10/3/05
#040841
submitted by
Commissioner Donovan

AGENDA AUSPICES, EXPLANATION & RECOMMENDATION AMENDMENTS

MEMBERS OF THE CITY COMMISSION

040841 RFP for Independent Consultation on Meeting Future Electric Supply Needs (NB)

Explanation:

1. Commissioners will discuss the process by which they will select the Consultant(s) who will perform the scope of work (eg, (a) final selection this evening versus inviting top three candidates for public interviews; (b) voting using GRU's tabulation sheets versus voting on the top two candidates to be invited for interviews, similar to our voting method for the new city manager; etc.).
2. Commissioners will then discuss their preferred candidates, each commissioner explaining his or her top two or three preferences.
3. Commissioners will then vote according to the voting procedure agreed upon.
4. Commissioners will then discuss and select the next steps necessary to move to final selection of the Consultant(s), including, as necessary, an interview schedule and process, the method of final voting and selection, the assignment of contract negotiations, etc.
5. Commissioners will then direct staff to communicate the Commission's decision(s) to the relevant parties and to prepare for the next step in our process.

Recommendation:

The City Commission follow the procedure outlined above in the Explanation.

#040841

10/3/05 submitted by J. Dickinson

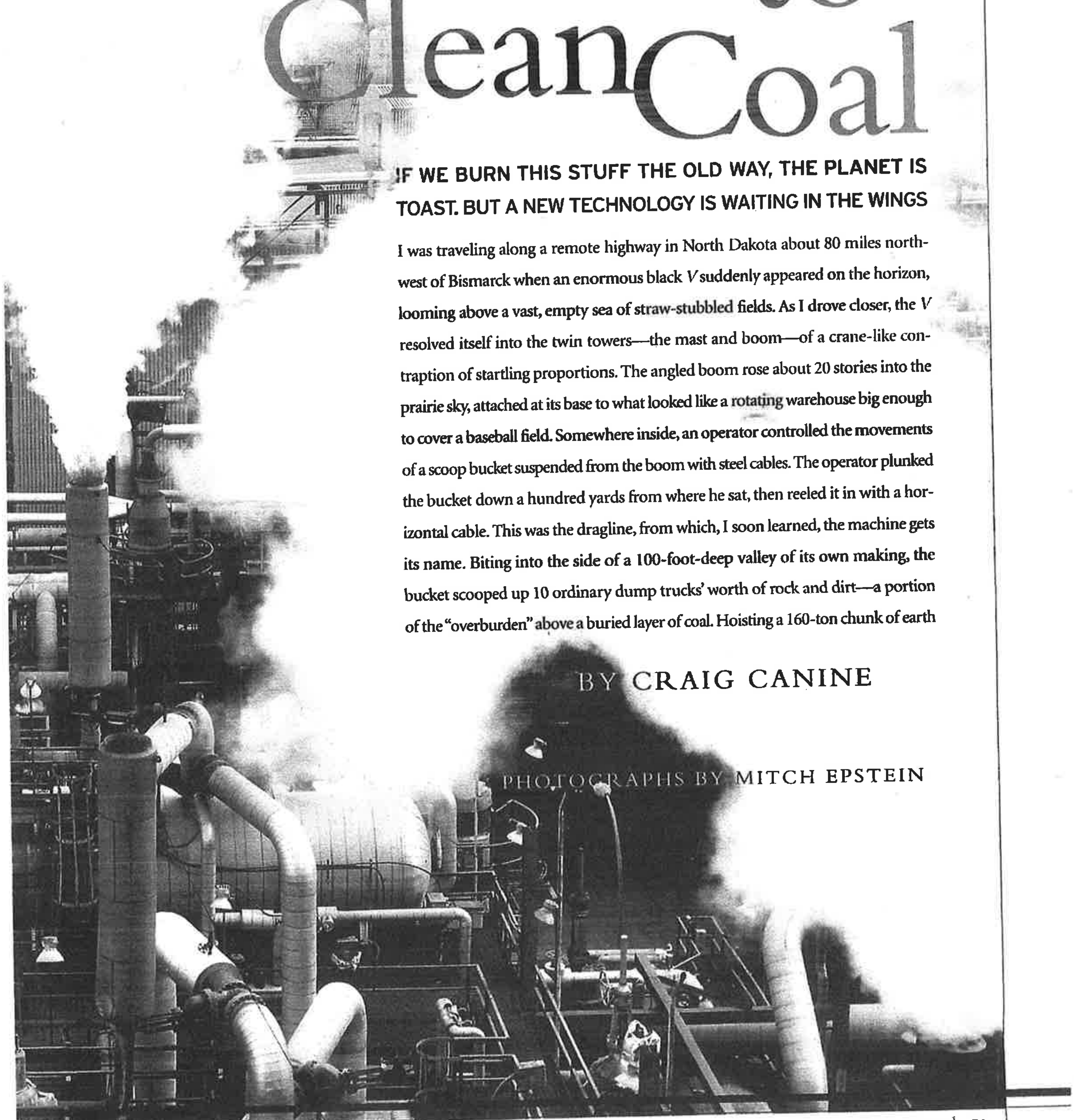
How to Clean Coal

IF WE BURN THIS STUFF THE OLD WAY, THE PLANET IS TOAST. BUT A NEW TECHNOLOGY IS WAITING IN THE WINGS

I was traveling along a remote highway in North Dakota about 80 miles northwest of Bismarck when an enormous black *V* suddenly appeared on the horizon, looming above a vast, empty sea of straw-stubbled fields. As I drove closer, the *V* resolved itself into the twin towers—the mast and boom—of a crane-like contraption of startling proportions. The angled boom rose about 20 stories into the prairie sky, attached at its base to what looked like a rotating warehouse big enough to cover a baseball field. Somewhere inside, an operator controlled the movements of a scoop bucket suspended from the boom with steel cables. The operator plunked the bucket down a hundred yards from where he sat, then reeled it in with a horizontal cable. This was the dragline, from which, I soon learned, the machine gets its name. Biting into the side of a 100-foot-deep valley of its own making, the bucket scooped up 10 ordinary dump trucks' worth of rock and dirt—a portion of the "overburden" above a buried layer of coal. Hoisting a 160-ton chunk of earth

BY CRAIG CANINE

PHOTOGRAPHS BY MITCH EPSTEIN



into the sky, the dragline performed a pirouette, then upended its bucket atop a ridge of artificial mountains off to the side.

