IGCC with Carbon Capture and Storage

Opportunities and Challenges for Labor

COWS
center on wisconsin strategy

AFSCME 171

IGCC with Carbon Capture and Storage: Opportunities and Challenges for Labor

Gail Francis, Kate Gordon, Kyle Hanniman, and Satya Rhodes-Conway
Center on Wisconsin Strategy

October 2007

Abstract

America is on the cusp of a new energy future—a new industrial revolution that will rely on the skills and ingenuity of American workers, including union members. Integrated gasification combined cycle (IGCC) power plants, with their potential for carbon capture and storage (CCS), may be an important piece of this energy future, especially as carbon regulation comes into effect. This paper describes IGCC and CCS from a technical, environmental, and especially a jobs perspective, and discusses labor's potential to be at the forefront of the move toward this cleaner energy technology and away from outdated power generation technologies like pulverized coal. The paper also stresses labor's potential role in the broader clean energy economy, and the importance of being at the table now to ensure that this economy includes high quality, family-supporting jobs and worker benefits.

The Center on Wisconsin Strategy

The Center on Wisconsin Strategy (COWS) is a nonprofit, nonpartisan "think-and-do tank" dedicated to improving economic performance and living standards in the state of Wisconsin and nationally. Based at the University of Wisconsin-Madison, COWS works to promote "high road" strategies that support living wages, environmental sustainability, strong communities, and public accountability.

For more information, visit: www.cows.org

Table of Contents

Abbreviations

BVC	Best value contracting
CCPI	Clean Coal Power Initiative
CCS	Carbon capture and storage (also known as "carbon capture and sequestration")
CO	Carbon monoxide, a regulated pollutant
CO_2	Carbon dioxide, the most prevalent greenhouse gas
CWA	Communication Workers of America
DOE	U.S. Department of Energy
EOR	Enhanced oil recovery
EPA	U.S. Environmental Protection Agency
Hg	Mercury
IBEW	International Brotherhood of Electrical Workers
IGCC	Integrated gasification combined cycle
MW	Megawatt
NGCC	Natural gas combined cycle
NO_X	Nitrogen oxide, a catchall term for several regulated pollutants, including nitrogen dioxide (NO_2)
NRDC	Natural Resources Defense Council
PC	Pulverized coal
PLA	Project labor agreement
PM	Particulate matter, a regulated pollutant
RGGI	Regional Greenhouse Gas Initiative
SCPC	Supercritical pulverized coal
SNG	Substitute natural gas
SO_X	Sulfur oxide, a catchall term for several regulated pollutants, including sulfur dioxide (SO_2)
USCAP	United States Climate Action Partnership
WRCAI	Western Regional Climate Action Initiative

Executive Summary

The labor movement in the United States faces a number of opportunities and challenges as a new energy economy emerges to replace old technologies. Unions must rise to the challenge of capturing the jobs that will be found in the realm of cleaner energy; in doing so they will ensure that these will be good, safe jobs, and also seize the opportunity to expand their power in one of the most essential industries in the nation. Unions in the manufacturing, transportation, and construction sectors also have a tremendous stake in developing strategies to promote the energy supplies that will remain stable as our country moves to regulate greenhouse gas pollution.

For decades the United States has relied heavily on power plants that burn pulverized coal, because coal is relatively inexpensive and is mined domestically. However, mounting environmental concerns and regulations make pulverized coal less attractive. Pulverized coal faces an imminent threat in the form of taxes or caps on carbon dioxide (CO_2) emissions, now being implemented in three regions of the country and being considered in Congress for a national roll-out.

The United States' long-term power future may center on renewables, such as wind and solar, as well as more efficient use of electricity. But for now, technologies that use coal more efficiently and with less environmental damage will be important. Labor, which has a significant stake in the political and regulatory debates around new power generation, will continue to be asked to support new pulverized coal plants, but proactive unions should consider advocating instead for new generation that is more economically and environmentally sustainable.

One cleaner-coal technology being developed is called "integrated gasification combined cycle," or IGCC. Instead of simply burning pulverized coal in a boiler to heat the steam for power generation, IGCC plants gasify coal or other feedstock, then burn the gas in a combustion turbine and use waste heat to power a steam turbine—an efficient process similar to those in natural gas combined cycle plants. IGCC plants use less water and emit less airborne sulfur oxides, nitrogen oxides, particulates, and mercury than do pulverized coal plants. IGCC also lends itself to making use of non-coal feedstock such as refinery waste or agricultural products.

IGCC plants, like other power plants, produce CO_2, the primary culprit in global warming. But the CO_2 in an IGCC plant can be concentrated and removed prior to combustion, making carbon capture and storage (CCS) a more economical option.

IGCC with CCS, with its ability to comply more easily with current and projected environmental regulations, can provide more stable employment for utility workers than can environmentally riskier pulverized coal. In addition, IGCC with CCS provides employment in the building trades, coal mining, and coal transport industries, as well as in carbon transport, manufacturing, and in a variety of downstream markets that can use plants' byproducts. Captured CO_2, for example, can be pumped into oilfields where conventional extraction is not feasible.[i] Even the agriculture and forestry industry may benefit, because IGCC plants can use certain organic matter as well as coal for fuel.[ii]

IGCC plants may cost more to build and operate than do pulverized coal plants, but the cost advantage reverses if regulation drives up the cost of emitting CO_2. Regional cooperatives of states in the Northeast, Midwest and West area already shaping CO_2 pricing programs and Congress is considering national regulation. As these efforts develop, some states are already offering incentives for IGCC plants, utilities are beginning to propose new IGCC plants, and some environmental groups that are unalterably opposed to pulverized coal have offered support for IGCC with CCS.

Unions must assert their role in promoting technologies like IGCC with CCS. They have already crafted tools such as project labor agreements, apprenticeship programs, job quality standards, and other policy goals, while helping their industries transition to a more environmentally and economically sustainable path. Unions can focus these efforts on IGCC with CCS by:

- Talking to regulatory bodies to let them know that the union would look favorably on IGCC proposals;

- Meeting with legislators and energy task forces to encourage them to begin making IGCC part of the states' plan for meeting energy needs when new coal capacity is considered;

- Passing resolutions and local, state, district, and national union bodies endorsing IGCC with carbon capture and storage;

- Educating members and community about IGCC through guest speakers, educational materials, or community forums;

- Using bargaining and other meetings with employers to get companies to investigate the feasibility of IGCC with CCS for any new generation;

- Emphasizing the importance of union labor not only in plant construction, but also in maintenance, operations, mining, and coal transport.

1 Introduction

America is on the cusp of a new energy future that brings new opportunities and challenges for all workers. The vast majority of Americans recognize that we must break our dependence on an outmoded energy system that hurts the environment and makes our country less secure. Politicians in Washington are finally coming to the same realization and are moving toward a carbon regulation system that will make outdated energy technologies more expensive to build and operate. Global warming is no longer a catchphrase of the environmental movement; it is a scientific reality, and one we need to address now to slow the radical climate change that has already begun.

The new energy future will demand a new industrial revolution. With some strategic planning on the part of workers' organizations, American industry will provide the backbone of the next-generation energy system—from short-term solutions like cleaning up coal-fired and natural gas power plants, to the longer-term goals of widespread energy efficiency programs and a significant increase in the use of renewable power from the wind and the sun. From manufacturing to installation to maintenance and operations, workers and their unions are crucial at every phase of these projects. And unions are also critical to ensure that the benefits of the new energy economy spread fairly to those workers through family-supporting wages, high labor standards, and safe and healthy work environments. Organized labor must be at the table with policymakers and regulators to help stimulate job creation and to ensure that worker rights are respected in the clean energy economy.

In this paper we explore labor's role in just two types of new energy technology: a new type of power plant called "integrated gasification combined cycle," or IGCC; and carbon capture and storage, or CCS. Whatever this country's long-term energy solution, there is little doubt that coal will be part of its immediate future. At the moment more than half of America's electricity is generated using coal. Many of the country's existing coal-fired power plants are between 30 and 50 years old. Because of increasing electricity demands, about 150 new coal plants were being planned as of early 2007. Nearly all these plants use traditional, high-pollution pulverized coal technology.

IGCC is a promising technology for generating electricity from gasifed coal and other feedstocks. If combined with technology to remove and bury the carbon dioxide produced in a plant, it could dramatically reduce carbon dioxide emissions from power plants—and therefore slow global warming. Because of coal's significance in the energy mix, the sheer number of new plants coming on line, and labor's strong presence in the utility and coal industries, we focus here on the challenges and opportunities presented to labor unions by IGCC. In Section 2 we provide a brief background on IGCC, including technological and environmental aspects. Section 3 discusses the jobs available in IGCC plants and associated industries. In Section 4, we explore the economic and political feasibility of IGCC as compared to pulverized coal. And in Section 5, we suggest practical ways labor unions can ensure a place in the new energy economy.

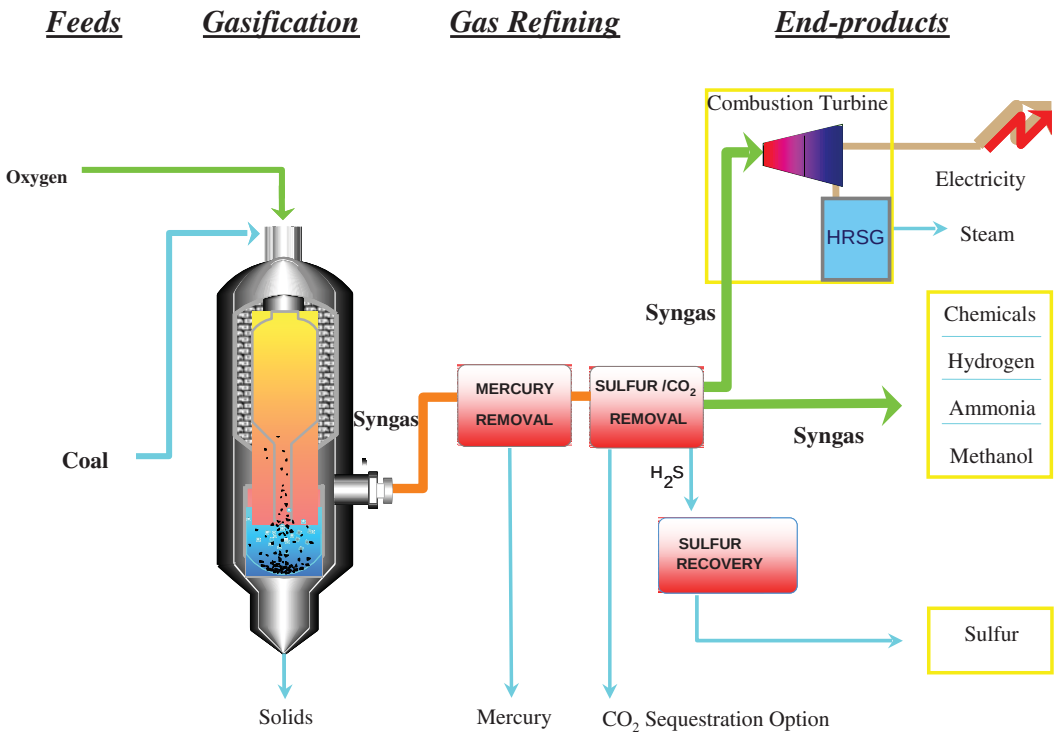
2 Background on IGCC with Carbon Capture and Storage

IGCC

Integrated gasification combined cycle (IGCC) power plant technology is often described as an innovation, but in fact it simply brings together two longstanding technologies: coal (or other feedstock) gasification and combined cycle electricity generation.

