturally are usually both too small to allow gas to be extracted in economic quantities. In most situations, it is necessary to encourage the coal to give up the methane that it holds tightly within its matrix by providing artificially induced flow paths through which the gas can flow. Such methods of coalbed *stimulation* currently involve injecting water or other fluids at high pressure in order to fracture the strata, and the use of sand grains or other proppants in an attempt to maintain induced fractures open after the fluid pressure is released.

Even with these stimulation techniques, an occasional borehole may yield large quantities of gas while others produce very little within the same geographical area. The reasons for such variations are often unclear, but arise from the large number of interacting phenomena that influence the three-phase flow of gases, water and solid particulates through strata whose permeability has been created by a combination of natural and man-made actions. Current hypotheses include the suggestion that hydrofracturing opens relatively few cracks along planes of weakness and similarly preferential paths, but does little to affect the tightly bound microporous structure of coal where the methane is adsorbed onto the walls of the pores. Another explanation is that the injection of water causes swelling and displacement of clay particles such that flow paths are effectively and rapidly blocked after completion of the injection phase.

Although several computer models have been developed by the Gas Research Institute and others to assist in understanding the behavior of coalbed methane reserves, most field attempts to induce an enhancement of rock permeability have essentially been trial-and-error, based on the judgment of the local operators. With the assistance of two companies operating in southwestern Virginia and with financial assistance from the state-funded Center for Innovative Technology, the Department of Mining and Minerals Engineering at Virginia Tech is currently investigating new methods of increasing the permeability of coalbed-methane-source rocks. The research involves a combination of fundamental investigations and practical application. The involvement of the industrial partners includes facilities, personnel and cooperation for full-scale field tests. Further information on this research will be featured in upcoming editions of the *Energy Outlook*.

ENERGY SCOUT: News from the Net

A new resource has recently become available to those with access to the Internet. This is CEEDNet, which provides access to an extensive and useful collection of data about coal. Featuring such on-line headings as Facts About Coal, Communications/Bulletins, Enviroment, Electricity Production, Educational Materials, and Major CEED studies, CEEDNet promises to be an excellent source of coal-related information.

The acronym CEED stands for the Center for Energy and Economic Development, an organization established with the mission of countering destructive anti-coal publicity with facts, and of correcting false and misleading impressions about America's most abundant and economic energy source. CEEDNet notes that coal generaties nearly 60 percent of this county's electricity, and that "inexpensive electricity fosters economic development, stimulates job growth, and raises standards of living... CEED will produce and sustain a long-term education and information effort to communicate strong positive messages about coal and our nation's economy, ...new technologies, and environmental progress and compatibility." The address of CEEDNet is http://www.conx.com/ceed.

Meanwhile, in recogntion of the growing power of the Internet as a widely accessible source of information, the Virginia Center for Coal and Energy Research is in the process of developing its own home page on the World Wide Web. This will be an excellent fit with one of the VCCER's primary functions: to dissemintate coal and energy research information and data to users in the Commonwealth of Virginia. The VCCER Internet site is expected to be up and running within a matter of months. Keep your eye on this space for further developments.

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