The dragline was one of two such machines that work 24 hours a day at the Freedom Mine, one of the dozen largest coal mines in the United States. The sheer scale of the spectacle was awe inspiring, but I also found it deeply unsettling. Coal, as the petroleum geologist Kenneth Deffeyes writes in his recent book *Beyond Oil*, "is the best of fuels; it is the worst of fuels." It is best because it's the most plentiful and least expensive U.S. domestic energy source. It is worst, Deffeyes writes, "for a long list of reasons: killer smog, acid rain, atmospheric carbon dioxide, mercury pollution, acid mine drainage, and a choice between hazardous underground mines and surface-disturbing open-pit mines." For many people in the environmental movement, coal's liabilities far outweigh whatever assets it may have. Yet the use of coal has increased every year, without a pause, for two centuries. Last year, the world burned more than five billion tons of coal, spewing 10 billion tons of carbon dioxide into the atmosphere. (The multiplication of mass occurs because each atom of carbon from the burned coal combines with two heavier atoms of oxygen from the atmosphere, thereby more than doubling the weight of the original coal in CO_2 emissions.) Coal-fired power plants are the single largest source of man-made CO_2, accounting for one quarter to one third of the world's total.

We now stand at a watershed moment. An entire generation of obsolete coal-fired power plants built in the 1950s and 1960s needs to be replaced, and U.S. utility companies have announced their intention of building more than 100 new coal plants over the next 10 to 15 years. Unless something happens soon to tilt the balance toward more environmentally benign alternatives, nearly all of those power plants will use the old-fashioned, intrinsically dirty technology known as pulverized coal. The largest plants will have generating capacities of around 1,000 megawatts (MW), enough to supply electricity to as many as 900,000 homes. Such a plant costs close to $1 billion to build and has an operating expectancy of 60 years or longer. Every year of its lifetime, it will spout six million tons of CO_2 into the atmosphere—about the same as two million cars.

Each of these high-carbon investments is "a Pandora's box that we are handing to our kids," says David Hawkins, director of the Climate Center at the Natural Resources Defense Council (NRDC). "If the plants are not designed up front to capture their CO_2, they will lock us into large amounts of global-warming emissions for their entire operating lifetimes."

The threat of massive carbon lock-in becomes truly staggering when the rest of the world enters the picture. Although the United States now emits more CO_2 than any other country, accounting for 20 percent of the world's total, China is catching up fast and will probably take the lead by 2020. It has already overtaken the United States as the world's largest coal consumer. Coal fuels 90 percent of China's electricity demand. That demand is increasing so rapidly that China expects to expand its generating capacity over the next 30 years by 300,000 MW, or almost half of America's current consumption. As matters now stand, nearly all of China's projected new capacity will use standard pulverized coal technology.

These projections are alarming enough to convince some environmentalists that coal simply has no acceptable future as a major energy source. "Coal is the enemy," says Roel Hammerschlag, a widely respected energy analyst who runs the Institute for Lifecycle Environmental Assessment in Seattle. "It's worse than oil. We're going to run out of oil in the next century, but it's easy to synthesize methanol and other liquid fuels from coal. So coal will replace oil. And there's at least 300 years' worth of coal still in the ground. That's enough to raise atmospheric CO_2 to insanely high concentrations—10 times preindustrial levels."

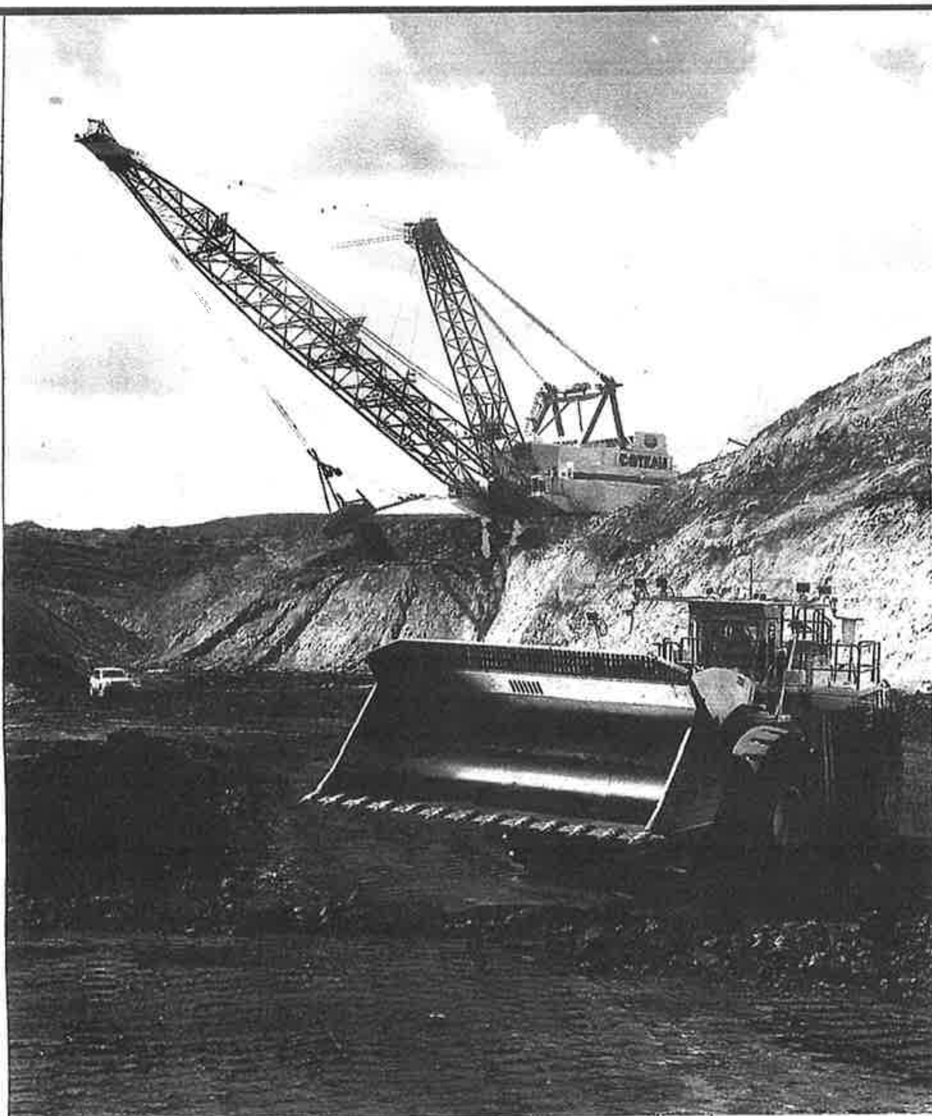
Before the Industrial Revolution, the atmosphere contained about 270 to 280 parts per million (ppm) of CO_2. That level has risen to more than 380 ppm today. With polar ice caps and arctic permafrost melting, ocean levels rising, and climate patterns changing at the present atmospheric CO_2 concentration, what might happen at 450 ppm, 600 ppm, or higher still? "We cannot put the world on hold while we figure it out," Hawkins says.