Gasification, the first component of IGCC, is a process wherein coal or another feedstock (such as wood waste) is converted into synthetic gas or "syngas." The technology dates to the 1700s, when coal was used to generate "town gas," which in turn was used to light streetlamps. Later, coal-rich Germany gasified coal to make aviation fuel during World War II, and South Africa produced synthetic fuel from coal during the apartheid-era embargo. More benignly, the United States has gasified coal to produce hydrogen and other chemicals since at least 1954.[1] Many countries, including our own, currently gasify coal to produce fertilizers, hydrogen, methane, and other valuable products. Only recently has syngas been used to generate electricity: The first plant to gasify coal and then burn the gas to generate electricity came online in 1984 as a test project for the U.S. Department of Energy (DOE), operated by Southern California Edison.[2]

Figure 1
Integrated Gasification Combined Cycle (IGCC)



Source: Clean Air Task Force.[3]

Combined cycle generation, the other half of the IGCC equation, is the process of burning fuel in a combustion turbine, then using the waste heat from the exhaust to produce steam to power a second turbine. This second turbine gives the technology an efficiency edge over the single-turbine technology in use at traditional pulverized coal (PC) plants, which rely on the steam cycle alone. Combined cycle technology is currently widely used in natural gas combined cycle (NGCC) power plants, but utilities are increasingly looking at the virtues of combining this technology with coal gasification at IGCC facilities.

Figure 1 illustrates the IGCC process. This diagram, and the charts in Figures 2 and 3, highlight one of the key environmental advantages of this technology over pulverized coal technology: its ability to remove mercury, sulfur oxides (SO_X), and carbon dioxide (CO_2) from coal-fired power plant emissions. A further benefit is that the air used in the gasification is almost pure oxygen, resulting in lower nitrogen oxide (NO_X) content in emissions as well. Finally, because the plants burn syngas rather than coal, they produce less particulate matter (PM). Most of these pollutants are currently subject to federal regulation (see box below).

Regulated Pollutants

The federal government currently regulates a number of pollutants originating from point sources such as power plants. These include sulfur dioxide, nitrogen oxides, particulate matter, and mercury. Regulation of carbon dioxide is expected soon.

Sulfur dioxide: Sulfur dioxide, or SO_2, is a gas that is created during the combustion of coal and other organic materials containing sulfur. It is part of a class of gases commonly referred to as SO_x. The gas itself can lead to respiratory disease and can worsen heart and lung conditions. When it is dissolved in water vapor, it leads to acid rain. Emissions from utilities account for more than 65 percent of sulfur dioxide being released.

Nitrogen oxides: Also known as NO_X, nitrogen oxides are by-products of fossil fuel combustion. They contribute to smog, respiratory problems, and acid rain. They also degrade water quality and react with other compounds to form toxic chemicals. Nitrogen dioxide, or NO_2, one of the oxides, is also a powerful greenhouse gas. Utilities are responsible for 22 percent of NO_X emissions.

Particulate matter: The federal government regulates two types of particulate matter (PM): inhalable coarse particles (PM_{10}) and fine particles ($PM_{2.5}$). Health problems posed by these particles include respiratory illness, increased risk of heart attack, and decreased lung and heart functioning. Particulates also damage water quality, crops, forests, and soil, and contribute to smog.

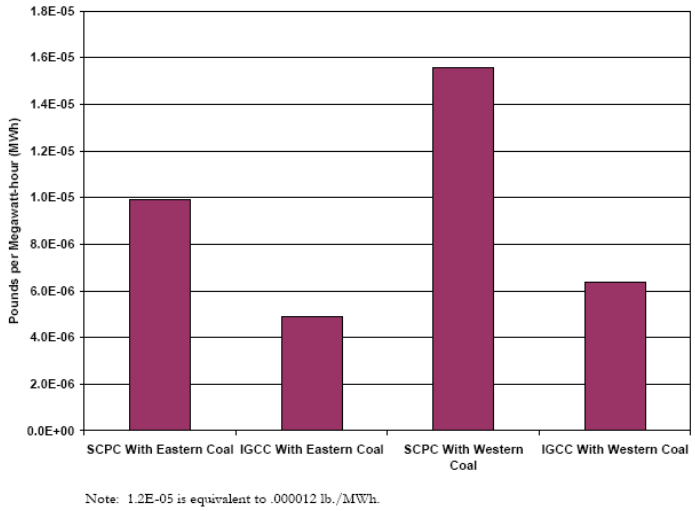
Mercury: Mercury, or Hg, is a toxic element that damages the nervous system and brain development. Power plants are the largest single source of mercury in the environment. Once emitted from a plant, mercury finds its way to water and soil, where it enters the food chain, damaging ecosystems and human health.

Carbon monoxide: This gas is mostly emitted from vehicles, but electric generation contributes to this form of pollution as well. Carbon monoxide (CO) contributes to smog, aggravates heart conditions, and can lead to neural problems.

Figures 2 and 3 show improvements in emissions that are possible with IGCC technology as opposed to old coal technology. Figure 2 indicates that IGCC plants consistently emit less mercury per megawatt-hour than even the best pulverized coal plants (known as supercritical or SCPC), regardless of whether they are burning Eastern or Western U.S. coal. Figure 3 demonstrates IGCC's superior performance with other pollutants.

Figure 2

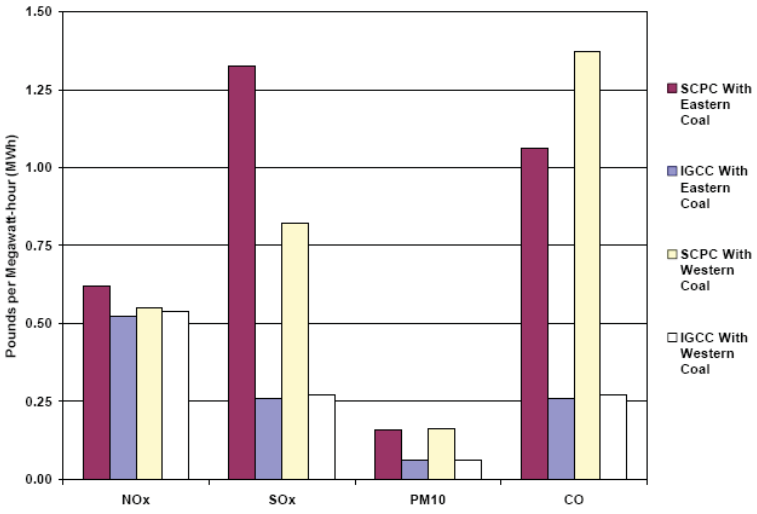
Mercury Emission Rates, IGCC vs. Pulverized Coal Plants



Source: Wisconsin Public Service Commission.[4]

Figure 3

Other Pollutant Emission Rates, IGCC vs. Pulverized Coal Plants



Source: Wisconsin Public Service Commission.[5]

Other environmental benefits of IGCC include a 25–40 percent reduction in water use compared with pulverized coal plants—which take enormous quantities of water from nearby lakes and rivers for steam generation and cooling—and the increased efficiency gained from the two-turbine technology. In addition, the sulfur and mercury removed from the syngas in an IGCC plant are contained in higher-concentration, lower-volume waste streams. Depending on the type of coal burned, IGCC plants produce 15–50 percent less waste volume than pulverized coal plants do.[6] The sulfur can be sold as a feedstock for the chemical industry, and the lower volume of mercury waste results in significantly less environmental risk compared to the exhaust gas cleanup wastes from pulverized coal plants.

Besides volume, a key difference between the solid waste produced by an IGCC plant and conventional plants is the form of the waste. IGCC plants produce slag that is vitrified in a glass-like substance that makes it less prone to leaching from landfills into the environment.

Carbon Capture and Storage

Of all these environmental benefits, the most important—and most controversial—is the ability to remove CO_2 prior to combustion, thus keeping it from entering the atmosphere.

Because CO_2 can be removed from the gas stream during the IGCC process more readily than in a pulverized coal plant, where it must be removed from smokestack emissions, IGCC's potential to include "carbon capture and storage," or CCS, is by far its most important environmental advantage over traditional pulverized coal plants.

Once the CO_2 is captured, it must be stored safely. In most cases, such storage will take place underground, in rock formations. Such storage will be discussed in more detail below.

Reducing the amount of CO_2 in the Earth's atmosphere is the key battle in the fight against global warming. CO_2 levels have been rising steadily ever since the industrial revolution, but in recent decades the levels have increased so rapidly that we face the real possibility of massive loss of life—and economic stability—from floods, droughts, famine, and poverty. Scientists point out that we are already experiencing climate change, and that it has contributed to phenomena such as increased storm intensity, extinction of plant and animal life, and falling water levels in the Great Lakes. CO_2 reduction is essential.

Unlike the other pollutants discussed above and in the sidebar, all of which have been regulated by the U.S. Environmental Protection Agency (EPA) for years, CO_2 only became classified as a regulated pollutant in an April 2007 U.S. Supreme Court case, *Massachusetts vs. Environmental Protection Agency*.[7] The Supreme Court said that "A well-documented rise in global temperatures has coincided with a significant increase in the concentration of carbon dioxide in the atmosphere," and held that carbon dioxide emissions should be considered an "air pollutant" by the EPA and thus regulated by that agency in the same way that it regulates other airborne pollutants.

Even before this decision, the federal government had been moving toward CO_2 regulation. Regulating CO_2 will have a significant impact on all types of coal plants, and will certainly influence the economic feasibility of building an IGCC plant. We discuss this issue at greater length in Section 4.

IGCC and CCS Plants in Operation Today

IGCC

IGCC (without CCS) is a well-established technology. Altogether there are 10 commercial-scale IGCC plants worldwide, ranging in capacity from 185 to 300 MW.[8] They use a variety of feedstocks, but primarily coal, petroleum coke, and asphalt.[9] These plants have an average availability of better than 82 percent.[10] (See Table 1.)

Because of increased understanding of global warming, and the resulting caps on carbon dioxide emissions in place or proposed in many countries, developers, utilities, and investors are all gaining interest in IGCC. More than 20 major coal- or petcoke-fueled IGCC projects are currently being proposed in the United States (see Table 2), with additional projects under way in Europe, Asia, India, and Australia.

Not all of these projects will be built. They must first secure approval from various regulatory bodies such as public service/utility commissions, and this step often requires the support of environmental and labor groups. The following projects are considered particularly viable:

Illinois, 777 MW, ERORA/Tenaska: The state of Illinois has supported this project with $5 million,[11] and it is moving fairly smoothly through the permitting process. It will have one gasifier that can switch to methane production when desired.

Indiana, 630 MW, Duke Energy: The DOE has selected this project to receive $136 million in tax credits. Additional tax incentives are available through county and state incentives.[12] No major obstacles have presented themselves to permitting this plant, and it is being supported by labor and some environmental organizations.

New York, 630 MW, NRG Energy: NRG has received permission to build an IGCC plant near Buffalo. The permission is contingent on resolving rate issues resulting from the higher capital cost of the plant.[13] The labor community is working hard to make this project a reality.

Ohio, 600 MW, AEP: AEP has received active support from labor and some environmental organizations to build this plant. No major obstacles have materialized in the permitting process. Ohio's regulatory body has granted permission for AEP to recover pre-construction costs.

The deployment of these and other IGCC projects represents a step forward for cleaner air, but in order to realize their full environmental potential, carbon capture and storage technology must also be deployed.

Carbon capture and storage (CCS)

At the time of this writing, there are no IGCC plants in the United States that also include CCS. However, the following CCS methods are possible, some of them already being used at various non-IGCC facilities.