If the next generation of coal-fired power plants is not designed up front to capture CO_2, we will be locked into staggering amounts of global-warming emissions for their entire operating lifetimes

In spite of this grim outlook, Hawkins is far from ready to concede defeat. He's among the most prominent and outspoken advocates of a bold scheme that would take advantage of the nation's abundant coal resources while at the same time curbing CO_2 levels in the atmosphere. This scenario relies on a combination of technologies that would enable a new breed of coal-fueled power plants to "capture" CO_2 and other pollutants efficiently and economically. The captured CO_2 gas would then be piped deep below the earth's surface for permanent storage. This concept, often referred to as "carbon capture and sequestration" (CCS, for short), has in recent years gained a great deal of currency in the halls of Congress, in the boardrooms of utility companies, and nearly anyplace else—even the White House—where energy policy and responses to global warming are discussed.

The National Commission on Energy Policy, a bipartisan panel of coal-fired plant. Together, these two plants, and a third generating station nearby, consume the Freedom Mine's annual output of 16 million tons of a type of coal called lignite. "We call it dirt that burns," said Floyd Robb, my guide to the complex. "It's as soft and as low in energy density as coal gets. Any less than that and it's peat."

Most coal started out as peat—plant debris that accumulated over many thousands of years in moist bogs. Deep beds of peat were eventually buried under sedimentary deposits, which gradually compressed the peat and subjected it to geothermal heat for a few hundred million years. In general, the longer coal bakes in its geologic oven, the harder and blacker it gets. Lignite, the youngest and brownest type of coal, occupies the bottom rank of the coal hierarchy. Next up, in terms of hardness, carbon content, and heating value, is sub-bituminous coal, found largely in the Powder River Basin of eastern Wyoming and Montana, which is now home to the largest coal mines in the country (all open-pit surface mines, the domain of mammoth draglines like the ones at the Freedom Mine). Bituminous coal, the rank above sub-bituminous, is typical of the eastern half of the United States, from Illinois to Appalachia. It has a higher sulfur content than most western coal but packs a bigger energy wallop, pound for pound. Hardest and hottest-burning of all is anthracite. So black it's iridescent, anthracite comes mainly from those shaft mines in western Pennsylvania that haven't already been exhausted and abandoned.



Giant draglines such as these at the Freedom Mine in North Dakota have become the most common tools for recovering coal in the United States, especially in the West, which produces 40 percent of the nation's supply.

16 energy experts from industry, academia, government, and non-profit groups, released a landmark report last December that includes carbon capture and sequestration among its key policy recommendations. "In addition to our own domestic coal reserves, which are the largest in the world, China and India have enormous resources of low-cost coal," says Sasha Mackler, a senior analyst with the commission. "It's hard to imagine them not using it. Developing systems with which these countries can continue to utilize their coal, but in a way that does not increase carbon emissions, is a huge priority. Carbon capture and sequestration is the most viable pathway for that."

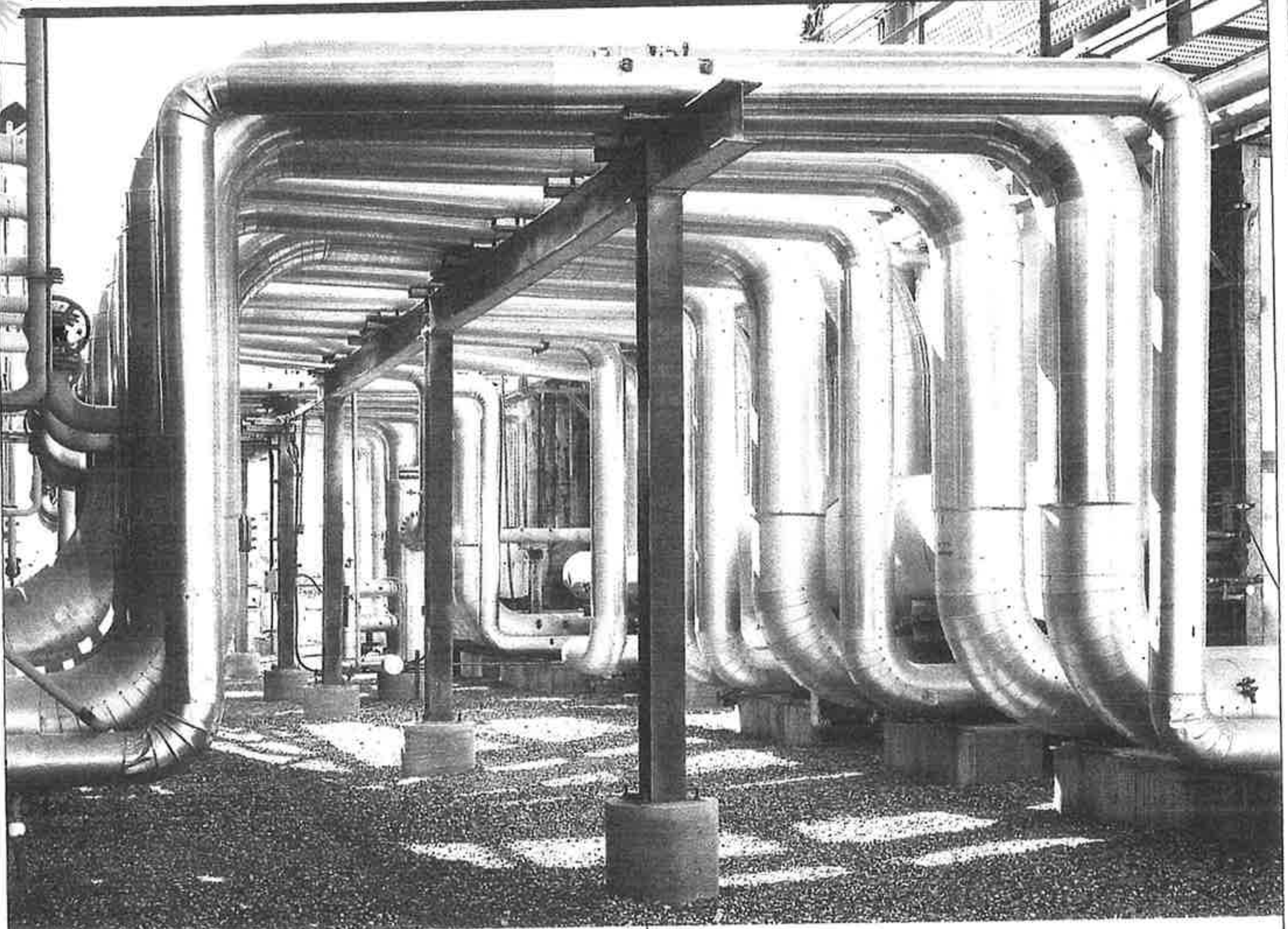
ON THE CARBON TRAIL

I decided to take an exploratory journey down that pathway, in effect following coal's carbon trail from cradle to grave. That's what took me to the Freedom Mine near Beulah, North Dakota. The mine serves as the fuel source for a sprawling complex that includes two large coal-based energy plants: the Dakota Gasification Company's Great Plains Synfuels Plant, which gasifies coal to produce a form of natural gas, and the Antelope Valley Station, a 900-MW traditional

Unlike hard, dry anthracite, lignite has a high moisture content. "Our lignite here is about 35 percent water," said Robb, vice president of communications for the Basin Electric Power Cooperative, which owns the coal from the Freedom Mine as well as the two energy plants adjacent to it. "You can't economically ship it, because you'd be shipping so much water. That's why the power plant is right next to the mine. The only way to ship lignite economically is on wires, as electricity."

Basin Electric is shipping its lignite a second way as well: through a pipeline, as "synthetic natural gas" (an oxymoron of the energy business). The Great Plains Synfuels Plant is a product of the Arab oil embargo of the early 1970s. Not only was oil in short supply, but predictions of a natural-gas shortage made America's energy situation seem all the more precarious. Building an ambitiously large-scale facility in western North Dakota would take some of the region's cheap, abundant lignite and convert it, through a carefully orchestrated series of chemical reactions, into synthetic gas—a process known as coal gasification. (The process is not new: It fueled, for example, the German Luftwaffe in World War II.) Plans, permits, and financing came together in the late 1970s; construction of the North Dakota plant began in 1980.

By the time it started operating four years later, however, the



Before it can be injected into the ground, carbon dioxide is compressed, sent through these pipes to large cooling units, and compressed again.

plant was already a white elephant. It was a technical success, capable of gasifying enough coal to produce 150 million cubic feet of synthetic gas per day, enough to keep 300,000 houses toasty through a North Dakota winter's night. But the price of natural gas (that is, "natural" natural gas, which consists mainly of methane and comes from underground deposits, much like oil) had come down to the point where the plant's synthetic product was no longer cost-competitive. The U.S. Department of Energy operated the plant at a loss for a few years, then Basin Electric bought it at auction for a bargain price.

When you gasify coal, you don't actually burn it. You heat it to about 2,000 degrees Fahrenheit in a sealed chamber. Along with adding some steam, you inject a bit of oxygen, but not enough to allow the coal to burst into flames. Instead, the coal breaks down into its chemical building blocks. Dozens of chemical reactions occur in the gasifier. The gas that emerges is made up mostly of carbon monoxide, hydrogen, sulfur, and nitrogen compounds, plus smaller amounts of elements such as mercury. Most of the gasification facility at Basin Electric—a square mile covered with a Brobdingnagian rat's nest of pipes, minaret-like distillation towers, storage tanks, and mustard-yellow steel buildings—is devoted to cleaning up the synthesis gas, removing impurities from the methane stream, which is the desired end product.

Many of the impurities are, in fact, valuable by-products, and Basin Electric has greatly improved the finances of the plant by finding markets for them. It sells anhydrous ammonia and ammonium sulfate as agricultural fertilizers. A steady procession of railroad cars and semitrucks hauls the stuff away. The plant sells phenol, mainly to a Canadian company that manufactures resins for wood products, such as plywood. Naphtha and liquid nitrogen leave the plant by the millions of gallons.

The gasification plant also produces carbon dioxide—200 million cubic feet of it per day, or just over four million tons per year. In that respect, the plant is no different from the 900-MW pulverized-coal power plant next door: Whether you burn coal outright in a boiler or break it down chemically in a gasifier, there's no getting around the CO_2 problem. But there is a crucial difference between the two ways of producing it. Capturing the CO_2 from a conventional power plant, while theoretically possible, is prohibitively expensive and impractical. With a gasification plant, by contrast, separating CO_2 from the rest of the synthetic-gas stream is a straightforward chemistry project that requires little or no added expense. The North Dakota synfuels plant did not capture its CO_2 stream, however. For its first two decades of operation, it had nowhere to put it except up a 300-foot-tall stack.