Table 1
IGCC Plants of at Least 250 MW in Operation Today

Plant	Location	Startup Year	MW
Nuon[14]	Netherlands	1994	250 MW
Wabash[15]	Indiana	1995	260 MW
Polk[16]	Florida	1996	250 MW
SUV[17]	Czech Republic	1996	350 MW
Elcogas[18]	Spain	1998	320 MW
ISAB Energy[19]	Italy	2000	510 MW
Sarlux[20]	Italy	2000	548 MW
Api Energia[21]	Italy	2002	280 MW
Nippon[22]	Japan	2003	342 MW
Eni AGIP[23]	Italy	2006	250 MW

Table 2
Proposed U.S. IGCC Projects

State	Feed Stock	MW	Developer
Alaska[24]	Coal	350 MW	Agrium
Colorado[25]	Coal (sub-bituminous)	350 MW	Xcel
Idaho[26]	Coal (bituminous)	500 MW	Energy Development Group
Idaho[27]	Coal	250 MW	Mountain Island Energy Holdings
Illinois[28]	Coal (mine-mouth bituminous)	500 MW	Madison Power Co.
Illinois[29]	Coal	2400 MW	Clean Coal Power Resources
Illinois[30]	Coal (bituminous)	545 MW	Steelhead
Illinois[31]	Coal (bituminous)	777 MW	ERORA/Tensaka
Indiana[32]	Coal (bituminous)	630 MW	Duke Energy
Minnesota[33]	Coal (sub-bituminous)	630 MW	Excelsior
Mississippi[34]	Coal (lignite)	600 MW	Mississippi Power
New York[35]	Coal (bituminous)/Petcoke	630 MW	NRG Energy
Ohio[36]	Coal (bituminous)/Petcoke	600 MW	Global Energy
Ohio[37]	Coal (bituminous)	600 MW	AEP
Oregon[38]	Coal (bituminous)	520 MW	Westward
Texas[39]	Petcoke	1200 MW	Hunton
Washington[40]	Coal (sub-bituminous)/Petcoke	600 MW	Energy Northwest
West Virginia[41]	Coal (bituminous)	600 MW	AEP
Wyoming[42]	Coal (sub-bituminous)	200 MW	DKRW
Wyoming[43]	Coal (sub-bituminous)	300 MW	Wyoming Infrastructure Authority
Wyoming[44]	Coal	1100 MW	Buffalo Energy

Enhanced oil recovery (EOR): CO_2 is injected into oil wells, where it pushes the oil up toward the surface. This process has been used for over 50 years, but until recently the carbon dioxide has been allowed to vent to the air once it does its job. One large-scale permanent carbon storage/EOR projects currently exists:

- *Weyburn, Saskatchewan*. The EnCana Corp. takes CO_2 produced 200 miles away at a coal gasification plant in North Dakota and pipes it underground into the Weyburn Oil Fields. This project, which began in 2003, sequesters more than 1 million tons of carbon dioxide per year.

Injection into underground geologic formations: CO_2 is injected as a fluid into deep geologic formations, such as saline aquifers; the formations chosen for carbon storage have natural cap rocks, such as shale, that prevent the CO_2 from leaking upward to re-enter the atmosphere. Over time, the liquid CO_2 dissolves into the aquifer fluids and forms new minerals, further reducing the ability of the CO_2 to leak upward. Two large projects currently employing this method of carbon storage.

- *Sleipner, Norway*. The company Statoil strips CO_2 from its natural gas supply in order to avoid a Norwegian carbon tax. The CO_2 is injected into the Utsira saline aquifer, storing roughly 1 million tons per year. Injections began in 1996.[45]

- *In Salah, Algeria*. A joint project of BP, Statoil, and Sonatrach takes CO_2 out of natural gas from the Krechba fields and injects it into saline acquifers. The project, which began in 2004, sequesters about 1 million tons of carbon dioxide per year.[46]

Enhanced coal bed methane recovery: CO_2 is injected into un-mineable coal seams in order to push out the methane, leaving the CO_2 trapped below. The methane can then be refined and sold commercially. An important caveat about this storage method is that it has never been tested on a commercial scale.

Existing CCS projects have provided valuable insight into the mechanisms, practicality, and safety of long-term carbon storage, but more research is urgently needed to develop a broader understanding of the types of underground structures that may house carbon dioxide, the long-term fate of the stored gas, and the legal aspects of such storage. To begin to understand the full potential of CCS, a recent report from the Massachusetts Institute of Technology urges immediate development of 10 additional CCS sites with the capacity to handle at least a million tons of CO_2 per year.[47] According to that report, 18 such projects are currently being proposed worldwide, with two of these in the United States.

Two other methods of carbon storage are not yet considered able to reliably store the large quantities of CO_2 that are emitted from fossil-fuel electric generation. One is terrestrial storage, in which land management practices are altered to maximize the CO_2 intake from vegetation. One promising variation on terrestrial storage involves using biomass as a feedstock (see box on next page). The other is chemical conversion, in which CO_2 is chemically combined with other compounds to prevent its release into the atmosphere. Such materials might be safely used in construction.

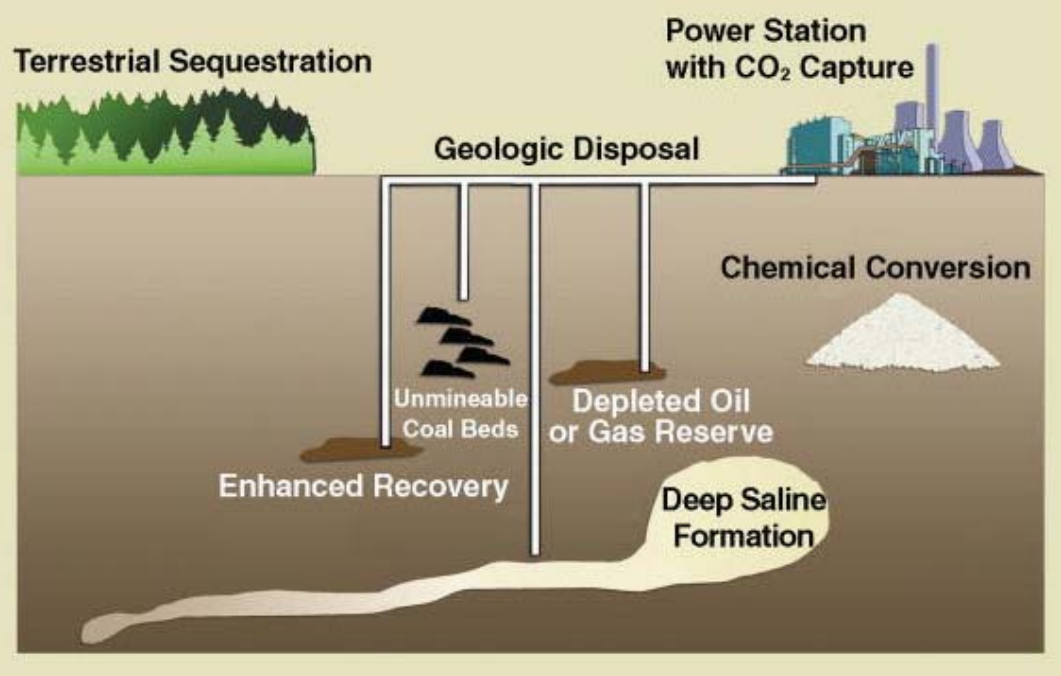
Co-firing with Biomass

Biomass is plant material, such as waste from agriculture or forestry, that is used to produce energy. Co-firing biomass with other IGCC feedstocks can be an indirect method of carbon storage.

As plants grow, they remove CO_2 from the air, and some of the carbon is transferred to the soil. How much carbon is put into the soil and how much is retained by the plant varies greatly by species and environmental conditions. Some species, such as switchgrass, appear to be able to store significant amounts of carbon in the soil—more than they release when harvested and burned. Thus, burning such forms of biomass can result in a net reduction of CO_2 from the environment.

The IGCC plant operated by Tampa Electric Co. in Florida conducted a test burn of biomass in 2002. It mixed 60 local eucalyptus trees with the usual feedstock of coal and petcoke, so that the trees made up roughly 1.2% of the input to the gasifier. Although the biomass was found to have a lower heating value than the fossil fuels, it also produced lower levels of regulated pollutants. TEC did not find any technical impediments to co-firing biomass with fossil fuel feedstocks.[48]

Figure 4
Carbon Dioxide Storage Options



Source: Department of Energy[49]

Putting IGCC and CCS Together

IGCC is widely regarded as the technology that most easily facilitates carbon capture for coal. Many of the proposed IGCC plants claim to be built as "capture ready," meaning that they are initially able to capture 15%–30% of CO_2 from the gas stream.[50] Significant changes to the gasifier, cooling system, feedstock, and other aspects of the process would most likely be required to convert from a "capture ready" IGCC plant to one that captures the majority of CO_2.[51] Environmentalists and regulators are beginning to consider a demand that new IGCC plants actually capture and store at least some portion of their carbon dioxide from the outset.[52]

Figure 4 on the previous page graphically depicts the various forms of CCS discussed above.

3 The Jobs

IGCC: Employment

IGCC is an interesting technology from an environmental perspective. It has the potential to allow continued coal use with less of the harmful emissions associated with traditional pulverized coal power plants. IGCC may be the best short-term solution to our electricity needs, as we develop longer-term energy efficiency and renewable energy solutions for the future. But the transition from pulverized coal to IGCC will not happen unless it is economically and politically feasible, and it should not happen unless it is good for the workers who will make the transition from one plant type to another. We discuss the current job potential at IGCC plants in this section, and move on to the economic and political feasibility in Section 4.

Utility workers

The utility industry is changing. The outcome of these changes is not yet known, but one thing is certain: Carbon regulation will be one of the fundamental aspects of the industry's future, and plants that adjust to this new reality will be more able to provide a stable or growing workforce.

Renewable energy systems such as wind turbines and solar cells offer the best prospects for long-term job security in a carbon-constrained world. But coal is abundant, it is relatively cheap, and it is a domestic source of energy. For these reasons, it is likely to play a role, at least in the near term, in America's energy future. The future of coal must involve reduced emissions of carbon dioxide and other pollutants. In this regard, IGCC is a better bet for power plant workers than pulverized coal, because IGCC plants can be designed (or retrofitted) to include carbon capture more efficiently than PC plants.[53]

Building trades

The employment advantages of IGCC as opposed to pulverized coal are not limited to the workforce that operates and maintains the facilities, but also to the building trades and to the businesses that provide services to the thousands of workers who are needed to construct a plant over the course of three to five years. (See Appendix A for an estimate of jobs in these industries.) The building trades unions not only can offer their members steady employment on such a project, but they can use the project as an organizing tool to bring in new members to meet the demand for labor.

Mining

IGCC offers particular benefits to Midwestern miners and utilities. Currently, many Midwestern power plants use Powder River Basin coal, shipped from Wyoming. This coal is favored, despite its lower heating value, because its low sulfur content makes it easier to comply with SO_x regulations.[54] As a result, the coal industry in the West has boomed, while coal mining areas in the Midwest and East have suffered. In West Virginia alone, mining employment has gone from more than 100,000 jobs to fewer than 20,000 jobs in the last 60 years.[55]

However, since removal of sulfur is significantly easier and more thorough in an IGCC facility than in a pulverized coal plant, the technology allows Midwest utilities to enjoy the higher heating value and closer proximity of coal from Illinois, Indiana, Kentucky, Ohio, Pennsylvania, and West Virginia. More coal from the Midwest means more jobs in the Midwest: One government study predicts that every 2.8 million tons of coal consumed in Illinois creates 700–800 mining jobs in the state.[56] Another study asserts that one Indiana IGCC plant would result in 300 jobs mining Indiana coal.[57]

We do not want to minimize the environmental harm of coal mining, especially of "mountaintop removal." But as a near-term energy solution, as miners and utility workers begin the transition to an economy based more on efficiency and renewables than on fossil fuels, IGCC may be beneficial to the Midwestern communities that depend on mining activities.

Coal transport

More Midwestern coal means more work for the engineers, conductors, maintenance of way, and other rail workers in the Midwest whose job it is to move coal from the mine to the power plant. Power plants require such volume of coal that the only viable means of transport are rail and water, and even water transport is dependent on rail to bring the coal to and from port.

Rail employment provides more than 25,000 jobs in the five-state region of Wisconsin, Illinois, Michigan, Indiana, and Ohio.[58] Most of the work is both well-paying and unionized, so any new jobs in this area are highly valuable to workers and to the labor movement generally.

Carbon transport

Carbon capture and storage adds additional jobs at the other end of the labor chain, transporting the CO_2 through pipelines from the power plants to its place of storage, such as an oil field or other geologic formation. In particular, considerable work will be generated for pipefitters and other building trades workers. The length of the pipelines, and thus the number of pipeline construction jobs, will depend on the situation of the plant relative to the carbon storage location. Employment during construction will also depend on other factors such as the terrain between the plant and the storage area.

Manufacturing

Outside the immediate utility and transport areas, IGCC with CCS holds great promise as a job creation engine in the manufacturing sector. One obvious area for potential job growth is in the manufacture of IGCC and CCS plant components. One IGCC plant manager complained to this paper's authors that parts at his plant had to be imported from other countries, and that his company incurred heavy transportation costs as a result. To bring down these costs, which are likely to go up as fuel prices rise, current U.S.-based component manufacturers could easily move into the business of IGCC and CCS components. IGCC with CCS presents domestic manufacturing opportunities for many parts, including:

- Gas and steam turbines
- Gasifiers
- Air separation units
- Refractory materials
- Compression pumps
- Control instruments

Agriculture and forestry

The use of biomass as an IGCC fuel opens up opportunities for farmers and foresters who may be able to convert the waste parts of plants (corn stover, tree canopies, etc.) to feedstock, or directly produce energy crops such as switchgrass.

Indirect economic benefits: downstream markets

IGCC with CCS creates byproducts that can themselves be sold, creating new jobs, extra income for IGCC plant operators, and, indirectly, for the surrounding communities. Following are some of the co-products or downstream byproducts from the IGCC process and the potential markets for them. No single plant will produce all these products simultaneously; this list is merely meant to illustrate the potential for developing new aspects of a clean energy economy. Some of the technologies, such as carbon nanofibers, are still in the early development stages, while others, such as fertilizer, have well-developed markets.

- **Oil**: Carbon dioxide pumped into oil and gas fields can recover resources that would be difficult to extract by other means.[59] Dakota Gasification Co. in North Dakota currently generates revenue by selling carbon dioxide it captures from its syngas production for enhanced oil recovery.
- **Natural gas**: Some of the IGCC projects proposed have the capability of burning the syngas directly for energy or converting the syngas to substitute natural gas (SNG). The SNG is refined so it to can be injected into existing natural gas pipelines.
- **Carbon nanofibers**: Carbon harvested from IGCC can be used to produce carbon nanofibers, which are then used to create industrial coatings, airline shells, and many other products. Applied Sciences Inc., in fact, has already expressed the intent to build a carbon nanofiber plant in Lima, Ohio, after an IGCC plant is built there.[60]
- **Commercial greenhouses**: Carbon dioxide is added to the air inside commercial greenhouses to enhance plant growth.[61]
- **Ammonia and fertilizer**: Ammonia and fertilizer are already primary products at coal and petroleum gasification plants, and are possible co-products for an IGCC plant.[62]
- **Methanol**: The ingredients for this racing fuel can be derived during the process of cleaning up syngas prior to combustion.[63]
- **Sulfur**: Elemental sulfur pulled from syngas is already sold as a byproduct at both the Wabash and the Polk IGCC facilities in the United States. It is used to make sulfuric acid and/or fertilizers.[64]
- **Slag**: IGCC slag is more versatile than slag from other types of coal plants because it is inert and less prone to leaching. Uses include road and building construction.[65]
- **Hydrogen**: Hydrogen that is recovered from the IGCC process has potential to turn yet another turbine or be used in fuel cells for vehicles and appliances.[66]
- **Urea**: Captured carbon dioxide can be combined with ammonia to produce urea, a nitrous compound used in plastics, fertilizers, de-icing agents, diesel exhaust treatment, hair products, and even pretzels.[67]

Realizing the employment potential

IGCC and CCS pose advantages for wide-ranging groups of workers. Probably the best way to maximize the opportunities in these new technologies is for union leaders to act together to promote their deployment. A coalition of unionists in manufacturing, mining, utilities, and building trades could form a powerful united voice to influence policy-makers and regulators.

4 Economic & Political Feasibility

Even with its potential environmental and workforce benefits, IGCC with CCS will not become a reality unless it is cost-competitive with pulverized coal—and this will not happen without carbon regulation. In this section we explore the economic and political feasibility of IGCC with CCS, focusing primarily on carbon regulation as the crux of both issues.

The Economics of IGCC with CCS

In the current non-carbon constrained economy, it is cheaper to build and operate a pulverized coal plant than it would be to build an IGCC plant. However, several recent studies indicate that if the United States were to pass sufficiently stringent carbon regulation policies, this result would be reversed. In a carbon-regulated world, traditional pulverized coal power plants would have to reduce carbon emissions, buy carbon credits to offset emissions, or pay a financial penalty on emissions. Carbon capture technology can allow power generators to reduce emissions at reasonable cost, and this technology can more easily and inexpensively be added to IGCC plants than to PC plants.[68, 69] The economic case for IGCC and CCS is strengthened by the fact that both technologies are becoming more commercially viable by the day, as evidenced by the improved availability rates at existing sites and the improved organization of the manufacturing supply chain. Finally, often overlooked is the enormous potential for exporting IGCC and CCS technologies abroad.

The bottom line is that the economic viability of IGCC with CCS hinges on the federal government adopting CO_2 regulation. Such regulation is politically more likely now than it has ever been. There is growing support for some form of regulation from citizens, environmental groups, and even several large coal-burning utilities. David Ratcliffe, CEO of Southern Co., has admitted that "[t]here certainly is enough public pressure and enough Congressional discussion that it is likely we will see some form of regulation."[70] David Crane, head of NRG Energy, is also convinced. He warns that "we're talking about the type of business issue that comes along perhaps once in a century. Those companies and industries which deny the issue will be marginalized."[71]

We discuss the growing political momentum behind carbon regulation in more detail below. The momentum is real and is already affecting the investment decisions of a number of utilities, which are scaling back plans to invest in traditional plants and announcing plans to invest in IGCC. As this change occurs, IGCC with CCS emerges as one viable alternative for the utility industry.

The relative costs of PC and IGCC with and without carbon regulation

A host of factors affect the competitiveness of IGCC, including construction costs, coal type, and the availability of carbon storage and transportation networks. There is widespread consensus that in the absence of carbon regulation, capital and operating costs are significantly lower at PC plants. The findings of two recent major studies by the Wisconsin Department of Natural Resources and the MIT Coal Group are consistent with this claim. The Wisconsin study found that, in the absence of carbon regulation, a 600 MW IGCC plant without carbon capture entails higher construction costs, lower operational reliability, and lower heating efficiency than a 600 MW supercritical pulverized coal (SCPC) plant. The cost of operating the IGCC plant was $5 to $7 per MW-hour more than the cost of operating the super-critical pulverized coal plant.[72] Similarly, comparing the capital costs of PC and IGCC plants without carbon capture, the MIT study found that capital costs for building 500 MW PC and IGCC plants were $726 million and $759 million respectively, while projected annual operating costs were $26.3 million and $31.2 million.[73]

But the results change when carbon regulation is added to the mix, because of the carbon capture and storage potential of IGCC plants. There is broad consensus among experts: Assuming sufficiently high penalties on carbon emissions, building IGCC plants with CCS technology is less costly than building traditional pulverized coal plants. Even investing in IGCC technology without CCS can help utilities to avoid future charges on carbon emissions, because these plants are cheaper to combine and retrofit with CCS technology than PC plants. According to the Wisconsin study, building and operating a SCPC plant in a carbon-regulated environment costs $10 per MW-hour more than if there are no restrictions on carbon emissions.

What level of regulation is necessary for IGCC to become financially preferable to PC? An MIT study puts the tipping point at $23.28 per ton of carbon dioxide emission. The MIT study admits that this is a rather aggressive fee that might lack immediate political support. However, the study notes that carbon dioxide emissions were trading at $30 per ton under the European cap-and-trade system at the time of publication.[74] Once the United States enters the carbon trading market, it will become part of a global trading system in which carbon dioxide has value—value that will probably only go up as the threat of global warming is better understood.

IGCC commercial viability

There is still skepticism in the investment community about the commercial viability of IGCC, but this situation is changing. For example, one concern about IGCC has been the low availability of these plants—that is, that the plants are not always available to produce power when needed. But the industry is seeing improvement. Technology over a decade old at the Polk (Florida) and Wabash (Indiana) IGCC plants is fast approaching commercial reliability standards: Both had reached availability of more than 80 percent by 2003.[75]

Another concern about IGCC has been the difficulty of piecing together design and technology components from disparate sources. However, this situation has improved over the past few years, as large corporations have formed partnerships to offer complete packages for the design, construction, and deployment of IGCC facilities.

And finally, governments are starting to lower investment risks for IGCC plants through tax-based incentives (in, for example, Illinois, Minnesota, Kansas, and Indiana), credit-based incentives (in, for example, Colorado, New York, and Ohio) and regulatory incentives (in, for example, Pennsylvania, Wisconsin, and Minnesota).[76] Table 3 describes these incentives in more detail.

Table 3
Existing State-Based Incentives for IGCC Development

State	Incentive
Colorado	Requires approval of IGCC facilities that use Colorado or Western coal upon a showing of feasibility, environmental benefits, and cost-effectiveness.
Illinois	Provides up to $300 million in bonds for new gasification facilities and $5 million in public-private support for the $1.1 billion IGCC Taylorville Energy Center, among other incentives.
Indiana	Provides a variety of financial incentives for "clean coal and energy projects" using Illinois Basin coal or gas.
Kansas	Offers a property tax exemption to certain integrated coal gasification power plant property. Offers tax credits for the development of new coal gasification facilities.
Kentucky	Provides tax credits for integrated coal gasification power plants. Requires the Public Service Commission to approve certain long-term contracts by utilities for synthetic gas from coal.
Minnesota	Offered incentives for proposed Mesaba Energy gasification plant and entitles Excelsior Energy to sign a 450 MW power purchase agreement with Xcel Energy.
New Mexico	Provides the following tax credits to clean energy investments: advanced energy tax credit; gross receipts tax; compensating tax; withholding tax. Includes IGCC in the definition of clean energy investments and allows for Department of Environment certification for IGCC.
Ohio	Offers conduit funding, loans, loan guarantees, grants, tax incentives, and funding for demonstration projects and the development of clean coal technology.
Pennsylvania	Includes IGCC in definition of "alternative sources" under its renewable energy requirement for utilities. Provides low interest loans for IGCC, and permits long-term power purchase contracts to assist with funding.
Texas	Funded site screening for potential FutureGen plant, approved $22 million in grants and incentives for low-emission projects, and expedited permitting for FutureGen-type projects.
Virginia	Creates a Clean Coal Technology Research Fund to assess new clean coal investments and technology.
West Virginia	Provides basic assistance for clean coal industry under the West Virginia Clean Coal Technology Act. Offers rate incentives for utility investment in qualified clean coal and clean air control technology facilities.
Wyoming	Offers a sales and use tax exemption for equipment purchased to make new IGCC or coal liquefaction facilities operational. Creates a clean coal research account where funds are deposited from mine product taxes and used for clean coal research.

Source: National Conference of State Legislatures[77]

Export manufacturing potential

If the United States aggressively develops IGCC and CCS technology, it could become an exporter of this technology to other countries. This is an area of tremendous export potential. Emerging markets in places like China, India, and Russia are in desperate need of clean energy technologies to serve their exploding demand for electricity. Countries with carbon dioxide regulations may also be target export markets for this kind of technology. At the same time, the United States is currently the world's largest producer and consumer of coal, making it the ideal laboratory for testing and developing better, cleaner coal technologies. The United States is already the world's leader in gasification technology, with 27 gasification projects in 16 states.[78]

Political Feasibility of IGCC with CCS

The clean energy economy, with all its labor and environmental benefits, may finally end the historic tension between economic prosperity and environmental sustainability. This new industrial revolution also brings great opportunity for new innovation and ingenuity, and ultimately for American dominance in a new set of industries and technologies. This promise explains the increasingly favorable attitude of labor and business toward clean energy technology and even, in some cases, for carbon regulation. It also explains the environmental community's increasingly favorable attitude toward policies that promote employment and economic growth.