That changed in the late 1990s, when Basin Electric actually found a customer for its CO_2. PanCanadian Petroleum, one of Canada's largest oil and natural-gas producers, operated an oil field near Weyburn, Saskatchewan, about 200 miles northwest of the Beulah gasification plant. Production from the Weyburn field was declining, and its owners were interested in extending the field's life using a technique known as enhanced oil recovery—basically, pumping CO_2 into the ground to push more oil out of the source rock, 4,600 feet below the surface. Enhanced oil recovery by means of CO_2 had been a standard practice for more than 20 years in the aging oil fields of west Texas. But these operations used CO_2 from naturally occurring reservoirs of the gas in southern Colorado—a natural "recycling" that did not result in a net reduction of greenhouse gases escaping into the atmosphere. The Weyburn project would represent the first time in North America that man-made CO_2 destined for atmospheric release would instead be pumped deep into the earth, where it might potentially be sequestered for thousands or even millions of years.

PanCanadian Petroleum (now called EnCana) agreed to pay handsomely for the CO_2 (it's now paying $2.5 million every month for what was formerly a waste product). But Basin Electric first had to transport the gas, so it built a 205-mile pipeline from Beulah to Weyburn. Basin Electric also had to pressurize the CO_2 so it would arrive at Weyburn compressed to just over 2,000 pounds per square inch, the force required to push it nearly a mile below the ground and make the oil flow. This would require some of the most powerful gas compressors of their kind ever built.

I saw these brutish compressors during my tour of the gasification plant. There were two of them, housed in a hangar-like yellow building, each powered by a 20,000-horsepower electric motor. They appeared to be the size of the jet engines on a Boeing 747, and were just about as noisy. "When you compress the CO_2 that much, it gets very hot," said Daren Eliason, a chemical engineer who showed me around the plant. "We have to bring the temperature down with air-cooled units." We walked around behind the battleship-gray coolers. A white pipe the circumference of a watermelon emerged from the coolers, made a 90-degree bend, and disappeared into the brown gravel, beginning its underground trip to Weyburn.

If coal is to have a future as a major fuel, this is what it might look like: smokestacks effectively turned upside down, shooting CO_2 into subterranean rock formations rather than up into the sky

MAP BY BLUEMARBLE MAPS

BURIAL CHAMBERS

Weyburn, a town of 10,000 in southeastern Saskatchewan, was the next stop on my journey as I followed the trail from carbon capture to carbon sequestration. North Dakota, much of which is impressively flat, looks like Tibet compared with this part of Canada's prairie provinces. The horizon was a ruler-straight line where the ocher grain fields met the big topaz sky. "It's so flat here that if your dog runs away, you can see him for three days," one oil roustabout told me, repeating a favorite local one-liner. I didn't spot any running dogs, but I did see lots of oil wells, each one marked by a pump jack that bobbed its iron head like a thirsty horse. "This oil field, the Weyburn Unit, measures 10 miles by 7 miles," said Dave Craigen, an EnCana community relations representative. "Over that 70 square miles, there are about 700 producing oil wells."

Craigen and I, both clad in protective EnCana coveralls, safety glasses, and hard hats, stood outside a tall, barbed-wire-topped fence enclosing the white CO_2 pipeline where it emerges from the wind-whipped prairie. It wasn't much to see, really—just a bit of industrial plumbing. I had to remind myself that this was no ordinary bit of gas pipe. This was ground zero in the first large-scale test in North America of geologic sequestration of CO_2 from gasified coal. "Over the life of our CO_2 injection project on this oil field," Craigen told me, "20 million tons of CO_2 will be sequestered. That's 20 million tons of CO_2 that would otherwise be going up the flue stack at the gasification plant."

We got into Craigen's black pickup truck and drove a mile or so down an asphalt road, then turned into a gravel driveway that led to a brown igloo-shaped structure. "This is one of our CO_2 injection wells," my tour guide said as he opened a gate in the fence, then unlocked a door in the plastic igloo. "We have 88 of these distributed around the Weyburn unit." He stepped inside the dark dome. It housed a stack of bolted-together pipeline fittings as tall as he was—an iron Christmas tree bristling with star-shaped manual shut-off valves. "We inject 110 million cubic feet of CO_2 per day," he said. At that rate, EnCana is burying more CO_2 in a year than 100,000 cars release in their operating lifetimes.

"A 50-year-old producing oil field is practically unheard-of," Craigen explained. "But with the CO_2 flooding, we expect to recover an additional 120 million barrels over the next 20 years or so."

I realized I was witnessing a burial of sorts. Fossil carbon, which I had seen extracted from the ground as coal at the Freedom Mine and wrung of its energy value at the gasification plant, was here being recommitted to the earth. Ashes to ashes, dust to dust, carbon cradle to carbon grave. If coal is to have a future as a major fuel in the twenty-first century and beyond, this is what it might look like: smokestacks effectively turned upside down, shooting CO_2 into subterranean rock formations rather than up into the sky.

But if the CO_2 in question is used to produce oil, which in turn will lead to more greenhouse-gas emissions, is there a net benefit to the planet? Sasha Mackler, the analyst for the National Commission on Energy Policy, believes there is. "If the sequestered CO_2 were just promoting more oil consumption," he says, "then you'd have to question how much good it's doing. But by enhancing oil recovery, you're not necessarily increasing the demand for oil. You are basically offsetting oil production that would happen elsewhere, perhaps in the Middle East. You also have to consider that enhanced oil recovery using CO_2 is happening now, and will continue to happen in the future. If, instead of using naturally occurring CO_2 from a well, you can use CO_2 from things like the combustion of coal, then you are very substantially decreasing what would otherwise be emissions to the atmosphere. From a climate standpoint, that's clear progress."

That assumes, of course, that the sequestered carbon is staying put. I asked Craigen if the CO_2 would remain in its mile-deep burial vault. "Since we started the CO_2 flood in 2000," he replied, "we've been cooperating with a consortium of scientific organizations led by the International Energy Agency to study that question." In June 2004, researchers presented a report from a four-year study. In a nutshell, they said that sequestration is working. "In this particular oil-field geology," Craigen summarized, "the CO_2 is staying down there."

Although results from Weyburn are encouraging, it's too soon to conclude that geologic sequestration can play a major role in solving the world's climate-change problem. For one thing, relatively few of the country's largest population centers, and the power plants that serve them, happen to be located near oil fields. But researchers are considering other types of geologic formations as candidates for CO_2 sequestration. The most plentiful and widely distributed of these are called saline aquifers, or brine formations. "Brine formations are found where there's the same kind of highly porous rock where you'd find oil and gas reservoirs," says Sally Benson, head of the carbon sequestration program at Lawrence Berkeley National Laboratory in California. "But there was no source of hydrocarbons in these sponge-like reservoirs, so they ended up being filled with water instead of oil or gas. The water can be up to five times saltier than seawater, because of salts that have dissolved out of the surrounding rocks. The high level of salinity suggests that these formations are isolated from sources of circulating fresh water," and thus pose little risk of contaminating aquifers.