National context

Elected officials in the United States, as in many other parts of the world, are responding to public anxiety over the environmental consequences of greenhouse gas emissions. A host of clean energy and energy efficiency initiatives have come out of Congress in the past few years. Here we focus on initiatives related to coal-based power generation, and on the political context for carbon dioxide regulation. One important caveat: The political context is constantly changing, and so many of the following programs and initiatives may be outdated soon after this paper is released.

As of this writing, the federal government funds the Clean Coal Power Initiative (CCPI), which, in turn, funds research and development of clean coal technology at DOE's National Energy Technology Laboratory. DOE also sponsors a Carbon Sequestration Program, funded at $450 million over the next four years. The program funds seven regional partnerships in their quest to prove that "capture, transportation, injection and long-term storage of carbon dioxide can be done safely, permanently, and economically." The federal government has also invested $1 billion to develop the first emission-free coal power plant, called FutureGen. Final selection for the site may be made this year; construction is slated to begin in 2009 and end in 2012.[79]

On carbon dioxide regulation, in the past year alone members of Congress have proposed multiple pieces of cap-and-trade legislation, calling for drastic emissions reductions from current levels. Other legislators have called for carbon dioxide taxes or other caps. Because these bills keep changing, and new bills keep being introduced, we will not provide a list of current bills here. However, it is clear from the sheer number of proposals on the table that Congress takes carbon regulation very seriously, and that some sort of regulation is likely soon.[80]

The only U.S.-based system in place at the moment for trading greenhouse gas emissions, including carbon dioxide, is the Chicago Climate Exchange. This is a voluntary but legally binding system that allows participating businesses and governments to trade emissions offsets.

State and regional levels

At the time of writing, 10 states have incentives to develop IGCC technology, and three states are considering such incentives. Kansas, for example, offers tax credits for the development of new gasification facilities. Ohio offers funds, loans, loan guarantees, grants and tax incentives for gasification development projects. (See Table 3 for more details.)

On carbon regulation, while there have been tremendous regulatory and policy strides at the federal level, progress has been even more impressive at the state and regional level, where several carbon trading schemes are already in place. Eight northeastern states now belong to the Regional Greenhouse Gas Initiative (RGGI), a plan to establish the first American controls for greenhouse gas emissions.[81, 82] RGGI will ultimately combine a mandatory emissions cap with an emissions allowance trading system; the program is seen as a potential model for national legislation. In the West, the governors of California, New Mexico, Oregon, Washington, Arizona, and British Columbia signed the Western Regional Climate Action Initiative (WRCAI) in early 2007. Similar in principle to RGGI, the agreement calls for the establishment of a jointly set emissions target and a market-based system—possibly cap-and-trade—to meet that target.

At the individual state level, California has made the greatest strides. In addition to the WRCAI, California enacted the Global Warming Solutions Act, requiring the state to reduce greenhouse gas emissions to 1990 levels by the year 2020, and to 80 percent below 1990 levels by 2050. But California is by no means the only state taking measure to improve air quality. As of March 2007, 13 other states had established greenhouse gas reduction targets. (See Appendix B.)

Political movement does not happen without strong interest group participation, and the interests of the labor, environmental, and business lobbies will be especially important as the country moves toward acceptance of carbon regulation, new energy technologies, and cleaner coal technologies. We have already discussed labor's growing interest in these issues, and will spend more time in the next section on how labor can strategically position itself to be a major player in the new energy economy. The remainder of the section focuses on recent developments in the positions of environmental and business groups concerning carbon regulation and clean coal technology.

Types of Carbon Regulation

The national carbon regulation schemes currently proposed generally fall under two categories: cap-and-trade systems and carbon taxes.

Under **cap-and-trade** systems, the government sets a "cap" limiting emissions from polluters, including utilities, at a level below their current emissions. The government then issues permits to individual utilities representing the ability to produce the allowable level of emissions. These permits can either be issued for free by the government or auctioned off, with auction proceeds going back to the government to use for other clean energy programs, such as loans for renewable energy research and development grants to states for workforce training programs for clean energy industries. Utilities or other industries that pollute in excess of their permits can purchase permits from companies with low emissions, creating a financial incentive to limit emissions on both sides.

A cap-and-trade system for sulfur emissions has succeeded in the United States, and the European Union has a similar system (the European Trading System) in place already for carbon dioxide emissions. Because it uses market mechanisms and allows companies flexibility in how they comply with carbon caps, cap-and-trade is a popular proposal among legislators.

A carbon tax is a less popular alternative, though it is favored by some economists.[83] A carbon tax would place a flat charge on each ton of carbon dioxide emitted, creating a clear financial incentive to limit emissions while also creating tax revenue for the government to use on clean energy programs. Its proponents argue that it is easier to administer and less susceptible to evasion and cheating than a cap-and-trade system, but opponents claim that it hurts consumers because utilities will just pass the taxes through to ratepayers.

Whatever the form of final carbon regulation, some unions are pressuring lawmakers to ensure that working Americans aren't forgotten. Perhaps the most notable example is the IBEW's plan, created in conjunction with the utility AEP, to require that the cost of carbon credits be attached to certain imports from countries that do not control carbon emissions.

Environmental interest groups

Environmental organizations have long been supporters of renewable energy and energy efficiency, and are clear proponents of a strong national carbon dioxide regulation scheme. Now, some environmental groups are supporting cleaner-burning coal technologies in the short term, so long as those technologies include some carbon dioxide capture and storage elements. Prominent organizations like the Clean Air Task Force and the Natural Resources Defense Council are accepting IGCC and CCS as short-term alternatives to traditional coal technology. This represents a fundamental shift in opinion from just a few years ago, when nearly all mainstream environmental groups opposed the construction of any new coal plants, regardless of technology. It is important to note, however, that many environmental groups are not on board with IGCC.[84]

Among environmental groups, the Natural Resource Defense Council (NRDC) has been the most outspoken proponent of next-generation coal technology. According to NRDC Climate Center director David Hawkins, coal consumption and cleaner air are not incompatible goals. In his 2003 testimony to the House Subcommittee on Energy and Air Quality, Hawkins argued that CCS has the potential to "decouple" the politics of coal with the politics of global warming."[85]

The NRDC and several other environmental groups such as the World Wildlife Federation are advancing three-prong strategies for reducing carbon emissions: increased energy efficiency, increased deployment of renewable energy technologies, and improved methods for capturing and storing CO_2. Although these groups prioritize efficiency and renewable energy as long-term solutions, they recognize that coal will inevitably be part of our near-term energy future. Some groups, such as the Clean Air Task Force, have argued that because coal is likely to be utilized for many decades to come both in the United States and in fast-growing economics like China and India, a major effort should be made to significantly reduce the CO_2 emissions and environmental impacts of coal, rather than just trying to stop its use altogether.

Accordingly, this group of environmental organizations tends to support policies such as providing incentives to companies to invest in IGCC and CCS, and also to support carbon emissions regulations that will lower the relative cost of cleaner coal technologies. At the same time, NRDC, the Sierra Club, and others are powerful advocates of employment-friendly technologies and potential allies of labor in the struggle for a cleaner and more prosperous future.

Business interest groups

Support for IGCC and CCS technologies is also gaining steam among investors, energy utilities and manufacturers. Public alarm over climate change has grown so acute that many corporations now believe carbon regulation is inevitable and are looking for solutions to cut future emissions costs. As a general rule, businesses desire cost certainty. Most business experts now agree that some form of carbon regulation is inevitable; however, they are unable to predict its content, scope and timing. Business leaders are also concerned about the fragmented and potentially unstable patchwork of regulatory arrangements emerging at the state and regional levels, which creates an uncertain cost environment for utilities investing in increased energy capacity. Earlier this year in Washington, Jim Rogers, CEO of Duke Energy, captured the anxiety of energy executives at an international conference of legislators: "Today, in the U.S., we don't know what the cost of carbon [dioxide emissions] is. If you don't know the cost of carbon, you can't make an informed investment decision."[86]

Even in the absence of regulation, polluting corporations face potential costs—financial, legal, and otherwise—for jeopardizing environmental and public health. The costs associated with regulation and litigation create risks for businesses engaged in traditional energy generation. Shareholders are urging utilities to take the technological lead in clean energy markets—and at the same time, to reconsider investment in old, outdated technologies such as pulverized coal. Several large institutional investors have launched initiatives demanding that large utilities assess the risks and opportunities of climate change before investing in costly coal plants.[87] Some are even asking the Securities and Exchange Commission to require corporations to disclose information about these risks and opportunities.[88]

National regulation provides a number of potential advantages for business. It provides manufacturers with a helpful incentive for bringing new technologies such as IGCC up to commercial speed. And under cap-and-trade systems, clean and efficient producers can sell their surplus carbon dioxide credits to polluting utilities.[89] As Shell Oil Co. explains, "It is time to pursue stable, market-based policies that help energy users and suppliers pursue innovative energy solutions."[90]

As a result, utilities and other energy producers are a major force behind the many legislative initiatives for carbon dioxide regulation now moving at the federal and state levels. Several corporations, including BP, Lehman, Duke Energy and FPL Group, are part of the newly formed U.S. Climate Action Partnership (USCAP), which is pressing Congress to adopt a cap-and-trade system and to reduce emissions by 10 to 30 percent over the next 15 years. Kohlberg Kravis Roberts and Co. and Texas Pacific Group, the two equity firms that recently purchased TXU, have also joined USCAP.[91] Corporate support for regulation may be the surest signal that mandatory emissions targets will be enacted sooner rather than later.

Corporate consensus and support for regulation should not be exaggerated. Some utilities still oppose regulation, and there is some evidence that several utilities support regulation only on the assumption that it will exempt, or "grandfather," existing and planned PC facilities. But it is unlikely that grandfathering will be widespread. All that is clear is that corporate support for regulation is growing rapidly, making mandatory controls more likely than not.

Labor must be prepared for the shifting tide

Carbon dioxide regulation is coming. Its inevitability makes old energy technologies like pulverized coal increasingly risky, a fact recognized by many utilities and investors. At the same time, carbon dioxide regulation will make investments in new, cleaner technology financially competitive. Recognizing the reality that coal is a part of the nation's short-term energy future, even some environmental groups are starting to support cleaner coal technology like IGCC with CCS. This cooperation among players with such traditionally diverse interests is key to the political success of both carbon dioxide regulation and new coal technologies.

With some exceptions, the labor community has been less enthusiastic about carbon regulation. However, unions are increasingly aware of the economic advantages of deploying cleaner energy alternatives, and the labor opportunities inherent in the development of any new industry. The key issue for labor will be that new energy industries such as IGCC and CCS provide benefits to workers through family-supporting jobs, strong labor standards, and union organizing opportunities. The next section explores these issues further.

Dirty Coal: Risky Business
TXU Case Study

The recent shift in investment plans by Dallas-based utility TXU is a telling story of the risks of investing in conventional coal technologies. TXU had planned to build 11 PC power plants in Texas alone, as well as additional conventional plants out of state. But the investment strategy could not withstand the intense and widespread opposition it mobilized. Opposition came from Texas legislators, Gov. Rick Perry, TXU's major institutional investors, prominent environmental groups, and a coalition of local officials led by Dallas' then-Mayor Laura Miller.

These forces made it virtually impossible for TXU to proceed with its construction plans. The utility's shareholders—including the New York pension funds, the Connecticut State Treasurer's Office, and the Benedictine Sisters of Boerne—warned that, with carbon regulation on the political agenda, it might soon be costly to generate power at pulverized coal plants. "Given the anticipated focus on federal regulations of CO_2 emissions in the new Congress, TXU's strategic thinking seems glaringly short-sighted and unsustainable," argued New York Comptroller William C. Thompson Jr.[92] The message from institutional investors was clear: Companies must either internalize the risks of climate change into their decision-making or suffer the consequences.

When two private equity firms bought out TXU earlier this year, the company agreed to cancel plans to build eight of 11 plants as well as all planned out-of-state PC plants. They also agreed to join a growing number of utilities in supporting nationwide carbon regulation. More recently, TXU has agreed to consider bids for the construction of two IGCC demonstration plants and may install CCS at one or more of these facilities.

The TXU story illustrates the dangers of unwise investments in PC. These investments represent huge liabilities for utilities and often generate public resentment. It is in the interests of construction and utility workers to steer their employers away from these investments toward more promising solutions.

5 Labor's Role in the New Energy Economy

When imagining labor's role in the new energy economy, it is useful to look back at its role in the old energy economy—the fossil fuel economy. In the early days of Western urbanization and industrialization, neither environmental stewardship nor concern for worker rights held much political weight. In the absence of a strong public voice, decisions about fuel and energy were made entirely according to the law of profit. Coal, for example, was originally seen as a fuel that involved too much hassle to be worthwhile while wood was plentiful—so England's forests were nearly decimated before society began to turn seriously to the notion of burning coal. Coal use became widespread and its superior heating value helped launch the industrial revolution, but no public policy checked the smoky emissions that darkened the great cities of London, Manchester, Pittsburgh, and Cleveland. Similarly, no one bothered to ensure that workers in these filthy plants were paid a decent, family-supporting wage, or given adequate health and safety protections.

Only as labor unions, women's groups, and other civic organizations grew in strength was sufficient pressure applied to industry to force companies to consider the human cost of industrial growth. Throughout the first part of the 20th century, unions made tremendous strides in bringing a measure of justice to the workplace. But outside the workplace, emissions from factories and power plants continued to jeopardize public health. Not only did particulate matter pose a direct health risk, but acid rain, smog-causing gases, mercury, and other emissions damaged the entire ecosystem. In the second half of the 20th century, understanding of these risks led to an environmental movement that was able to limit coal-fired power plant emissions of SO_x, NO_x, and particulates.

We are at the cusp of a new industrial revolution, and once again labor unions are in a key position to ensure the economic security, safety, and health of the workers in the factories and plants on which the revolution depends. Labor has the opportunity to be at the forefront of the movement, helping to design a new energy future where workers are treated fairly, jobs are secure, and the right to organize is protected. IGCC with CCS is just one of thousands of new technologies associated with the new energy economy, but it is a crucial one because it arises in an industry that is already heavily unionized, and also because of the sheer number of power plants currently being proposed. If IGCC with CCS becomes an alternative to pulverized coal, labor needs to be at the table making sure that workers benefit and that the union is made stronger. Going further, we argue that labor ought to be on board actively supporting less-polluting alternatives like IGCC with CCS over pulverized coal, because in a carbon-regulated world, these alternatives are simply less risky for workers.

The Challenge and the Opportunity for Labor Unions

The biggest challenge for labor unions today is to keep their fight for the safety, wages, and dignity of all workers at the forefront of national policy. With increased union membership comes increased power to advance a pro-worker agenda at the federal and state level. Unfortunately, due to anti-worker developments such as bad trade agreements and corporate anti-union campaigns, in combination with the reality of de-industrialization, union density is at its lowest level in decades.[93] Building up membership is therefore the biggest priority of most labor unions today. Growing concern among the public about income disparity and unsafe imports may be creating new political space to change some of the worst policies and replace them with legislation such as the Employee Free Choice Act.

Union organizing victories in the energy sector—and its ancillaries, such as mining, transportation, construction, and component manufacturing—have a special role in building union power because of these sectors' central position in the economy and the difficulty of outsourcing the work to other countries. By getting ahead of the changes coming to utilities, labor can gain a strategic advantage disproportionate to the number of people employed in the industry. Union voices in the power industry are amplified by the fact that the work they perform is essential to the American lifestyle. As a result, power sector unions have a unique opportunity to use debates around new technologies such as IGCC and CCS to advance worker-friendly policies including decent wages, job security, health and safety standards, and environmental regulations.

Getting Ahead of the Curve
Cellular Phone Case Study

As early as 1992, the Communication Workers of America (CWA), the International Brotherhood of Electrical Workers (IBEW), and other communication unions recognized that the heavily unionized telephone industry was about to be transformed by the emergence of something called the cellular phone. SBC wanted the union's help in regulatory hearings; the union wanted to organize the wireless division. The two sides began negotiating, and a card-check neutrality agreement was reached that not only added nearly 20,000 members to the union, but kept the union relevant in a rapidly changing essential industry.[94] As the fight to organize the wireless industry continues, the base established by forward-thinking unions in the 90s has aided the labor movement considerably.

Unions in the energy industry understand that they are at a similar point where technology and regulation are changing rapidly. They face complicated questions of how best to advocate for the job security of their members and also capture new jobs in the expanding green sector.

Seizing the Opportunity

The question for union leaders is how to seize the opportunities offered by the changing energy economy, to grow the labor movement, and to promote the overall pro-worker objectives of organized labor. Like most of the country, labor often finds itself caught between the known route of established technology and the desire for something better—better for its members, better for the environment, better for the economy. Promotion of old, recognized technologies like pulverized coal plants seems easy, but if carbon dioxide regulation is enacted, these technologies will become more costly and jobs at these plants will be at risk. As unions take advantage of jobs in the energy economy of the future, they must still guard against the risks inherent in the transition to a new set of technologies, including loss of past-practice or work rules, and the de-skilling of work.

Unions share the frustration of many businesses and community leaders that carbon dioxide regulation has not yet been defined. The manner and stringency of such regulation will be the primary shaper of future energy policy, and thus of future energy technology. With uncertainty, unions do not always see a clear way to position themselves to take advantage of the opportunities in the changing energy industry. Currently, unions in the United States do not have a cohesive strategy to help the labor movement take advantage of this opportunity.

Organized labor need not and should not wait for all uncertainties to be resolved before staking out positions that will grow unions and deepen community alliances. Indeed, waiting to see where the carbon dioxide regulation chips fall will reduce labor's power in the new energy economy. Given unions' ability to act at the grassroots and federal political level, they stand to benefit from emerging technologies by looking for ways to capture the jobs and strategic leverage the new energy industry will bring. At the same time, policymakers need to do their part to ensure that workers are protected during this historic shift toward cleaner power.

The remainder of this section lays out some concrete steps that labor unions and policymakers can take to make the clean energy/good jobs vision a reality.

Labor

There are six general strategies the labor movement can employ to ensure that the new energy economy works for everyone:

- Political engagement to help shape the debate around the new energy economy.
- Training and certification in new technologies related to these industries.
- Prudent investment of pension and building funds in funds that promote a new and just energy economy.
- Strategic alliances and partnerships with other stakeholders, as through the Apollo Alliance and the Blue/Green Alliance.
- Education about risks inherent in outdated industries and opportunities presented in new clean energy industries.
- Strategic organizing and membership drives for workers in new renewable, efficiency, and cleaner coal industries.

On IGCC with CCS specifically, here are some steps that unions can take to get more involved in making IGCC part of the just transition to a cleaner economy:

- Join the network of unions working regionally for IGCC deployment with CCS.
- Talk to regulatory bodies to let them know that the union would look favorably on IGCC proposals.
- Set up meetings with legislators and energy task forces to encourage them to begin making IGCC part of the state's plan for meeting energy needs when new coal capacity is needed.
- Pass resolutions at local, state, district, and national union bodies endorsing IGCC with carbon capture and storage.
- Educate members and community about IGCC through guest speakers, educational materials, or community forums.
- Use bargaining and other meetings with employers to get companies to investigate the feasibility of IGCC with CCS for any new generation.
- Emphasize the importance of union labor not only in plant construction, but also in maintenance, operations, mining, and coal transport.

Policymakers

Organized labor can also help policymakers understand their important role. Policymakers must do their part to ensure that high labor standards and certification requirements are included in any legislation promoting clean energy and energy efficiency, including any legislation providing tax incentives or other grants for IGCC and CCS projects. Any time taxpayer dollars are used to promote the new energy economy, labor standards, such as local hire policies, apprenticeship requirements, living wage/prevailing wage requirements, and benefits standards, should be included. Similarly, it should be government policy to use best value contracting.

Specifically, unions should inform policymakers about the following tools:

- Agreements between units of government and contractors carrying out publicly funded projects, that include requirements or incentives for employing workers trained through state-approved apprenticeship programs.
- State-approved apprenticeship programs, which tie together economic development and workforce development and offer benefits directly to the community, existing workers, and employers.
- Job quality standards in exchange for taxpayer dollars. Any business receiving a government subsidy or tax credit must provide employees decent, family-supporting wages and/or benefits. These standards ensure that new jobs created will be "high road" jobs: providing a decent income and health benefits, and helping residents avoid the "hidden taxpayer costs" that occur when working families rely on state government subsidies like food stamps, Medicare, and the Earned Income Tax Credit.
- Local-hire requirements on public contracts.
- Best value contracting (BVC). BVC, also known as "negotiated contracting" and "competitive sealed proposal contracting," is a procurement method that provides an alternative to the traditional lowest-bid method of contracting. BVC requires contracts to be awarded to the contractor offering the best combination of price and qualifications, including the use of skilled, high-quality workers; past performance; and the ability to complete projects in a safe, timely, and cost-effective manner.

6 Conclusion

The economy is changing in response to public pressure and scientific reality. New energy technologies are being developed every day, with government encouragement and financial support. Carbon dioxide regulation is widely seen as inevitable, bringing with it an entirely new set of incentives for utilities to build less-polluting generating capacity, such as IGCC plants. America's long-term energy picture will surely include major energy efficiency initiatives, electricity generation from renewable sources like the wind and sun, and homegrown electricity from crops and forests. But in the short term, there is little question that coal—currently the source of over half America's electricity—will be part of the picture.

Unions have the opportunity to get on board now to ensure that workers will benefit from the short- and long-term energy economy. The fights now taking place over the coal plants currently proposed in the United States are one place for labor to become involved to ensure that workers and the environment are not left behind in the scramble for new power generation. Will these plants be built using old, outdated technology that runs the risk of obsolescence as soon as Congress or the states pass carbon dioxide regulation? Or will they be built using newer, cleaner technology such as IGCC with CCS, which offers promise for a host of unionized workers in the utility industry and beyond? In the longer term, unions can help ensure that truly clean energy alternatives like wind, solar, geothermal, and energy efficiency are built and installed using high-quality labor and pro-worker policies.

Through proactive policy action labor unions will benefit from the sea change that is coming as a result of growing understanding of climate change, and growing acceptance of carbon regulation. As in the first industrial revolution, workers will be left behind if unions are not out in front ensuring that new energy projects, including IGCC plants, are built to the highest labor and environmental standards. The time is now for unions to dive into the carbon regulation debates, the regulatory fights over particular plants, and the general conversation about how the American economy will change to deal with global warming.