The evidence collected so far in about a dozen small-scale monitoring projects around the world, Benson says, supports the viability of geologic CO_2 sequestration in deep brine aquifers. "If you have a good, isolated formation with an impermeable cap rock as a lid to keep the CO_2 from escaping upward, then the gas should stay down there indefinitely. The bigger question now is, how much CO_2 could you put in these brine formations? Some rough calculations done in the 1990s came up with some very large capacities—as much as 50,000 billion tons of CO_2." That would be enough to entomb every last ounce of projected CO_2 emissions for centuries.

Europe is ahead of the United States in testing large-scale CO_2 sequestration. That's because there are already mandatory restrictions on greenhouse-gas emissions in most of Europe. (The European Union and several additional countries in Eastern and Western Europe ratified the Kyoto Protocol limits on greenhouse-gas emissions in 2002, and the terms of the agreement went into effect early this year.) Even before Kyoto, Norway's state-owned oil company had begun capturing about a million tons of CO_2 per year from offshore petroleum platforms and injecting it into a geologic formation deep below the bed of the North Sea.

So far, though, nobody is capturing and sequestering CO_2 from an electrical power plant. In June 2005, British Petroleum and three partnering companies announced an ambitious project to change that. The partnership plans to add equipment to an existing natural-gas-fueled power plant near Peterhead, Scotland, that will convert natural gas to CO_2 and hydrogen. The CO_2 will be piped to a nearly depleted North Sea oil reservoir, where it will be injected 2.5 miles beneath the ocean floor for enhanced oil recovery. The hydrogen will be used as a "decarbonized" fuel to generate electricity. When the project fires up (current plans call for a 2009 start), it's expected to capture and store around 1.4 million tons of CO_2 each year and provide carbon-free electricity to the equivalent of 250,000 homes.

Generating carbon-free electricity from coal is somewhat more complicated and expensive than the natural-gas-based process to be used in the Scottish project. But it can be done, using a combination of technologies known as integrated gasification combined cycle (IGCC). Four IGCC power plants are up and running today—two in Europe and two in the United States. One of the U.S. plants is located on the Wabash River in Indiana; the other, a newer, state-of-the-art facility, sits on land reclaimed from an abandoned phosphate mine near Tampa, Florida. After saying good-bye to Dave Craigen at the Weyburn oil field one chilly May afternoon, I headed down to Tampa to warm up and to see how IGCC might fit into coal's future.

> The most striking thing about the facility is that it looks nothing like a power plant, especially one that uses coal for fuel. It appears far too clean and shiny, and produces only a fraction of the pollutants

INTO THE FUTURE

The most striking thing about Tampa Electric's IGCC facility is that it looks nothing like a power plant, especially not one that uses coal for fuel. It appears far too clean and shiny for that. The most prominent feature of a standard coal-burning plant is its smokestack (or, more typically, two or three stacks, one for each of the plant's towering boiler units). Here, however, I had to look hard to find a vent stack. When I finally did spot it, I had to look even harder to see anything coming out of it.

"Occasionally, you'll see some steam coming from a relief valve on the side of the stack," said Vernon Shorter, a retired energy company employee who gives tours of the power station. We craned our necks, squinting up at the mouth of the gray steel flue vent. "You're looking at 300 MW of power from coal," he said. "Before we gasify it, we combine the coal with some petroleum coke, the gunk that's left at the bottom of the oil barrel after you refine out everything else. That's nasty stuff, but you can't see anything coming out of the stack. It's as clean as a natural-gas power plant, but the fuel's a lot cheaper and it's more efficient."

From our vantage point on an open steel deck about 40 feet above the ground, we could see most of the plant. Looming high above our heads was its most dramatic feature, a 300-foot-tall gasifier tower. It looked like a rocket gantry at Cape Canaveral. We could also see a hundred square miles of surrounding Polk County. The landscape was nearly as flat as the Saskatchewan prairie, but far more lush. A pair of ospreys fussed over a big twig nest perched on the crossbars of a utility pole. Tampa Electric had severed the wires to the pole and built a wooden platform to support the nest. Shorter gestured toward a distant citrus grove. "Some of the electrons from this plant are going up there to Disney World, 30 miles north, and powering Pirates of the Caribbean."

Shorter led the way down several flights of stairs. As we walked, he delivered a primer on coal-fired power generation. "With a traditional coal plant," he said, "coal is introduced to the boiler and ignites. The heat converts water to pressurized steam, which turns a steam turbine that generates electricity. Here it's a little different."

By now we were standing on the ground next to a barn-size metal structure that contained something resembling a rocket engine turned on its side. "In any IGCC power plant, there are two turbines," Shorter said, "a gas turbine and a steam turbine. This is the gas turbine. It works like an aviation jet." The gas turbine, he explained, takes purified syngas from the coal gasifier and combusts it. Heat from the burning gas creates a stream of rapidly expanding hot air, which spins the turbine's blades and powers a generator.

"But there's lots of heat left over in the combustion turbine's exhaust," Shorter said. "You capture that heat to make steam, which drives the second turbine. It's a very efficient system—15 percent more efficient to run than a conventional pulverized-coal plant. And you can't beat it, environmentally."

Compared with conventional coal-burning power plants, the Polk power station produces only a fraction of the pollutants currently regulated under the Clean Air Act, such as sulfur dioxide (SO_2), the main cause of acid rain; nitrogen oxides (NO_x), which lead to ground-level ozone and brown haze; particulate matter; and mercury.

"IGCC has the ability to achieve much higher capture of SO_2, NO_x, and mercury than you can get with a traditional coal-fired unit," said Charles Black, president of Tampa Electric, when I talked to him at the company's headquarters in Tampa. "That's because of the advantages of removing them before the coal is combusted." The technology can reduce these regulated pollutants by more than 90 percent—a level that's unattainable by pulverized-coal plants, even after they have added sulfur scrubbers, bag houses to filter out particulates, and other pollution-control devices.