Appendix

Employment Estimates for IGCC

Direct Employment:

Proposed Project	Peak Construction Jobs	Permanent Jobs
Texas Energy Center 1200 MW Houston, Texas[95]	More than 1,200	150
Huntley Re-Powering Project 552 MW Tonawanda, New York[96]	Up to 1,000	100
ERORA Energy Project 770 MW Taylorville, Illinois[97]	1,000	200
Tondu IGCC 600 MW Corpus Christi, Texas[98]	1,000	80
Pacific Mountain Energy Center Two 300 MW turbines Kalama, Washington[99]	1,400	100

Indirect Employment Opportunities

DOE's National Energy Technology Labs say that 75,000 new manufacturing and other jobs per year could be derived from clean coal technology such as IGCC, with that number rising to 200,000 by 2020.[100]

EngineerLive.com says that the 795 MW IGCC plant proposed in Edwardsport, Ind., would create 300 coal-mining jobs in Indiana.[101]

The Illinois Department of Commerce found that every 2.8 million tons of Illinois coal consumed per year results in 750–800 new mining jobs.[102]

The Illinois Coal Association's president, in reference to 700 jobs created or reopened in southern Illinois, claims an upswing in the industry is in part due to coal gasification plants.[103]

The Public Service Commission of Wisconsin notes that in general, jobs in the utility sector create more indirect employment than jobs in most other sectors.[104]

B Appendix

State-level greenhouse gas goals

Entity	Target
Arizona Statewide	2000 levels by 2020 50% below 2000 by 2040
California Statewide	2000 levels by 2010 1990 levels by 2020 80% below 1990 by 2050
Major industries statewide	1990 levels by 2020
Connecticut Statewide	1990 levels by 2010 10% below 1990 by 2020
Illinois Statewide	1990 levels by 2020 60% below 1990 levels by 2050
Maine Statewide	1990 levels by 2010 10% below 1990 by 2020 75–80% below 2003 long-term
Massachusetts Statewide	1990 levels by 2010 10% below 1990 by 2020 75–85% below 1990 long-term
Electric utilities	10% below 1997–1999*
New Hampshire Statewide	1990 levels by 2010 10% below 1990 by 2020 75–85% below 2001 long-term
Electric utilities	1990 levels by 2006*
New Jersey Statewide	1990 levels by 2020 80% below 2006 levels by 2050
New Mexico Statewide	2000 levels by 2012 10% below 2000 by 2020 75% below 2000 by 2050
New York Statewide	5% below 1990 by 2010 10% below 1990 by 2020
Oregon Statewide	Stabilize by 2010 10% below 1990 by 2020 75% below 1990 by 2050
Rhode Island Statewide	1990 levels by 2010 10% below 1990 by 2020
Vermont Statewide	1990 levels by 2010 10% below 1990 by 2020 75–85% below 2001 long-term
Washington Statewide	1990 levels by 2020 25% below 1990 levels by 2035 50% below 1990 levels by 2050
Regional Greenhouse Gas Initiative Power plants	Cap emissions at current levels in 2009 Reduce emissions 10% by 2019
New England Governors and Eastern Canadian Premiers Regional economy-wide	1990 levels by 2010 10% below 1990 by 2020 75–85% below 2001 long-term

*CO_2 only.

Source: Pew Center for Global Climate Change.[105]

Bibliography

Associated Press, "DOE Approves Florida Clean Coal Plant," Forbes.com (Apr. 11, 2007).

Elvia Aguilar, "Power Plant Planned for Ship Channel," Caller-Times (Oct. 3, 2006).

Erin Bowie, "The CWA's Experience: A Tale of Two Card-Check Agreements," Labor Notes (April, 2003).

Bureau of Labor Statistics, "May 2006 State Occupational Employment and Wage Estimates" (2006): available at http://www.bls.gov/oes/current/oessrcst.htm.

Burns & McDonnell, "Burns & McDonnell Awarded Contract by ERORA Group for Next-Generation Coal Gasification Project" (Burns & McDonnell, n.d.): available at http://www.burnsmcd.com/news/erora.html.

Dario Camozzi-Snamprogetti, et al., "Eni Refining & Marketing Sannazzaro Gasification Plant Project Update and Startup Experience" (Washington: 2006): available at http://www.gasification.org/Docs/2006_Papers/14CAMO-Paper.pdf.

Ceres, "Shareholders Challenge TXU on New Coal Plants and Energy Efficiency," (Dec. 8, 2006).

John Chiang & Mindy S. Lubber, "SEC has a role in addressing global warming," San Francisco Chronicle (Apr. 20, 2007).

ChevronTexaco, "Worldwide Gasification Technology," (2003): available at http://www.gasification.org/Docs/2003_Papers/21STUR.pdf.

Clean Air Task Force, "Advanced Coal Background and Highlights": available at http://www.catf.us/projects/power_sector/advanced_coal/igcc.jpg

Clean Air Task Force, "Indiana Wildlife Federation/Clean Air Task Force Intervene in Duke/Vectren Coal Plant Case" (2007): available at http://www.catf.us/press_room/20070409-Duke_Vectren_Coal_Plant_Case.pdf.

Clean Air Task Force, "Indiana Wildlife Federation/Clean Air Task Force Intervene in Duke/Vectren Coal Plant Case" (2007): available at http://www.catf.us/press_room/20070409-Duke_Vectren_Coal_Plant_Case.pdf.

Clean Air Task Force, "Response of the Clean Air Task Force to MIT's 'Future of Coal' Study" (Boston: 2007): available at http://www.catf.us/projects/power_sector/advanced_coal/200707-CATF_Response_to_MIT_Study.pdf.

Kenneth S. Deffeyes, Beyond Oil: The View from Hubbert's Peak (New York: Hill and Wang, 2005).

John Deutch, et al., "The Future of Coal: Options for a Carbon-Constrained World" (Boston: MIT, 2007): available at http://web.mit.edu/coal/.

Tracey Drury, "Tonawanda Plant Gets $1.5B Investment," Buffalo Business First (June 22, 2006).

"Duke Energy Indiana to Receive Major Tax Credits for Plant," Inside INdiana Business (Nov. 30, 2006).

Emerging Energy Research, "IGCC Prospects in US Power Generation" (Cambridge, MA: 2007).

Energy Prospects West, "Arizona IGCC Plant Would Test Terrestrial Sequestration," Western Interconnection Policy & Resource News (May 1, 2007).

Engineer Live, "US $1b tax credit boost for clean coal power and gasification technologies," (2007).

Juliet Eilperen & Steven Mufson, "Tax on Carbon Emissions Gains Support," Washington Post (Apr. 1, 2007).

Environmental Protection Agency, "IGCC and CCS Background Document: State Clean Energy-Environment Technical Forum: Integrated Gasification Combined Cycle (IGCC): Background and Technical Issues" (2006): available at http://www.epa.gov/cleanenergy/pdf/keystone/9_20_revised_final_IGCC_Report_8_24_06.pdf.

Barbara Freese & Stever Clemmer, "Gambling with Coal: How Future Climate Laws Will Make New Coal Power Plants More Expensive" (Union of Concerned Scientists, 2006): available at www.eere.energy.gov/windandhydro/windpoweringamerica/pdfs/workshops/2007_summit/clemmer.pdf.

Gasification Technologies Council, personal communication with Public Service Commission of Wisconsin (June 30, 2006).

Global Wholesale Supply, "Global Wholesale Supply—The direct world-wide supplier of Urea": available at http://www.globalwholesalesupply.com/urea.html.

Greenpeace, "Unmasking the Truth Behind 'Clean Coal': available at http://www.greenpeace.org/seasia/en/asia-energy-revolution/dirty-energy/clean-coal-myth.

David Greising, "Big Business Sweats Climate Change Laws," Chicago Tribune (Mar. 2, 2007).

Bill Hoback, "Practicoal: Illinois Coal and Energy Development" (Office of Coal Development of Department of Commerce and Economic Opportunity, 2005): available at http://www.gasification.org/Docs/Workshops/2005/Knoxville%20Pres/13Hoback.pdf.

Hunton Energy, "Hunton Energy Announces $2.4 Billion Clean Energy Power Plant" (Fort Bend County, TX: 2007): available at http://www.huntonenergy.com/attachments/20070124.pdf.

"IGCC Technology" (General Electric): available at http://www.ge-energy.com/prod_serv/products/gas_turbines_cc/en/igcc/technology.htm.

Labor Research Associates, "U.S. Union Membership, 1948–2004" (LRA Online, n.d.): available at http://www.lraonline.org/charts.php?id=29.

Massachusetts v. Environmental Protection Agency, 549 U.S. ___, 127 S.Ct. 1438 (2007).

Jim Muir, "American Coal Company Recalls Hundreds of Miners," The Southern (Carbondale, Ill., Feb. 13, 2007).

National Energy Technology Laboratory, et al., "Clean Coal Technology Roadmap: Background Information • Community Jobs in the Green Economy": available at http://www.netl.doe.gov/technologies/coalpower/cctc/ccpi/pubs/CCT-Roadmap-Background.pdf

National Energy Technology Laboratory, "Tracking New Coal-Fired Power Plants: Coal's Resurgence in Electric Power Generation" (Department of Energy, 2007): available at http://www.netl.doe.gov/coal/refshelf/ncp.pdf.

National Conference of State Legislatures, personal communication with Center on Wisconsin Strategy (September 2007).

Natural Resources Council of Maine, "The Regional Greenhouse Gas Initiative": available at http://www.nrcm.org/economic_benefits_RGGI.asp.

NRG Energy, "NRG Energy, Inc. Receives Conditional Award to Build Advanced Coal-Gasification Power Plant in Western New York: Will Enter into a Strategic Alliance with NYPA" (2006): available at http://www.snl.com/irweblinkx/file.aspx?IID=4057436&FID=3211361.

Takuya Ono, "NPRC Negishi Startup and Operation" (San Francisco: JGC Corporation, 2003): available at http://www.gasification.org/Docs/2003_Papers/05ONO_paper.pdf.

Office of the Governor, "Gov. Blagojevich Announces $5 Million Investment for New Coal Gasification Project at Taylorville Energy Center" (2006): available at http://www.illinois.gov/PressReleases/ShowPressRelease.cfm?SubjectID=1&RecNum=4576.

Oregon Department of Energy, "Meetings of Siting Council, May 10, 2007" (Salem, OR: 2007): available at http://www.oregon.gov/ENERGY/SITING/announce.shtml.

Pacific Mountain Energy Center EFSEC Application 2006–01: available at http://www.efsec.wa.gov/PMEC/App/PMEC%20Sec%204.pdf.

Pew Center for Global Climate Change, "A Look at Emissions Targets": available at http://www.pewclimate.org/what_s_being_done/targets.

Shar Porier, "SW Power Works Toward Cleaner Coal Plant," Arizona Range News (Sept. 5, 2007).

Tim Rausch, "$60 Million Grant Sought to Create Lima Megacenter," Lima News (Dec. 5, 2006).

"Sarlux IGCC Power Plant, Italy" (Power-Technology.com): available at http://www.power-technology.com/projects/sarlux/.

Tina Seeley, "U.S. Utilities Urge Congress to Establish CO_2 Limits," Bloomberg.com (Apri1 4, 2006).

Ram C. Sekar, et al., "Future Carbon Regulation and Current Investments in Alternative Coal-Fired Power Plant Designs" (Cambridge, MA: MIT Joint Program on the Science and Policy of Climate Change, No. 129, 2005): available at http://web.mit.edu/globalchange/www/MITJPSPGC_Rpt129.pdf.

Shell, "The Shell Report 2004: Meeting the Energy Challenge—Our Progress in Contributing to Sustainable Development" (2004): available at http://www.shell.com/static/envirosoc-en/downloads/sustainability_reports/shell_report_2004.pdf.

Statoil, "Carbon Dioxide Storage Prized" (2000): available at http://www.statoil.com/statoilcom/SVG00990.NSF?OpenDatabase&artid=01A5A730136900A3412569B90069E947.

"Summary of Climate Change Bills Introduced in the 110th Congress" (Resources for the Future, Feb. 16, 2007): available at www.rff.org/rff/News/Features/loader.cfm?url=/commonspot/security/getfile.cfm&PageID=27873&CFID=7320089&CFTOKEN=37729091.

Tampa Electric Co., "Biomass Test Burn Report Polk Power Station Unit 1" (Tampa Electric Company, 2002): available at http://www.treepower.org/TECO/polk-cofiring-testburn.pdf.

U.S. Climate Action Partnership: available at http://www.us-cap.org.

U.S. Congress, House of Representatives, Subcommittee on Energy and Air Quality, "Future Options for Generation of Electricity from Coal." Hearing, 24 June 2003. 108th Cong., 1st sess. David G. Hawkins, Director of the Climate Center at the Natural Resources Defense Council: available at http://energycommerce.house.gov/reparchives/108/Hearings/06242003hearing968/Hawkins1552.htm.

U.S. Department of Energy, (2006): available at http://www.whitehouse.gov/omb/budget/fy2006/images/energy-4.jpg.

U.S. Department of Energy, "Fact Sheet: Clean Coal Technology Ushers in New Era in Energy" (2006): available at http://www.state.gov/g/oes/rls/or/2006/77196.htm.

U.S. Environmental Protection Agency, "Environmental Footprints and Costs of Coal-Based Integrated Gasification Combined Cycle and Pulverized Coal Technologies" (Washington: U.S. Environmental Protection Agency, No. EPA 430/R–06–006, 2006): available at http://www.epa.gov/air/caaac/coaltech/2007_01_epaigcc.pdf.

U.S. Geological Survey, "CO_2 Sequestration Research in the USGS: Helpful Definitions" (U.S. Geological Survey): available at http://energy.er.usgs.gov/health_environment/co2_sequestration/co2_definitions.html.

Maryanne Vollers, "Razing Appalachia," Mother Jones, (July/August 1999).

Wisconsin Department of Natural Resources & Public Service Commission of Wisconsin, "Integrated Combined-Cycle Gasifcation Technology: Costs, Benefits, and Prospects for Future Use in Wisconsin" (Madison, WI: 2007): available at http://psc.wi.gov/CleanCoal/documents/IGCCFinalReport.pdf.

Wyoming Infrastructure Authority, "Wyoming Coal Gasification Project Partnership Announced": available at http://www.wyia.org/announce.htm. Lain Wright, "CO_2 Geological Storage: Lessons Learned from In Salah (Algeria)" (British Petroleum, 2006): available at http://www.cdm-saudiconference.com/cdm/web-resources/docs/1%20-%20OPEC%20CCS%202b%20In%20Salah%20Wright.ppt.

Endnotes

i. United States Geological Survey, "CO2 Sequestration Research in the USGS: Helpful Definitions" (United States Geological Survey): available at http://energy.er.usgs.gov/health_environment/co2_sequestration/co2_definitions.html.

ii. Tampa Electric Co., "Biomass Test Burn Report Polk Power Station Unit 1" (2002): available at http://www.treepower.org/TECO/polk-cofiring-testburn.pdf.

1. Barbara Freese & Stever Clemmer, "Gambling with Coal: How Future Climate Laws Will Make New Coal Power Plants More Expensive" (Union of Concerned Scientists, 2006).
2. Kenneth S. Deffeyes, Beyond Oil: The View from Hubbert's Peak (New York: Hill and Wang, 2005).
3. Clean Air Task Force, "Advanced Coal Background and Highlights."
4. Wisconsin Department of Natural Resources & Public Service Commission of Wisconsin, "Integrated Combined-Cycle Gasifcation Technology: Costs, Benefits, and Prospects for Future Use in Wisconsin" (Madison: 2007).
5. Ibid.
6. U.S. Environmental Protection Agency, "Environmental Footprints and Costs of Coal-Based Integrated Gasification Combined Cycle and Pulverized Coal Technologies" (Washington: U.S. Environmental Protection Agency, No. EPA 430/R-06-006, 2006).
7. Massachusetts v. Environmental Protection Agency, 549 U.S. ___, 127 S.Ct. 1438 (2007).
8. John Deutch, et al., "The Future of Coal: Options for a Carbon-Constrained World" (Boston: MIT, 2007).
9. Ibid.
10. Ibid.
11. Office of the Governor, "Gov. Blagojevich Announces $5 Million Investment for New Coal Gasification Project at Taylorville Energy Center" (2006).
12. "Duke Energy Indiana to Receive Major Tax Credits for Plant," Inside INdiana Business (Nov. 30, 2006).
13. NRG Energy, "NRG Energy, Inc. Receives Conditional Award to Build Advanced Coal-Gasification Power Plant in Western New York: Will Enter into a Strategic Alliance with NYPA" (2006).
14. Gasification Technologies Council, personal communication with Public Service Commission of Wisconsin (June 30, 2006).
15 Ibid.
16. Ibid.
17. Ibid.
18. Ibid.
19. Ibid.
20. "Sarlux IGCC Power Plant, Italy" (Power-Technology.com).
21. Gasification Technologies Council.

22. Takuya Ono, "NPRC Negishi Startup and Operation" (San Francisco: JGC Corporation, 2003).
23. Dario Camozzi-Snamprogetti, et al., "Eni Refining & Marketing Sannazzaro Gasification Plant Project Update and Startup Experience" (Washington: 2006).
24. National Energy Technology Laboratory, "Tracking New Coal-Fired Power Plants: Coal's Resurgence in Electric Power Generation" (Department of Energy, 2007).
25. National Energy Technology Laboratory.
26. Ibid.
27. Ibid.
28. Ibid.
29. Ibid.
30. Ibid.
31. Ibid.
32. Ibid.
33. Ibid.
34. Ibid.
35. Ibid.
36. Ibid.
37. Ibid.
38. Oregon Department of Energy, "Meetings of Siting Council, May 10, 2007" (Salem, OR: 2007).
39. Hunton Energy, "Hunton Energy Announces $2.4 Billion Clean Energy Power Plant" (Fort Bend County, TX: 2007).
40. National Energy Technology Laboratory.
41. Ibid.
42. Ibid.
43. Wyoming Infrastructure Authority, "Wyoming Coal Gasification Project Partnership Announced."
44. National Energy Technology Laboratory.
45. Statoil, "Carbon Dioxide Storage Prized" (2000).
46. Iain Wright, "CO_2 Geological Storage: Lessons Learned from In Salah (Algeria)" (British Petroleum, 2006).
47. Deutch, et al.
48. Tampa Electric Co., "Biomass Test Burn Report Polk Power Station Unit 1" (2002).
49. United States Department of Energy, (2006).
50. Clean Air Task Force, "Indiana Wildlife Federation/Clean Air Task Force Intervene in Duke/Vectren Coal Plant Case" (2007).
51. Deutch, et al.
52. Clean Air Task Force, "Indiana Wildlife Federation/Clean Air Task Force Intervene in Duke/Vectren Coal Plant Case" (2007).
53. Deutch, et al., p. 35.
54. Ibid. p. 36.
55. Maryanne Vollers, "Razing Appalachia," Mother Jones (July/August, 1999).
56. Bill Hoback, "Practicoal: Illinois Coal and Energy Development" (Office of Coal Development of Department of Commerce and Economic Opportunity, 2005).

57. Engineer Live, "US $1b tax credit boost for clean coal power and gasification technologies" (2007).

58. Bureau of Labor Statistics, "May 2006 State Occupational Employment and Wage Estimates" (2006).

59. United States Geological Survey, "CO_2 Sequestration Research in the USGS: Helpful Definitions."

60. Tim Rausch, "$60 Million Grant Sought to Create Lima Megacenter," Lima News (Dec. 5, 2006).

61. Energy Prospects West, "Arizona IGCC Plant Would Test Terrestrial Sequestration," Western Interconnection Policy & Resource News (May 1, 2007).

62. Gasification Technologies Council.

63. "IGCC Technology" (General Electric).

64. U.S. Congress, House of Representatives, Subcommittee on Energy and Air Quality, "Future Options for Generation of Electricity from Coal." Hearing, 24 June 2003, 108th Cong., 1st sess, David G. Hawkins, Director of the Climate Center at the Natural Resources Defense Council.

65. Tondu Corp.

66. ChevronTexaco, "Worldwide Gasification Technology" (2003).

67. Global Wholesale Supply, "Global Wholesale Supply—The direct world-wide supplier of Urea."

68. Ram C. Sekar, et al., "Future Carbon Regulation and Current Investments in Alternative Coal-Fired Power Plant Designs" (Cambridge, MA: MIT Joint Program on the Science and Policy of Climate Change, No. 129, 2005).

69. Wisconsin Department of Natural Resources.

70. Tina Seeley, "U.S. Utilities Urge Congress to Establish CO_2 Limits," Bloomberg.com (April 4, 2006).

71. Natural Resources Council of Maine, "The Regional Greenhouse Gas Initiative."

72. Wisconsin Department of Natural Resources.

73. Sekar, et al.

74. Ibid.

75. Environmental Protection Agency, "IGCC and CCS Background Document: State Clean Energy-Environment Technical Forum: Integrated Gasification Combined Cycle (IGCC): Background and Technical Issues" (2006).

76. Wisconsin Department of Natural Resources.

77. National Conference of State Legislatures, personal communication with Center on Wisconsin Strategy (September 2007).

78. Emerging Energy Research, "IGCC Prospects in US Power Generation" (Cambridge, MA: 2007).

79. Department of Energy, "Fact Sheet: Clean Coal Technology Ushers in New Era in Energy" (2006).

80. "Summary of Climate Change Bills Introduced in the 110th Congress" (Resources for the Future, Feb. 16, 2007).

81. Natural Resources Council of Maine.

82. Signatories to the original RGGI agreement were Connecticut, Delaware, Maine, New Hampshire, New Jersey, New York and Vermont. Maryland has since joined. Three other states and five Canadian provinces have been invited to join RGGI.

83. Juliet Eilperen & Steven Mufson, "Tax on Carbon Emissions Gains Support," Washington Post (April 1, 2007).

84. Greenpeace, "Unmasking the Truth Behind 'Clean Coal.'"

85. U.S. Congress, House of Representatives.

86. David Greising, "Big Business Sweats Climate Change Laws," Chicago Tribune (Mar. 2, 2007).

87. Some of these initiatives are worth noting. Ceres, an organization of investors, environmental groups, and other public interest groups, informs investors of sustainability challenges. Its members range from Trillium Asset Management to the Union of Concerned Scientists to the AFL-CIO (http://www.ceres.org). The Greenwave investment initiative in California calls on the state's two largest public pension funds—the California Public Employees' Retirement System (CalPERS) and the California State Teachers' Retirement System (CalSTERS)—to invest in environmentally friendly technologies and companies (http://www.treasurer.ca.gov/greenwave/green_facts.pdf). Finally, there is the Investor Network on Climate Risk (INCR). The INCR, like Ceres, promotes awareness about the risks of climate change among institutional investors, including pension fund mangers, through summits, conferences and forums (http://www.incr.com/index.php?page=2\).

88. Christopher Cox, chairman of the SEC, received a letter in March 2007 from a group of investors worth $4 trillion in assets, calling on the commission to enact tougher disclosure laws and to support measures to drastically reduce greenhouse gas emissions. The group included the California Controller's Office and Ceres, as well as 24 CEOs from firms including Dupont, Alcoa, and Sun Microsystems. See John Chiang & Mindy S. Lubber, "SEC has a role in addressing global warming," San Francisco Chronicle (April 20, 2007).

89. Greising.

90. Shell, "The Shell Report 2004: Meeting the Energy Challenge—Our Progress in Contributing to Sustainable Development" (2004).

91. United States Climate Action Partnership.

92. Ceres, "Shareholders Challenge TXU on New Coal Plants and Energy Efficiency" (Dec. 8, 2006).

93. Labor Research Associates, "U.S. Union Membership, 1948–2004" (LRA Online, n.d.).

94. Erin Bowie, "The CWA's Experience: A Tale of Two Card-Check Agreements," Labor Notes (April, 2003).

95. Hunton Energy.

96. Tracey Drury, "Tonawanda Plant Gets $1.5B Investment," Buffalo Business First (June 22, 2006).

97. Burns & McDonnell, "Burns & McDonnell Awarded Contract by ERORA Group for Next-Generation Coal Gasification Project" (Burns & McDonnell, n.d.).

98. Elvia Aguilar, "Power Plant Planned for Ship Channel," Caller-Times (Oct. 3, 2006).

99. Pacific Mountain Energy Center EFSEC Application 2006-01, pp. 105–112.

100. National Energy Technology Laboratory, et al., "Clean Coal Technology Roadmap: Background Information."

101. Engineer Live.

102. Hoback.

103. Jim Muir, "American Coal Company Recalls Hundreds of Miners" The Southern (Carbondale, Ill., Feb. 13, 2007).

104. Wisconsin Department of Natural Resources.

105. Pew Center for Global Climate Change, "A Look at Emissions Targets."