But CO_2 is not regulated as a pollutant in this country, so Tampa Electric's IGCC plant is not compelled to capture it. The greenhouse gas goes up the flue pipe, invisibly but surely. "We could be recovering CO_2 from the gas stream at that plant in pretty good quantities," said Black. "It's not a need now. But if there were ever any legislation with respect to CO_2 removal, IGCC is better suited to that than any of the other, more traditional coal-fired technologies. As we look at building power plants for the future, we try to anticipate what regulations might be, then evaluate the options based on their ability to meet those future regulations. IGCC looks pretty good if you do that."

If IGCC power plants look so promising, why haven't more of them been built? The short answer is the low price of natural gas in the 1990s. Rosy talk of nearly endless supplies of domestic and Canadian natural gas, combined with the clean-burning attributes of the fuel relative to coal, led utilities to invest heavily in natural-gas-fueled generating capacity. Predictably, however, all these new gas-fired power plants caused an upsurge in demand for the "fuel of the future." Prices reacted accordingly, tripling from around $2 per thousand cubic feet in 1999 to more than $6 currently. Scores of pristine natural-gas power plants suddenly couldn't produce electricity at competitive rates. Today large numbers of these plants stand idle, repossessed by the banks that financed them. Utility companies have turned back to coal—not to carbon-capture-ready IGCC, which they view as untried and risky, but to old-fashioned pulverized coal.

The plastic igloos on this Saskatchewan oil field house pipes that inject CO_2 into the ground to force out the very last drops of oil.

PHOTOGRAPH BY MARK DUFFY

U.S. utilities have been slow to warm up to IGCC and carbon sequestration technology for the same reason they opposed the Kyoto treaty: Higher costs for environmental protection, they say, would handicap the country's ability to compete with India and China. And yet some industry leaders have broken ranks, calling for the United States to take the lead in embracing technologies and policies that acknowledge the enormity of the global-warming challenge.

One such forward-looking utility executive is Paul Anderson, CEO of Duke Energy and soon-to-be chairman of the mega-utility resulting from the merger of Duke and Cinergy. "It frustrates me to hear some folks say, 'Why should we spend money to reduce emissions when China and India aren't part of the effort?'" Anderson said in a speech to business leaders last spring. "That is akin to begrudging a modest meal to a neighbor while you are sitting down to a sumptuous feast." He went on to say that he favors mandatory legal controls on greenhouse-gas emissions.

Other large utility companies have followed suit. Cinergy and American Electric Power (AEP), two of the largest coal consumers in the United States, have both announced plans to build IGCC power plants. James Rogers, Cinergy's chairman and CEO, is one of the utility industry's most vocal boosters of the technology. Carbon constraints are inevitable, he believes, and IGCC is the most financially prudent way for a coal-dependent company like Cinergy to prepare for their coming. "I have a sense of urgency," he said during a meeting of leaders from the energy industry and government last fall. "We need gasification now." Both Cinergy and AEP are looking at the geology underlying their prospective IGCC plant locations to determine the sites' suitability for eventual CO_2 storage.

Pressure to get the IGCC ball rolling is also coming from businesses that supply utility companies with equipment such as gas turbines. Chief among these is General Electric, the largest publicly traded company in the United States. Last May, GE announced an initiative that it is marketing with the label "ecoimagination," to address global warming, energy conservation, and other environmental issues. The company has pledged to reduce its own global-warming emissions and to double its investment by 2010 in developing more environmentally benign products, including efficient jet engines, hybrid locomotives, and clean-coal technologies. GE built the turbines used in Tampa Electric's IGCC plant. It also owns the coal-gasification technology used in the plant, having purchased it in 2004 from Chevron, which developed it. GE has teamed up with engineering and construction giant Bechtel to offer utility companies a turnkey IGCC package. ConocoPhillips and Shell market competing coal-gasification processes and have also aligned themselves with large power-plant contractors.

Until recently, said Neville Holt, a technical fellow at the Electric Power Research Institute (EPRI), an industry-supported R&D organization based in Palo Alto, California, "the lack of a single supplier who could put everything together and guarantee the results has been a barrier for potential utility customers. But now there are three teams offering IGCC plants with commercial guarantees," a signal that IGCC is ready to make the leap from small demonstration projects to large-scale adoption.

Ironically, among the biggest remaining obstacles are the state utility commissions whose job it is to protect the public from over-reaching utility companies. In 2003, the Wisconsin Public Service Commission (PSC) rejected an application from Wisconsin Electric Power (known as We Energies) to build a medium-size 600-MW IGCC plant on the shores of Lake Michigan, near Milwaukee. The commission ruled that "IGCC technology, while promising, is still expensive and requires more maturation." Its main objection was that We Energies might have to raise electricity rates to cover the premium cost of building the plant. Consumer-protection and environmental groups have appealed the panel's decision, which is now under review by the state supreme court. It's widely seen as a bellwether case for scores of new power plants across the country that are now in the early planning stages.

In neighboring Minnesota, a private energy-development group called Excelsior Energy is doing its best to tilt the regulatory debate in favor of IGCC. Tom Micheletti, Excelsior's co-president (a title he shares with his business partner, Julie Jorgensen), maintains that IGCC's reputation of being more expensive than conventional coal-burning technology is based on flawed reckoning. Excelsior has won strong bipartisan support at both the state and federal levels to build a 600-MW IGCC plant in the Mesaba Iron Range area of northeastern Minnesota, to begin operating by early 2011. "If you consider only the up-front cost of putting the plant in the ground," Micheletti says, "then yeah, IGCC probably costs between 10 and 20 percent more than pulverized coal. But if you do a life-cycle cost analysis, my view is that IGCC is the best bet from a purely economic point of view, because you're never going to have to worry about putting on additional pollution-control equipment. Anyone who takes a look at where the country's going knows that we're going to end up with more stringent control requirements for mercury, particulate matter, CO_2, you name it. If you figure all that in, IGCC is a better deal."

Another objection to IGCC often raised by traditional coal-plant operators—a change-resistant group Micheletti refers to as "the boiler boys"—is that the newer technology will inevitably be more finicky and less reliable than the tried-and-true standard. But Tampa Electric's operating experience over the past 10 years does not bear that out. "Last year, Tampa Electric's IGCC facility was the most reliable coal-fired plant on its grid," Vernon Shorter said. "This is the most consistently available and lowest-cost electricity on its system."

The Bush administration has made support for clean coal technologies a highlight of its energy policy, even as it continues to resist mandatory greenhouse-gas limits. The Energy Department's Clean Coal Power Initiative provides joint government and industry financing for selected projects that demonstrate new power-plant technologies, including IGCC. (Under this program, for example, Excelsior Energy was awarded $36 million toward the estimated $1.2 billion cost of the IGCC plant it's planning to build in northeastern Minnesota.) The department has also earmarked $100 million to support a handful of carbon-sequestration R&D projects around the country. But these are just warm-up acts for the administration's 10-year, $1 billion FutureGen project. When it's built late in this decade at a site that's yet to be determined, FutureGen will be the first power plant in the country, and possibly the world, to combine IGCC electricity production with the capture and geologic sequestration of CO_2.

The Bush administration cites FutureGen as evidence of its commitment to sustainable energy production. Others wonder if it's a case of too little, too late. "When put up against things like the National Commission on Energy Policy's recommendation to deploy 10,000 to 20,000 megawatts of IGCC plants across the country in the next 10 years, one FutureGen project, which sometimes gets funded and sometimes doesn't, is extremely disappointing," says Rusty Mathews, senior legislative adviser at the Washington-based law firm Dickstein, Shapiro, Morin & Oshinsky, and a former Senate staffer who worked on the 1990 amendments strengthening the Clean Air Act.

The long-awaited energy bill that Congress passed just before the summer recess contains tax incentives and subsidies to produce electricity using clean-coal technologies. It also contains small incentives for power generation from wind, solar, and other renewables, as well as energy efficiency and conservation. But it fails to impose limits on greenhouse-gas emissions and provides generous subsidies for the oil and gas industry at a time when crude oil is selling for near-record

U.S. utilities have been slow to warm up to new technologies for capturing and storing carbon, arguing that higher costs would handicap their ability to compete with China and India

prices. "The bill misses so many opportunities to change the fundamental direction of energy policy in this country," says Karen Wayland, NRDC's legislative director. "If it's not going to reduce the price of oil, address global warming in a serious way, or increase our energy security, what good is it?"

THE GRAND BARGAIN

The question "What good is it?" could also be leveled at any policy recommendation that encourages more coal mining over the next century. Widespread adoption of coal-fueled IGCC power plants coupled with carbon sequestration might lead to good things for the atmosphere, but what does it portend for the earth's already scarred surface? The coal-mining industry has changed dramatically over the past three decades. It has, in general, moved from the iconic shaft mines of Pennsylvania and Appalachia, manned by legions of black-smudged, pick-wielding men, to enormous surface mines in western states, where relatively few laborers operate the largest machines on earth, such as the dragline excavators I saw working the lignite beds of North Dakota. About 20 of these super-mines, most in the Powder River Basin, now produce more than 400 million tons of coal a year, about 40 percent of all U.S. production.

While these mines can to some extent be remediated, the same cannot be said of mountaintop removal, a method of surface mining practiced in the eastern United States, which causes grotesque and permanent damage. Approximately 600 Appalachian strip mines, including mountaintop removal operations, unearth 145 million tons of coal a year, about 15 percent of the nation's annual total. In mountaintop removal, draglines, dozers, and huge dump trucks blast and scrape off summits and push the displaced earth into the valleys below. The procedure creates an eerily unrelieved, amputated landscape, filled with muddy stumps, acid mine runoff, and piles of toxic coal sludge.

David Hawkins, NRDC's clean-coal visionary, is acutely aware of the downsides of coal mining. "Even if some form of grand bargain were struck with the coal industry on dealing with the downstream effects of carbon emissions," he says, "the environmental community is not going to walk away from concerns about the upstream side, where the coal comes out of the ground.

"As far as I know, it's a matter of economics that causes people to decapitate mountains rather than mine the coal in a less abusive fashion. So if we're going to use coal, we should pay the price that is needed in order to avoid ruining the landscape. The way to do it," he suggests, "is to have a policy that says, 'Here are the rules.' And the coal industry will say, 'Well, those rules mean it's going to cost more.' And the answer has to be, 'Yup, that's right: Here are the rules.' "

The coal industry's response to a Hawkins-style vision of responsible coal use is mixed at best. On the bright side, the United Mine Workers of America voiced its acceptance of the need for restrictions on carbon emissions last December, when it endorsed the report of the National Commission on Energy Policy. (The report recommends phasing in a mandatory cap on carbon emissions based on a gradual reduction in the carbon intensity of the U.S. economy, starting in 2010.)

Kennecott Energy, the nation's third-largest coal producer, has also acknowledged the severity of the global-warming problem. Kennecott is one of 10 private-sector parties that have volunteered to participate in the FutureGen project, pledging $20 million. But Kennecott is an exception in the coal industry. "The other major coal companies are staunchly opposed to anything that has to do with carbon management of any kind, under any circumstances," says Rusty Mathews. "They're not willing to acknowledge yet that there's some writing on the wall." Only a groundswell of public and political pressure to end the era of pulverized-coal power plants seems likely to budge the industry from its intransigence.

Can we hand down to future generations a world that is not irreversibly compromised by a failure to accept the consequences of our choices? There may be no single answer. Ingenious ways of avoiding the worst consequences of coal combustion, such as IGCC and carbon sequestration, are necessary parts of the solution, but they are not sufficient by themselves. "There are three big tools in the global-warming toolbox: efficiency, renewable energy, and carbon capture and storage for fossil fuels," David Hawkins says. "We need to use all of them. It will take all three to put together national and global recipes that can bring the problem of global warming under control."

WHY IT'S SUCH A GAS

Integrated Gasification Combined Cycle (IGCC) technology produces many fewer airborne pollutants than a conventional coal-fired plant and can capture carbon dioxide before it enters the atmosphere. Neither of the IGCC plants now in operation in the U.S. is yet equipped to capture and store CO_2 but could easily be adapted to do so.